FREE eBook

LEARNING SVG

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#svg

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About

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Chapter 1: Getting started with SVG

Remarks

Scalable Vector Graphics (SVG) is a W3C standard for drawing vector images.

Here is a simple standalone SVG file:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <circle cx="50" cy="50" r="25" fill="blue"/>
</svg>
```

SVG can also be embedded in HTML, in which case the `xmlns` attribute is not required.

Other graphical elements are:

- `<line>`
- `<ellipse>`
- `<path>`
- `<polygon>` and `<polyline>`
- `<text>` including child elements such as `<tspan>` and `<textPath>`

CSS is used for styling although not all CSS properties apply to SVG and SVG itself defines some specific properties such as `fill` and `stroke` that are not used elsewhere.

Shapes can be filled with gradients or patterns and additional raster effects can be achieved using filters.

Clipping is available by using the above graphical elements as clip paths.

Regarding versions of the W3C SVG standard:

- The current version is SVG 1.1 (Second Edition)
- The W3C are currently working on a draft of SVG 2

Versions

Version	Release Date
1.0	2001-09-04
1.1 First edition	2003-01-14
1.2 Tiny	2008-12-22
1.1 Second edition	2011-08-16

Examples

Inline SVG

Inline SVG allows SVG markup, written within HTML, to generate graphics in the browser.

When using SVG inline, a DOCTYPE is not strictly required. Instead just the `<svg>` opening and closing tags together with either a viewBox or width and height attributes will suffice:

```
<svg width="100%" height="100%">
    <!-- SVG elements go here -->
</svg>
```

The `<svg>` fragment above acts as both a container and a structural element. This fragment establishes its own coordinate system.

Below is an example of rendering an SVG fragment with some content. It will produce a rectangle with "Hello World!" text within it.

```
<svg width="50%" viewBox="0 0 10 10">
    <rect x="1" y="1" width="5" height="3" fill="teal" />
    <text x="2" y="2" font-family="Palatino, Georgia, serif" font-size="3%" font-weight="bold"
fill="white">Hello World!</text>
</svg>
```

Result:

SVG as an

You can render the contents of an SVG file as an image within an HTML document using an `<img>` tag. For example:

```
<img src="my_svg_file.svg" alt="Image description">
```

The dimensions of the image will, by default, display according to the **width** and **height** properties specified in the SVG file referenced in the `src` attribute.

It's worth noting various limitations inherent in this approach:

- Browser support, whilst good, doesn't include Internet Explorer 8 and earlier versions, nor Android 2.3 and earlier versions.
- You can't style the individual elements contained within the SVG file using CSS which is external to the SVG file. All CSS must be within the image file itself.
- JavaScript won't run.
- The image must be complete in a single file. For example, if the SVG file contains raster images then those internal images must be encoded as data URLs.

SVG as a background image

You can display an SVG file within an HTML document, by specifying it as a background image in CSS. For example:

```
.element {
    background-size: 100px 100px;
    background: url(my_svg_file.svg);
    height: 100px;
    width: 100px;
}
```

If the dimensions specified in your SVG file are larger than the dimensions of your HTML element, it may be desirable to specify the `background-size` property, to scale the SVG to fit within its element.

As with using SVG as an `<img>`, it's worth noting some limitations with this approach:

- Browser support doesn't include Internet Explorer 8 and earlier versions, nor Android 2.3 and earlier versions.
- You can't style the individual elements contained within the SVG file using CSS which is external to the SVG file. All CSS must be within the image file itself.

Read Getting started with SVG online: https://riptutorial.com/svg/topic/963/getting-started-with-svg

Chapter 2: Animation

Remarks

SMIL animation via the `<animate>` element is currently (July 2016) supported in major browsers with the exception of Microsoft browsers. There is a library (fakeSMIL) which can be used as a polyfill for Microsoft compatibility.

Chrome 45 deprecated SMIL in favor of CSS animations and forthcoming Web animations declarative animation syntax, which unfortunately, is only partially implemented in current browsers. But the Chrome developers recently suspended their intent (see this StackOverflow answer)

Examples

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <rect x="50" y="50" height="100" width="100" stroke="black" fill="yellow">
        <animate
            attributeType="XML"
            attributeName="height"
            begin="0s"
            dur="10s"
            from="100"
            to="200"
            repeatCount="indefinite"
        />
    </rect>
</svg>
```

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <rect x="50" y="50" height="100" width="100" stroke="black" fill="yellow">
        <animateTransform
            attributeType="XML"
            attributeName="transform"
            type="rotate"
            begin="0s"
            dur="10s"
            from="0"
            to="360"
            repeatCount="indefinite"
        />
    </rect>
</svg>
```

Read Animation online: https://riptutorial.com/svg/topic/3260/animation

Chapter 3: Circle

Parameters

Parameters	Details
cx	x-coordinate of center of circle.
cy	y-coordinate of center of circle.
r	Radius of circle.
stroke	Colour of circle border.
fill	Colour *inside* circle border.

Remarks

Detailed information on the SVG 'circle' element can be found in the W3C Recommendation for SVG.

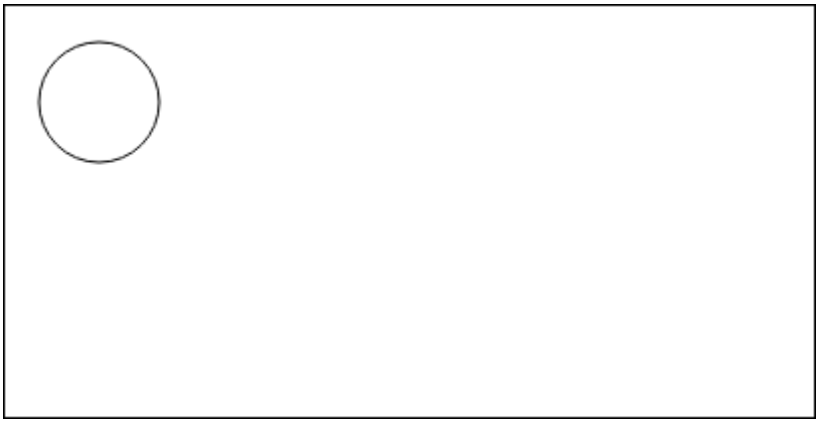
Examples

Draw a black circle without fill

- The `cx` and `cy` values designate the location of the center of the circle.
- The `r` attribute specifies the size of the radius of the circle.

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <circle cx="40" cy="40" r="30" stroke="black" fill="none" />
</svg>
```

Result:



Read Circle online: https://riptutorial.com/svg/topic/1559/circle

Chapter 4: clipPath

Parameters

Parameter	Description
clipPathUnits	the coordinate system of the pattern contents either *objectBoundingBox* or *userSpaceOnUse*

Remarks

Related W3C Recommendation informations

Examples

Clipping to a circle path

```
<svg xmlns="http://www.w3.org/2000/svg" viewBox="0 0 100 100"
xmlns:xlink="http://www.w3.org/1999/xlink">
  <defs>
    <clipPath id="circleClip">
      <circle cx="50" cy="60" r="20" />
    </clipPath>
  </defs>
  <image width="100" height="100" style="clip-path:url(#circleClip)"
xlink:href="https://cdn.sstatic.net/Sites/stackoverflow/company/img/logos/so/so-icon.png" />
</svg>
```

Original logo	Logo after clipping
	

Read clipPath online: https://riptutorial.com/svg/topic/4840/clippath

Chapter 5: Colors

Examples

Named colors - use predefined names for fill and stroke attributes

A list of recognised color keyword names can be found in the W3C Recommendation for SVG.

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
  <circle r="30" cx="100" cy="100" fill="red" stroke="green" />
  <rect x="200" y="200" width="50" height="50" fill="yellow" stroke="blue" />
</svg>
```

RGB Colors Using Hexadecimal Notation

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
  <circle r="30" cx="100" cy="100" fill="#ff0000" stroke="#00ff00" />
  <rect x="200" y="200" width="50" height="50" fill="#ffff00" stroke="#00ffff" />
</svg>
```

Same as above using shorthand hexadecimal form:

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
  <circle r="30" cx="100" cy="100" fill="#f00" stroke="#0f0" />
  <rect x="200" y="200" width="50" height="50" fill="#ff0" stroke="#0ff" />
</svg>
```

RGB colors with functional notation - integer values or percentages

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
  <circle r="30" cx="100" cy="100" fill="rgb(255, 0, 0)" stroke="rgb(0, 255, 0)" />
  <rect x="200" y="200" width="50" height="50" fill="rgb(100%, 100%, 0%)" stroke="rgb(0%,
100%, 100%)" />
</svg>
```

in functional notation, RGBA values are also supported.

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <circle r="30" cx="100" cy="100" fill="rgba(255, 0, 0, 0.5)" stroke="rgba(0, 255, 0,5
0.5)" />
    <rect x="200" y="200" width="50" height="50" fill="rgba(100%, 100%, 0%, 0.5)"
stroke="rgba(0, 100%, 100%, 0.5)" />
</svg>
```

The currentColor keyword

`currentColor` is most usefull in inline SVGs. With this you can inherit the parents css color and use it everywhere colors are used in SVG.

In this example the first circle uses the text color as fill color, and the second circle uses it as the stroke color.

```
<html>
    <head>
        div{color:green}
    </head>
    <body>
        <div>
            some Text
            <svg width="2em" height="1em" viewBox="0 0 200 100">
                <circle cx="50" cy="50" r="45" fill="currentColor"/>
                <circle cx="150" cy="50" r="45" fill="none" stroke-width=5
stroke="currentColor"/>
            </svg>
        </div>
    </body>
</html>
```

Read Colors online: https://riptutorial.com/svg/topic/2463/colors

Chapter 6: Creating fonts

Introduction

SVG Fonts are not directly supported by Browsers any more. Still they are very convenient for programmatically generating fonts such as symbol fonts or barcode fonts. There are many tools out there that allow you to convert svg fonts to any other font format.

Remarks

Here is a list of tools you can use with SVG fonts.

Converters

- https://github.com/fontello/svg2ttf

Examples

a simple font

A simple example of an svg font. A few things to note here:

- the coordinate system of the glyphs is in opposition to the usual coordinate system in svg. **the y axis points upwards**. The point 0,0 is in the lower right corner.
- All paths in a font must be drawn counter clockwise.
- In most tools only the d attribute of the glyph element is supported. Child elements won't work, though they are technically allowed.

```
<svg xmlns="http://www.w3.org/2000/svg">
  <font id = "myFont"
        horiz-adv-x   = "1000"
        vert-origin-x = "0"
        vert-origin-y = "0" >
    <font-face font-family  = "myFont"
               font-weight  = "normal"
               units-per-em = "1000">
      <font-face-src>
        <font-face-name name="myFont"/>
      </font-face-src>
    </font-face>`
    <glyph unicode="a" d="M0 0 H1000 L500 1000z M200 200 L500 800 L800 200z" />
    <glyph unicode="b" d="M0 0 H1000 L500 1000z M200 200 L500 800 L800 200z" />
  </font>
</svg>
```

If you have wider or narrower glyphs, just change the horiz-adv-x on the glyph element itself.

```
<glyph unicode="a" horiz-adv-x="512" d="M0 0 H1000 L500 1000z M200 200 L500 800 L800 200z" />
```

font picking

the unicode property is used for later glyph selection. You can use simple letters or unicode codepoints as well as ligatures (combination of letters or unicode codepoints)

- `unicode="abc"`
- `unicode="ab"`
- `unicode="abab"`
- `unicode="a"`
- `unicode="b"`

glyphs are always selected by first match, so do have all ligatures before any single character.

unicode codepoints can be written in decimal `{` or in hexadecimal `&#x1f` notation.

ascent, descent and baseline

the units-per-em property is one of the most important font properties. It's used to give any value of any other property any meaning.

the CSS2 font spec has a nice definition of the em sqare:

> Certain values, such as width metrics, are expressed in units that are relative to an abstract square whose height is the intended distance between lines of type in the same type size

the **default baseline is at 0** in the em square. for line-height calculation and alignement purposes the two prperties ascent and descent are of most importance.

Ascent is the maximum distance from the baseline to the highest point of your largest glyph. Usaually that is 1em, so the value you gave for units-per-em.

Descent is the maximum distance from the baseline to the lowest point in any glyph of your font.

Here is a font with glyphs rendering a line at the lowest and highest point as well as at the baseline.

```
<svg xmlns="http://www.w3.org/2000/svg" viewBox="0 0 1000 1000">
  <font id = "myFont"
        horiz-adv-x   = "1000"
        vert-origin-x = "0"
        vert-origin-y = "0" >
    <font-face font-family  = "myFont"
               font-weight  = "normal"
               units-per-em = "1000"
               descent="500"
               ascent="1000">
      <font-face-src>
```

```
        <font-face-name name="myFont"/>
      </font-face-src>
    </font-face>`
    <glyph unicode = "a" d = "M0 900h1000v100h-1000z" />
    <glyph unicode = "b" d = "M0 0h1000v100h-1000z" />
    <glyph unicode = "c" d = "M0 -500h1000v100h-1000z" />
  </font>
</svg>
```

Ascent and descent are used to determine the line-height. Units-per-em and baseline are used to determine the position and size relative to other fonts used..

Read Creating fonts online: https://riptutorial.com/svg/topic/8147/creating-fonts

Chapter 7: defs

Syntax

- `<defs>` ... *defined elements* ... `</defs>`

Parameters

Parameter	Details
defs	The defs element has no parameters

Remarks

The `<defs>` element is used as a container element for elements that are intended to be used solely by reference and not rendered directly. Elements that would normally be rendered (e.g. `<rect>`, `<circle>`) that are declared inside a `<defs>` block are treated as if their style included `display:none`.

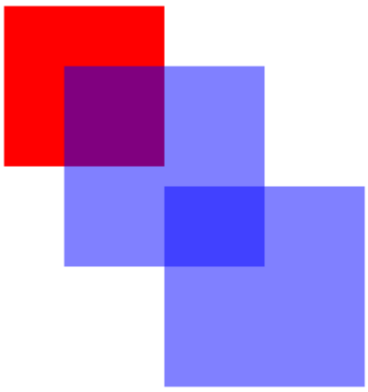
Although it's not strictly necessary, the SVG spec. recommends putting all gradient, filter, pattern, mask, symbol, and marker definitions within a `defs` block.

Examples

Basic example

```
<svg width="400px" height="400px">
<defs>
  <rect id="defrect" fill="blue" fill-opacity=".5" x="50" y="50" width="100" height="100"/>
</defs>

<rect fill="red" x="20" y="20" width="80" height="80"/>
<use xlink:href="#defrect"/>
<use xlink:href="#defrect" x="50" y="60"/>

</svg>
```

Result



Read defs online: https://riptutorial.com/svg/topic/5592/defs

Chapter 8: Ellipse

Parameters

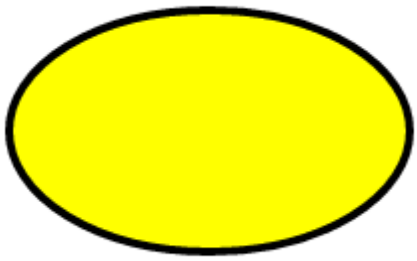
Parameter	Details
`cx`	X coordinate of the center of the ellipse
`cy`	Y coordinate of the center of the ellipse
`rx`	Horizontal radius
`ry`	Vertical radius

Examples

Simple yellow ellipse

```
<svg height="80" width="160">
  <ellipse cx="80" cy="40" rx="50" ry="30"
    style="fill:yellow; stroke:black; stroke-width:2" />
</svg>
```

Rendered:



Read Ellipse online: https://riptutorial.com/svg/topic/3993/ellipse

Chapter 9: Filters

Syntax

- Filter declaration: `<filter id="filter-id">` ...list of child primitives ... `</filter>`
- Apply filter via SVG attribute: `<elementname filter="url(#filter-id)" ... />`
- Apply filter via CSS property: *(-prefix-)*filter: url("#filter-id");

Parameters

Element attributes	Details
Filter region	The filter element may optionally define the position, dimensions, resolution, and units for the output of a filter effect. The position and dimensions of a filter may be specified using the following parameters: x, y, width, height. The default values are *not intuitive* and are: x: -10% y: -10% width: 120% height: 120%
Filter resolution	The `filterRes` attribute is an optional attribute in SVG 1.1 that can be used to specify the resolution at which the filter is processed. This attribute had uneven support and is now deprecated in current browsers.
Filter units	By default, the units and coordinate system for the filter effects region (x,y,width,height) of a filter element are set relative to the bounding box of the element referencing the filter. In SVG terms, this is called the "objectBoundingBox". When we write x="50%" it means "set the starting x position of the filter region at the left side of the bounding box of the referencing element + 50% of the width of the element". But you may also specify the units and coordinates explicitly by setting the filterUnits property. The two alternatives are "objectBoundingBox" (the default which we're just described) or "userSpaceOnUse". userSpaceOnUse sets the filter units and the coordinate system to the canvas of the referencing element, or in SVG terms, the "userSpaceOnUse".
Primitive Units	In addition to the unit system for the filter itself, you may also specify the unit system that the filter's child filter primitives will use via the primitiveUnits attribute. Once again, the choice is between userSpaceOnUse and objectBoundingBox. These affect the 0,0 coordinates and the unit values for the filter primitives in the same way as for filterUnits.
Color Space	The default color space for SVG filters is linearRGB. The optional `color-interpolation-filters` attribute can be set to `sRGB` to change the color space to the more conventional sRGB space.

Remarks

Most filter attributes are animateable via the `<animate>` element, although you must use the "fakeSMIL" library on IE to achieve the same results. SMIL animation (the `<animate>` element) will be deprecated in favor of the new Web Animations spec - which has very limited support as of mid 2016.

Child elements of the Filter element - filter primitives - have two optional attributes that specify the color space within which color interpolation calculations are performed: color-interpolation and color-interpolation-filters. The default for the former is sRGB, and the default for the latter is linearRGB. Manipulations that invert the color space (through feColorMatrix or feComponentTransfer) can result in non-intuitive results - for those used to the CSS sRGB color space. For example, a color inversion of a greyscale image in linearRGB will result in a pronounced shift toward whiter tones. This can be corrected by setting the value of the primitive to sRGB. These attributes can be set on the individual filter primitives or inherited from the filter element itself.

If no other input is specified, but one is required, the first filter primitive within a filter will take a rasterized (bitmapped) version of the referring element as its input. Subsequent filter primitives that expect an input will take the result of the immediately preceding filter primitive as input.

In complex filters, it can become difficult to keep track (and debug) inputs and outputs if they are left implicit; and it is good practice to explicitly declare inputs and outputs for each primitive.

SVG filter primitives can be colloquially divided into inputs, transformations, lighting effects and combinations.

Inputs:

feFlood: generates a color field

feTurbulence: generates a wide variety of noise effects

feImage: generates an image from an external image reference, data URI or object reference (object references are not supported in Firefox as of mid Dec '12)

Transformations:

feColorMatrix: transforms the input values of an RBGA pixel into output values

feComponentTransfer: adjusts the color curve of an individual color channel

feConvolveMatrix: replaces each pixel with a new pixel calculated from pixel values in an area relative to the current pixel)

feGaussianBlur: replaces the current pixel with a weighted average of pixels in an area around the pixel

feDisplacementMap: moves each pixel from its current position based on the R,G or B values from another input graphic.

feMorphology: replaces each pixel with a new pixel calculated from the maximum or minimum value of all pixels in a rectangular area around that pixel.

feOffset: moves the input from its current position

Lighting Effects:

feSpecularLighting: provides a "shiny" 2D or pseudo-3D lighting effect

feDiffuseLighting: provides a "matte" 2D or pseudo-3D lighting effect

feDistantLight: provides a distant light source for specular or diffuse lighting

feSpotLight: provides a conic section light source for specular or diffuse lighting

fePointLight: provides a point light source for specular or diffuse lighting

Combinations:

feMerge: creates a simple over composite from multiple inputs (including previous filter inputs)

feBlend: blends multiple inputs using mixing rules

feComposite: combines multiple inputs using set combination rules, taking into account alpha values.

feTile: tiles input to create a repeating pattern

Other Notes

Although SVG is a vector graphics technology, it is important to emphasize that SVG Filters perform *pixel-level* operations on all inputs (including SVG shapes) and produce rasterized (bitmapped) outputs at a specified level of resolution. Applying a 10x scale transform (for example) on an plain SVG curve that has been filtered at normal screen resolution will produce pixelated edges since the anti-aliasing of the original graphic has been converted to pixels by the filter and scaled up. (It is unclear whether this is spec compliant or just a limitation of current implementations)

Remember that SVG is XML when you write filters, so all tags must be closed and many properties and attributes are required to be specified explicitly or the filter will not execute.

A filter element is never rendered directly. It is only referenced using the filter property on the element to which the filter is applied. Note that the display property does not apply to the filter element and elements are not directly rendered even if the display property is set to a value other than "none". Conversely, filter elements are available for referencing even when thedisplay property on the filterelement or any of its ancestors is set to "none".

SVG filters can be referenced via a CSS Filter, although as of mid 2016, only a subset of primitives are supported via this mechanism, and this mechanism is not supported in Microsoft browsers.

Examples

Blur Filters: feGaussian Blur (basic)

```
<svg width="900px" height="400px" viewBox="0 0 900 400">
   <defs>
      <filter id="basicGaussian">
         <feGaussianBlur stdDeviation="5"/>
      </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#basicGaussian)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

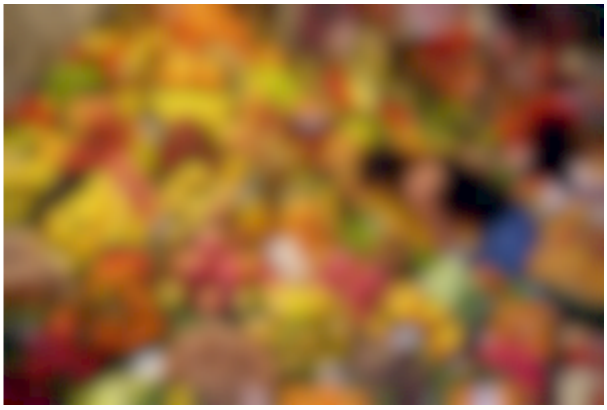
Blur Filters: feGaussianBlur (x-axis and y-axis blur set separately)

```
<svg width="900px" height="400px" viewBox="0 0 900 400">
   <defs>
      <filter id="xAxisGaussian">
         <feGaussianBlur stdDeviation="5 0"/>
      </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#xAxisGaussian)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Blur Filters: feGaussianBlur with hard edges & 100% Opacity

```
<svg width="900px" height="400px" viewBox="900 400">
   <defs>
      <filter id="GaussianHardEdge" x="0%" y="0%" width="100%" height="100%">
         <feGaussianBlur stdDeviation="5"/>
         <feComponentTransfer>
           <feFuncA type="table" tableValues="1 1"/>
         </feComponentTransfer>
      </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#GaussianHardEdge)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```

(Source image by *Daderot* at Wikimedia Commons)

Blur Filters: Box Blur

```
<svg width="900px" height="400px" viewBox="900 400">
   <defs>
      <filter id="GaussianHardEdge" >
         <feConvolveMatrix order="3" kernelMatrix=" 1 1 1
                                                    1 1 1
                                                    1 1 1"/>
```

```
      </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#GaussianHardEdge)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Blur Filters: Bokeh Blur (3 layers, clipped)

```
<svg width="900px" height="400px" viewBox="0 0 900 400">
   <defs>
<filter id="BokehBlur" color-interpolation-filters="sRGB">
      <feGaussianBlur stdDeviation="2" result="blurSource"/>
      <feColorMatrix type="luminanceToAlpha"/>
      <feComponentTransfer result="brightness-mask" >
        <feFuncA type="discrete" tableValues="0 0 0 1 1"/>
        </feComponentTransfer>


     <!--bokeh Layer 1 -->
     <feTurbulence type="fractalNoise" seed="1" baseFrequency=".67" numOctaves="3"/>
    <feColorMatrix type="luminanceToAlpha"/>
      <feComponentTransfer>
        <feFuncA type="discrete" tableValues="0 0 0 1"/>
     </feComponentTransfer>
      <feComposite operator="in" in="brightness-mask"/>
      <feComposite operator="in" in="blurSource"/>

      <feMorphology operator="dilate" radius="5"/>
      <feGaussianBlur stdDeviation="8"/>
      <feColorMatrix type="matrix" values="1 0 0 0 0  0 1 0 0 0  0 0 1 0 0
                                           0 0 0 9 0" />
      <feComponentTransfer result="bokeh1">
        <feFuncA type="linear" slope=".5" />
     </feComponentTransfer>



      <!--bokeh Layer 2 -->
     <feTurbulence type="fractalNoise" seed="49" baseFrequency=".67" numOctaves="3"/>
```

```
    <feColorMatrix type="luminanceToAlpha"/>
      <feComponentTransfer>
        <feFuncA type="discrete" tableValues="0 0 0 1"/>
     </feComponentTransfer>
      <feComposite operator="in" in="brightness-mask"/>
      <feComposite operator="in" in="blurSource"/>

      <feMorphology operator="dilate" radius="10"/>
      <feGaussianBlur stdDeviation="12"/>
      <feColorMatrix type="matrix" values="1 0 0 0 0  0 1 0 0 0  0 0 1 0 0
                                           0 0 0 15 0" />
      <feComponentTransfer result="bokeh2">
        <feFuncA type="linear" slope=".3" />
     </feComponentTransfer>

    <!--bokeh Layer 3 -->

    <feTurbulence type="fractalNoise" seed="44" baseFrequency=".67" numOctaves="3"/>
    <feColorMatrix type="luminanceToAlpha"/>
      <feComponentTransfer>
        <feFuncA type="discrete" tableValues="0 0 0 1"/>
     </feComponentTransfer>
      <feComposite operator="in" in="brightness-mask"/>
      <feComposite operator="in" in="blurSource"/>

      <feMorphology operator="dilate" radius="10"/>
      <feGaussianBlur stdDeviation="18"/>
      <feColorMatrix type="matrix" values="1 0 0 0 0  0 1 0 0 0  0 0 1 0 0
                                           0 0 0 15 0" />
      <feComponentTransfer result="bokeh3">
        <feFuncA type="linear" slope=".2" />
     </feComponentTransfer>

    <!--Merge -->
     <feBlend mode="multiply" in="bokeh3" in2="bokeh2"/>
     <feBlend mode="lighten" in2="bokeh1"/>

      <feMorphology operator="erode" radius="0" result="bokeh"/>
      <feGaussianBlur stdDeviation="9" in="SourceGraphic"/>
      <feComposite operator="over" in="bokeh"/>
      <feComposite operator="in" in2="SourceGraphic"/>

    </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#BokehBlur)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```

(Source image by *Daderot* at Wikimedia Commons)

Shadow Filters: Basic Dropshadow

```
<svg width="800px" height="600px">
<defs>
  <filter id="drop-shadow">
    <feGaussianBlur in="SourceAlpha" stdDeviation="4"/>
    <feOffset dx="5" dy="5" result="offsetblur"/>
    <feFlood flood-color="red"/>
    <feComposite in2="offsetblur" operator="in"/>
    <feMerge>
      <feMergeNode/>
      <feMergeNode in="SourceGraphic"/>
  </feMerge>
</filter>
  </defs>

  <text filter="url(#drop-shadow)" x="30" y="100" font-size="80">SVG Filters</text>

</svg>
```

Shadow Filters: Inner Glow

```
<svg width="800px" height="600px">
<defs>
  <filter id="inner-glow">
    <feFlood flood-color="red"/>
    <feComposite in2="SourceAlpha" operator="out"/>
    <feGaussianBlur stdDeviation="2" result="blur"/>
    <feComposite operator="atop" in2="SourceGraphic"/>
</filter>
  </defs>

  <text filter="url(#inner-glow)" x="30" y="100" font-size="80" font-family="Sans-Serif" font-
weight="bold">SVG Filters</text>

</svg>
```

Shadow Filters: Complex Dropshadow (Contoured, Noisy, Shaped)

```
<svg width="800px" height="600px">
<defs>
```

```
<filter id="complex-shadow" color-interpolation-filters="sRGB" x="-50%" y="-50%" height="200%"
width="200%">

<!-- Take source alpha, offset it by angle/distance and blur it by size -->
<feOffset id="offset" in="SourceAlpha" dx="11" dy="6" result="SA-offset"/>
<feGaussianBlur id="blur" in="SA-offset" stdDeviation="4" result="SA-o-blur"/>

<!-- Apply a contour by using a color curve transform on the alpha and clipping the result to
the input -->

<feComponentTransfer in="SA-o-blur" result="SA-o-b-contIN">
  <feFuncA id="contour" type="table" tableValues="0 1 .3 .1 0.05 .1 .3 1 "/>
</feComponentTransfer>

<feComposite operator="in" in="SA-o-blur" in2="SA-o-b-contIN" result="SA-o-b-cont"/>

<!-- Adjust the spread by multiplying alpha by a constant factor --> <feComponentTransfer
in="SA-o-b-cont" result="SA-o-b-c-sprd">
  <feFuncA id="spread-ctrl" type="linear" slope="2.8"/>
</feComponentTransfer>

<!-- Adjust color and opacity by adding fixed offsets and an opacity multiplier -->
<feColorMatrix id="recolor" in="SA-o-b-c-sprd" type="matrix" values="0 0 0 0 0.945 0 0 0 0
0.137 0 0 0 0 0.137 0 0 0 0.49 0" result="SA-o-b-c-s-recolor"/>

<!-- Generate a grainy noise input with baseFrequency between approx .5 to 2.0. And add the
noise with k1 and k2 multipliers that sum to 1 -->
<feTurbulence result="fNoise" type="fractalNoise" numOctaves="6" baseFrequency="1.98"/>
<feColorMatrix in="fNoise" type="matrix" values="1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 7 -3"
result="clipNoise"/>
<feComposite id="noisemix" operator="arithmetic" in="SA-o-b-c-s-recolor" in2="clipNoise"
k1="0.67" k2="0.33" result="SA-o-b-c-s-r-mix"/>

<!-- Merge the shadow with the original -->
<feMerge>
  <feMergeNode in="SA-o-b-c-s-r-mix"/>
  <feMergeNode in="SourceGraphic"/>
</feMerge>
</filter>
  </defs>

  <text filter="url(#complex-shadow)" x="30" y="100" font-size="80" font-family="Sans-Serif"
font-weight="bold">SVG Filters</text>

</svg>
```

Color Manipulation Filters: Basic Greyscale

```
<svg width="800px" height="600px">
   <defs>
     <filter id="greyscale">
     <feColorMatrix type="matrix"
             values="0.2126  0.7152  0.0722  0 0
                     0.2126  0.7152  0.0722  0 0
                     0.2126  0.7152  0.0722  0 0
                     0 0 0 1 0"/>
     </filter>
   </defs>
```

```
   <image

xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#greyscale)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Color Manipulation Filters: Greyscale (Green Channel Only)

```
<svg width="800px" height="600px">
   <defs>
     <filter id="greyscale">
     <feColorMatrix type="matrix"
             values="0  1  0  0 0
                     0  1  0  0 0
                     0  1  0  0 0
                     0 0 0 1 0"/>
     </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#greyscale)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Color Manipulation Filters: Monotone

```
<svg width="800px" height="600px">
   <defs>
     <filter id="greyscale">
     <feColorMatrix type="matrix"
             values=".2  .2  .2  0 0
                     .6  .6  .6  0 0
                     .2  .2  .2  0 0
                     0 0 0 1 0"/>
     </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#greyscale)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Blur Filters: Focus Blur (Gaussian)

```
<svg width="800px" height="600px">
   <defs>
  <filter id="focus-blur" >
    <feDiffuseLighting result = "diffOut" diffuseConstant = "1" lighting-color="white">
       <feSpotLight id="spotlight" x = "500" y = "100" z = "150" pointsAtX = "500" pointsAtY =
"100" pointsAtZ = "0" specularExponent ="12" limitingConeAngle="70"/>
    </feDiffuseLighting>

     <feColorMatrix in="diffOut" result="alphaMap" type="luminanceToAlpha"/>
     <feComponentTransfer in="alphaMap" result="invertlight">
        <feFuncA type="table" tableValues="1 0 0"/>
     </feComponentTransfer>

     <feGaussianBlur in="invertlight" result="featherspot" stdDeviation="5"/>
     <feComposite operator="xor" result="infocus" in2="SourceGraphic" in="featherspot"/>
     <feGaussianBlur in="SourceGraphic" result="outfocus" stdDeviation="2"/>
     <feComposite operator="over" in="infocus" in2="outfocus"/>
    <feComposite operator="in" in2="SourceGraphic"/>
</filter>
   </defs>
```

```
   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="20px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#focus-blur)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/a/af/Fruit_Stall_in_Barcelona_Market.jpg"
x="340px" y="20px" width="300px" height="200px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```


(Source image by *Daderot* at Wikimedia Commons)

Color Manipulation Filters: Posterizing

```
<svg width="800px" height="600px" >
   <defs>
     <filter id="posterize" color-interpolation-filters="sRGB">
     <feComponentTransfer>
       <feFuncR type="discrete" tableValues="0 0.25 0.75 1.0"/>
       <feFuncG type="discrete" tableValues="0 0.25 0.75 1.0"/>
       <feFuncB type="discrete" tableValues="0 0.25 0.75 1.0"/>
     </feComponentTransfer>
     </filter>
   </defs>

   <image
xlink:href="https://upload.wikimedia.org/wikipedia/commons/4/42/Andy_Warhol_1975.jpg" x="20px"
y="20px" width="300px" height="600px" preserveAspectRatio="xMinYMin meet" />
   <image filter="url(#posterize)"
xlink:href="https://upload.wikimedia.org/wikipedia/commons/4/42/Andy_Warhol_1975.jpg"
x="340px" y="20px" width="300px" height="600px" preserveAspectRatio="xMinYMin meet"/>
</svg>
```

Blur Filters: Highlight Blur

This filter selects only the high luminance areas of a source graphic, blurs the contents and composites the blurred content on top of the original.

```
<svg width="800px" height="600px">
    <defs>
        <filter id="highlightblur" color-interpolation-filters="sRGB">
           <feColorMatrix type="luminanceToAlpha" in="SourceGraphic" result="lumMap"/>
           <feComponentTransfer in="lumMap" result="highlightMask">
              <feFuncA type="discrete" tableValues="0 0 0 0 0 0 0 1"/>
           </feComponentTransfer>
```

```
           <feComposite operator="in" in="SourceGraphic" in2="highlightMask"
result="highlights"/>
           <feGaussianBlur in="highlights" stdDeviation="3" result="highBlur"/>
           <feComposite operator="over" in="highBlur" in2="SourceGraphic" result="final"/>
        </filter>
     </defs>

    <image filter="url(#highlightblur)" x="0" y="-40" width="780" height="600"
preserveAspectRatio="true"
xlink:href="http://i554.photobucket.com/albums/jj424/allbowerpower/Christmas%202009/ChristmasTablesett

    />
</svg>
```

Read Filters online: https://riptutorial.com/svg/topic/3262/filters

Chapter 10: Gradients

Parameters

common	definition
gradientUnits	the coordinate system of the gradient attributes. Either objectBoundingBox or userSpaceOnUse
gradientTransform	the transform to apply to the gradient contents
spreadMethod	defines what happens outside the gradient boundaries. Either pad, reflect or repeat
xlink:href	link to another gradient which provides attributes or content
------	------
Linear Gradient	Definition
------	------
x1	defines the gradient vector
x2	see x1
y1	see x1
y2	see x1
------	------
Radial Gradient	Definition
------	------
cx	the x coordinate of the outer gradient centre
cy	the y coordinate of the outer gradient centre
r	the outer radius of the gradient. The location of a 100% stop
fx	the x coordinate of the inner gradient centre. The location of a 0% stop
fy	the y location of the inner gradient centre. The location of a 0% stop

Remarks

SVG is case sensitive so remember to use a capital G in the middle.

Examples

linearGradient

```
<svg>
  <defs>
        <linearGradient id='g' y1="100%" x2="100%">
            <stop offset='0%' stop-color='yellow' />
            <stop offset='100%' stop-color='green' />
        </linearGradient>
    </defs>
    <rect width='100%' height='100%' fill='url(#g)'/>
</svg>
```

radialGradient

```
<svg>
  <defs>
    <radialGradient id="g">
      <stop offset="10%" stop-color="green" />
      <stop offset="90%" stop-color="white" />
    </radialGradient>
  </defs>

  <rect width='100%' height='100%' fill='url(#g)'/>
</svg>
```

Read Gradients online: https://riptutorial.com/svg/topic/3346/gradients

Chapter 11: Line

Parameters

Attribute	Description
x1	Horizontal position of start of line.
y1	Vertical position of start of line.
x2	Horizontal position of end of line.
y2	Vertical position of end of line.
stroke	Color of line.
stroke-width	Width of line.
stroke-opacity	Opacity of line.
stroke-dasharray	Dash pattern for the line
stroke-linecap	How line ends render

Remarks

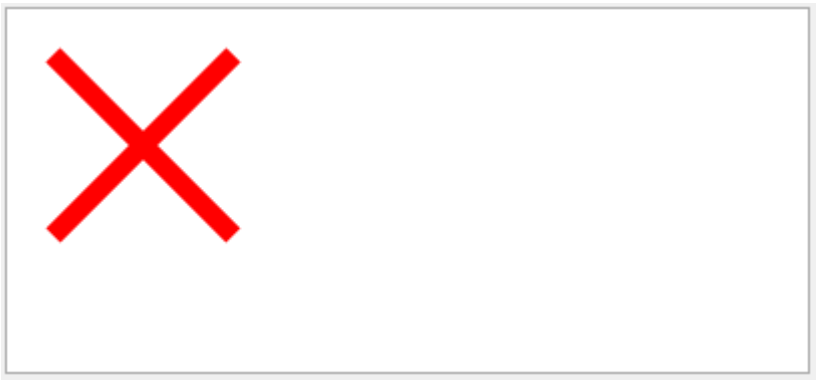
Detailed information on the SVG 'line' element can be found in the W3C Recommendation for SVG.

Examples

Draw a cross using diagonal red lines

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <line x1="10" y1="10" x2="100" y2="100" stroke="red" stroke-width="10" />
    <line x1="100" y1="10" x2="10" y2="100" stroke="red" stroke-width="10" />
</svg>
```

Result:



Dashed line drawing with stroke-dasharray

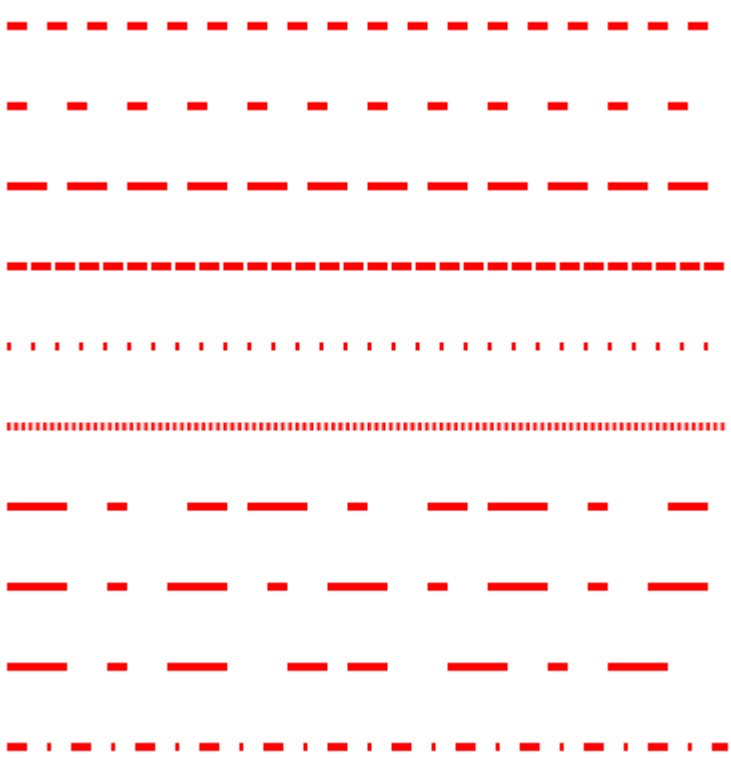
```
<svg width="400px" height="400px" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
    <line x1="10" y1="10" x2="300" y2="10" stroke="red" stroke-width="10" stroke-
dasharray="20,2,5,2"/>
</svg>
```

Result

Different examples of stroke-dasharray:

```
<svg width="200" height="200" viewBox="0 0 200 200" version="1.1"
xmlns="http://www.w3.org/2000/svg">
  <line stroke-dasharray="5, 5"              x1="10" y1="10" x2="190" y2="10" />
  <line stroke-dasharray="5, 10"             x1="10" y1="30" x2="190" y2="30" />
    <line stroke-dasharray="10, 5"             x1="10" y1="50" x2="190" y2="50" />
    <line stroke-dasharray="5, 1"              x1="10" y1="70" x2="190" y2="70" />
    <line stroke-dasharray="1, 5"              x1="10" y1="90" x2="190" y2="90" />
    <line stroke-dasharray="0.9"               x1="10" y1="110" x2="190" y2="110" />
    <line stroke-dasharray="15, 10, 5"         x1="10" y1="130" x2="190" y2="130" />
    <line stroke-dasharray="15, 10, 5, 10"     x1="10" y1="150" x2="190" y2="150" />
    <line stroke-dasharray="15, 10, 5, 10, 15" x1="10" y1="170" x2="190" y2="170" />
    <line stroke-dasharray="5, 5, 1, 5"        x1="10" y1="190" x2="190" y2="190" />
    <style><![CDATA[
    line{
        stroke: red;
        stroke-width: 2;
    }
    ]]></style>
 </svg>
```

Result:



Line cap alternatives using stroke-linecap

```
<svg width="600px" height="400px" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">

    <line x1="10" y1="20" x2="300" y2="20" stroke="red" stroke-width="20" stroke-
linecap="butt"/>
      <text x="320" y="20">stroke-linecap="butt" (default)</text>
    <line x1="10" y1="70" x2="300" y2="70" stroke="red" stroke-width="20" stroke-
linecap="round"/>
      <text x="320" y="70">stroke-linecap="round"</text>
    <line x1="10" y1="120" x2="300" y2="120" stroke="red" stroke-width="20" stroke-
linecap="square"/>
      <text x="320" y="120">stroke-linecap="square"</text>
</svg>
```

Result

Read Line online: https://riptutorial.com/svg/topic/3034/line

Chapter 12: marker

Syntax

- `<marker` viewBox="*x y width height*" refX="*xoffset*" refY="*yoffset*" orient="*orientation*" ... *optional parameters*>
- *...elements drawing the marker...*
- `</marker`>
- <*elementname* marker-start="url(*#markerid*)"/> applies a marker to the start of an element
- <*elementname* marker-mid="url(*#markerid*)"/> applies a marker to the middle of a segment of an element
- <*elementname* marker-end="url(*#markerid*)"/> applies a marker to the end of an element
- Markers can be applied to the `<line>`, `<polyline>`, `<polygon>` and `<path>` elements

Parameters

Parameter	Details
viewBox	Specifies the unit system for the elements that draw the marker
refX	Distance the x axis of the coordinate system for drawing the marker should be offset from the default drawing point. Defaults to 0.
refY	Distance the y axis of the coordinate system for drawing the marker should be offset from the default drawing point. Defaults to 0.
orient	Values are `auto` or `angle in degrees` and specifies the rotation applied to the marker. It is applied after all other coordinate adjustments are made (viewBox, preserveAspectRaio and refX, refY). Defaults to 0. Calculation of the angle for `auto` is complex - see the SVG spec for details.
markerUnits	`strokeWidth` or `userSpaceOnUse`. Defaults to `strokeWidth`.
markerWidth	Width of the marker in markerUnits. Defaults to 3.
markerHeight	Height of the marker in markerUnits. Defaults to 3

Remarks

Scripting: rendered marker elements are not exposed in the DOM, so it is impossible to adjust properties or elements for specific rendered markers (although it's completely possible to script the defined marker element).

The `overflow` property of the marker element is automatically set to `hidden`. This is what clips any drawing that overflows the marker tile. This can be explicitly set to `visible` in CSS. As of July 2016,

Chrome does not support markers with `overflow: visible` - but a workaround is to set a filter on the marker element - which seems to disable the overflow clipping.

Filters can be applied to elements within a marker. Although not explicitly permitted in the spec, filters also seem to work when specified on the marker element itself.

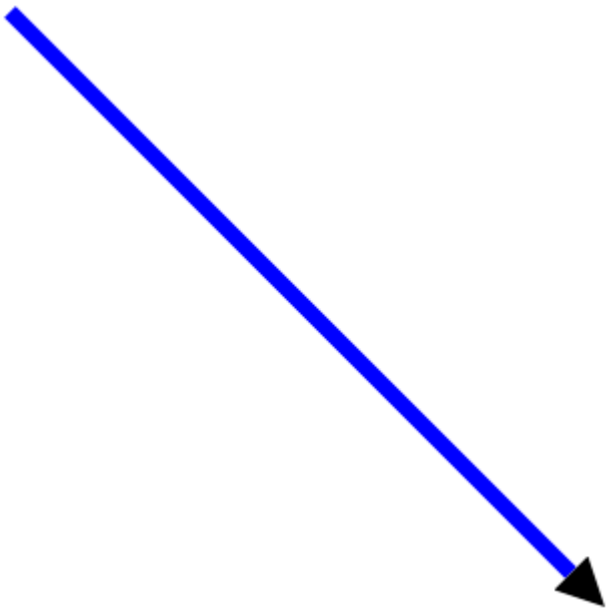
For more details on the marker element, please see the marker section in the SVG 1.1 spec.

Examples

Basic marker

This is an example of an end marker specified with a minimal number of parameters. Note that the stroke color of the original element is not inherited by the marker.

```
<svg width="800px" height="600px">
<defs>
      <marker id="examplemarker"
        viewBox="0 0 10 10"
        refX="0" refY="5"
        orient="auto">
        <path d="M 0 0 L 10 5 L 0 10 z" />
      </marker>
  </defs>

  <line x1="20" y1="20" x2="300" y2="300" stroke-width="8" stroke="blue" marker-
end="url(#examplemarker)" />
</svg>
```

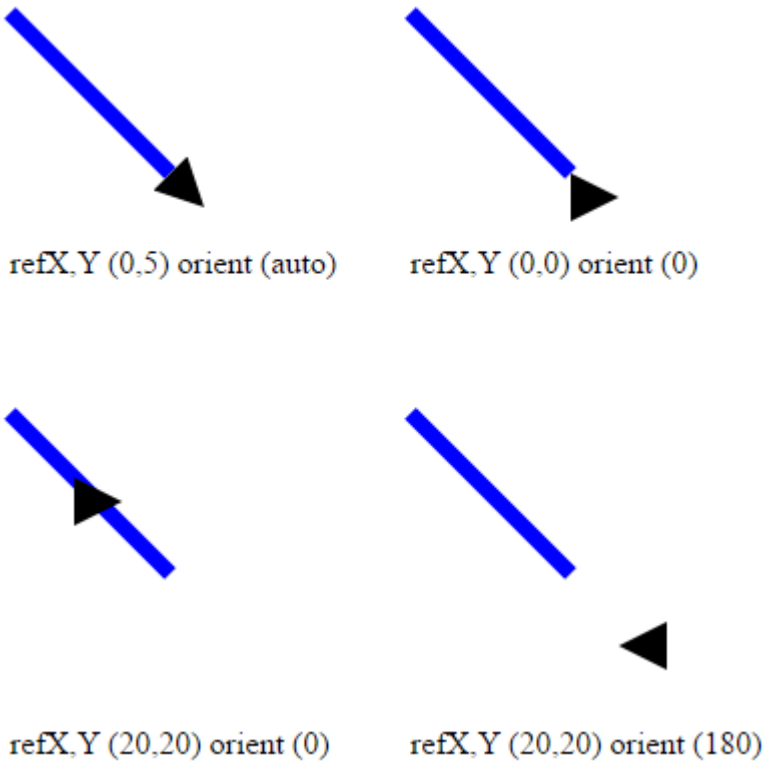


Effects of alternate values for refX, refY and orient

The axis offsets for drawing the marker that are specified by `refX` and `refY` are applied *before* the rotation specified by the `orient` parameter. Below you can see the effects of various combinations

of `orient` and `refX`, `refY` to illustrate this.

```
<svg width="800px" height="600px">
<defs>
      <marker id="marker1"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto" >
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker2"
      viewBox="0 0 10 10" refX="0" refY="0" orient="0" >
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker3"
      viewBox="0 0 10 10" refX="20" refY="20" orient="0" >
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker4"
      viewBox="0 0 10 10" refX="20" refY="20" orient="180" >
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
  </defs>

  <line  x1="20" y1="20" x2="100" y2="100" stroke-width="8" stroke="blue" marker-
end="url(#marker1)" />

  <text x="20" y="150"> refX,Y  (0,5) orient (auto) </text>

  <line  x1="220" y1="20" x2="300" y2="100" stroke-width="8" stroke="blue" marker-
end="url(#marker2)" />

    <text x="220" y="150"> refX,Y  (0,0) orient (0) </text>

  <line  x1="20" y1="220" x2="100" y2="300" stroke-width="8" stroke="blue" marker-
end="url(#marker3)" />

      <text x="20" y="390"> refX,Y  (20,20) orient (0) </text>

  <line  x1="220" y1="220" x2="300" y2="300" stroke-width="8" stroke="blue" marker-
end="url(#marker4)" />

      <text x="220" y="390"> refX,Y  (20,20) orient (180) </text>
</svg>
```

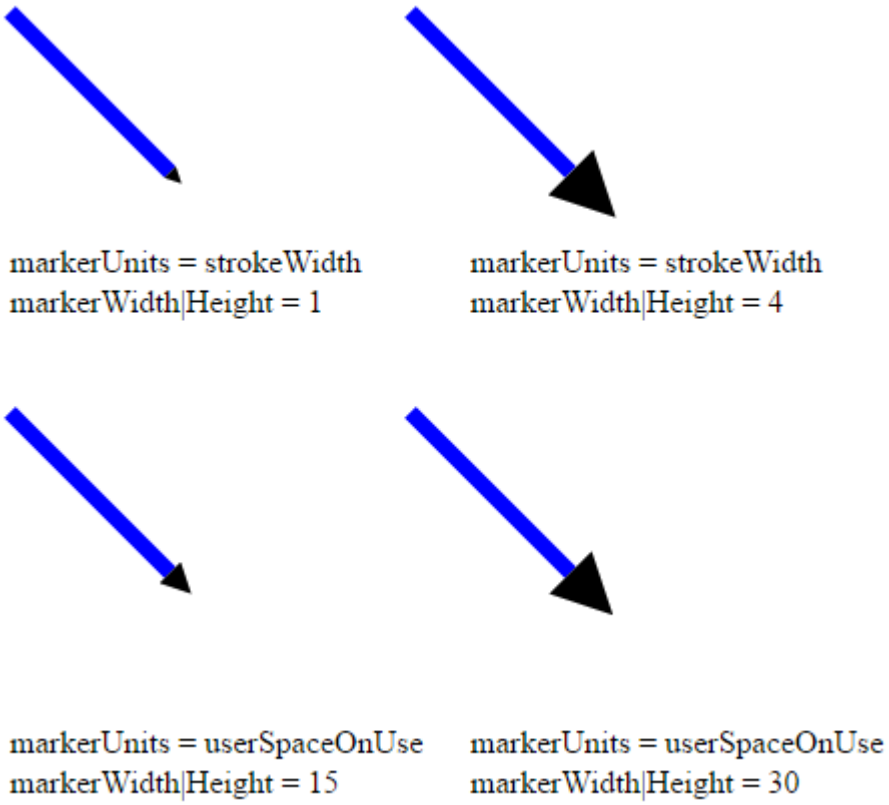


Effects of alternative values for markerUnits, markerWidth, markerHeight

The default for drawing markers is to use the stroke width of the calling element, but you can explicitly specify that markers be drawn using the unit system for the element the marker is being applied to by specifying `markerUnits="userSpaceOnUse"`. Markers are drawn into a 3x3 markerUnits box (3 strokewidths if markerUnits are not specified). But the width and height of the box can be explicitly specified with `markerHeight` and `markerWidth`. See below for the effects of various combinations of `markerUnits`, `markerHeight` and `markerWidth`.

```
<svg width="800px" height="600px">
<defs>
      <marker id="marker1"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto" markerUnits="strokeWidth"
markerWidth="1" markerHeight="1">
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker2"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto" markerUnits="strokeWidth"
markerWidth="4" markerHeight="4">
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker3"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto" markerUnits="userSpaceOnUse"
markerWidth="15" markerHeight="15">
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
      <marker id="marker4"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto" markerUnits="userSpaceOnUse"
markerWidth="30" markerHeight="30">
      <path d="M 0 0 L 10 5 L 0 10 z" />
                                    </marker>
```

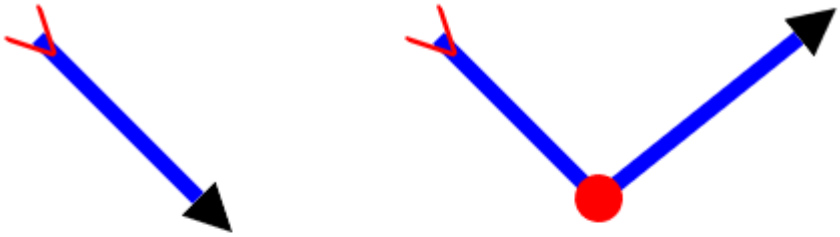
```
  </defs>

  <line  x1="20" y1="20" x2="100" y2="100" stroke-width="8" stroke="blue" marker-
end="url(#marker1)" />
    <text x="20" y="150"> markerUnits = strokeWidth </text>
    <text x="20" y="170"> markerWidth|Height = 1 </text>

  <line  x1="220" y1="20" x2="300" y2="100" stroke-width="8" stroke="blue" marker-
end="url(#marker2)" />
    <text x="250" y="150"> markerUnits = strokeWidth </text>
    <text x="250" y="170"> markerWidth|Height = 4 </text>

  <line  x1="20" y1="220" x2="100" y2="300" stroke-width="8" stroke="blue" marker-
end="url(#marker3)" />
      <text x="20" y="390"> markerUnits = userSpaceOnUse </text>
      <text x="20" y="410"> markerWidth|Height = 15 </text>

  <line  x1="220" y1="220" x2="300" y2="300" stroke-width="8" stroke="blue" marker-
end="url(#marker4)" />
      <text x="250" y="390"> markerUnits = userSpaceOnUse </text>
      <text x="250" y="410"> markerWidth|Height = 30 </text>
</svg>
```



Start, mid and end markers on line, polyline, polygon and path elements

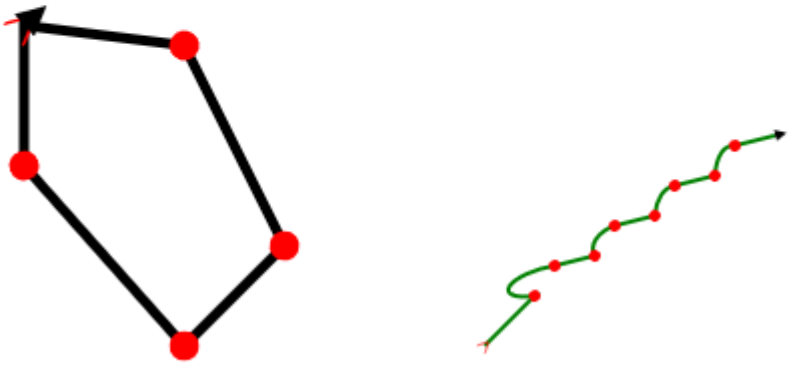
Elements can specify start, mid and end markers separately. Below are examples of start, mid and end markers for all elements that can be marked. Please note that Chrome does not currently (July 2016) calculate auto orientation correctly for start and end markers for polygons (bug# 633012), and also does not correctly place mid markers for arc path segments (bug #583097)

```
<svg width="800px" height="600px">
<defs>
      <marker id="red-chevron"
      viewBox="0 0 10 10" refX="5" refY="5" orient="auto" >
         <path d="M 0 0 L 10 5 L 0 10" fill="none" stroke="red" />
      </marker>

      <marker id="black-arrow"
      viewBox="0 0 10 10" refX="0" refY="5" orient="auto">
         <path d="M 0 0 L 10 5 L 0 10 z" />
      </marker>

      <marker id="red-circle"
      viewBox="0 0 10 10" refX="5" refY="5" orient="auto" >
         <circle fill="red" cx="5" cy="5" r="5" />
      </marker>
  </defs>

  <line  x1="20" y1="20" x2="100" y2="100" stroke-width="8" stroke="blue" marker-
start="url(#red-chevron)" marker-end="url(#black-arrow)" marker-mid="url(#red-circle)" />
  <text x="20" y="150"> line: marker-mid not applied</text>

  <polyline  points="220,20 300,100 400,20" fill="none" stroke-width="8" stroke="blue" marker-
start="url(#red-chevron)" marker-end="url(#black-arrow)" marker-mid="url(#red-circle)" />
    <text x="250" y="150"> polyline </text>

  <polygon  points="20,190 100,200 150,300 100,350 20,260" marker-start="url(#red-chevron)"
marker-end="url(#black-arrow)" marker-mid="url(#red-circle)" fill="none" stroke-width="5"
stroke="black" />
   <text x="20" y="390"> polygon: end/start overlap </text>

  <path d="M250,350 l 25,-25
        a15,5 -16 0,1 10,-15 l 20,-5
        a15,10 -16 0,1 10,-15 l 20,-5
        a15,25 -16 0,1 10,-15 l 20,-5
        a15,35 -16 0,1 10,-15 l 20,-5"
        fill="none" stroke="green" stroke-width="2" marker-start="url(#red-chevron)" marker-
end="url(#black-arrow)" marker-mid="url(#red-circle)"  />
      <text x="250" y="390"> path with arc segments </text>
</svg>
```



line: marker-mid not applied

polyline



polygon: end/start overlap

path with arc segments

Read marker online: https://riptutorial.com/svg/topic/4839/marker

Chapter 13: mask

Introduction

The `mask` element allows you to "clip" with soft edges. You can compose masks from multible elements including text. Everything of a mask that is white will be completely opaque. Everything that is black will be completely transparent. Values between white and black will be semi transparent.

Remarks

Be aware that masks are a computational expensive operation. The calculation needs to be made for every pixel in the area of the mask. So keep the area of your mask as small as possible.

Examples

basic mask

A green rect with a round hole in the middle showing the image background underneth.

```
<svg viewBox="0 0 100 100" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
    <mask id="myMask">
        <rect x="0" y="0" width="100" height="100" fill="white"/>
        <circle cx="50" cy="50" r="45" fill="black"/>
    </mask>
    <image xlink:href="https://cdn.pixabay.com/photo/2013/04/06/05/06/ship-100978_960_720.jpg"
width="100" height="100"/>
    <rect x="0" y="0" width="100" height="100" fill="green" mask="url(#myMask)"/>
</svg>
```

complex example with text and shapes

A green rect with a complex mask applied to it showing the background image.

```
<svg viewBox="0 0 100 100" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
    <mask id="myMask0">
        <circle cx="50" cy="50" r="30" fill="white"/>
    </mask>
    <mask id="myMask">
        <rect x="0" y="0" width="100" height="100" fill="white"/>
        <text x="5" y="60" font-size="40">Mask</text>
        <circle cx="50" cy="50" r="30" fill="black"/>
        <text x="5" y="60" font-size="40" mask="url(#myMask0)" fill="white">Mask</text>
    </mask>
    <image xlink:href="https://cdn.pixabay.com/photo/2013/04/06/05/06/ship-100978_960_720.jpg"
width="100" height="100"/>
    <rect x="0" y="0" width="100" height="100" fill="green" mask="url(#myMask)"/>
```

```
</svg>
```

semi transparency

a green rect (again...) with 4 holes created using 4 greyscale values resulting in 4 different opacities.

```
<svg viewBox="0 0 100 100" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
    <mask id="myMask">
        <rect x="0" y="0" width="100" height="100" fill="white"/>
        <circle cx="25" cy="25" r="20" fill="black"/>
        <circle cx="75" cy="25" r="20" fill="#333"/>
        <circle cx="25" cy="75" r="20" fill="#666"/>
        <circle cx="75" cy="75" r="20" fill="#999"/>
    </mask>
    <image xlink:href="https://cdn.pixabay.com/photo/2013/04/06/05/06/ship-100978_960_720.jpg"
width="100" height="100"/>
    <rect x="0" y="0" width="100" height="100" fill="green" mask="url(#myMask)"/>
</svg>
```

a mask with a gradient

A green rect with a hole in the middle, with soft edges.

```
<svg viewBox="0 0 100 100" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
    <radialGradient id="rg">
      <stop offset="0" stop-color="black"/>
      <stop offset="1" stop-color="white"/>
    </radialGradient>
    <mask id="myMask">
        <rect x="0" y="0" width="100" height="100" fill="white"/>
        <circle cx="50" cy="50" r="45" fill="url(#rg)"/>
    </mask>
    <image xlink:href="https://cdn.pixabay.com/photo/2013/04/06/05/06/ship-100978_960_720.jpg"
width="100" height="100"/>
    <rect x="0" y="0" width="100" height="100" fill="green" mask="url(#myMask)"/>
</svg>
```

Read mask online: https://riptutorial.com/svg/topic/8143/mask

Chapter 14: Paths

Introduction

Paths are the most flexible element of SVG. A path is a series of cubic or quadratic Bezier curves, arranged in connected splines. A path may be open or closed into a loop, or it may be complex with several sub-components. If a path is not simple, the fill rule is important in deciding which areas are inside or outside of the path.

Paths will normally be generated by automatic editors. Typically quadratic paths are used for fonts, and cubic paths for illustrations.

Parameters

Attributes / parameters	Description
d	Defines a sequence of drawing commands that create the shape. e.g. d="M 50,60 L50,60". Uppercase drawing commands designate absolute coordinates. Lowercase drawing commands designate relative coordinates.
(...)	**Drawing Commands**
m/M	Move current drawing position to XY d="M XY"
l/L	Draw a line to X,Y d="L XY"
v/V	Draw a vertical line to Y d="V Y"
h/H	Draw a horizontal line to X d="H X"
a/A	Draw an arc to X,Y with an implied radius of Rx and Ry and a rotation specified by X-axis-rotation. The large arc and sweep flags select which of the 4 possible arcs that satisfy these constraints should be drawn. d="A Rx Ry X-axis-rotation(degrees) large-arc-flag (0/1) sweep-flag(0/1) X,Y".
q/Q	Draw quadratic bezier curve to X,Y using control point X1Y1 d="X1Y1 X Y"
t/T	Draw a shorthand quadratic bezier curve (the control point is calculated as a reflection of the control point of the previous q/Q drawing command through the current drawing position)
c/C	Draw a cubic bezier curve to X,Y using control points X1,Y1 and X2,Y2 d="C X1Y1, X2Y2, XY"
s/S	Draw a shorthand cubic bezier curve (first control point is calculated as a

Attributes / parameters	Description
	reflection of the second control point of the previous c/C drawing command through the current drawing position).
- z/Z	Close the path by drawing a line to start of path (or pathsegment if another z has been used previously)
(...)	*(end of list)*
pathLength	(Optional) Allows the author to specify a nominal pathLength which will be used for calibration in other calculations, for example for text along a path
Stroke Parameters	*common among to all shape and drawing elements*
stroke	Color of path
stroke-width	Width of path

Remarks

Detailed information on the SVG `path` element can be found in the W3C Recommendation for SVG .

Examples

Draw a diagonal blue line using the L path command

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <path d="M 10,10 L 100,50" stroke="blue" stroke-width="5" />
</svg>
```

Result:

Draw a horizontal orange line using the H drawing command

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <path d="M 10,10 H 200" stroke="orange" stroke-width="5" />
</svg>
```

Result:

Draw a red cross using l (relative line) path commands

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <path d="M 10,10 l 90,90 M 100,10 l -90,90" stroke="red" stroke-width="10" />
</svg>
```

Result:

Draw a vertical green line using the V path command

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <path d="M 10,10 V 200" stroke="green" stroke-width="5" />
</svg>
```

Result:

Read Paths online: https://riptutorial.com/svg/topic/2397/paths

Chapter 15: Patterns

Parameters

parameter	description
patternUnits	the coordinate system of the pattern attributes either objectBoundingBox (default) or userSpaceOnUse
patternContentUnits	the coordinate system of the pattern contents either objectBoundingBox or userSpaceOnUse(default)
patternTransform	the transform to apply to the pattern contents
x	the x offset of the pattern (default is zero)
y	the y offset of the pattern (default is zero)
width	the width of the pattern (required)
height	the height of the pattern (required)
xlink:href	link to another pattern that provides some attributes or content
preserveAspectRatio	whether the aspect ratio of the pattern should be preserved

Remarks

By default, the pattern will be tiled by setting the middle of the pattern unit at the top left corner of the shape.

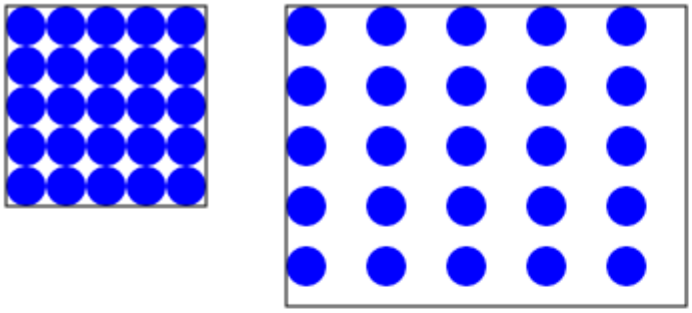
Examples

Example pattern with objectBoundingBox units

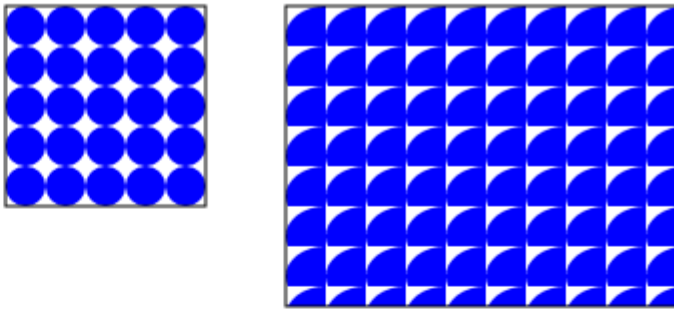
```
<svg width="400" height="400">
<defs>
  <pattern id="pattern1" width="0.2" height="0.2" patternUnits="objectBoundingBox">
      <circle cx="10" cy="10" r="10" fill="#0000ff" />
  </pattern>
</defs>

<rect x="10" y="10" width="100" height="100" stroke="black" fill="url(#pattern1)"/>
</svg>
```

Pattern coverage with combinations of patternUnits and patternContentUnits

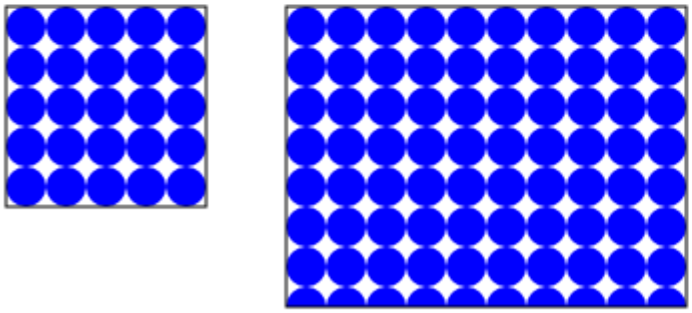
SVG Patterns behave significantly differently than CSS background images when filling equivalent shapes. This can lead to significant surprises for new-comers to SVG. Below are examples of a pattern defined in all possible combinations of patternUnits and patternContentUnits - showing how these settings affect fill behavior.



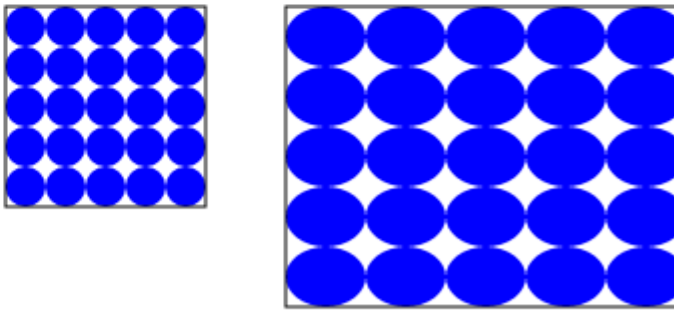
patternUnits="objectBoundingBox" (20% of shape)
patternContentUnits="userSpaceOnUse" (20px circle)
(Units used by default)



patternUnits="userSpaceOnUse" (10px square box)
patternContentUnits="objectBoundingBox"(radius=



patternUnits="userSpaceOnUse" (10px square box)
patternContentUnits="userSpaceOnUse" (20px circle)



patternUnits="objectBoundingBox" (20% of shape)
patternContentUnits="objectBoundingBox"(radius=

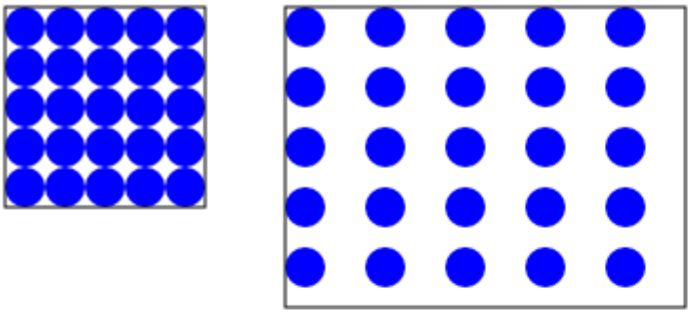
```
<svg width="800px" height="800px">
<defs>
<pattern id="pattern1" x="0" y="0" width="0.2" height="0.2"  patternUnits="objectBoundingBox"
patternContentUnits="userSpaceOnUse">
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>

    <pattern id="pattern2" x="10" y="10" width="20" height="20"  patternUnits="userSpaceOnUse"
patternContentUnits="objectBoundingBox">
      <circle cx=".1" cy=".1" r="0.1" fill="blue" />
  </pattern>

    <pattern id="pattern3" x="10" y="10" width="20" height="20"  patternUnits="userSpaceOnUse"
patternContentUnits="userSpaceOnUse">
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>

    <pattern id="pattern4" x="0" y="0" width="0.2" height="0.2"
patternUnits="objectBoundingBox" patternContentUnits="objectBoundingBox">
```

```
      <circle cx=".1" cy=".1" r="0.1" fill="blue" />
  </pattern>
</defs>

<rect x="10" y="10" width="100" height="100" stroke="black" fill="url(#pattern1)"/>
<rect x="150" y="10" width="200" height="150" stroke="black" fill="url(#pattern1)"/>
  <text x="10" y="200">patternUnits="objectBoundingBox" (20% of shape)</text>
  <text x="10" y="220">patternContentUnits="userSpaceOnUse" (20px circle) </text>
  <text x="10" y="240" stroke="blue" stroke-width="1">(Units used by default)</text>

<rect x="10" y="310" width="100" height="100" stroke="black" fill="url(#pattern3)"/>
<rect x="150" y="310" width="200" height="150" stroke="black" fill="url(#pattern3)"/>
  <text x="10" y="500">patternUnits="userSpaceOnUse" (10px square box)</text>
  <text x="10" y="520">patternContentUnits="userSpaceOnUse" (20px circle) </text>

<rect x="410" y="10" width="100" height="100" stroke="black" fill="url(#pattern2)"/>
<rect x="550" y="10" width="200" height="150" stroke="black" fill="url(#pattern2)"/>
  <text x="410" y="200">patternUnits="userSpaceOnUse" (10px square box)</text>
  <text x="410" y="220">patternContentUnits="objectBoundingBox"(radius="10%") </text>

<rect x="410" y="310" width="100" height="100" stroke="black" fill="url(#pattern4)"/>
<rect x="550" y="310" width="200" height="150" stroke="black" fill="url(#pattern4)"/>
  <text x="410" y="500">patternUnits="objectBoundingBox" (20% of shape)</text>
  <text x="410" y="520">patternContentUnits="objectBoundingBox"(radius="10%")  </text>

</svg>
```

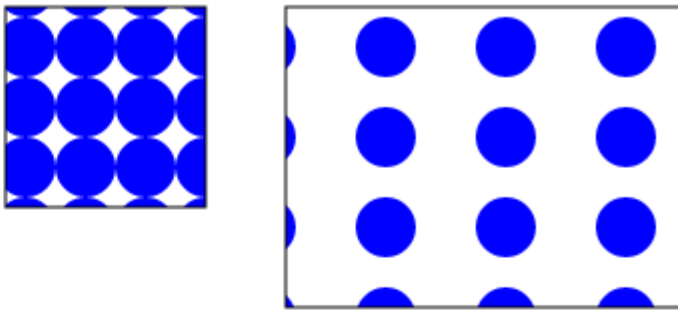
patternTransform examples

```
<svg width="800px" height="800px">
<defs>
<pattern id="pattern1" x="0" y="0" width="0.2" height="0.2" >
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>

  <pattern id="pattern2" x="0" y="0" width="0.2" height="0.2" patternTransform="scale(1.5)">
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>

  <pattern id="pattern3" x="0" y="0" width="0.2" height="0.2"   patternTransform="skewX(45)">
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>

  <pattern id="pattern4" x="0" y="0" width="0.2" height="0.2"  patternTransform="matrix(1.5,-
.70,.10,1.1,-30,10)">
      <circle cx="10" cy="10" r="10" fill="blue" />
  </pattern>


</defs>

<rect x="10" y="10" width="100" height="100" stroke="black" fill="url(#pattern1)"/>
<rect x="150" y="10" width="200" height="150" stroke="black" fill="url(#pattern1)"/>
  <text x="10" y="200">Original</text>

<rect x="410" y="10" width="100" height="100" stroke="black" fill="url(#pattern2)"/>
<rect x="550" y="10" width="200" height="150" stroke="black" fill="url(#pattern2)"/>
  <text x="410" y="200">patternTransform="scale(1.5)"</text>
```

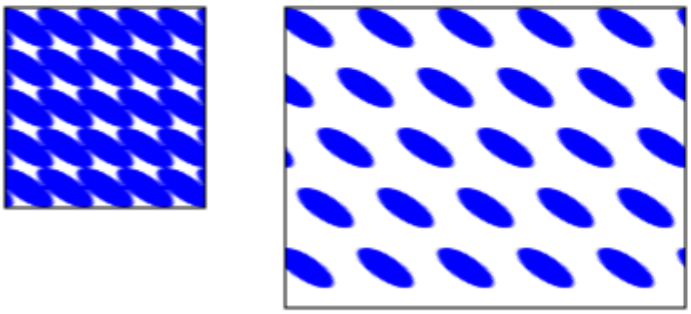
```
<rect x="10" y="310" width="100" height="100" stroke="black" fill="url(#pattern3)"/>
<rect x="150" y="310" width="200" height="150" stroke="black" fill="url(#pattern3)"/>
  <text x="10" y="500">patternTransform="skewX(45)"</text>

<rect x="410" y="310" width="100" height="100" stroke="black" fill="url(#pattern4)"/>
<rect x="550" y="310" width="200" height="150" stroke="black" fill="url(#pattern4)"/>
  <text x="410" y="500">patternUnits="matrix(1.5,-.70,.10,1.1,-30,10)"</text>

</svg>
```



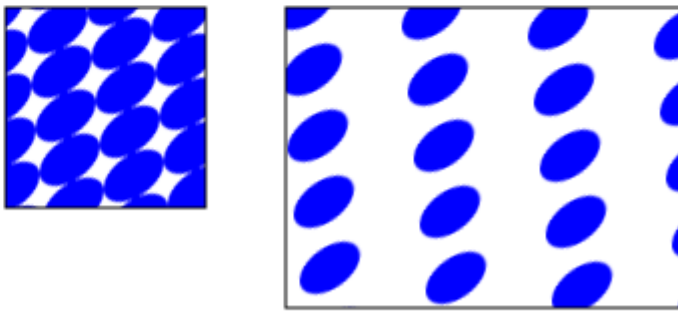
Original



patternTransform="scale(1.5)"



patternTransform="skewX(45)"



patternUnits="matrix(1.5,-.70,.10,1.1,-30,10)"

Read Patterns online: https://riptutorial.com/svg/topic/3251/patterns

Chapter 16: pointer-events

Introduction

With the `pointer-events` property, you can control wich part of your drawing will react to pointer events.

Examples

none

the most common use case is to set pointer-events to `none` to prevent certain shapes or all of your drawing to capture mouse events, and to let the shapes underneath them to receive the events.

If you hover over the area where the red circle overlaps the blue circle, the blue circle will still receive the mouse events, as pointer-events is set to `none`

```
<svg viewBox="0 0 150 100">
    <style>
        .target:hover{fill:green}
    </style>
    <circle class="target" cx="50" cy="50" r="50" fill="blue"/>
    <circle cx="100" cy="50" r="50" fill="red" pointer-events="none"/>
</svg>
```

fill

Setting `pointer-events="fill"` lets you receive mouse events on a shape even if its fill is set to `none`

```
<svg viewBox="0 0 100 100">
    <style>
        circle:hover{fill:green}
    </style>
    <circle class="target" cx="50" cy="50" r="50" fill="none"/>
</svg>
```

Read pointer-events online: https://riptutorial.com/svg/topic/8166/pointer-events

Chapter 17: Polyline

Syntax

- `<polyline points="10,5 25,15 20,10" />`

Parameters

Parameter	Details
points	The points attribute defines a list of points. Each point is defined by a x and a y coordinate in the user coordinate system.
stroke-width	Width of stroke
stroke-opacity	Opacity of stroke
stroke-dasharray	(Optional) Specifies the dash pattern for the stroke
stroke-linecap	(Optional) Specifies whether line end should be flush, round or squared off ("butt" (default)/"round"/"square")
stroke-linejoin	(Optional) Specifies how line segments should be joined - mitered, rounded or beveled ("miter" (default)/"round"/"bevel")
stroke-miterlimit	(Optional) Specifies the maximum dimension of a miter. Mitered joins that exceed this limit are converted to a bevel join. Default="4"

Examples

SVG including a polyline

```
<svg xmlns="http://www.w3.org/2000/svg" version="1.1">
  <polyline points="10,5 25,15 20,10" />
</svg>
```

Polylines with alternative linejoins, linecaps and miterlimits

```
<svg width="600px" height="600px" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">

    <polyline points="10,10,50,40,80,30,120,90,130,10,180,50,250,100,300,10" fill="none"
stroke="red" stroke-width="10" />
```

```
      <text x="320" y="20">Default drawing stroke</text>

      <g transform="translate(0,150)">
      <polyline points="10,10,50,40,80,30,120,90,130,10,180,50,250,100,300,10" fill="none"
stroke="red" stroke-width="10" stroke-linecap="butt" stroke-linejoin="miter" stroke-
miterlimit="2"/>

      <text x="320" y="20">stroke-linecap="butt" (default)</text>
      <text x="320" y="40">stroke-linejoin="miter"(default)</text>
      <text x="320" y="60">stroke-miterlimit="2"</text>
  </g>

  <g transform="translate(0,300)">
      <polyline points="10,10,50,40,80,30,120,90,130,10,180,50,250,100,300,10" fill="none"
stroke="red" stroke-width="10" stroke-linecap="round" stroke-linejoin="round" />

      <text x="320" y="20">stroke-linecap="round" </text>
      <text x="320" y="40">stroke-linejoin="round" </text>

  </g>
  <g transform="translate(0,450)">
      <polyline points="10,10,50,40,80,30,120,90,130,10,180,50,250,100,300,10" fill="none"
stroke="red" stroke-width="10" stroke-linecap="square" stroke-linejoin="bevel"/>

      <text x="320" y="20">stroke-linecap="square"</text>
      <text x="320" y="40">stroke-linejoin="bevel"</text>
  </g>

</svg>
```

Result

Default drawing stroke

stroke-linecap="butt" (default)
stroke-linejoin="miter"(default)
stroke-miterlimit="2"

stroke-linecap="round"
stroke-linejoin="round"

stroke-linecap="square"
stroke-linejoin="bevel"

Read Polyline online: https://riptutorial.com/svg/topic/3842/polyline

Chapter 18: Rectangle

Parameters

Attribute	Description
x	Horizontal position of rectangle from left margin.
y	Vertical position of rectangle from top margin.
width	Width of rectangle.
height	Height of rectangle.
rx	Horizontal radius of ellipse used to round corners of rectangle
ry	Vertical radius of ellipse used to round corners of rectangle
stroke	Colour of rectangle border.
stroke-width	Width of rectangle border.
fill	Colour *inside* rectangle border.

Remarks

Detailed information on the SVG 'rect' element can be found in the W3C Recommendation for SVG.

Examples

Draw a black rectangle without fill

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <rect x="10" y="10" width="50" height="100" stroke="black" stroke-width="5" fill="none" />
</svg>
```

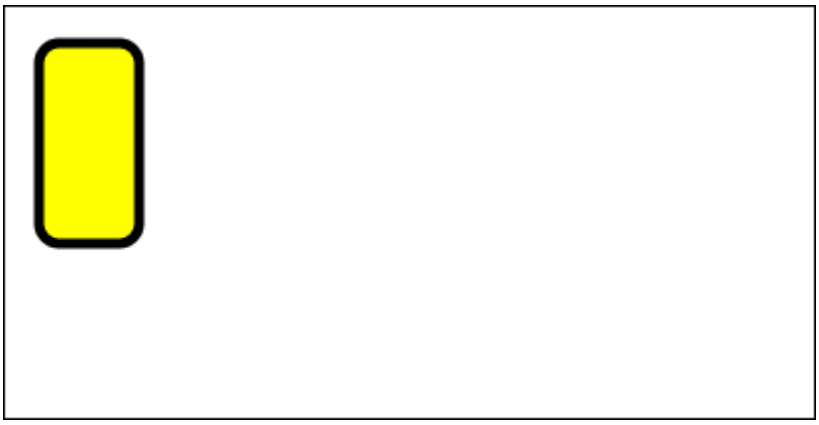
Result:

Draw a black rectangle with yellow fill and rounded corners

- The `width` and `height` attributes designate the dimensions of the rectangle. These values are in pixels by default
- The `fill` value sets the color for the rectangle. If no value for `fill` is specified, black is used by default

```
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
    <rect x="10" y="10" width="50" height="100" rx="10" ry="10" stroke="black" stroke-
width="5" fill="yellow" />
</svg>
```

Result:



Read Rectangle online: https://riptutorial.com/svg/topic/2993/rectangle

Chapter 19: Scripting

Remarks

Scripting SVG using the native DOM interfaces is currently (2016) in a state of slight change. The current SVG standard (1.1) is implemented well by most major web browsers. However, as the SVG 2.0 standard is under development, some browsers have begun to remove SVG 1.1 features that will be obsolete in 2.0. You can see a full list of proposed changes from SVG 1.1 to SVG 2.0 in Appendix L of SVG 2.0.

Replacing `pathSegList` and other `SVGPathSeg` usage

In SVG 1.1 `<path>` elements are defined to have a `pathSegList` property that gives access to a native representation of all path commands. Google Chrome v48 removed this property at the end of 2015, in preparation for a proposed replacement in SVG 2.0. Until SVG 2.0 support is added, you must use a polyfill to either get the 1.1 functionality back, or to implement the proposed 2.0 API.

Replacing `getTransformToElement()`

Chrome v48 also removed the `SVGGraphicsElement.getTransformToElement()` method. A simple polyfill exists to implement the old method.

Examples

Creating an Element

The simplest way to understand creating and modifying SVG elements is to operate on the elements using the DOM Level 2 Core interfaces, as you would with HTML or XML.

It is imperative that the *elements* created from JavaScript are created in the same namespace declared in the SVG element - in this example: "http://www.w3.org/2000/svg". However, almost all *attributes* of SVG elements are not in any namespace. You must **not** place them in the SVG namespace.

Here we demonstrate SVG hosted inside of HTML, as this is a common case:

```
<!doctype HTML>
<html><title>Creating an Element</title>
<body>
  <svg xmlns="http://www.w3.org/2000/svg"
       width="100%" height="100%"
       viewBox="0 0 400 300"></svg>

  <script>
     var svgNS = "http://www.w3.org/2000/svg";
```

```
    // Create a circle element (not part of the DOM yet)
    var circle = document.createElementNS(svgNS,'circle'); // Creates a <circle/>
    circle.setAttribute('fill','red'); // Note: NOT setAttributeNS()
    circle.setAttribute('cx',150);     // setAttribute turns 150 into a string
    circle.setAttribute('cy','80');    // using a string works, too
    circle.setAttribute('r',35);       // give the circle a radius so we can see it

    // Now, add the circle to the SVG document so we can see it
    var svg = document.querySelector('svg'); // the root <svg> element
    svg.appendChild(circle);
  </script>
</body></html>
```

There are a few attributes that need to be created in a particular namespace. They are the ones listed with colons in their names in the SVG Attribute Index. Specifically, they are: `xlink:actuate`, `xlink:arcrole`, `xlink:href`, `xlink:role`, `xlink:show`, `xlink:title`, `xlink:type`, `xml:base`, `xml:lang`, and `xml:space`. Set these attributes using `setAttributeNS()`:

```
var svgNS   = "http://www.w3.org/2000/svg";
var xlinkNS = "http://www.w3.org/1999/xlink";
var img = document.createElementNS( svgNS, 'image' );
img.setAttributeNS( xlinkNS, 'href', 'my.png' );
```

If you are creating elements often, particularly with many attributes, a helper function like the following can save you typing, avoid mistakes, and make your code easier to read:

```
<!doctype HTML>
<html><title>Creating an Element</title>
<body>
  <svg xmlns="http://www.w3.org/2000/svg"></svg>
  <script>
     var svg = document.querySelector('svg');
     var circle = createOn( svg, 'circle', {fill:'red', cx:150, cy:80, r:35} );

    // Create an SVG element on another node with a set of attributes.
    // Attributes with colons in the name (e.g. 'xlink:href') will automatically
    // find the appropriate namespace URI from the SVG element.
    // Optionally specify text to create as a child node, for example
    //   createOn(someGroup,'text',{x:100,'text-anchor':'middle'},"Hello World!");
    function createOn(parentEl,name,attrs,text){
      var doc=parentEl.ownerDocument, svg=parentEl;
      while (svg && svg.tagName!='svg') svg=svg.parentNode;
      var el = doc.createElementNS(svg.namespaceURI,name);
      for (var a in attrs){
        if (!attrs.hasOwnProperty(a)) continue;
        var p = a.split(':');
        if (p[1]) el.setAttributeNS(svg.getAttribute('xmlns:'+p[0]),p[1],attrs[a]);
        else      el.setAttribute(a,attrs[a]);
      }
      if (text) el.appendChild(doc.createTextNode(text));
      return parentEl.appendChild(el);
    }
  </script>
</body></html>
```

Reading/Writing Attributes

You can use either DOM Level 2 Core methods `getAttribute()`, `getAttributeNS()`, `setAttribute()`, and `setAttributeNS()` to read and write values from SVG elements, or you can use custom properties and methods specified in the SVG 1.1 IDL (Interface Definition Language).

Simple Numeric Attributes

For example, if you have an SVG circle element:

```
<circle id="circ" cx="10" cy="20" r="15" />
```

you can either use DOM methods to read and write the attributes:

```
var circ = document.querySelector('#circ');
var x = circ.getAttribute('cx') * 1; // Use *1 to convert from string to number value
circ.setAttribute('cy', 25);
```

...or you can use the custom `cx`, `cy`, and `r` properties defined for `SVGCircleElement`. Note that these are not direct numbers, but instead—as with many accessors in SVG 1.1—they allow for access to animated values. These properties are of type `SVGAnimatedLength`. Disregarding animation and length units, you can use such attributes like:

```
var x = circ.cx.baseVal.value; // this is a number, not a string
circ.cy.baseVal.value = 25;
```

Transformations

SVG groups may be used to move, rotate, scale, and otherwise transform multiple graphical elements as a whole. (For details on SVG translations, see Chapter 7). Here is a group that makes a smiley face that you can adjust the size, rotation, and placement of by adjusting the `transform`:

```
<g id="smiley" transform="translate(120,120) scale(5) rotate(30)">
  <circle r="20" fill="yellow" stroke-width="2"/>
  <path fill="none" d="M-10,5 a 5 3 0 0 0 20,0" stroke-width="2"/>
  <circle cx="-6" cy="-5" r="2" fill="#000"/>
  <circle cx="6"  cy="-5" r="2" fill="#000"/>
</g>
```

Using script to adjust the scale of this via DOM methods requires manipulating the entire `transform` attribute as a string:

```
var face = document.querySelector('#smiley');

// Find the full string value of the attribute
var xform = face.getAttribute('transform');

// Use a Regular Expression to replace the existing scale with 'scale(3)'
xform = xform.replace( /scale\s*\([^)]+\)/, 'scale(3)' );
```

```
// Set the attribute to the new string.
face.setAttribute('transform',xform);
```

With the SVG DOM one can traverse the specific transforms in the list, find the desired one, and modify the values:

```
var face = document.querySelector('#smiley');

// Get the SVGTransformList, ignoring animation
var xforms = face.transform.baseVal;

// Find the scale transform (pretending we don't know its index)
for (var i=0; i<xforms.numberOfItems; ++i){
  // Get this part as an SVGTransform
  var xform = xforms.getItem(i);
  if (xform.type == SVGTransform.SVG_TRANSFORM_SCALE){
    // Set the scale; both X and Y scales are required
    xform.setScale(3,3);
    break;
  }
}
```

- For traversing and manipulating the number of transforms, see `SVGTransformList`.
- For manipulating individual transforms, see `SVGTransform`.

Dragging SVG Elements

Using the mouse to drag an SVG element (or group of elements) can be accomplished by:

1. Adding `mousedown` handler to starts the drag: adding a translation on the element to use during dragging (if needed), tracking `mousemove` events, and adding a `mouseup` handler to end the drag.
2. During `mousemove`, transforming the position of the mouse from screen coordinates into the local coordinates for the object you are dragging, and update the translation accordingly.
3. During `mouseup`, removing the `mousemove` and `mouseup` handlers.

```
// Makes an element in an SVG document draggable.
// Fires custom `dragstart`, `drag`, and `dragend` events on the
// element with the `detail` property of the event carrying XY
// coordinates for the location of the element.
function makeDraggable(el){
  if (!el) return console.error('makeDraggable() needs an element');
  var svg = el;
  while (svg && svg.tagName!='svg') svg=svg.parentNode;
  if (!svg) return console.error(el,'must be inside an SVG wrapper');
  var pt=svg.createSVGPoint(), doc=svg.ownerDocument;

  var root = doc.rootElement || doc.body || svg;
  var xlate, txStartX, txStartY, mouseStart;
  var xforms = el.transform.baseVal;

  el.addEventListener('mousedown',startMove,false);

  function startMove(evt){
```

```
    // We listen for mousemove/up on the root-most
    // element in case the mouse is not over el.
    root.addEventListener('mousemove',handleMove,false);
    root.addEventListener('mouseup',  finishMove,false);

    // Ensure that the first transform is a translate()
    xlate = xforms.numberOfItems>0 && xforms.getItem(0);
    if (!xlate || xlate.type != SVGTransform.SVG_TRANSFORM_TRANSLATE){
      xlate = xforms.createSVGTransformFromMatrix( svg.createSVGMatrix() );
      xforms.insertItemBefore( xlate, 0 );
    }
    txStartX=xlate.matrix.e;
    txStartY=xlate.matrix.f;
    mouseStart = inElementSpace(evt);
    fireEvent('dragstart');
  }

  function handleMove(evt){
    var point = inElementSpace(evt);
    xlate.setTranslate(
      txStartX + point.x - mouseStart.x,
      txStartY + point.y - mouseStart.y
    );
    fireEvent('drag');
  }

  function finishMove(evt){
    root.removeEventListener('mousemove',handleMove,false);
    root.removeEventListener('mouseup',  finishMove,false);
    fireEvent('dragend');
  }

  function fireEvent(eventName){
    var event = new Event(eventName);
    event.detail = { x:xlate.matrix.e, y:xlate.matrix.f };
    return el.dispatchEvent(event);
  }

  // Convert mouse position from screen space to coordinates of el
  function inElementSpace(evt){
    pt.x=evt.clientX; pt.y=evt.clientY;
    return pt.matrixTransform(el.parentNode.getScreenCTM().inverse());
  }
}
```

Read Scripting online: https://riptutorial.com/svg/topic/5021/scripting

Chapter 20: switch

Remarks

`<switch>` is a conditional processing attribute. It doesn't prevent elements from being referenced by other elements. In our case, `<switch>` evaluates the **systemLanguage** value on its direct child elements that matches the user's language. Once is found, the child is rendered and the other children will be bypassed.

If the **systemLanguage** is not specified, the child will be displayed, allowing us specifying a fallback.

Related W3C Recommendation informations

Examples

Alternate viewing depending on the user's language

```
<svg xmlns="http://www.w3.org/2000/svg">
  <switch>
    <text systemLanguage="en-UK" x="10" y="10">UK English</text>
    <text systemLanguage="fr" x="10" y="10">Français</text>
    <text systemLanguage="ru" x="10" y="10">Русский</text>
    <text x="10" y="20">English</text> <!-- fallback (if none of the languages match) -->
  </switch>
</svg>
```

Read switch online: https://riptutorial.com/svg/topic/4702/switch

Chapter 21: Text

Parameters

<text>	Details
x	The x position of the text.
y	The y position of the text.
dx	Relative shift in x position.
dy	Relative shift in y position.
rotate	Specifies the angular displacement for text glyphs.
textLength	Fits the text into the given length.
lengthAdjust	Specifies whether just kerning or kerning & glyphs are compressed/stretched to fit text into textLength specified. Values: spacing or spacingAndGlyphs
--	**Parameters common to all text chunking elements (text, tref, textPath, tspan)**
text-anchor	Specifies horizontal alignment. Values: start, middle, end.
baseline-shift	Shifts text baseline based on either values provided by the font table for superscript or subscript positioning (sub, super) or by a positive or negative % or length. Values: sub, super, %, or length.

Remarks

baseline-shift is not supported by the most current versions of Firefox and Microsoft browsers as of July 2016.

Examples

Draw text

```
<svg xmlns="http://www.w3.org/2000/svg">
    <text x="40" y="60" font-size="28">Hello World!</text>
</svg>
```

The x and y coordinate specifies the position of the bottom-left corner of the text (unless text-anchor has been modified).

Super- and subscript

Using the baseline-shift parameter, you can specify super- or subscript. But this is not supported by all major browsers.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <text x="10" y="20">x<tspan baseline-shift="super">2</tspan></text>
    <text x="10" y="60">f<tspan baseline-shift="sub">x</tspan></text>
</svg>
```

For a cross-browser solution, you can use dy, dx and relative font size.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <text x="10" y="40">x<tspan dy="-7" font-size=".7em">2</tspan></text>
    <text x="10" y="80">f<tspan dy="3" font-size=".7em">x</tspan></text>
</svg>
```

Rotate text

The rotate property rotates each character by the specified angle.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <text x="10" y="20" rotate="30">Each character is rotated</text>
</svg>
```

To rotate the whole text element, you have to use the transform property.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <text transform="translate(10, 60) rotate(30)">The whole text is rotated</text>
</svg>
```

Individual Letter Positioning With Arrays of X & Y Values

```
<svg width="400px" height="200px">
 <text x="1em, 2em, 3em, 4em, 5em" y="3em, 4em, 5em">
    Individually Spaced Text
  </text>
</svg>
```

The Text element supports individual placement of letters by accepting an array of values for x and y.

Read Text online: https://riptutorial.com/svg/topic/3033/text

Chapter 22: The SVG element

Examples

viewBox

The viewBox attribute defines the coordinate system for an `<svg>` element. This allows you to easily change the size and relative proportion of an SVG graphic without having to adjust the position and dimensions of every individual drawn element.

```
<!-- stretches a small icon to 60px square -->
<svg viewBox="0 0 16 16" height="60px" width="60px">
    <path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021l4.912 3.57-1.904
5.834h.021l4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
</svg>
```

That code looks like this:

Without the viewBox, it looks like this:

preserveAspectRatio

`preserveAspectRatio` is an attribute that indicates whether the image should be scaled uniformly. This attribute only works if the `<svg>` element also has a `viewBox`.

The default value is `xMidYMid`, which maintains the aspect ratio and centers the path inside the SVG container:

```
<!-- when not included `preserveAspectRatio` defaults to `xMidYMid` -->
<svg viewBox="0 0 16 16" height="60" width="120">
    <path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021l4.912 3.57-1.904
5.834h.021l4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
</svg>
```

When `preserveAspectRatio` is set to `none`, the icon stretches to fit the box:

```
<svg viewBox="0 0 16 16" height="60" width="120" preserveAspectRatio="none">
    <path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021 4.912 3.57-1.904
5.834h.021 4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
</svg>
```

There are many other values for `preserveAspectRatio`, but these two are by far the most common.

preserveAspectRatio - meet and slice attributes

The `preserveAspectRatio` attribute has an optional parameter: `meet` | `slice`. The default behavior is `meet` which stretches the content in both the x and y dimension until it fills ***either*** the width or height of the viewBox. The alternative - `slice` preserves the aspect ratio of the content but scales up the graphic until it fills ***both*** the width and height of the viewbox (clipping the content that overflows the viewBox).

This is the example using `slice`

```
<svg viewBox="0 0 16 16" height="60px" width="120px" preserveAspectRatio="xMinYMin slice">
<path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021 4.912 3.57-1.904
5.834h.021 4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
```

which renders as:

and the same example using `meet`

```
    <svg viewBox="0 0 16 16" height="60px" width="120px" preserveAspectRatio="xMinYMin meet">
    <path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021 4.912 3.57-1.904
5.834h.021 4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
</svg>
```

which renders as:

Read The SVG element online: https://riptutorial.com/svg/topic/6923/the-svg-element

Chapter 23: Transformation

Remarks

Graphic elements can be altered by adding a *transform* attribute.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="0" y="0" width="30" height="30" transform="translate(10, 10)" />
</svg>
```

Instead of the top left origin being rendered at coordinates (0, 0), it will be shown down and right, from point (10, 10).

Whole groups of elements can be transformed together, and transformations can add to one another.

```
<svg xmlns="http://www.w3.org/2000/svg">
    <g transform="rotate(45)">
        <rect x="0" y="0" width="30" height="30" />
        <circle cx="5" cy="5" r="5" transform="scale(3)" />
    </g>
</svg>
```

First, every point of the circle will be scaled with the factor 3 in relation to the origin, bringing the center of the circle to the middle of the rectangle at (15, 15) and its radius to 15. Then, the rectangle and the circle will be rotated together by 45 degrees clockwise around the origin.

Examples

translate

Move a rectangle 10 units to the right and 20 units down:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="0" y="0" width="30" height="30" transform="translate(10, 20)" />
</svg>
```

Move it 0 units horizontally and 20 units up:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="0" y="20" width="30" height="30" transform="translate(0, -20)" />
</svg>
```

Move it 10 units to the left and 0 units vertically:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="10" y="0" width="30" height="30" transform="translate(-10)" />
```

```
</svg>
```

scale

Scale a rectangle horizontally by factor 2 and vertically by factor 0.5:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="10" y="10" width="40" height="40" transform="scale(2, 0.5)" />
</svg>
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="20" y="5" width="80" height="20" />
</svg>
```

Mirror a rectangle horizontally:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="0" y="0" width="20" height="40" transform="scale(-1, 1)" />
</svg>
```

Scale does operate in relation to the origin, so this is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="-20" y="0" width="20" height="40" />
</svg>
```

rotate

Rotate a polygon clockwise by 90 degrees around the origin:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 15,20" transform="rotate(90)" />
</svg>
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 0,30 -20,15" />
</svg>
```

The center of rotation may be given explicitely:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 15,20" transform="rotate(90, 15, 15)" />
</svg>
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="30,0 30,30 10,15" />
</svg>
```

skewX, skewY

skew a polygon horizontally by 45 degrees:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 30,30 0,30" transform="skewX(45)" />
</svg>
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 60,30 30,30" />
</svg>
```

x values are computed as `x + y * tan(angle)`, y values remain unchanged

skew a polygon vertically by 30 degrees:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 30,30 0,30" transform="skewY(30)" />
</svg>
```

The result is equivalent to (allowing for rounding)

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,17.32 30,47.32 0,30" />
</svg>
```

x values remain unchanged, y values are computed as `y + x * tan(angle)`

matrix

Apply a transformation matrix to a polygon:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="0,0 30,0 30,30 0,30" transform="matrix(1,0.6,-1.2,1,40,10)" />
</svg>
```

Every point (x,y) will be transformed by applying matrix(a, b, c, d, e, f) like this:

```
┌ x_new ┐     ┌ a  c  e ┐ * ┌ x_old ┐    ┌ x_old * a + y_old * c + e ┐
└ y_new ┘ =   └ b  d  f ┘   │ y_old │ = └ x_old * b + y_old * d + f ┘
                            └   1   ┘
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <polygon points="40,10 70,28 34,58 4,40" />
</svg>
```

Multiple transformations

Transformations can be concatenated and are applied **right to left**

Rotate a rectangle by 90 degrees and then move it down by 20 units and to the right by 20 units:

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="-10" y="-20" width="20" height="40"
        transform="translate(20 20) rotate(90)" />
</svg>
```

The result is equivalent to

```
<svg xmlns="http://www.w3.org/2000/svg">
    <rect x="0" y="10" width="40" height="20" />
</svg>
```

Read Transformation online: https://riptutorial.com/svg/topic/3249/transformation

Chapter 24: Transformation

Syntax

- transform="*[functions]**"
- translate(x[,y])
- rotate(θ[,x,y])
- scale(x[,y])
- skewX(θ)
- skewY(θ)
- matrix(a,b,c,d,e,f)

Examples

Applying Transformations

Transformations can be applied to elements by adding a `transform` attribute:

```
<circle cx="0" cy="0" r="50" transform="translate(50,50)"/>
```

Or to groups of elements enclosed in `<g>` tags:

```
<g transform="translate(50,50)">
<circle cx="0" cy="0" r="50"/>
<circle cx="0" cy="0" r="25" fill="white"/>
</g>
```

More transformations can be applied to the same element by adding them separated by spaces:

```
<circle cx="0" cy="0" r="50" transform="translate(50,50) scale(.5)"/>
```

Transformation functions

Translate

`translate` moves graphics along specified vectors:

```
<circle cx="0" cy="0" r="50" transform="translate(50,50)"/>
```

The first value is the x translation, and the second the y. If the y is omitted, it will default to 0.

Scale

`scale` resizes elements by specified ratios:

```
<circle cx="50" cy="50" r="25" transform="scale(.5,2)"/>
```

Like `translate`, the arguments are x, then y. However, in `scale`, if the y is omitted, it will default to the value of x; in other words, it scales the element without changing the aspect ratio.

Rotate

`rotate` rotates elements by specified angles.

```
<!-- <rect> used for this example because circles can't be rotated -->
<rect width="100" height="5" transform="rotate(90,50,50)"/>
```

The first value is the angle, in degrees. The transformation is applied clockwise. The other two values represent the point to be rotated around, defaulting to the origin.

Read Transformation online: https://riptutorial.com/svg/topic/7100/transformation

Chapter 25: use

Parameters

Parameter	Details
x	x-axis coordinate of the upper left corner
y	y-axis coordinate of the upper left corner
width	width of the `<use>` element
height	height of the `<use>` element
xlink:href	resource identifier (refers to the ID of another element) SVG 2 proposes to deprecate this and replace it with a simple href attribute

Remarks

Details can be found in the W3C Recommendation for SVG as well as the new Candidate Recommendation for SVG2

Examples

Using an Icon

The `<use>` element is often used for reuseable icons, in collaboration with the `<symbol>` element. That looks like this:

```
<svg>
    <symbol viewBox="0 0 16 16" id="icon-star">
        <path d="M16 6.216l-6.095-.02L7.98.38 6.095 6.196 0 6.215h.021l4.912 3.57-1.904
5.834h.021l4.972-3.59 4.932 3.59-1.904-5.815L16 6.215" />
    </symbol>
</svg>
```

And the `<use>` element:

```
<svg>
    <use xlink:href="#icon-star"/>
</svg>
```

The `<use>` element copies the `<symbol>` and displays it. You can also override the styles on the `<symbol>` on individual `<use>` elements, e.g.

```
<style>
```

```
    .red {
        fill: red;
    }
</style>

<svg>
    <use class="red" xlink:href="#icon-star"/>
</svg>
```

Read use online: https://riptutorial.com/svg/topic/6904/use

Credits

S. No	Chapters	Contributors
1	Getting started with SVG	almcd, Community, Robert Longson, Timothy Miller, uruloke, w5m, web-tiki
2	Animation	Joachim Schirrmacher, Michael Mullany
3	Circle	almcd, Kake_Fisk, w5m
4	clipPath	Danny_ds, lodz
5	Colors	Danny_ds, Holger Will, Joachim Schirrmacher, Michael Mullany, w5m
6	Creating fonts	Holger Will
7	defs	Michael Mullany
8	Ellipse	adius
9	Filters	Anko, Michael Mullany, RamenChef
10	Gradients	Robert Longson
11	Line	Deni Spasovski, Michael Mullany, w5m
12	marker	Michael Mullany
13	mask	Holger Will
14	Paths	Malcolm McLean, Michael Mullany, w5m
15	Patterns	Michael Mullany, Robert Longson
16	pointer-events	Holger Will
17	Polyline	adius, Michael Mullany
18	Rectangle	almcd, w5m
19	Scripting	Michael Mullany, Phrogz
20	switch	lodz
21	Text	Kake_Fisk, Michael Mullany

22	The SVG element	Michael Mullany, Timothy Miller
23	Transformation	ccprog, Michael Mullany, Stephen Leppik
24	use	Robert Longson, Timothy Miller