SVG++ Documentation

Release 1.0

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CHAPTER 1

About

SVG++ library can be thought of as a framework, containing parsers for various SVG syntaxes, adapters that simplify handling of parsed data and a lot of other utilities and helpers for the most common tasks. Take a look at *Tutorial* to get the idea about what it is. Library sources available at https://github.com/svgpp/svgpp.

SVG++ features

- Is a header-only library
- Can be used with any XML parser
- Compile time configured - no virtual functions
- Minimal runtime overhead - you pay only for what you get
- Has wide range of possible uses:
  - Fully functional, conforming SVG viewers
  - Simple in-app SVG rasterizers
  - Import modules of vector editing software
  - Implementing path-only input of SVG format with minimal efforts in any graphics or math software
- Requires only Boost library itself (demo, tests and sample have their own requirements)
- Compatible with C++03, but requires conforming implementation, due to heavy usage of templates
- Supports any character type (*char* and *wchar_t*). Other (Unicode from C++11) were not tested, but should be ok.

SVG 1.1 features covered by SVG++

- Path data - parsing, simplification
- Transform list - parsing, simplification
- Color, including ICC color - parsing
- Lengths - highly configurable handling of SVG lengths, full support of all SVG length units
- Basic shapes - optional conversion to path

- Style attribute - parsing, taking in account differences in parsing presentation attributes and style properties
- Automatic marker positions calculation
- Viewport and viewbox handling

SVG++ is NOT

- An SVG viewer or library that produces raster image from SVG (though C++ demo app included, which renders SVG with AGG, GDI+ or Skia graphics library)
- Renders anything itself

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1.1 Installation

The latest version of SVG++ can be downloaded from SVG++ repository, at https://github.com/svgpp/svgpp, or as a package at https://github.com/svgpp/svgpp/archive/master.zip

SVG++ requires Boost library (was tested with Boost >= 1.55). Only header-only libraries from Boost are used, no build required.

SVG++ consists of header files only and does not require any libraries to link against. Including `svgpp/svgpp.hpp` will be sufficient for most projects.

Library was tested with this compilers:

- Visual Studio 2010, 2012, 2013, 2015
- GCC 4.8 (in C++11 mode it requires Boost >= 1.56)
- Clang 3.2

Note: Compilation of module that uses a lot of SVG++ features may require large amount of RAM. Please be aware of this when compiling on VMs.

1.2 Tutorial

This tutorial introduces SVG++ features by adding them one-by-one into some sample application.

All SVG++ headers may be included through this one:

```
#include <svgpp/svgpp.hpp>
```

All SVG++ code is placed in `svgpp` namespace. We'll import the entire namespace in our sample.

1.2.1 Handling Shapes Geometry

Basic pattern of SVG++ usage: call `document_traversal::load_document` method, passing XML element and *context* to it. Library will call methods of *context*, passing the parsed data.

```
#include <svgpp/svgpp.hpp>

using namespace svgpp;

class Context
{
public:
  void path_move_to(double x, double y, tag::coordinate::absolute);
  void path_line_to(double x, double y, tag::coordinate::absolute);
  void path_cubic_bezier_to(
    double x1, double y1,
    double x2, double y2,
    double x, double y,
    tag::coordinate::absolute);
  void path_quadratic_bezier_to(
    double x1, double y1,
    double x, double y,
    tag::coordinate::absolute);
  void path_elliptical_arc_to(
    double rx, double ry, double x_axis_rotation,
    bool large_arc_flag, bool sweep_flag,
    double x, double y,
    tag::coordinate::absolute);
  void path_close_subpath();
  void path_exit();

  void on_enter_element(tag::element::any);
  void on_exit_element();
};

typedef
  boost::mpl::set<
    // SVG Structural Elements
    tag::element::svg,
    tag::element::g,
    // SVG Shape Elements
    tag::element::circle,
    tag::element::ellipse,
    tag::element::line,
    tag::element::path,
    tag::element::polygon,
    tag::element::polyline,
    tag::element::rect
  >::type processed_elements_t;

void loadSvg(xml_element_t xml_root_element)
{
  Context context;
  document_traversal<
    processed_elements<processed_elements_t>,
    processed_attributes<traits::shapes_attributes_by_element>
  >::load_document(xml_root_element, context);
}
```

document_traversal is a facade that provides access to most library capabilities.

In most cases only some subset of SVG elements is needed, so we pass *named template parameter processed_elements* to `document_traversal` template class. In our case it is `processed_elements_t` - `boost::mpl::set`

that combines `traits::shape_elements` (enumerates SVG shapes) with **svg** and **g** elements.

SVG++ references SVG element types by *tags*.

We choose SVG attributes subset and pass it as *processed_attributes* parameter. `traits::shapes_attributes_by_element` contains attributes, that describe geometry of all shapes ({**x**, **y**, **width**, **height**, **rx** and **ry**} for **rect**, {**d**} for **path** etc.).

In this sample the same context instance is used for all SVG elements. `Context::on_enter_element(element_tag)` is called when moving to child SVG element, type of child element passed as tag in the only argument (`tag::element::any` is a base class for all element tags). `on_exit_element()` is called when processing of child element is finished:

XML element	Call to context
`<svg>`	`on_enter_element(tag::element::svg())`
`<rect`	`on_enter_element(tag::element::rect())`
`x="100" y="200"`	
`/>`	`on_exit_element()`
`<g>`	`on_enter_element(tag::element::g())`
`<rect`	`on_enter_element(tag::element::rect())`
`x="300" y="100"`	
`/>`	`on_exit_element()`
`</g>`	`on_exit_element()`
`</svg>`	`on_exit_element()`

Calls like `path_XXXX` except `path_exit` correspond to SVG path data commands. `path_exit` is called after path data attribute was parsed.

SVG++ by default (see *Path Policy* for details):

- converts relative coordinates to absolute ones;
- commands for horizontal and vertical lines (**H**, **h**, **V**, **v**) converts to calls to `path_line_to` with two coordinates;
- shorthand/smooth curveto and shorthand/smooth quadratic Bézier curveto replaces with calls with full parameters list.

SVG++ by default converts basic shapes to path (see *Basic Shapes Policy* for details).

1.2.2 XML Parser

We didn't declared `xml_element_t` yet. Let's use RapidXML NS library (it is a clone of RapidXML with namespace handling added) that comes with SVG++ in the `third_party/rapidxml_ns/rapidxml_ns.hpp` file. It's a single header library, so we just need to point to its header:

```
#include <rapidxml_ns/rapidxml_ns.hpp>
```

Then we must include SVG++ *policy* for chosen XML parser:

```
#include <svgpp/policy/xml/rapidxml_ns.hpp>
```

XML policy headers don't include parser header because their location and names may differ. The programmer must include appropriate XML parser header herself before including policy header.

Setting appropriate XML element type for RapidXML NS parser:

```
typedef rapidxml_ns::xml_node<> const * xml_element_t;
```

You can find the full cpp file here: src/samples/sample01a.cpp.

1.2.3 Handling Transformations

Just add `tag::attribute::transform` to `processed_attributes` list and `transform_matrix` method to `Context` class:

```
void transform_matrix(const boost::array<double, 6> & matrix);

typedef
  boost::mpl::insert<
    traits::shapes_attributes_by_element,
    tag::attribute::transform
  >::type processed_attributes_t;

/* ... */

document_traversal<
  processed_elements<processed_elements_t>,
  processed_attributes<processed_attributes_t>
>::load_document(xml_root_element, context);
```

Passed `matrix` array `[a b c d e f]` correspond to this matrix:

$$\begin{bmatrix} a & c & e \\ b & d & f \\ 0 & 0 & 1 \end{bmatrix}$$

The *default* SVG++ behavior is to join all transformations in `transform` attribute into single affine transformation matrix.

Source file: src/samples/sample01b.cpp.

1.2.4 Handling Viewports

The **svg** element may be used inside SVG document to establish a new viewport. To process new viewport coordinate system and new user coordinate system several attributes must be processed (**x**, **y**, **width**, **height**, **preserveAspectRatio**, **viewbox**). SVG++ will do it itself if we set `policy::viewport::as_transform` *Viewport Policy*

```
document_traversal<
  processed_elements<processed_elements_t>,
  processed_attributes<processed_attributes_t>,
  viewport_policy<policy::viewport::as_transform>
>::load_document(xml_root_element, context);
```

we also must append viewport attributes to the list of processed attributes:

```
typedef
  boost::mpl::fold<
    boost::mpl::protect<
      boost::mpl::joint_view<
        traits::shapes_attributes_by_element,
        traits::viewport_attributes
      >
    >,
    boost::mpl::set<
      tag::attribute::transform
    >::type,
    boost::mpl::insert<boost::mpl::_1, boost::mpl::_2>
  >::type processed_attributes_t;
```

Please note that this cryptic code just merges predefined sequences `traits::shapes_attributes_by_element` and `traits::viewport_attributes` with `tag::attribute::transform` attribute into single MPL sequence equivalent to the following:

```
typedef boost::mpl::set<
  // Transform attribute
  tag::attribute::transform,
  // Viewport attributes
  tag::attribute::x,
  tag::attribute::y,
  tag::attribute::width,
  tag::attribute::height,
  tag::attribute::viewBox,
  tag::attribute::preserveAspectRatio,
  // Shape attributes for each shape element
  boost::mpl::pair<tag::element::path,      tag::attribute::d>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::x>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::y>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::width>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::height>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::rx>,
  boost::mpl::pair<tag::element::rect,      tag::attribute::ry>,
  boost::mpl::pair<tag::element::circle,    tag::attribute::cx>,
  boost::mpl::pair<tag::element::circle,    tag::attribute::cy>,
  boost::mpl::pair<tag::element::circle,    tag::attribute::r>,
  boost::mpl::pair<tag::element::ellipse,   tag::attribute::cx>,
  boost::mpl::pair<tag::element::ellipse,   tag::attribute::cy>,
  boost::mpl::pair<tag::element::ellipse,   tag::attribute::rx>,
  boost::mpl::pair<tag::element::ellipse,   tag::attribute::ry>,
  boost::mpl::pair<tag::element::line,      tag::attribute::x1>,
  boost::mpl::pair<tag::element::line,      tag::attribute::y1>,
  boost::mpl::pair<tag::element::line,      tag::attribute::x2>,
  boost::mpl::pair<tag::element::line,      tag::attribute::y2>,
  boost::mpl::pair<tag::element::polyline,  tag::attribute::points>,
  boost::mpl::pair<tag::element::polygon,   tag::attribute::points>
>::type processed_attributes_t;
```

Now SVG++ will call the existing method `transform_matrix` to set new user coordinate system. And we must add some methods that will be passed with information about new viewport:

```
void set_viewport(double viewport_x, double viewport_y, double viewport_width, double␣
↪viewport_height);
void set_viewbox_size(double viewbox_width, double viewbox_height);
```

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```
void disable_rendering();
```

The full cpp file for this step can be found here: src/samples/sample01c.cpp.

1.2.5 Creating Contexts

Until now only one instance of context object was used for entire SVG document tree. It is convenient to create context instance on stack for each SVG element processed. This behavior is controlled by *context factories*, passed by *context_factories* parameter of `document_traversal` template class.

Context factories is a Metafunction Class that receives parent context type and child element tag as parameters and returns *context factory* type.

This sample application processes structural elements (**svg** and **g**) and shape elements (**path**, **rect**, **circle** etc). For the structural elements only **transform** attribute is processed, and for the shape elements - **transform** and attributes describing shape. So we can divide `Context` context class for `BaseContext` and `ShapeContext` subclass:

```
class BaseContext
{
public:
  void on_exit_element();
  void transform_matrix(const boost::array<double, 6> & matrix);
  void set_viewport(double viewport_x, double viewport_y, double viewport_width,␣
↪double viewport_height);
  void set_viewbox_size(double viewbox_width, double viewbox_height);
  void disable_rendering();
};

class ShapeContext: public BaseContext
{
public:
  ShapeContext(BaseContext const & parent);
  void path_move_to(double x, double y, tag::coordinate::absolute);
  /* ... other path methods ... */
};

struct ChildContextFactories
{
  template<class ParentContext, class ElementTag, class Enable = void>
  struct apply
  {
    // Default definition handles "svg" and "g" elements
    typedef factory::context::on_stack<BaseContext> type;
  };
};

// This specialization handles all shape elements (elements from traits::shape_
↪elements sequence)
template<class ElementTag>
struct ChildContextFactories::apply<BaseContext, ElementTag,
  typename boost::enable_if<boost::mpl::has_key<traits::shape_elements, ElementTag> >
↪::type>
{
  typedef factory::context::on_stack<ShapeContext> type;
};
```

`factory::context::on_stack<ChildContext>` factory creates context object `ChildContext`, passing reference to parent context in `ChildContext` constructor. Lifetime of context object - until processing of element content (child elements and text nodes) is finished. `on_exit_element()` is called right before object destruction.

`ChildContextFactories` is passed to `document_traversal`:

```
document_traversal<
  /* ... */
  context_factories<ChildContextFactories>
>::load_document(xml_root_element, context);
```

Source file: src/samples/sample01d.cpp.

1.2.6 The use Element Support

The **use** element is used to include/draw other SVG element. If **use** references **svg** or **symbol**, then new viewport and user coordinate system are established.

To add support for **use** in our sample we:

- Add `tag::element::use_` to the list of processed elements, and `tag::attribute::xlink::href` to the list of processed attributes (**x**, **y**, **width** and **height** already included through `traits::viewport_attributes`).
- Create context class `UseContext` to be used for **use** element, that will collect **x**, **y**, **width**, **height** and **xlink:href** attributes values.
- After processing all **use** element attributes (in method `UseContext::on_exit_element()`), look inside document for element with given **id** and load it with call to `document_traversal_t::load_referenced_element<...>::load()`.
- Implement *Viewport Policy* requirement - **svg** and **symbol** context must have method:

  ```
  void get_reference_viewport_size(double & width, double & height);
  ```

  that returns size of the viewport set in referenced **use** element. One of possible variant is creation of new context `ReferencedSymbolOrSvgContext`.

Full implementation is in file: src/samples/sample01e.cpp.

1.2.7 Calculating Marker Positions

SVG++ may solve complex task of calculating orientations of markers with attribute *orient="auto"*. Let's set *Markers Policy* that enables this option:

```
document_traversal<
  /* ... */
  markers_policy<policy::markers::calculate_always>
> /* ... */
```

Then add *Marker Events* method to `ShapeContext`:

```
void marker(marker_vertex v, double x, double y, double directionality, unsigned␣
↪marker_index);
```

The sample (src/samples/sample01f.cpp) just shows how to get marker positions. To implement full marker support we also need to process **marker**, **marker-start**, **marker-mid** and **marker-end** properties and process **marker** element (similar to processing of **use** element). Demo application may give some idea about this.

1.2.8 Processing of stroke and stroke-width Properties

Adding **stroke-width** property processing is trivial - just add `tag::attribute::stroke_width` to the list of processed attributes, and add method, that receives value, to the context class:

```
void set(tag::attribute::stroke_width, double val);
```

Property **stroke** has complex type *<paint>*:

```
<paint>:      none |
              currentColor |
              <color> [<icccolor>] |
              <funciri> [ none | currentColor | <color> [<icccolor>] ] |
              inherit
```

that is why so many methods are required to receive all possible values of the property:

```
void set(tag::attribute::stroke_width, double val);
void set(tag::attribute::stroke, tag::value::none);
void set(tag::attribute::stroke, tag::value::currentColor);
void set(tag::attribute::stroke, color_t color, tag::skip_icc_color = tag::skip_icc_
↪color());
template<class IRI>
void set(tag::attribute::stroke tag, IRI const & iri);
template<class IRI>
void set(tag::attribute::stroke tag, tag::iri_fragment, IRI const & fragment);
template<class IRI>
void set(tag::attribute::stroke tag, IRI const &, tag::value::none val);
template<class IRI>
void set(tag::attribute::stroke tag, tag::iri_fragment, IRI const & fragment,␣
↪tag::value::none val);
template<class IRI>
void set(tag::attribute::stroke tag, IRI const &, tag::value::currentColor val);
template<class IRI>
void set(tag::attribute::stroke tag, tag::iri_fragment, IRI const & fragment,␣
↪tag::value::currentColor val);
template<class IRI>
void set(tag::attribute::stroke tag, IRI const &, color_t val, tag::skip_icc_color =␣
↪tag::skip_icc_color());
template<class IRI>
void set(tag::attribute::stroke tag, tag::iri_fragment, IRI const & fragment, color_t␣
↪val, tag::skip_icc_color = tag::skip_icc_color());
```

Default *IRI Policy* is used that distinguishes absolute IRIs and local IRI references to fragments in same SVG document.

Source code: src/samples/sample01g.cpp.

Note: `svgpp_parser_impl.cpp` file was added to the project and a couple of macros was added at the start of the `sample01g.cpp` to get around Visual C++ 2015 "compiler out of memory" problem. See *description* of this solution.

1.2.9 Custom Color Factory

Suppose that default SVG++ color presentation as 8 bit per channel RGB value packed in `int` doesn't suit our needs. We prefer to use some custom type, e.g. `boost::tuple` (same as C++11 `std::tuple`):

```
typedef boost::tuple<unsigned char, unsigned char, unsigned char> color_t;
```

In this case we need our own *Color Factory*, that creates our custom color from components values, that was read from SVG:

```
struct ColorFactoryBase
{
  typedef color_t color_type;

  static color_type create(unsigned char r, unsigned char g, unsigned char b)
  {
    return color_t(r, g, b);
  }
};

typedef factory::color::percentage_adapter<ColorFactoryBase> ColorFactory;

document_traversal<
  /* ... */
  color_factory<ColorFactory>
> /* ... */
```

Usage of `factory::color::percentage_adapter` frees us from implementing `create_from_percent` method in our *Color Factory*.

Source file: src/samples/sample01h.cpp.

1.2.10 Correct Length Handling

On next step (src/samples/sample01i.cpp) of sample evolution we will add correct handling of *length*, that takes in account device resolution (dpi) and changes of viewport size by **svg** and **symbol** elements, that affects lengths, which are set in percent. So we:

- Add to `BaseContext` class constructor that receives device resolution in dpi (this constructor is only called by ourselves from `loadSvg` function).
- Add `length_factory_` field and access function. `length_factory_` settings (resolution, viewport size) will be passed to child contexts in copy constructor.
- In `BaseContext::set_viewport` and `BaseContext::set_viewbox_size` methods pass *viewport* size to the *Length Factory*.
- Set *Length Policy*, that will ask `BaseContext` class for *Length Factory* instance:

  ```
  document_traversal<
    /* ... */
    length_policy<policy::length::forward_to_method<BaseContext> >
  > /* ... */;
  ```

```
class BaseContext: public StylableContext
{
public:
```

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```
  BaseContext(double resolutionDPI)
  {
    length_factory_.set_absolute_units_coefficient(resolutionDPI, tag::length_
↪units::in());
  }

  /* ... */

  // Viewport Events Policy
  void set_viewport(double viewport_x, double viewport_y, double viewport_width,␣
↪double viewport_height)
  {
    length_factory_.set_viewport_size(viewport_width, viewport_height);
  }

  void set_viewbox_size(double viewbox_width, double viewbox_height)
  {
    length_factory_.set_viewport_size(viewbox_width, viewbox_height);
  }

  // Length Policy interface
  typedef factory::length::unitless<> length_factory_type;

  length_factory_type const & length_factory() const
  { return length_factory_; }

private:
  length_factory_type length_factory_;
};
```

According to SVG Specification, the size of the new viewport affects attributes of element that establish new viewport (except **x**, **y**, **width** and **height** attributes). As our *Length Factory* converts lengths to numbers immediately, we need to pass new viewport size to *Length Factory* before processing other attributes. To do so we will use *get_priority_attributes_by_element* parameter of *Attribute Traversal Policy*:

```
struct AttributeTraversal: policy::attribute_traversal::default_policy
{
  typedef boost::mpl::if_<
    // If element is 'svg' or 'symbol'...
    boost::mpl::has_key<
      boost::mpl::set<
        tag::element::svg,
        tag::element::symbol
      >,
      boost::mpl::_1
    >,
    boost::mpl::vector<
      // ... load viewport-related attributes first ...
      tag::attribute::x,
      tag::attribute::y,
      tag::attribute::width,
      tag::attribute::height,
      tag::attribute::viewBox,
      tag::attribute::preserveAspectRatio,
      // ... notify library, that all viewport attributes that are present was loaded.
      // It will result in call to BaseContext::set_viewport and BaseContext::set_
↪viewbox_size
```

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```
      notify_context<tag::event::after_viewport_attributes>
    >::type,
    boost::mpl::empty_sequence
  > get_priority_attributes_by_element;
};

document_traversal<
  /* ... */
  attribute_traversal_policy<AttributeTraversal>
> /* ... */;
```

Now we are sure that `BaseContext::set_viewport` (and `BaseContext::set_viewbox_size`) will be called before other attributes are processed.

1.2.11 Text Handling

On the next step (src/samples/sample01j.cpp) we will implement basic handling of **text** elements:

- Create new `TextContext` child of `BaseContext` that will receive **text** element data. `set_text` *method* will be called by SVG++ to pass character data content of element:

```
template<class Range>
void set_text(Range const & text)
{
  text_content_.append(boost::begin(text), boost::end(text));
}
```

- Add specialization of **ChildContextFactories** class that will create `TextContext` class for **text** elements (`tag::element::text`).
- Add `tag::element::text` to the list of processed elements `processed_elements_t`.

1.3 Library Organization

1.3.1 Context

Main pattern of SVG++ usage: programmer calls some library function, passing reference to *context* and reference to XML element or value of XML attribute; library calls static methods of corresponding *Events Policy*, passing *context* and parsed values as arguments.

Events Policies (*Value Events Policy*, *Transform Events Policy*, *Path Events Policy* etc) know how to pass value to corresponding *context* type. Default *Events Policies* treats *context* as an object, calling its methods.

1.3.2 Components

Below are shown the main SVG++ components, starting from the lowest level. Every following is based on the preceding:

Grammars Boost.Spirit implementations of grammars in SVG Specification.

Value Parsers *Value Parsers* are functions that convert string values of attributes and CSS properties to calls of user functions with convenient presentation of SVG data. Some of them use *grammars*.

E.g., attribute value **x="16mm"** may be passed as corresponding `double` value, taking into account units, and **d="M10 10 L15 100"** may become sequence of calls like `path_move_to(10,10); path_line_to(15, 100);`.

Adapters *Value Parsers* as much as possible saves SVG information, this allows, for example, to use SVG++ for SVG DOM generation. In other applications this information may be excessive. SVG++ provides some *adapters*, that may simplify processing of SVG. *Adapters* are configured by *policies*.

Attribute Dispatcher *Attribute Dispatcher* object is created internally for each element. It chooses and calls corresponding *Value Parser* for each attribute. Besides that *Attribute Dispatcher* manages adapters that processed several attributes of same element. For example, adapter that converts **line** element to **path** must collect values of **x1**, **y1**, **x2** and **y2** attributes - this is managed by *Attribute Dispatcher*.

Attribute Traversal

- *Attribute Traversal* object is created internally for each element and it calls methods of *Attribute Dispatcher*.
- Finds out numeric id of attribute by its name.
- Parses **style** attribute, so that values of attributes and values of CSS properties are handled identically.
- Checks presence of mandatory attributes in element.
- "Hides" presentation attribute, if this property is already set in the **style** attribute.
- Allows attribute ordering.

Document Traversal

- Traverses SVG document tree, processes elements selected for processing by the programmer.
- Checks content model, i.e. whether each child element is allowed for this parent.
- Creates instances of *Attribute Dispatcher* and *Attribute Traversal* and passes processing to them for each element.
- Passes to the user code child text nodes of SVG elements that are allowed to carry text content by SVG Specification.

Document Traversal provides convenient access to entire library and, in most cases, it is the only SVG++ component with which programmer interacts.

Grammars are quite independent components and can be easily used separately.

Value Parsers have simple interface and can be easily called from application if for some reason traversing of SVG document tree by *Document Traversal* isn't applicable or only few attributes need to be parsed.

Attribute Traversal and *Attribute Dispatcher* aren't described in the documentation and unlikely to be used from outside.

1.3.3 Tags

SVG++ widely uses *tag* concept to reference various SVG entities in compile time with overload resolution and metaprogramming techniques. *Tag* here is just an empty class.

```
namespace tag
{
  namespace element
  {
```

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```
    struct any {};    // Common base for all element tags. Made for convenience
    struct a: any {};
    struct altGlyph: any {};
    // ...
    struct vkern: any {};
  }

  namespace attribute
  {
    struct accent_height {};
    struct accumulate {};
    // ...
    struct zoomAndPan {};

    namespace xlink
    {
      struct actuate {};
      struct arcrole {};
      // ...
      struct type {};
    }
  }
}
```

Each SVG element corresponds to tag in `tag::element` C++ namespace, and each SVG attribute (or property) corresponds to tag in `tag::attribute` namespace. Attributes from XML namespace **xlink** corresponds to tags in namespace `tag::attribute::xlink`, and attributes from XML namespace **xml** corresponds to tags in namespace `tag::attribute::xml`. There are also other tags, described in other parts of the documentation.

1.3.4 Named Class Template Parameters

SVG++ widely uses named class template parameters for compile-time library configuration. It looks like this:

```
svgpp::document_traversal<
  svgpp::length_policy<SomeUserLengthPolicy>,
  svgpp::path_policy<SomeUserPathPolicy>
  /* ... */
>::load_document(/* ... */);
```

In this example `SomeUserLengthPolicy` type is passed as `length_policy` parameter, and `SomeUserPathPolicy` type is passed as `path_policy` parameter.

Named class template parameters are passed through SVG++ components down to *Value Parsers* level.

1.3.5 Library Customization

Policies allows customization of most library aspects. There are two ways of setting *policy*:

1. Pass policy as a named class template parameter. For example:

   ```
   document_traversal<
     length_policy<UserLengthPolicy>
   >::load_document(/* ... */);
   ```

2. Create specialization of class `default_policy` for the *context* type in proper C++ namespace:

```
namespace svgpp { namespace policy { namespace length
{
  template<>
  struct default_policy<UserContext>: UserLengthPolicy
  {};
}}}
```

1.3.6 XML Parser

SVG++ uses external XML parsing libraries. Interaction with XML parser is handled by specialization of *XML Policy* classes.

`XMLElement` template parameter is used to automatically choose *XML Policy* for XML parser used.

Programmer must include XML parser library header files, after that include header file of corresponding *XML Policy* from SVG++ and only after that include other SVG++ headers. For example:

```
#include <rapidxml_ns/rapidxml_ns.hpp>
#include <svgpp/policy/xml/rapidxml_ns.hpp>
#include <svgpp/svgpp.hpp>
```

Below are XML parsing libraries supported by SVG++, their respective *XML Policy* header files and expected XMLElement type:

XML Parser Library	Policy header	XMLElement template parameter
RapidXML NS	<svgpp/policy/xml/rapidxml_ns.hpp>	`rapidxml_ns::xml_node<Ch> const *`
libxml2	<svgpp/policy/xml/libxml2.hpp>	`xmlNode *`
MSXML	<svgpp/policy/xml/msxml.hpp>	`IXMLDOMElement *`
Xerces	<svgpp/policy/xml/xerces.hpp>	`xercesc::DOMElement const *`

1.3.7 Strings

SVG++ supports different character types - `char` and `wchar_t`, and on supporting compilers `char16_t` and `char32_t`. Character type is defined by XML parsing library used.

Strings are passed to the user code by some unspecified model of Forward Range concept. Example of processing:

```
struct Context
{
  template<class Range>
  void set(svgpp::tag::attribute::result, Range const & r)
  {
    std::string value;
    value_.assign(boost::begin(r), boost::end(r));
  }
};
```

If template function can't be used (e.g. it is virtual function), then boost::any_range can be used as string range type.

1.3.8 CSS Support

SVG++ parses properties in **style** attribute, if **style** processing is *enabled* by the programmer.

SVG++ doesn't support CSS cascading and CSS stylesheet in **style** element. It may be handled, if needed, by some other component, that provides result as **style** attribute.

1.4 Library Reference

1.4.1 Document Traversal

document_traversal Class

`document_traversal` template class is a facade that provides access to most features of SVG++ library.

`document_traversal` contains only static methods. Each `document_traversal` method receives *context* and *XML element* parameters. *Context* is a user defined object that will receive parsed data. *XML element* has *type* of XML element in chosen XML parser.

Named template parameters of `document_traversal` class allows to configure almost each aspect of SVG processing.

```
template<class Args...>
struct document_traversal
{
  template<class XMLElement, class Context>
  static bool load_document(XMLElement const & xml_root_element, Context & context)
    { return load_expected_element(xml_root_element, context, tag::element::svg()); }

  template<class XMLElement, class Context, class ElementTag>
  static bool load_expected_element(
    XMLElement const & xml_element,
    Context & context,
    ElementTag expected_element);

  template<class RefArgs...>
  struct load_referenced_element
  {
    template<class XMLElement, class Context>
    static bool load(XMLElement const & xml_element, Context & parent_context);
  };
};
```

Methods

```
template<class XMLElement, class Context>
static bool load_document(XMLElement const & xml_root_element, Context & context);
```

`load_document` - is a shortcut for `load_expected_element` that receives root element (**svg**) of SVG document as `xml_root_element` parameter.

```
template<class XMLElement, class Context, class ElementTag>
static bool load_expected_element(
  XMLElement const & xml_element,
  Context & context,
  ElementTag expected_element);
```

`load_expected_element` loads `xml_element` and its descendands and passes parsed data to `context`.

`load_expected_element` expects that XML name of `xml_element` corresponds to `ElementTag`. Otherwise exception `unexpected_element_error` is thrown (see *Error Policy*).

```
template<class RefArgs...>
template<class XMLElement, class Context>
static bool load_referenced_element<RefArgs...>::load(
  XMLElement const & xml_element,
  Context & parent_context);
```

`load_referenced_element` mainly used to load SVG elements that are referenced by other SVG element, e.g. **use** element or *gradients*. Unlike `load_expected_element`, allowed XML name of `xml_element` isn't limited to one and is passed as `expected_elements` sequence.

Named class template parameters of `document_traversal::load_referenced_element`

`expected_elements` ***(required)*** Value is Associative Sequence. Contains list of tags of expected elements for `xml_element`. If XML name of `xml_element` doesn't correspond to any from the list, exception `unexpected_element_error` (see *Error Policy*) is thrown.

Note: `traits::reusable_elements` contains list of elements, that can be referenced by **use** element.

`referencing_element` ***(optional)*** Value is tag of element that references `xml_element`. It is used only if *Viewport Policy* requires processing of viewport by SVG++ (for correct processing of **svg** and **symbol** elements, referenced by **image** or **use** elements).

`processed_elements` or `ignored_elements` ***(optional)*** Only one may be set. See *description* of `document_traversal` parameters with the same names. Allows to override `document_traversal` settings `processed_elements`/`ignored_elements` for the passed SVG element. Child elements will be processed with `document_traversal` settings.

document_traversal Named Class Template Parameters

`ignored_elements` and `processed_elements` One of them must be set to limit SVG elements processed. It must be model of Associative Sequence (e.g. `boost::mpl::set`), containing element tags.

If `processed_elements` is set, then only the listed elements are processed, otherwise if `ignored_elements` is set, then only non-listed elements are processed.

`ignored_attributes` and `processed_attributes` One of them must be set to limit SVG attributes processed. It must be model of Associative Sequence, containing attribute tags. Also it may contain pairs <element tag, attribute tag> like this `boost::mpl::pair<tag::element::g, tag::attribute::transform>`, such pair is matched if both processed element and processed attribute matches tags.

If `processed_attributes` is set, then only listed attributes are processed, otherwise if `ignored_attributes` is set, then only non-listed attributes are processed.

`passthrough_attributes` ***(optional)*** Is a Associative Sequence, that contains attribute tags. Values of listed attributes aren't parsed by SVG++, and passed to the user code as *string*.

`context_factories` ***(optional)*** See *Context Factories*.

attribute_traversal_policy ***(optional)*** See *Attribute Traversal Policy*.

Context Factories

When `document_traversal` traverses SVG tree, it, for each SVG element met, chooses context to be used to pass attribute values and character data by corresponding *event policy*. To configure this behavior `context_factories` parameter is used.

`context_factories` parameter accepts Metafunction Class, that receives:

- `ParentContext` - parent context type (context used for parent SVG element);
- `ElementTag` - element tag (corresponds to the SVG element met),

and returns *Context Factory*.

```
typedef
  typename context_factories::template apply<ParentContext, ElementTag>::type
    selected_context_factory;
```

SVG++ provides several *Context Factories*:

```
template<class ParentContext, class ElementTag>
class factory::context::same;
```

The new context object isn't created, parent context will be used. `on_enter_element(ElementTag())` and `on_exit_element()` methods of parent context will be called at the start and at the end of element processing respectively.

```
template<class ChildContext>
class factory::context::on_stack;
```

The new object of type `ChildContext` is created on stack. Constructor of the object is passed with the reference to the parent context. After element processing is finished, method `ChildContext::on_exit_element()` is called before destruction. Lifetime of context object matches processing of SVG element content (element attributes, child elements and text nodes).

`factory::context::on_stack_with_xml_element` is the same as `factory::context::on_stack`, but `ChildContext` constructor receives second parameter - XML element. Its type depends on XML parser used.

```
template<
  class ElementTag,
  class ChildContextPtr,
  class ChildContext = typename boost::pointee<ChildContextPtr>::type
>
class get_ptr_from_parent;
```

Pointer `ChildContextPtr` to context object is requested from parent context by call to the method `get_child_context(ElementTag())`. Pointer can be raw pointer or some smart pointer. `ChildContext::on_exit_element()` is called after element processing is finished.

Attribute Traversal Policy

Attribute Traversal Policy configures order and other aspects of SVG attributes and CSS properties processing.

```
struct attribute_traversal_policy_concept
{
  static const bool parse_style = /* true or false */;
  static const bool css_hides_presentation_attribute = /* true or false */;

  typedef /* Metafunction class */ get_priority_attributes_by_element;
  typedef /* Metafunction class */ get_deferred_attributes_by_element;
  typedef /* Metafunction class */ get_required_attributes_by_element;
};
```

parse_style = true Contents of **style** attribute is parsed as a sequence of semicolon-separated pairs property-value.

css_hides_presentation_attribute = true Is checked only if `parse_style = true`.

If the same property is set both in **style** attribute and as a *presentation attribute*, then only value in **style** attribute will be parsed (it has higher priority according to SVG).

If `css_hides_presentation_attribute = false`, then memory usage is lower, but both values (from **style** attribute and a *presentation attribute*) of the same property will be parsed and passed to the user code in the arbitrary order.

get_priority_attributes_by_element, get_deferred_attributes_by_element and get_required_attri They are Metafunction classes, receiving element tag and returning Forward Sequence of attribute tags.

Attributes, returned by `get_priority_attributes_by_element` metafunction for current element, will be processed before all others in the same order as in sequence.

Attributes, returned by `get_deferred_attributes_by_element` metafunction for current element, will be processed after all others in the same order as in sequence.

Note: Sequences, returned by `get_priority_attributes_by_element` and `get_deferred_attributes_by_element`, besides attribute tags may contain elements like `notify_context<EventTag>`. `EventTag` is an arbitrary tag, that will be passed to `notify` method of the context. `notify(EventTag())` will be called right after all previous attributes in the sequence are processed.

If element lacks any attribute from the sequence, returned by `get_required_attributes_by_element` metafunction for this element, then `required_attribute_not_found_error` exception will be thrown (see *Error Policy*). SVG++ contains definition of `traits::element_required_attributes` metafunction that returns mandatory attributes for element, according to SVG Specification. It can be used like this:

```
struct my_attribute_traversal_policy
{
  /* ... other members ... */
  typedef boost::mpl::quote1<traits::element_required_attributes>
    get_required_attributes_by_element;
};
```

1.4.2 How parsed values are passed to context

To find out how value of the SVG attribute will be passed to context, following algorithm should be applied:

1. If attribute tag is included in *passthrough_attributes* sequence, then its value will be passed by *Value Events Policy* as a *string*.

2. If for this element and attribute `traits::attribute_type<ElementTag, AttributeTag>::type` is `tag::type::string`, then value will also be passed by *Value Events Policy* as a *string*.
3. Otherwise type of the attribute should be found in its description in SVG Specification.
4. Attribute values of type <path data> (e.g. **d** attribute of **path** element) are described in *Path* section.
5. Attribute values of type <transform list> (e.g. **transform** attribute) are described in *Transform* section.
6. All others are passed through *Value Events Policy*.

Value Events Policy

Value Events Policy Concept

Value Events Policy is a class, containing static `set` methods, that receives reference to context object as a first argument, attribute tag as a second and a source tag as a third. Source tag is one of two types: `tag::source::css` and `tag::source::attribute` (they have common base `tag::source::any`). Source tag shows where value comes from – CSS value in **style** attribute or from separate SVG/XML attribute. Number and types of other parameters depends on an attribute type.

```
struct value_events_policy
{
  static void set(Context & context, AttributeTag tag, SourceTag source, ValueType1␣
↪const & value1);
  static void set(Context & context, AttributeTag tag, SourceTag source, ValueType1␣
↪const & value1, ValueType2 const & value2);
  /*...*/
};
```

`policy::value_events::forward_to_method` used by default forward calls to `set` methods of `context` object:

```
template<class Context>
struct forward_to_method
{
  template<class AttributeTag, class ...Args>
  static void set(Context & context, AttributeTag tag, tag::source::any const &, Args.
↪.. args)
  {
    context.set(tag, args...);
  }
};
```

Note: Source tag is dropped by default *Value Events Policy*, because default *Attribute Traversal Policy* processes only one value of the same property, even if both are provided (`css_hides_presentation_attribute = true`).

Note: Default *Value Events Policy* doesn't pass `tag::value::inherit` values of properties and presentation attributes, that are inherited (see `policy::value_events::skip_inherit`). **inherit** value for such attributes is equivalent to its absence.

Example of default *Value Events Policy* usage:

```
#include <svgpp/svgpp.hpp>

using namespace svgpp;

struct Context
{
  void set(tag::attribute::amplitude, double value)
  {
    std::cout << value << "\n";
  }
};

void func()
{
  Context context;
  value_parser<tag::type::number>::parse(tag::attribute::amplitude(), context,␣
↪std::string("3.14"), tag::source::attribute());
}
```

Example of own *Value Events Policy* implementation. Created `policy::value_events::default_policy` template class specialization for our context type (let it be `boost::optional<double>` in our example):

```
namespace svgpp { namespace policy { namespace value_events
{
  template<>
  struct default_policy<boost::optional<double> >
  {
    template<class AttributeTag>
    static void set(boost::optional<double> & context, AttributeTag tag,␣
↪tag::source::any, double value)
    {
      context = value;
    }
  };
}}}

void func()
{
  boost::optional<double> context;
  value_parser<tag::type::number>::parse(tag::attribute::amplitude(), context,␣
↪std::string("3.14"), tag::source::attribute());
  if (context)
    std::cout << *context << "\n";
}
```

Literal Values If literal is one of attribute possible values, then this value will cause call with tag from `tag::value` namespace. Example of attributes that may have literal values:

```
gradientUnits = "userSpaceOnUse | objectBoundingBox"
clip-path = "<funciri> | none | inherit"
```

gradientUnits is limited to two literal values. **clip-path**, besides **none** and **inherit** literal values may get values of *<FuncIRI>* type.

Example of context implementation, that receives values of **gradientUnits** attributes:

```
class GradientContext
```

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```
{
public:
  GradientContext()
    : m_gradientUnitsUserSpace(false)
  {}

  void set(tag::attribute::gradientUnits, tag::value::userSpaceOnUse)
  {
    m_gradientUnitsUserSpace = true;
  }

  void set(tag::attribute::gradientUnits, tag::value::objectBoundingBox)
  {
    m_gradientUnitsUserSpace = false;
  }

private:
  bool m_gradientUnitsUserSpace;
};
```

<length>* or *<coordinate> Is passed as single argument, whose type is set by *Length Factory* (by default `double`).

<IRI>* or *<FuncIRI> See *IRI*.

<integer> Single argument of `int` type is used.

<number>* or *<opacity-value> Is passed as single argument of **number_type_** (by default `double`).

<percentage>

<color> Is passed as single argument, whose type is set by *Color Factory* (by default 8 bit per channel RGB packed in `int`).

<color> [<icccolor>] If *<icccolor>* isn't set, then it is passed as single argument, whose type is set by *Color Factory*. Otherwise, second argument is added, whose type is set by *ICC Color Factory*. Example:

```
struct Context
{
  void set(tag::attribute::flood_color, int rgb);
  void set(tag::attribute::flood_color, int rgb, tag::skip_icc_color);
  void set(tag::attribute::flood_color, tag::value::currentColor);
  void set(tag::attribute::flood_color, tag::value::inherit);
};
```

<angle> Is passed as single argument, whose type and value are set by *Angle Factory* (by default `double` value in degrees).

<number-optional-number> Is passed as one or two arguments of **number_type_** type (by default `double`).

<list-of-numbers>*, *<list-of-lengths>* or *<list-of-points> Is passed as single argument of unspecified type, which is model of Boost Single Pass Range.

***range* items have type:**

- **number_type_** (by default `double`) in case of *<list-of-numbers>*;
- that is set by *Length Factory* in case of *<list-of-lengths>*;
- `std::pair<number_type, number_type>` (by default `std::pair<double, double>`) in case of *<list-of-points>*.

Example:

```
struct Context
{
  template<class Range>
  void set(tag::attribute::kernelMatrix, Range const & range)
  {
    for(typename boost::range_iterator<Range>::type it = boost::begin(range), end␣
↪= boost::end(range);
      it != end; ++it)
      std::cout << *it;
  }
};
```

Note: If template function can't be used (e.g. it is virtual function), then Boost any_range can be used as range type instead:

```
typedef boost::any_range<double, boost::single_pass_traversal_tag, double const &,
↪ std::ptrdiff_t> Range;
```

<shape> Is passed as 5 arguments - first is *tag* `tag::value::rect`, others are of **number_type_** type (by default `double`): `(tag::value::rect(), top, right, bottom, left)`.

viewBox attribute Is passed as 4 arguments of **number_type_** type (by default `double`): `(x, y, width, height)`.

bbox attribute Is passed as 4 arguments of **number_type_** type (by default `double`): `(lo_x, lo_y, hi_x, hi_y)`.

preserveAspectRatio attribute

Depending on value is passed as:

- `(bool defer, tag::value::none)`
- `(bool defer, AlignT align, MeetOrSliceT meetOrSlice)`

  Type `AlignT` is one of `tag::value::xMinYMin`, `tag::value::xMidYMin`, `tag::value::xMaxYMin`, `tag::value::xMinYMid`, `tag::value::xMidYMid`, `tag::value::xMaxYMid`, `tag::value::xMinYMax`, `tag::value::xMidYMax`, `tag::value::xMaxYMax`. Type `MeetOrSliceT` is `tag::value::meet` or `tag::value::slice`.

text-decoration property **none** and **inherit** values are passed as *Literal Values*. Other values are passed as 8 arguments, 4 of which is of type `bool`, each of them preceded with *tag*, describing argument meaning. Boolean parameters takes `true` value if corresponding text decoration is set in property:

```
struct Context
{
  void set(tag::attribute::text_decoration, tag::value::none);
  void set(tag::attribute::text_decoration, tag::value::inherit);
  void set(tag::attribute::text_decoration,
    tag::value::underline,    bool underline,
    tag::value::overline,     bool overline,
    tag::value::line_through, bool line_through,
    tag::value::blink,        bool blink);
};
```

enable-background property **accumulate**, **new** and **inherit** values are passed as *Literal Values*. Values as **new <x> <y> <width> <height>** are passed as 5 arguments, first of them is *tag*, other have type **number_type_** (by

default `double`): `(tag::value::new_(), x, y, width, height)`.

<paint> Possible combinations of argument types:

- (`tag::value::inherit`)
- (`tag::value::none`)
- (`tag::value::currentColor`)
- (<*color*>)
- (<*color*>, <*icccolor*>)
- (<*iri*>, `tag::value::none`)
- (<*iri*>, `tag::value::currentColor`)
- (<*iri*>, <*color*>)
- (<*iri*>, <*color*>, <*icccolor*>)

Which types corresponds to <*color*> and <*icccolor*> is described above.

If *IRI Policy* `policy::iri::distinguish_local` is used, then number of methods with <*iri*> is doubled:

- (`tag::value::inherit`)
- (`tag::value::none`)
- (`tag::value::currentColor`)
- (<*color*>)
- (<*color*>, <*icccolor*>)
- (<*iri*>, `tag::value::none`)
- (`tag::iri_fragment`, <*iri fragment*>, `tag::value::none`)
- (<*iri*>, `tag::value::currentColor`)
- (`tag::iri_fragment`, <*iri fragment*>, `tag::value::currentColor`)
- (<*iri*>, <*color*>)
- (`tag::iri_fragment`, <*iri fragment*>, <*color*>)
- (<*iri*>, <*color*>, <*icccolor*>)
- (`tag::iri_fragment`, <*iri fragment*>, <*color*>, <*icccolor*>)

Example:

```
typedef boost::variant<tag::value::none, tag::value::currentColor, int/* rgba */>␣
↪SolidPaint;

struct IRIPaint
{
  IRIPaint(
    std::string const & fragment,
    boost::optional<SolidPaint> const & fallback = boost::optional<SolidPaint>());
};

typedef boost::variant<SolidPaint, IRIPaint> Paint;
```

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```
template<class AttributeTag>
class PaintContext
{
public:
  void set(AttributeTag, tag::value::none)
  {
    m_paint = tag::value::none();
  }

  void set(AttributeTag, tag::value::currentColor)
  {
    m_paint = tag::value::currentColor();
  }

  void set(AttributeTag, int color, tag::skip_icc_color = tag::skip_icc_color())
  {
    m_paint = color;
  }

  template<class IRI>
  void set(AttributeTag tag, IRI const & iri)
  {
    throw std::runtime_error("Non-local references aren't supported");
  }

  template<class IRI>
  void set(AttributeTag tag, tag::iri_fragment, IRI const & fragment)
  {
    m_paint = IRIPaint(std::string(boost::begin(fragment), boost::end(fragment)));
  }

  template<class IRI>
  void set(AttributeTag tag, IRI const &, tag::value::none val)
  {
    // Ignore non-local IRI, fallback to second option
    set(tag, val);
  }

  template<class IRI>
  void set(AttributeTag tag, tag::iri_fragment, IRI const & fragment,␣
↪tag::value::none val)
  {
    m_paint = IRIPaint(std::string(boost::begin(fragment), boost::end(fragment)),␣
↪boost::optional<SolidPaint>(val));
  }

  template<class IRI>
  void set(AttributeTag tag, IRI const &, tag::value::currentColor val)
  {
    // Ignore non-local IRI, fallback to second option
    set(tag, val);
  }

  template<class IRI>
  void set(AttributeTag tag, tag::iri_fragment, IRI const & fragment,␣
↪tag::value::currentColor val)
  {
```

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```
    m_paint = IRIPaint(std::string(boost::begin(fragment), boost::end(fragment)),␣
↪boost::optional<SolidPaint>(val));
  }

  template<class IRI>
  void set(AttributeTag tag, IRI const &, agg::rgba8 val, tag::skip_icc_color =␣
↪tag::skip_icc_color())
  {
    // Ignore non-local IRI, fallback to second option
    set(tag, val);
  }

  template<class IRI>
  void set(AttributeTag tag, tag::iri_fragment, IRI const & fragment, int val,␣
↪tag::skip_icc_color = tag::skip_icc_color())
  {
    m_paint = IRIPaint(std::string(boost::begin(fragment), boost::end(fragment)),␣
↪boost::optional<SolidPaint>(val));
  }

private:
  Paint m_paint;
};
```

1.4.3 Length

Length Factory defines what type corresponds to SVG types <length> and <coordinate> and how instances of that types are created from text values that include units.

Length Policy specifies how *Length Factory* for the context is accessed. It permits configuration of *Length Factory* in runtime (e.g. when viewport size or font size is changed).

Length Factory Concept

```
struct length_factory
{
  typedef /* ... */ length_type;
  typedef /* ... */ number_type;

  length_type create_length(number_type number, tag::length_units::em) const;
  length_type create_length(number_type number, tag::length_units::ex) const;
  length_type create_length(number_type number, tag::length_units::px) const;
  length_type create_length(number_type number, tag::length_units::in) const;
  length_type create_length(number_type number, tag::length_units::cm) const;
  length_type create_length(number_type number, tag::length_units::mm) const;
  length_type create_length(number_type number, tag::length_units::pt) const;
  length_type create_length(number_type number, tag::length_units::pc) const;
  length_type create_length(number_type number, tag::length_units::none) const;

  length_type create_length(number_type number, tag::length_units::percent,␣
↪tag::length_dimension::width) const;
  length_type create_length(number_type number, tag::length_units::percent,␣
↪tag::length_dimension::height) const;
```

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```
  length_type create_length(number_type number, tag::length_units::percent,␣
↪tag::length_dimension::not_width_nor_height) const;
};
```

`create_length` method receives number and length tag and returns corresponding length value of the type `length_type`.

Lengths that are set with percent units may be treated differently, depending on whether value corresponds to width or height. That is why `create_length` receives the third parameter - one of the three tag types `tag::length_dimension::width`, `tag::length_dimension::height` or `tag::length_dimension::not_width_nor_height`.

Depending on the implementation of *Length Factory*, length may be of integer type or something more complex like object containing value and units used. SVG++ provides `factory::length::unitless`, that implements configurable *Length Factory* returning numeric values.

Unitless Length Factory

Unitless Length Factory `factory::length::unitless` - is a model of *Length Factory*, provided by SVG++ library. Name "unitless" means that lengths created by factory are numbers without information about units. *Unitless Length Factory* uses units information to apply the corresponding coefficient to the value.

```
template<
  class LengthType = double,
  class NumberType = double,
  class ReferenceAbsoluteUnits = tag::length_units::mm
>
class unitless
{
public:
  /* Skipped Length Factory methods */

  template<class AbsoluteUnits>
  void set_absolute_units_coefficient(NumberType coeff, AbsoluteUnits);
  template<class AbsoluteUnits>
  NumberType get_absolute_units_coefficient(AbsoluteUnits) const;

  void set_user_units_coefficient(NumberType coeff);
  NumberType get_user_units_coefficient() const;

  void set_viewport_size(LengthType width, LengthType height);

  void set_em_coefficient(NumberType coeff);
  void set_ex_coefficient(NumberType coeff);
  template<class UnitsTag>
  void set_em_coefficient(NumberType coeff, UnitsTag unitsTag);
  template<class UnitsTag>
  void set_ex_coefficient(NumberType coeff, UnitsTag unitsTag);
};
```

`set_absolute_units_coefficient` Sets coefficient that will be used for lengths in absolute units (*in*, *cm*, *mm*, *pt* or *pc*). The method should be called for any one of absolute units, coefficients for others will be calculated automatically. Example:

```
svgpp::factory::length::unitless<> factory;
// Let our length value be a pixel. Set 'in' coefficient to 90 (90 Dots per inch)
factory.set_absolute_units_coefficient(90, svgpp::tag::length_units::in());
// Coefficient for 'pc' (pica = 1/6 inch) will be 90/6 = 15
assert(factory.get_absolute_units_coefficient(svgpp::tag::length_units::pc()) ==␣
↪15);
```

set_user_units_coefficient Sets coefficient that will be used for lengths in user units (that are specified without units or in *px*). By default coefficient = 1.

set_viewport_size Sets width and height of the viewport to be used for percentage values that are defined to be relative to the size of viewport.

set_em_coefficient and set_ex_coefficient Sets coefficients for font-related *em* and *ex* units.

Length Policy Concept

Length Policy defines which *Length Factory* will be used for the context:

```
struct length_policy
{
  typedef /* ... */ length_factory_type;

  static length_factory_type & length_factory(context_type & context);
};
```

Default *Length Policy* returns constant reference to static instance of `factory::length::default_factory`.

Named class template parameter for *Length Policy* is `length_policy`.

To configure *Length Factory* named template parameter `length_policy` must be passed to `document_traversal`. For example, using library provided `policy::length::forward_to_method`:

```
typedef factory::length::unitless<> LengthFactory;

class Context
{
public:
  LengthFactory const & length_factory() { return m_LengthFactory; }

private:
  LengthFactory m_LengthFactory;
};

document_traversal<
  length_policy<policy::length::forward_to_method<Context, LengthFactory const> >,
  /* ... */
>::/* ... */
```

1.4.4 Transform

Transformation parsing is controlled by *Transform Policy* and *Transform Events Policy*. *Transform Policy* configures the adapter that simplifies application handling of coordinate system transformations (e.g. adapter may substitute simple transformation steps translate/scale/rotate/skew with corresponding transformation matrices, more convenient in some cases). *Transform Events Policy* defines how parsed data is passed to the user code.

Transform Events Policy Concept

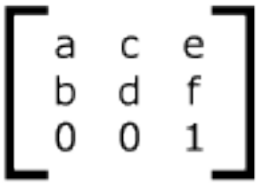
Transform Events Policy depends on compile-time settings in *Transform Policy*. If `policy::transform::raw` *Transform Policy* is used that preserves input data at much as possible then *Transform Events Policy* becomes:

```
struct transform_events_policy
{
  typedef /*...*/ context_type;

  static void transform_matrix(context_type & context, const boost::array<number_type,
↪ 6> & matrix);
  static void transform_translate(context_type & context, number_type tx, number_type␣
↪ty);
  static void transform_translate(context_type & context, number_type tx);
  static void transform_scale(context_type & context, number_type sx, number_type sy);
  static void transform_scale(context_type & context, number_type scale);
  static void transform_rotate(context_type & context, number_type angle);
  static void transform_rotate(context_type & context, number_type angle, number_type␣
↪cx, number_type cy);
  static void transform_skew_x(context_type & context, number_type angle);
  static void transform_skew_y(context_type & context, number_type angle);
};
```

Depending on *Transform Policy*, some of the methods aren't called by SVG++ and therefore shouldn't be implemented.

Note: Transformation matrix is passed as array of size 6 `[a b c d e f]`, corresponding to this matrix:



Named class template parameter for *Transform Events Policy* is `transform_events_policy`.

Default *Transform Events Policy* (`policy::transform_events::forward_to_method`) forwards calls to its static methods to methods of `context` object:

```
struct forward_to_method
{
  typedef Context context_type;

  template<class Number>
  static void transform_matrix(context_type & context, const boost::array<Number, 6> &
↪ matrix)
  {
    context.transform_matrix(matrix);
  }

  /*...*/
};
```

Example of handling transforms with default settings (`src/samples/sample_transform01.cpp`):

```
#include <svgpp/svgpp.hpp>
#include <algorithm>
#include <iterator>

using namespace svgpp;

struct Context
{
  void transform_matrix(const boost::array<double, 6> & matrix)
  {
    std::copy(matrix.begin(), matrix.end(),
      std::ostream_iterator<double>(std::cout, " "));
    std::cout << "\n";
  }
};

int main()
{
  Context context;
  value_parser<tag::type::transform_list>::parse(tag::attribute::transform(), context,
    std::string("translate(-10,-20) scale(2) rotate(45) translate(5,10)"),␣
↪tag::source::attribute());
  return 0;
}
```

In this example sequential transforms are joined in user code (`src/samples/sample_transform02.cpp`):

```
#include <svgpp/svgpp.hpp>
#include <boost/version.hpp>
#if BOOST_VERSION >= 106400
#include <boost/serialization/array_wrapper.hpp>
#endif
#include <boost/math/constants/constants.hpp>
#include <boost/numeric/ublas/assignment.hpp>
#include <boost/numeric/ublas/matrix.hpp>
#include <boost/numeric/ublas/io.hpp>

using namespace svgpp;
namespace ublas = boost::numeric::ublas;

typedef ublas::matrix<double> matrix_t;

struct TransformEventsPolicy
{
  typedef matrix_t context_type;

  static void transform_matrix(matrix_t & transform, const boost::array<double, 6> &␣
↪matrix)
  {
    matrix_t m(3, 3);
    m <<=
      matrix[0], matrix[2], matrix[4],
      matrix[1], matrix[3], matrix[5],
      0, 0, 1;
    transform = ublas::prod(transform, m);
  }
```

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```
  static void transform_translate(matrix_t & transform, double tx, double ty)
  {
    matrix_t m = ublas::identity_matrix<double>(3, 3);
    m(0, 2) = tx; m(1, 2) = ty;
    transform = ublas::prod(transform, m);
  }

  static void transform_scale(matrix_t & transform, double sx, double sy)
  {
    matrix_t m = ublas::identity_matrix<double>(3, 3);
    m(0, 0) = sx; m(1, 1) = sy;
    transform = ublas::prod(transform, m);
  }

  static void transform_rotate(matrix_t & transform, double angle)
  {
    angle *= boost::math::constants::degree<double>();
    matrix_t m(3, 3);
    m <<=
      std::cos(angle), -std::sin(angle), 0,
      std::sin(angle),  std::cos(angle), 0,
      0, 0, 1;
    transform = ublas::prod(transform, m);
  }

  static void transform_skew_x(matrix_t & transform, double angle)
  {
    angle *= boost::math::constants::degree<double>();
    matrix_t m = ublas::identity_matrix<double>(3, 3);
    m(0, 1) = std::tan(angle);
    transform = ublas::prod(transform, m);
  }

  static void transform_skew_y(matrix_t & transform, double angle)
  {
    angle *= boost::math::constants::degree<double>();
    matrix_t m = ublas::identity_matrix<double>(3, 3);
    m(1, 0) = std::tan(angle);
    transform = ublas::prod(transform, m);
  }
};

int main()
{
  matrix_t transform(ublas::identity_matrix<double>(3, 3));
  value_parser<
    tag::type::transform_list,
    transform_policy<policy::transform::minimal>,
    transform_events_policy<TransformEventsPolicy>
  >::parse(tag::attribute::transform(), transform,
    std::string("translate(-10,-20) scale(2) rotate(45) translate(5,10)"),␣
↪tag::source::attribute());
  std::cout << transform << "\n";
  return 0;
}
```

Transform Policy Concept

```
struct transform_policy_concept
{
  static const bool join_transforms = /* true or false */;
  static const bool no_rotate_about_point = /* true or false */;
  static const bool no_shorthands = /* true or false */;
  static const bool only_matrix_transform = /* true or false */;
};
```

Transform Policy is a class with `bool` static member constants. If they all are `false` (as in `policy::transform::raw`), then adapter isn't used and the parser passes parsed values as is. Setting some members to `true` programmer may simplify the application:

`join_transforms = true` All transformations in SVG attribute are joined in single transformation matrix. Values of other *Transform Policy* members are ignored. *Transform Events Policy* in this case contains only one method:

```
struct transform_events_policy
{
  typedef /*...*/ context_type;

  static void transform_matrix(context_type & context, const boost::array
↪<number_type, 6> & matrix);
}
```

`no_rotate_about_point = true` **rotate(<rotate-angle> <cx> <cy>)** substituted with **translate(<cx>, <cy>) rotate(<rotate-angle>) translate(-<cx>, -<cy>)**. `transform_rotate` method of *Transform Events Policy* with parameters `cx` and `cy` is not used.

`no_shorthands = true` Calls to `transform_translate` and `transform_scale` with one number substituted with corresponding calls with two numbers.

`only_matrix_transform = true` Each transformation step is substituted with corresponding call to `transform_matrix`. Therefore only this method is used in *Transform Events Policy*.

File `svgpp/policy/transform.hpp` contains some predefined *Transform Policies*. `policy::transform::matrix`, used by default, sets `join_transforms = true`.

Named class template parameter for *Transform Policy* is `transform_policy`.

1.4.5 Path

Path parsing is controlled by *Path Policy* and *Path Events Policy*. *Path Policy* configures the adapter that simplifies path handling for application (e.g. adapter may substitute relative coordinates with absolute ones relieving programmer from this duty). *Path Events Policy* defines how parsed path data is passed to the user code.

Path Events Policy Concept

```
struct path_events_concept
{
  typedef /*...*/ context_type;

  static void path_move_to(context_type & context, number_type x, number_type y,␣
↪AbsoluteOrRelative absoluteOrRelative);
```

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```
  static void path_line_to(context_type & context, number_type x, number_type y,␣
↪AbsoluteOrRelative absoluteOrRelative);
  static void path_line_to_ortho(context_type & context, number_type coord, bool␣
↪horizontal, AbsoluteOrRelative absoluteOrRelative);
  static void path_cubic_bezier_to(context_type & context, number_type x1, number_
↪type y1,
                                   number_type x2, number_type y2,
                                   number_type x, number_type y,
                                   AbsoluteOrRelative absoluteOrRelative);
  static void path_cubic_bezier_to(context_type & context,
                                   number_type x2, number_type y2,
                                   number_type x, number_type y,
                                   AbsoluteOrRelative absoluteOrRelative);
  static void path_quadratic_bezier_to(context_type & context,
                                   number_type x1, number_type y1,
                                   number_type x, number_type y,
                                   AbsoluteOrRelative absoluteOrRelative);
  static void path_quadratic_bezier_to(context_type & context,
                                   number_type x, number_type y,
                                   AbsoluteOrRelative absoluteOrRelative);
  static void path_elliptical_arc_to(context_type & context,
                                   number_type rx, number_type ry, number_type x_
↪axis_rotation,
                                   bool large_arc_flag, bool sweep_flag,
                                   number_type x, number_type y,
                                   AbsoluteOrRelative absoluteOrRelative);
  static void path_close_subpath(context_type & context);
  static void path_exit(context_type & context);
};
```

`absoluteOrRelative` parameter may have type `tag::coordinate::absolute` or `tag::coordinate::relative` depending on whether absolute or relative coordinates are passed in other parameters.

Depending on *Path Policy*, some of the methods aren't called by SVG++ and therefore shouldn't be implemented.

Default *Path Events Policy* (`policy::path_events::forward_to_method`) forwards calls to its static methods to `context` object methods:

```
struct forward_to_method
{
  typedef Context context_type;

  template<class Coordinate, class AbsoluteOrRelative>
  static void path_move_to(Context & context, Coordinate x, Coordinate y,␣
↪AbsoluteOrRelative absoluteOrRelative)
  {
    context.path_move_to(x, y, absoluteOrRelative);
  }

  /*...*/
};
```

Named class template parameter for *Path Events Policy* is `path_events_policy`.

Path Policy Concept

```
struct path_policy_concept
{
  static const bool absolute_coordinates_only     = /* true or false */;
  static const bool no_ortho_line_to              = /* true or false */;
  static const bool no_quadratic_bezier_shorthand = /* true or false */;
  static const bool no_cubic_bezier_shorthand     = /* true or false */;
  static const bool quadratic_bezier_as_cubic     = /* true or false */;
  static const bool arc_as_cubic_bezier           = /* true or false */;
};
```

Path Policy is a class with `bool` static member constants. If they all are `false` (as in `policy::path::raw`), then adapter isn't used and parser passed parsed values to the user code as is. By setting some members to `true` programmer may simplify his work:

absolute_coordinates_only = true Relative coordinates are replaced with corresponding absolute. Therefore *Path Events Policy* methods with `tag::coordinate::relative` parameter aren't used.

no_ortho_line_to = true Instead of call to `path_line_to_ortho` with one coordinate call is made to `path_line_to` with two coordinates.

no_quadratic_bezier_shorthand = true Instead of `path_quadratic_bezier_to` with two coordinates (shorthand/smooth curve) overload of same method with four coordinates is used.

no_cubic_bezier_shorthand = true Instead of `path_cubic_bezier_to` with four coordinates (shorthand/smooth curve) overload of same method with six coordinates is used.

quadratic_bezier_as_cubic = true Call to `path_quadratic_bezier_to` is replaced with call to `path_cubic_bezier_to`.

arc_as_cubic_bezier = true Elliptical arc is approximated with cubic Bézier curve. Call to `path_elliptical_arc_to` substituted with series of calls to `path_cubic_bezier_to`.

Named class template parameter for *Path Policy* is `path_policy`.

File `svgpp/policy/path.hpp` contains some predefined *Path Policies*. `policy::path::no_shorthands` used by default limits *Path Events Policy* interface as much as possible not using approximation. In this case *Path Events Policy* becomes:

```
struct path_events_no_shorthands_concept
{
  typedef /*...*/ context_type;

  static void path_move_to(context_type & context, number_type x, number_type y,␣
↪tag::coordinate::absolute);
  static void path_line_to(context_type & context, number_type x, number_type y,␣
↪tag::coordinate::absolute);
  static void path_cubic_bezier_to(context_type & context, number_type x1, number_
↪type y1,
                                   number_type x2, number_type y2,
                                   number_type x, number_type y,
                                   tag::coordinate::absolute);
  static void path_quadratic_bezier_to(context_type & context,
                                   number_type x1, number_type y1,
                                   number_type x, number_type y,
                                   tag::coordinate::absolute);
```

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```
  static void path_elliptical_arc_to(context_type & context,
                                     number_type rx, number_type ry, number_type x_
↪axis_rotation,
                                     bool large_arc_flag, bool sweep_flag,
                                     number_type x, number_type y,
                                     tag::coordinate::absolute);
  static void path_close_subpath(context_type & context);
  static void path_exit(context_type & context);
};
```

It is better to inherit own *Path Policy* from some provided by SVG++ to easy upgrade to future versions of SVG++.

1.4.6 Basic Shapes

Basic shapes (**rect**, **circle**, **ellipse**, **line**, **polyline** and **polygon**) can be automatically converted to *path* commands.

Basic Shapes Policy Concept

```
struct basic_shapes_policy
{
  typedef /* Associative Sequence */ convert_to_path;
  typedef /* Associative Sequence */ collect_attributes;

  static const bool convert_only_rounded_rect_to_path = /* true or false */;
};
```

convert_to_path Associative Sequence (e.g. `boost::mpl::set`), containing SVG *basic shapes* elements tags, which will be converted to **path**. Generated **path** uses *Path Policy* and *Path Events Policy* settings.

collect_attributes Associative Sequence, containing any of **rect**, **circle**, **ellipse** or **line** element tags. Geometry of elements included in the sequence will be passed with single call instead of separate attribute handling (see *Basic Shapes Events Policy*).

convert_only_rounded_rect_to_path If static member constant `convert_only_rounded_rect_to_path` equals to `true` and `tag::element::rect` is included in `convert_to_path` sequence, then only rounded rectangles will be converted to **path**, and regular rectangles will be handle like if `tag::element::rect` is included in `collect_attributes`.

In `document_traversal` processing of attributes describing *basic shapes* geometry (**x**, **y**, **r** etc) must be *enabled*, i. e. they must be included in `processed_attributes` or excluded from `ignored_attributes`. Associative Sequence `traits::shapes_attributes_by_element` contains tags of all such attributes for *basic shapes*.

Named class template parameter for *Basic Shapes Policy* is `basic_shapes_policy`.

Basic Shapes Events Policy Concept

```
struct basic_shapes_events_policy
{
  static void set_rect(Context & context, Coordinate x, Coordinate y, Coordinate␣
↪width, Coordinate height,
    Coordinate rx, Coordinate ry);
  static void set_rect(Context & context, Coordinate x, Coordinate y, Coordinate␣
↪width, Coordinate height);
```

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```
  static void set_line(Context & context, Coordinate x1, Coordinate y1, Coordinate x2,
↪ Coordinate y2);
  static void set_circle(Context & context, Coordinate cx, Coordinate cy, Coordinate␣
↪r);
  static void set_ellipse(Context & context, Coordinate cx, Coordinate cy, Coordinate␣
↪rx, Coordinate ry);
};
```

Basic Shapes Events Policy is used for *basic shapes* (except **polyline** and **polygon**) elements, that are listed in `collect_attributes` field of *Basic Shapes Policy*.

Adapters that implement these conversions, use `length_to_user_coordinate` method of *Length Factory* to get *user coordinates* value by *length*. These adapters passes default values if attributes are missing and check correctness of attributes. If value disables rendering of the element according to SVG specification, then *Basic Shapes Events Policy* methods aren't called, and if an attribute has negative value that is not permitted by specification, then `negative_value` function of *Error Policy* is called.

Default *Basic Shapes Events Policy* (`policy::basic_shapes_events::forward_to_method`) forwards calls to its static methods to `context` object methods:

```
struct forward_to_method
{
  template<class Coordinate>
  static void set_rect(Context & context, Coordinate x, Coordinate y, Coordinate␣
↪width, Coordinate height,
    Coordinate rx, Coordinate ry)
  {
    context.set_rect(x, y, width, height, rx, ry);
  }

  /*...*/
};
```

Named class template parameter for *Basic Shapes Events Policy* is `basic_shapes_events_policy`.

1.4.7 Color

Color Factory defines what type corresponds to <color> SVG type and how values of this type are created from SVG color description.

ICC Color Factory defines what type corresponds to <icccolor> SVG type and how values of this type are created from SVG ICC color description.

Color Factory Concept

```
struct color_factory
{
  typedef /* ... */ color_type;
  typedef /* floating point number type */ percentage_type;

  static color_type create(unsigned char r, unsigned char g, unsigned char b);
  static color_type create_from_percent(percentage_type r, percentage_type g,␣
↪percentage_type b);
};
```

`create_from_percent` is called when color components are set as percents (e.g. **rgb(100%,100%,100%)**). Percent values are passed as is, i.e. **100%** is passed as `100`.

In other cases `create` function is called with integer component values in range `0` to `255`. Recognized color keyword names are converted to corresponding component values by SVG++ library.

System colors aren't handled yet.

Named class template parameter for *Color Factory* is `color_factory`.

Integer Color Factory

SVG++ by default uses `factory::color::integer<>` as *Color Factory*. This factory returns color packed in `int` value: Red component in 3rd byte, Green in 2nd, Blue in 1st (least significant). Component offsets and number type can be configured.

ICC Color Factory Concept

```
struct icc_color_factory
{
  typedef /* floating point number type */ component_type;
  typedef /* ... */ icc_color_type;
  typedef /* ... */ builder_type;

  template<class Iterator>
  void set_profile_name(builder_type &, typename boost::iterator_range<Iterator>␣
↪const &) const;
  void append_component_value(builder_type &, component_type) const;

  icc_color_type create_icc_color(builder_type const &) const;
};
```

`icc_color_type` is a type that will be passed to the user code.

`builder_type` is used as a temporary object during building `icc_color_type` from color profile name and some components values.

Pseudo-code that illustrates usage of *ICC Color Factory* from inside SVG++ to parse **icc-color(profile1 0.75, 0.15, 0.25)** value:

```
void parse_icc(icc_color_factory const & factory)
{
  icc_color_factory::builder_type builder;
  factory.set_profile_name(builder, boost::as_literal("profile1"));
  factory.append_component_value(builder, 0.75);
  factory.append_component_value(builder, 0.15);
  factory.append_component_value(builder, 0.25);
  value_events_policy::set(context, attribute_tag, factory.create_icc_color(builder));
}
```

ICC Color Policy Concept

ICC Color Policy defines which *ICC Color Factory* instance is used for the context. It can be used to configure *ICC Color Factory* in runtime, e.g. taking in account referenced color profiles in SVG document.

```
struct icc_color_policy
{
  typedef /* ... */ context_type;
  typedef /* ... */ icc_color_factory_type;

  static icc_color_factory_type & icc_color_factory(Context const &);
};
```

Default *ICC Color Policy* returns static instance of `factory::icc_color::stub`. `factory::icc_color::stub` is a model of *ICC Color Factory* that skips passed values and returns instance of empty `tag::skip_icc_color` class as ICC color.

Named class template parameter for *ICC Color Policy* is `icc_color_policy`.

1.4.8 Error handling

Returned values

In most cases when SVG++ methods returns `bool` values, they can be used as an alternative to exceptions - if method returns `false`, then calling method immediately returns with `false` result and so on.

Error reporting is controlled by *Error Policy*. `policy::error::raise_exception` used by default throws exception objects, derived from `std::exception` and `boost::exception`. In this case only `true` may be returned as a result code.

Default Error Handling

Default `policy::error::raise_exception` uses Boost.Exception for transporting arbitrary data to the catch site.

`boost::error_info` uses tags `tag::error_info::xml_element` and `tag::error_info::xml_attribute` to pass information about place in SVG document where error occured alongside with the exception object. Value type depends on XML parser and *XML Policy* used.

Example of SVG++ exception handling when RapidXML NS parser is used:

```
typedef rapidxml_ns::xml_node<> const * XMLElement;

try
{
  /* ... */
  document_traversal</* ... */>::load_document(/* ... */);
}
catch(svgpp::exception_base const & e)
{
  typedef boost::error_info<svgpp::tag::error_info::xml_element, XMLElement> element_
↪error_info;
  std::cerr << "Error reading SVG";
  if (XMLElement const * element = boost::get_error_info<element_error_info>(e))
    std::cerr
      << " in element '"
      << std::string((*element)->name(), (*element)->name() + (*element)->name_size())
      << "'";
  std::cerr << ": " << e.what() << "\n";
}
```

Error Policy Concept

```
struct error_policy
{
  typedef /* ... */ context_type;

  template<class XMLElement, class ElementName>
  static bool unknown_element(
    context_type const &,
    XMLElement const & element,
    ElementName const & name);

  template<class XMLAttributesIterator, class AttributeName>
  static bool unknown_attribute(context_type &,
    XMLAttributesIterator const & attribute,
    AttributeName const & name,
    BOOST_SCOPED_ENUM(detail::namespace_id) namespace_id,
    tag::source::attribute);

  template<class XMLAttributesIterator, class AttributeName>
  static bool unknown_attribute(context_type &,
    XMLAttributesIterator const & attribute,
    AttributeName const & name,
    tag::source::css);

  static bool unexpected_attribute(context_type &,
    detail::attribute_id id, tag::source::attribute);

  template<class AttributeTag>
  static bool required_attribute_not_found(context_type &, AttributeTag);

  template<class AttributeTag, class AttributeValue>
  static bool parse_failed(context_type &, AttributeTag,
    AttributeValue const & value);

  template<class XMLElement>
  static bool unexpected_element(context_type &, XMLElement const & element);

  template<class AttributeTag>
  static bool negative_value(context_type &, AttributeTag);

  typedef /* ... */ intercepted_exception_type;

  template<class XMLElement>
  static bool add_element_info(intercepted_exception_type & e,
    XMLElement const & element);
};
```

If *Error Policy* method returns `true`, then SVG++ continues SVG processing skipping the part with the error. In some cases it may lead to problems in further processing.

If method returns `false`, then processing immediately stops.

1.4.9 IRI

IRIs, including ones that are set with FuncIRI syntax, are passed to the user code the same way as other *strings* in SVG++.

The only setting in *IRI Policy* configures whether to distinguish local references to document fragment (IRIs prefixed with "#") from non-local IRI references. If `policy::iri::distinguish_local` used (as by default), then local reference to document fragment is passed as pair of parameters: {`tag::iri_fragment()`, <*fragment string*>}. If `policy::iri::raw` is set, then any IRI is passed as single *string*.

Named class template parameter for *IRI Policy* is `iri_policy`.

Example of using default *IRI Policy* (`src/samples/sample_iri.cpp`):

```
#include <svgpp/svgpp.hpp>

using namespace svgpp;

struct Context
{
  template<class String>
  void set(tag::attribute::xlink::href, String const & iri)
  {
    std::cout << "IRI: " << std::string(boost::begin(iri), boost::end(iri)) << "\n";
  }

  template<class String>
  void set(tag::attribute::xlink::href, tag::iri_fragment, String const & iri)
  {
    std::cout << "Fragment: " << std::string(boost::begin(iri), boost::end(iri)) <<
↪"\n";
  }
};

int main()
{
  Context context;
  value_parser<tag::type::iri>::parse(tag::attribute::xlink::href(), context,
    std::string("http://foo.com/bar#123"), tag::source::attribute());
  value_parser<tag::type::iri>::parse(tag::attribute::xlink::href(), context,
    std::string("#rect1"), tag::source::attribute());
  // Output:
  //  "IRI: http://foo.com/bar#123"
  //  "Fragment: rect1"
  return 0;
}
```

1.4.10 Markers

SVG++ provides option to automatically calculate marker symbols orientation on lines (**path**, **line**, **polyline** or **polygon** element).

Markers Policy turns on/off and configures marker position calculations. *Marker Events Policy* defines how marker positions are passed to the user code.

Markers Policy Concept

```
struct makers_policy_concept
{
  typedef /* ... */ directionality_policy;
```

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```
  static const bool calculate_markers = /* true or false */;
  static const bool always_calculate_auto_orient = /* true or false */;
};
```

calculate_markers = true Enables marker position calculations. If `calculate_markers = false`, then other class members aren't used.

Marker properties define which vertices contain markers. Depending on the value of **orient** attribute of **marker** element, marker orientation may be fixed or calculated by line geometry (**auto** value).

always_calculate_auto_orient = true In this case marker orientation is calculated for each vertex (orentation required in **orient="auto"** case).

always_calculate_auto_orient = false In this case, before processing each line element, `marker_get_config` method of *Marker Events Policy* is called, to request from user code which verteces markers are required (user code should know this from marker properties). Marker positions are returned by *Marker Events Policy* only for vertices, for which user code requested marker calculations.

directionality_policy Class that defines how marker orientation is calculated and passed. By default marker orientation is `double` value, containing angle in radians.

File `svgpp/policy/markers.hpp` contains some predefined *Markers Policies*: `policy::markers::calculate_always`, `policy::markers::calculate` and `policy::markers::raw`. `policy::markers::raw` used by default disables automatic marker calculation.

Named class template parameter for *Markers Policy* is `markers_policy`.

Marker Events Policy Concept

```
namespace svgpp
{
  enum marker_vertex { marker_start, marker_mid, marker_end };
  enum marker_config { marker_none, marker_orient_fixed, marker_orient_auto };
}
```

```
struct marker_events_policy_concept
{
  typedef /* ... */ context_type;

  static void marker_get_config(context_type & context,
    marker_config & start, marker_config & mid, marker_config & end);

  static void marker(context_type & context, marker_vertex v,
    number_type x, number_type y, directionality_type directionality, unsigned marker_
↪index);
  static void marker(context_type & context, marker_vertex v,
    number_type x, number_type y, tag::orient_fixed directionality, unsigned marker_
↪index);
};
```

`marker_get_config` method is called if `makers_policy::always_calculate_auto_orient = false`. User code must set for each vertex type (`start`, `mid` and `end`), whether it wants to calculate orientation and position (`marker_orient_auto`), position only (`marker_orient_fixed`) or neither of them (`marker_none`).

`marker` method is called for each vertex calculated with this arguments:

`x` and `y` - marker position

`v` - vertex type (`marker_start`, `marker_mid` or `marker_end`)

`directionality` - marker orientation (by default `double` value in radians). If `marker_get_config` returned `marker_orient_fixed` for this type of vertex, then tag `tag::orient_fixed` is passed instead of orientation value.

`marker_index` Marker orientations aren't always calculated and passed in the order, because orientation of marker on first vertex of *subpath* may be calculated only after *subpath* is finished. `marker_index` is the 0-based index of the marker in drawing order.

Named class template parameter for *Marker Events Policy* is `marker_events_policy`.

Default *Marker Events Policy* (`policy::marker_events::forward_to_method`) fowards calls to its static methods to `context` object methods.

Example:

```
class Context
{
public:
  void marker(svgpp::marker_vertex v, double x, double y, double directionality,␣
↪unsigned marker_index)
  {
    if (markers_.size() <= marker_index)
      markers_.resize(marker_index + 1);
    auto & m = markers_[marker_index];
    m.v = v;
    m.x = x;
    m.y = y;
    m.directionality = directionality;
  }

private:
  struct MarkerPosition
  {
    svgpp::marker_vertex v;
    double x, y, directionality;
  };

  std::vector<MarkerPosition> markers_;
};

void load()
{
  document_traversal<
    /* ... */
    svgpp::markers_policy<svgpp::policy::markers::calculate_always>
  >::load_document(xml_root_element, context);
}
```

1.4.11 Viewport

When establishing new viewport by elements **svg**, **symbol** (instanced by **use**) or **image** several attributes must be processed (**x**, **y**, **width**, **height**, **preserveAspectRatio**, **viewbox**) to get the new user coordinate system, viewport and

clipping path. SVG++ may do it itself and present result in convenient way. This behavior is configured by *Viewport Policy*. *Viewport Events Policy* defines how viewport information is passed to the user code.

marker element establish new viewport similar way, when it is instances in path vertices, so **marker** elements may also be handled by *Viewport Policy* and *Viewport Events Policy*.

Viewport Policy Concept

```
struct viewport_policy_concept
{
  static const bool calculate_viewport          = /* true or false */;
  static const bool calculate_marker_viewport   = /* true or false */;
  static const bool calculate_pattern_viewport  = /* true or false */;
  static const bool viewport_as_transform       = /* true or false */;
};
```

`calculate_viewport = true` Enables handling of viewport attributes for **svg** and **symbol** elements. Values will be passed by calls to `set_viewport` or `set_viewbox_transform` of *Viewport Events Policy*.

`calculate_marker_viewport = true` The same for **marker** elements.

`calculate_pattern_viewport = true` The same for **pattern** elements.

`viewport_as_transform = true` Is checked only if `calculate_viewport = true`. `set_viewbox_transform` method of *Viewport Events Policy* isn't used, new coordinate system is set by *Transform Events Policy* instead.

Named class template parameter for *Viewport Policy* is `viewport_policy`.

File `svgpp/policy/viewport.hpp` contains some predefined *Viewport Policies*. `policy::viewport::raw`, used by default, turns off viewport processing in SVG++. `policy::viewport::as_transform` sets all boolean members to `true`, thus enabling viewport attributes handling by SVG++ and passing coordinate system changes by *Transform Events Policy*.

Viewport Events Policy Concept

```
struct viewport_events_policy_concept
{
  static void set_viewport(context_type & context, number_type viewport_x, number_
↪type viewport_y,
    number_type viewport_width, number_type viewport_height);

  static void set_viewbox_transform(context_type & context, number_type translate_x,␣
↪number_type translate_y,
    number_type scale_x, number_type scale_y, bool defer);

  static void set_viewbox_size(context_type & context, number_type viewbox_width,␣
↪number_type viewbox_height);

  static void get_reference_viewport_size(context_type & context,
    number_type & viewport_width, number_type & viewport_height);

  static void disable_rendering(context_type & context);
};
```

`set_viewport` Sets new viewport position.

set_viewbox_transform Passes offset and scale that are set by combination of **viewbox** and **preserveAspectRatio**. Not used if `viewport_as_transform = true`.

set_viewbox_size Passes size of viewbox, set by **viewbox** attribute. Called only if **viewbox** attribute is present. It can be used to set viewport size in *Length Factory*.

get_reference_viewport_size See *Referenced element*.

disable_rendering SVG Specification says that "[**width** or **height** attribute] value of zero disables rendering of this element". `disable_rendering` will be called in such cases, so that application can behave in proper way. *Document Traversal Control Policy* may be used to skip processing of element content.

Named class template parameter for *Viewport Events Policy* is `viewport_events_policy`.

Referenced element

When processing **svg** element referenced by **use** or **image**, **symbol** referenced by **use** values of width and height of referencing element are required.

To pass to SVG++ information that element is referenced by **use** or **image**, tag of referenced element must be passed as *referencing_element* parameter of `document_traversal` class. In this case `get_reference_viewport_size` method of *Viewport Events Policy* will be called. Implementation of `get_reference_viewport_size` must set `viewport_width` to value of **width** attribute of referenced element, if this attribute is set. And set `viewport_height` value of **height** attribute of referenced element, if this attribute is set.

Processed attributes

If `calculate_viewport = true` or `calculate_pattern_viewport = true` in *Viewport Policy*, then SVG++ intercepts and processes attributes, listed in `traits::viewport_attributes`:

```
namespace traits
{
  typedef boost::mpl::set6<
    tag::attribute::x,
    tag::attribute::y,
    tag::attribute::width,
    tag::attribute::height,
    tag::attribute::viewBox,
    tag::attribute::preserveAspectRatio
  > viewport_attributes;
}
```

If `calculate_marker_viewport = true` in *Viewport Policy*, then SVG++ intercepts and processes marker attributes listed in `traits::marker_viewport_attributes`:

```
namespace traits
{
  typedef boost::mpl::set6<
    tag::attribute::refX,
    tag::attribute::refY,
    tag::attribute::markerWidth,
    tag::attribute::markerHeight,
    tag::attribute::viewBox,
    tag::attribute::preserveAspectRatio
  > marker_viewport_attributes;
}
```

Processing of this attributes must be *enabled* by the programmer.

Order of viewport processing

Viewport attributes will be processed and result will be passed by *Viewport Events Policy* after all SVG element attributes are processed or when *notification* with tag `tag::event::after_viewport_attributes` arrives.

1.4.12 Character Data

Character data content of elements, that supports it according to SVG Specification (**text**, **desc**, **title**, **style** etc), is passed to the user code by the *Text Events Policy*.

```
struct text_events_policy_concept
{
  template<class Range>
  static void set_text(Context & context, Range const & text);
};
```

It is not guaranteed that sequential blocks of text will be joined together. `set_text` is called for each TEXT or CDATA node returned by XML parser.

1.5 Advanced Topics

1.5.1 Adding new XML parser

Implementing support for the new XML parser requires creating new specializations for `svgpp::policy::xml::attribute_iterator` and `svgpp::policy::xml::element_iterator` class templates using one of existing implementations in folder `include/svgpp/policy/xml` as a sample.

Understanding following types may cause some difficulties:

```
template<>
struct attribute_iterator<CustomXMLAttribute>
{
  typedef /* ... */ string_type;
  typedef /* ... */ attribute_name_type;
  typedef /* ... */ attribute_value_type;
  typedef /* ... */ saved_value_type;

  /* ... */
};
```

`string_type` A model of Forward Range, with items of some character type (`char`, `wchar_t`, `char16_t`, `char32_t`). Easy solution is to use `boost::iterator_range<CharT const *>`.

`attribute_name_type` Copy constructible type, for which exists method `string_type attribute_iterator::get_string_range(attribute_name_type const &)`. Value of `attribute_name_type` is used only before `attribute_iterator` gets incremented and may become invalid after that.

`attribute_value_type` Copy constructible type, for which exists method `string_type attribute_iterator::get_string_range(attribute_value_type const &)`. Value of `attribute_value_type` must be accessible independently of `attribute_iterator` state changes.

saved_value_type Copy constructible type, for which exists method `attribute_value_type attribute_iterator::get_value(saved_value_type const &)`. Object of this type must as efficiently as possible save attribute value that may be not requested. For example XML parser provides access to XML attribute like this:

```
class XmlAttribute
{
public:
  std::string getValue() const;
};
```

In this case `saved_value_type` may be defined as `XmlAttribute const *`, instead of `std::string`, to avoid expences of creating and coping string that may not be requested later.

1.5.2 Value Parsers

To choose proper `value_parser` for the attribute, `traits::attribute_type` metafunction should be used:

```
template<class Element, class Attribute>
struct attribute_type
{
  typedef /*unspecified*/ type;
};
```

The returned type can be:

- One of type tags. E.g. **width**, as many others attributes has *<length>* type (corresponds to `tag::type::length`):

```
BOOST_MPL_ASSERT(( boost::is_same<
  traits::attribute_type<tag::element::rect, tag::attribute::width>::type,
  tag::type::length> ));
```

- Attribute tag. E.g. **viewBox** has its own syntax:

```
BOOST_MPL_ASSERT(( boost::is_same<
  traits::attribute_type<tag::element::svg, tag::attribute::viewBox>::type,
  tag::attribute::viewBox> ));
```

- Pair *<element tag, attribute tag>*. E.g. **type** attribute may get different values in elements **animateTransform**, **feColorMatrix**, **feTurbulence** etc.:

```
BOOST_MPL_ASSERT(( boost::is_same<
  traits::attribute_type<tag::element::animateTransform, tag::attribute::type>
↪::type,
  boost::mpl::pair<tag::element::animateTransform, tag::attribute::type> > ));
```

Attribute value parsers interface:

```
template<class ValueType, class Args..>
struct value_parser
{
  template<class AttributeTag, class Context, class AttributeValue, class␣
↪PropertySource>
  static bool parse(AttributeTag tag, Context & context, AttributeValue const &␣
↪attribute_value,
```

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```
                                    PropertySource source);
};
```

AttributeTag tag Is passed to context, isn't used by `value_parser` itself

Context & context Reference to the context that will *receive* parsed value.

AttributeValue const & attribute_value Attribute *string* value

PropertySource source One of two possible types: `tag::source::attribute` or `tag::source::css`, depending on whether value if from SVG attribute or CSS property.

1.6 FAQ

1.6.1 Compiler error: "Too many template arguments for class template 'document_traversal'"

Increase BOOST_PARAMETER_MAX_ARITY value from default `8` value. Place define like this before any Boost or SVG++ include:

```
#define BOOST_PARAMETER_MAX_ARITY 15
```

1.6.2 SVG++ stops parsing on incorrect attribute value and throws exception

SVG Specification says "The document shall be rendered up to, but not including, the first element which has an error". Therefore such behavior is correct, it will be better to fix SVG document.

But if you want to continue rendering document ignoring error in an attribute, you should inherit your class from `policy::error::raise_exception`, override its `parse_failed` method to not throw exception, but return `true` instead:

```
struct custom_error_policy: svgpp::policy::error::raise_exception<BaseContext>
{
    template<class AttributeTag, class AttributeValue>
    static bool parse_failed(BaseContext const &, AttributeTag,
                             AttributeValue const & value)
    {
        return true;
    }
};
```

where `BaseContext` is common base class for all contexts. Then pass this new class as template parameter `error_policy` to `document_traversal` class:

```
document_traversal<
  error_policy<custom_error_policy>
  /* ... */
>::/* ... */
```

1.6.3 Compiler is out of memory or compilation takes too long

Some compilers (e.g. Visual C++, especially 2015) may have difficulties building advanced applications that uses SVG++ library. Heavy usage of templates in SVG++ itself and also in its dependencies Boost.Spirit and Boost.MPL results in large number of templates instantiated during compilation.

SVG++ 1.1 introduces some workaround about this problem - some Boost.Spirit parsers now can be moved to another translation unit at the cost of additional call to the virtual function on each value that the parser produces.

Before first SVG++ header is included some macro should be defined for each parser to be moved:

```
#define SVGPP_USE_EXTERNAL_PATH_DATA_PARSER
#define SVGPP_USE_EXTERNAL_TRANSFORM_PARSER
#define SVGPP_USE_EXTERNAL_PRESERVE_ASPECT_RATIO_PARSER
#define SVGPP_USE_EXTERNAL_PAINT_PARSER
#define SVGPP_USE_EXTERNAL_MISC_PARSER
#define SVGPP_USE_EXTERNAL_COLOR_PARSER
#define SVGPP_USE_EXTERNAL_LENGTH_PARSER
```

And new source file should be added to the project that contains instantiations for some templates with parameters used in the application:

```
#include <svgpp/parser/external_function/parse_all_impl.hpp>

SVGPP_PARSE_PATH_DATA_IMPL(const char *, double)
SVGPP_PARSE_TRANSFORM_IMPL(const char *, double)
SVGPP_PARSE_PAINT_IMPL     (const char *, color_factory_t, svgpp::factory::icc_
↪color::default_factory)
SVGPP_PARSE_COLOR_IMPL     (const char *, color_factory_t, svgpp::factory::icc_
↪color::default_factory)
SVGPP_PARSE_PRESERVE_ASPECT_RATIO_IMPL(const char *)
SVGPP_PARSE_MISC_IMPL      (const char *, double)
SVGPP_PARSE_CLIP_IMPL      (const char *, length_factory_t)
SVGPP_PARSE_LENGTH_IMPL    (const char *, length_factory_t)
```

First parameters to `SVGPP_PARSE_..._IMPL()` macros are type of iterators that are provided by used XML parser policy. And the other parameters are *coordinate* type or different factories types used.

1.7 Licensing

Library is free for commercial and non-commercial use. The library is licensed under the Boost Software License, Version 1.0.

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1.8 Help and Feedback

Library support and development forum

Issue tracker at GitHub

Author can be contacted at olegmax@gmail.com

1.9 Acknowledgements

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