

Introduction to QuickDraw GX Graphics

This chapter introduces the main concepts found in the rest of this book and gives an overview of the three types of QuickDraw GX shapes you can use to make graphic images:

- geometric shapes
- bitmap shapes
- picture shapes

The other types of QuickDraw GX shapes (the typographic shapes) are discussed in *Inside Macintosh: QuickDraw GX Typography*.

You should be familiar with information described elsewhere in the *Inside Macintosh: QuickDraw GX* books before you read this chapter. In particular, you should read the information about QuickDraw GX shapes and objects in the chapter “Introduction to QuickDraw GX” in *Inside Macintosh: QuickDraw GX Objects*. You should also read the chapter “Shape Objects” in that book.

As you read this chapter and the other chapters in this book, you might want to be familiar with the other information in *Inside Macintosh: QuickDraw GX Objects*—in particular, you might also read the “Style Objects,” “Ink Objects,” and “Transform Objects” chapters in that book.

The next section reviews the objects that make up a QuickDraw GX shape and introduces the different types of graphic shapes. The remaining sections of this chapter briefly discuss

- the structure of geometric shapes
- the contents of geometric shape geometries
- the shape fill property and how it affects geometric shapes
- the properties of the style object that modify geometric shapes
- the geometric operations provided by QuickDraw GX
- the structure of bitmap shapes
- the structure of picture shapes

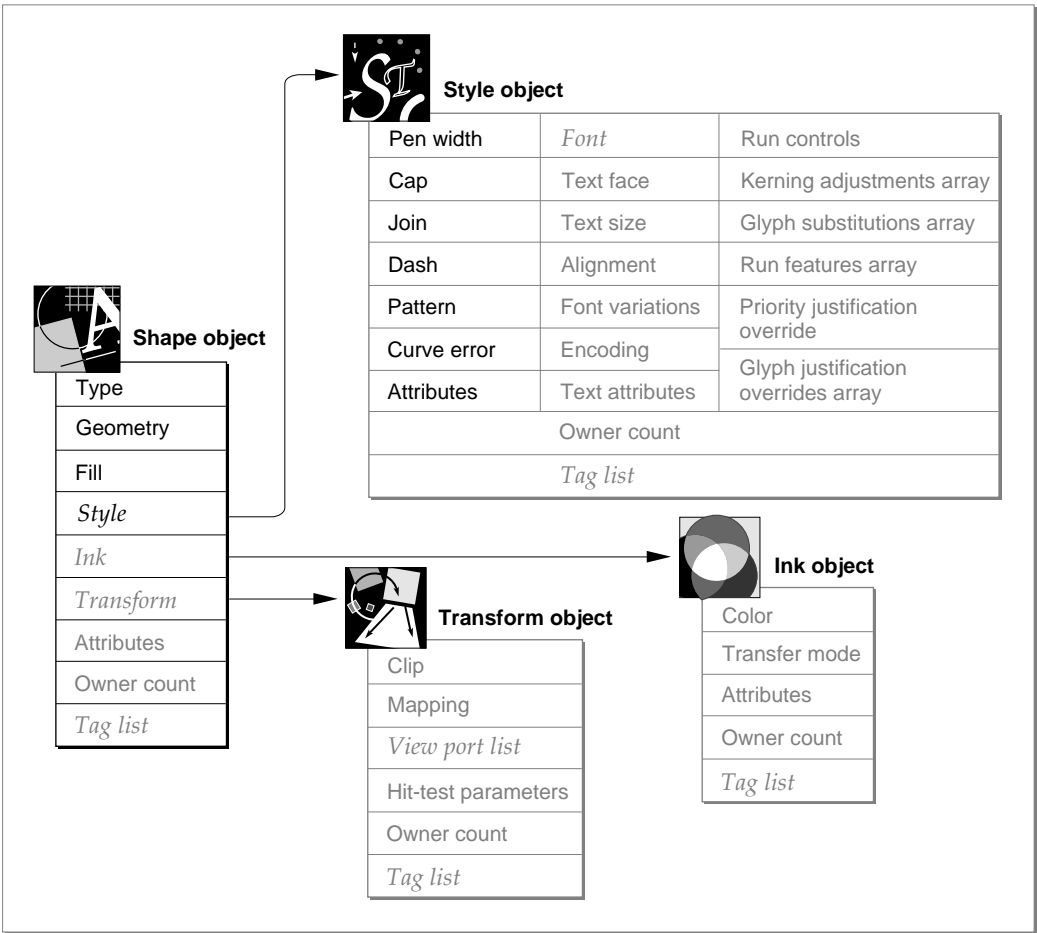
About QuickDraw GX Graphics

With QuickDraw GX, you create graphics by creating QuickDraw GX shapes. Graphics shapes include geometric shapes, bitmap shapes, and picture shapes:

- **Geometric shapes** are the building blocks for graphics. These shapes, which include points, lines, curves, rectangles, polygons, and paths, make up the graphic elements supported by most drawing programs. There are also two special types of geometric shapes: empty shapes, which cover no area, and full shapes, which cover all area.
- **Bitmap shapes** contain pixel images. These shapes allow you to create graphics by specifying the color value of each pixel in the image.
- **Picture shapes** are collections of QuickDraw GX shapes, including other picture shapes.

All QuickDraw GX shapes share the same basic structure. They are all represented by a shape object and its associated style, ink, and transform objects. Figure 1-1 shows the four basic QuickDraw GX objects and lists the properties of each. This figure includes all of the properties of these objects. However, this book examines only a subset of these properties. Properties not examined in this book are grayed out.

Figure 1-1 Shape object structure



Introduction to QuickDraw GX Graphics

Like all shapes, geometric shapes are represented by a shape object in memory. Three of the properties of the shape object—shape type, shape geometry, and shape fill—and how they apply to geometric shapes in particular, are introduced in the section “Geometric Shapes” beginning on page 1-7 and are fully discussed in the chapter “Geometric Shapes” in this book.

Geometric shapes use the style object properties highlighted in Figure 1-1. These properties are introduced in the section “Geometric Styles, Inks, and Transforms” beginning on page 1-11 and are fully examined in the chapter “Geometric Styles” in this book.

Geometric shapes also use the properties of their ink and transform objects. You can find more information about these objects in the chapters “Ink Objects” and “Transform Objects” in *Inside Macintosh: QuickDraw GX Objects*.

Bitmap shapes use their shape, style, ink, and transform objects, although they make limited use of some of the properties of these objects. Bitmap shapes are introduced in the section “Bitmap Shapes” beginning on page 1-17 and are fully examined in the chapter “Bitmap Shapes” in this book.

Picture shapes use their shape and transform objects, but do not use their style or ink objects. Picture shapes are introduced in the section “Picture Shapes” beginning on page 1-20 and are fully examined in the chapter “Picture Shapes” in this book.

QuickDraw GX allows you to convert between the different types of shapes. Table 1-1 describes where to look in each book for information regarding each possible kind of conversion.

Table 1-1 Where to find information on shape-type conversion

	To a geometric shape	To a bitmap shape	To a picture shape	To a typographic shape
From a geometric shape	See “Geometric Shapes” in this book	See “Bitmap Shapes” in this book	See “Picture Shapes” in this book	(not possible)
From a bitmap shape	(not possible)	See “Bitmap Shapes” in this book	See “Picture Shapes” in this book	(not possible)
From a picture shape	(not possible)	See “Bitmap Shapes” in this book	See “Picture Shapes” in this book	(not possible)
From a typographic shape	See “Typographic Shapes” in <i>QuickDraw GX Typography</i>	See “Bitmap Shapes” in this book	See “Picture Shapes” in this book	See “Typographic Shapes” in <i>QuickDraw GX Typography</i>

Geometric Shapes

QuickDraw GX provides eight types of geometric shapes—the basic building blocks of QuickDraw GX graphics. These shapes include empty shapes, full shapes, points, lines, rectangles, curves, polygons, and paths. You can use these shapes for drawing, for calculating areas, for clipping, as elements of more complex graphics, and so on.

As with all types of QuickDraw GX shapes, a geometric shape is represented by a shape object in QuickDraw GX memory. However, what defines a geometric shape—what makes it different from other types of shapes—is how it uses the properties of the shape object:

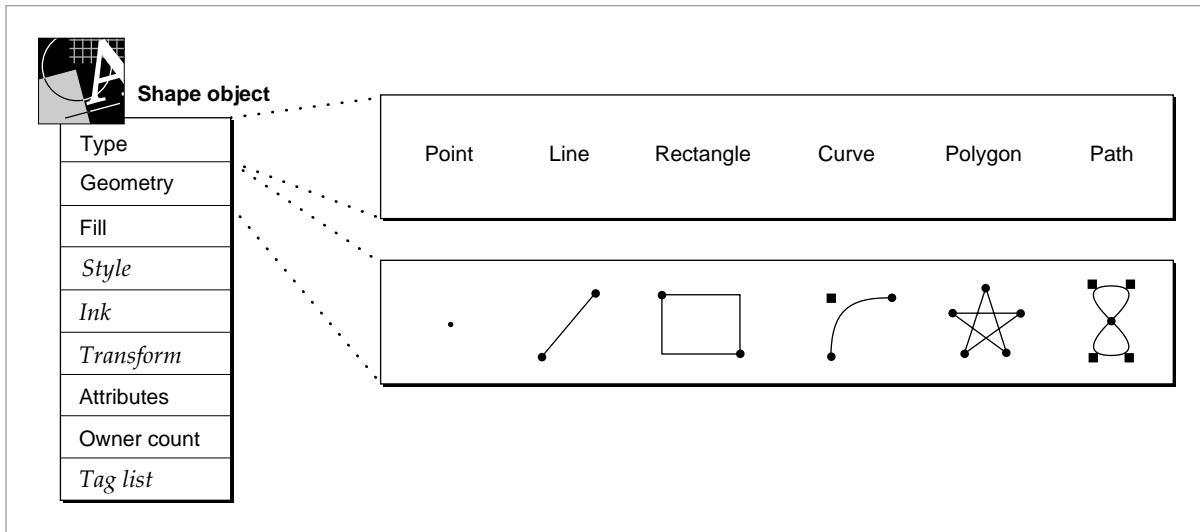
- The shape type property specifies the type of the geometric shape—empty, full, point, line, curve, rectangle, polygon, or path.
- The geometry property specifies the positions of the points that define the shape—for example, the end points of a line, or the corners of a rectangle.
- The shape fill property specifies how the geometry of the shape is interpreted—for example, as a framed outline or as a solid area.
- The style property references a style object, which specifies modifications to the geometric shape—for example, pen width, dashes, and patterns.
- The ink and transform properties reference an ink and a transform object. The ink object specifies the color and transfer mode applied to the shape when drawn. The transform object specifies mapping transformations made to the shape, how the shape is clipped, how the shape is hit-tested, and to what view ports the shape is finally drawn.
- The attributes, owner count, and tag list properties contain object-related information about the shape. These properties affect how the shape object is maintained in memory, when the memory held by the shape is freed, and other information you might want to specify for a particular shape.

Geometric shapes use all of the shape properties—to understand geometric shapes fully, you should be familiar with all of these properties, which are introduced in the chapter “Shape Objects” in *Inside Macintosh: QuickDraw GX Objects*. The way that geometric shapes use these properties differently from other types of shapes is described in this book, particularly in the chapters “Geometric Shapes” and “Geometric Styles.”

Geometric Shape Types

There are six basic types of geometric shapes and two special types. The basic geometric shapes include points, lines, rectangles, curves, polygons, and paths; the two special types are empty shapes and full shapes. Figure 1-2 lists the basic geometric shape types and also shows a sample geometry for each of them. Each geometry is made up of geometric points and edges that connect the geometric points. The next section, “Geometric Shape Geometries,” introduces these concepts in more detail.

Figure 1-2 The geometric shape types and examples of geometric shape geometries



The empty shape and the full shape are not shown in this figure. An empty shape is a shape that has no geometry and covers no area. A full shape is the inverse of an empty shape—it covers all area. For a complete description of each type of geometric shape, see the chapter “Geometric Shapes” in this book.

Geometric Shape Geometries

Each type of geometric shape uses the geometry property of its shape object in a slightly different manner. For example, empty shapes and full shapes store no information in their geometry, because they require no further geometry information—their shape type says it all.

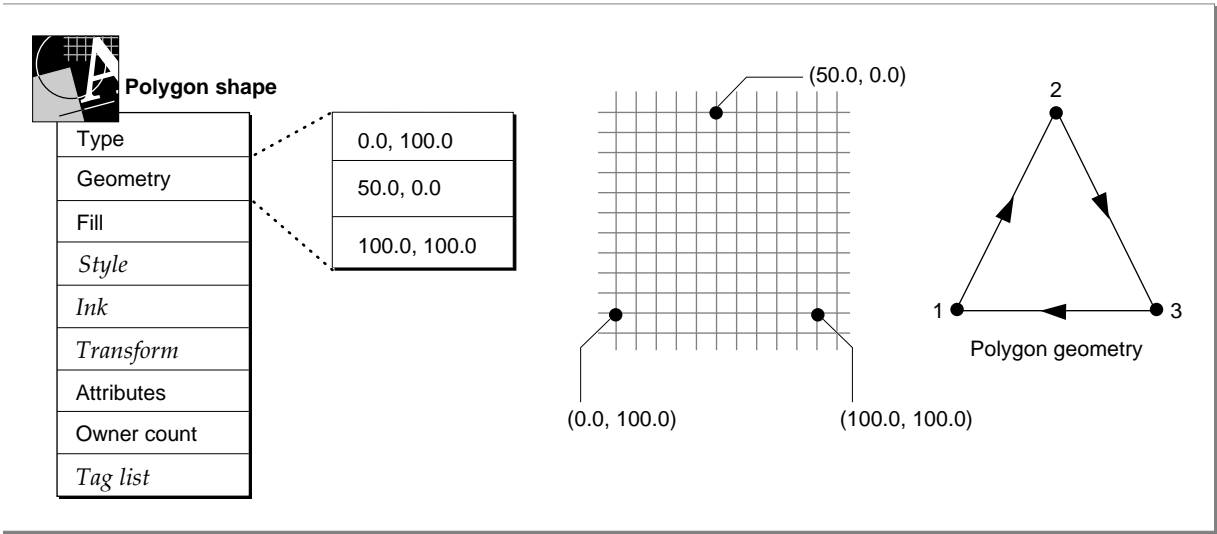
However, for other types of geometric shapes, the shape type does not contain all the geometry information necessary to define the shape. The geometries of these shapes contain (x, y) coordinate pairs called **geometric points**—points that specify the location, dimension, and form of the geometric shapes:

- Point geometries contain one geometric point—an x-coordinate and a y-coordinate—to specify the position of the point shape.
- Line geometries contain two geometric points—one point to specify where the line starts and one to specify where the line ends.
- Rectangle geometries also contain two geometric points—one point to specify one corner of the rectangle, and another point to specify the opposing corner.
- Curve shapes store three geometric points in their geometry—one to specify where the curve starts, another to specify where the curve ends, and another, called the **off-curve control point**, to specify the tangents used to define the curve.
- Polygon geometries are made up of zero, one, or more polygon contours. Each **polygon contour** is series of geometric points connected by straight edges.
- Path geometries are similiar to polygon geometries, but path geometries also store information about which geometric points are on-curve and which are off-curve control points. Therefore, **path contours** can have curves as well as straight lines.

For more information about the geometries of each geometric shape type, see the chapter “Goemetric Shapes” in this book.

Figure 1-3 shows a polygon shape with a single polygon contour made up of three geometric points. This figure shows three views of the polygon geometry: as a list of (x, y) coordinate pairs, as three geometric points plotted on a geometric grid, and as three points connected by three straight lines. This third way of viewing geometries is used frequently throughout this book, as it shows not only the geometric points, but also the implied **edges** that connect them. Notice that geometric points have fixed-point coordinates—you can specify fractional positions.

Figure 1-3 A polygon shape with a single polygon contour containing three geometric points



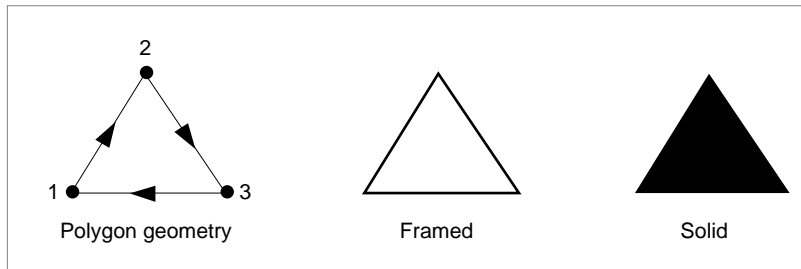
Geometric Shape Fills

The **shape fill** property specifies how QuickDraw GX interprets the geometric points of a geometric shape's geometry. There are two basic types of shape fills:

- **Framed fills.** These shape fills indicate that QuickDraw GX should interpret the shape as an outline—as a series of edges.
- **Solid fills.** These shape fills indicate that QuickDraw GX should interpret the shape as a solid area—the edges of the shape represent the boundaries of the area.

Figure 1-4 shows an example of a polygon contour similar to the one in Figure 1-3, and how QuickDraw GX might draw it with a framed fill and with a solid fill.

Figure 1-4 Framed shapes versus solid shapes



For more information about the various kinds of shape fills provided by QuickDraw GX, see the chapter “Geometric Shapes” in this book.

Geometric Styles, Inks, and Transforms

Like all QuickDraw GX shapes, geometric shapes reference a style object, an ink object, and a transform object. Figure 1-5 shows a condensed view of how a polygon shape might use these four objects.

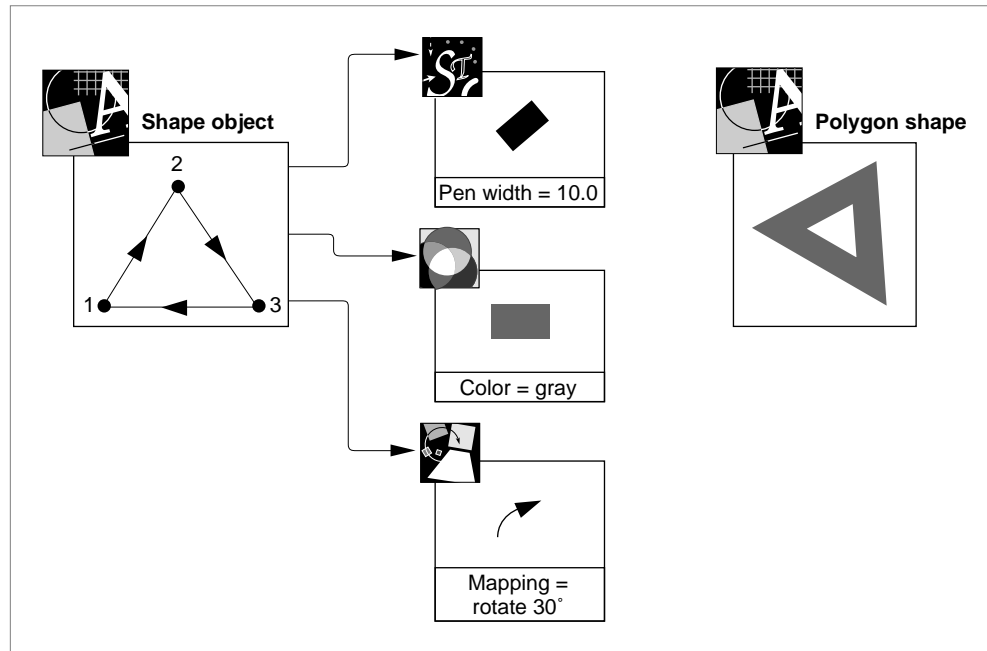
Instead of listing every property of each of these objects, the first half of Figure 1-5 (the left side) depicts a single important property for each object:

- For the shape object, it shows the polygon geometry.
- For the style object, it shows the pen width.
- For the ink object, it shows the color.
- For the transform object, it shows the transformation mapping.

This condensed view of these objects is used frequently throughout this book to highlight information important to a particular example.

The second half of Figure 1-5 (the right side) shows an even more condensed view of the polygon shape. In this view, all of the stylistic, color, and transform variations have been incorporated into the shape itself—basically showing the shape as it is drawn. This extremely condensed view is used occasionally throughout this book, particularly when many shapes must appear in a single figure, as in the chapter “Picture Shapes.”

Figure 1-5 Two condensed views of a polygon shape



Because the ink and transform objects are used in the same way by geometric and typographic shapes, these two objects are discussed in *Inside Macintosh: QuickDraw GX Objects*, rather than in this book.

However, geometric shapes use their style objects in a very different way than typographic shapes do.

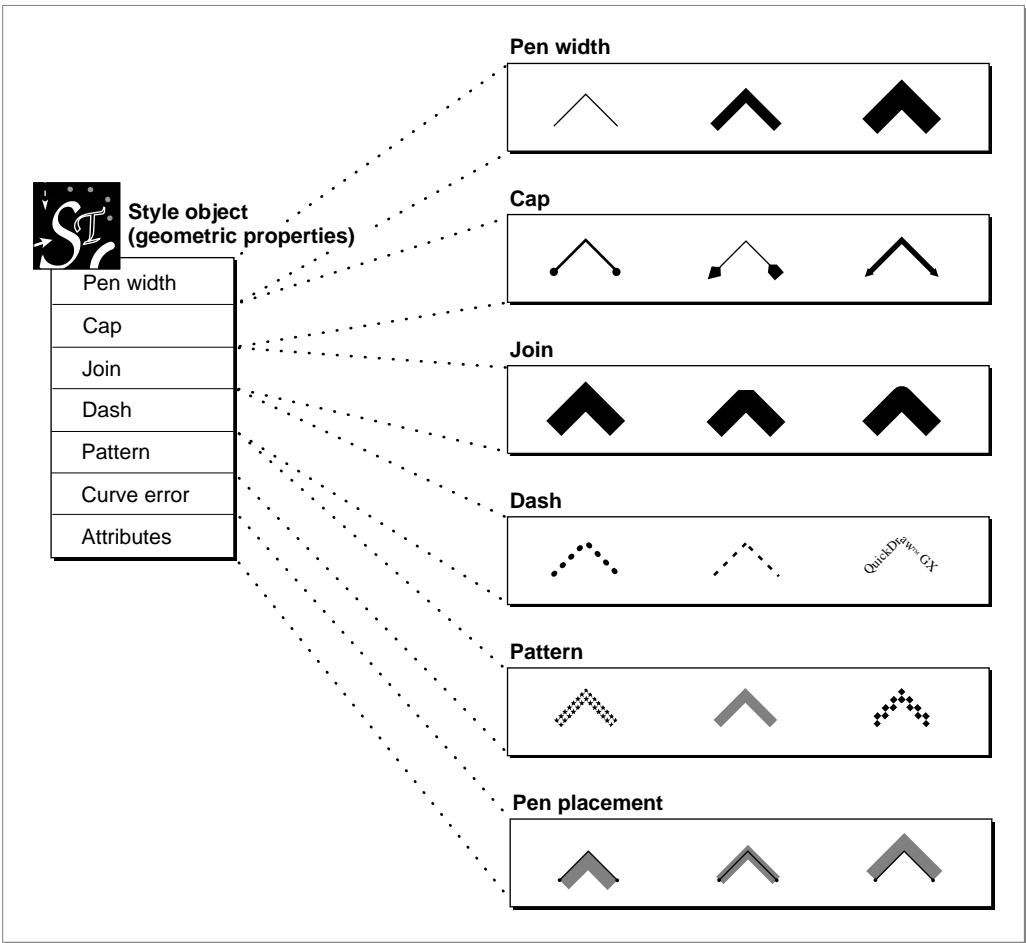
The style object has three types of properties:

- **Object-related style properties**, which are discussed in the chapter “Style Objects” in *Inside Macintosh: QuickDraw GX Objects*. These properties apply to the style as an object in memory.
- **Typographic style properties**, which are discussed in the chapter “Typographic Styles” in *Inside Macintosh: QuickDraw GX Typography*. These properties apply only to typographic shapes.
- **Geometric style properties**, which are discussed in the chapter “Geometric Styles” in this book. These properties apply primarily to geometric shapes.

The geometric style properties are the properties of the style object that specify modifications to geometric shapes. With these properties, you can specify how wide QuickDraw GX should draw a shape's edges, whether the edges should be solid or dashed, whether corners should be round or sharp, what pattern should fill a shape's area, and so on.

Figure 1-6 shows the geometric properties of the style object. This figure also gives examples of the effects of these properties.

Figure 1-6 The geometric style properties and some examples of their effects



Geometric Operations

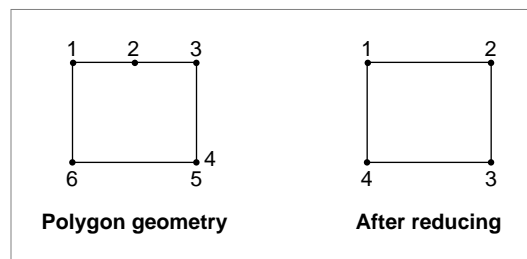
QuickDraw GX provides functions that allow you to modify the geometries of geometric shapes, obtain information about their geometries, and combine the geometries of two shapes.

One such geometric operation allows you to remove unnecessary or redundant geometric points from the shape's geometry—this process is called **reducing** a geometry.

Figure 1-7 shows a polygon geometry with two unnecessary geometric points:

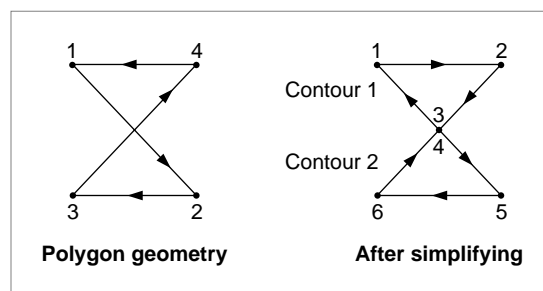
- Point 2 lies on the same line as points 1 and 3, and therefore has no effect on the geometry.
- Points 4 and 5 lie on top of one another, and so only one of them is necessary for this geometry.

Figure 1-7 An example of reducing a shape



In addition to unnecessary geometric points, a shape geometry can have a number of other complicating qualities, such as crossed edges or overlapping contours. QuickDraw GX provides a geometric operation that redefines a shape's geometry to eliminate these qualities. This process is called **simplifying** a shape. Figure 1-8 shows a polygon contour with two edges that cross and the result of simplifying this shape.

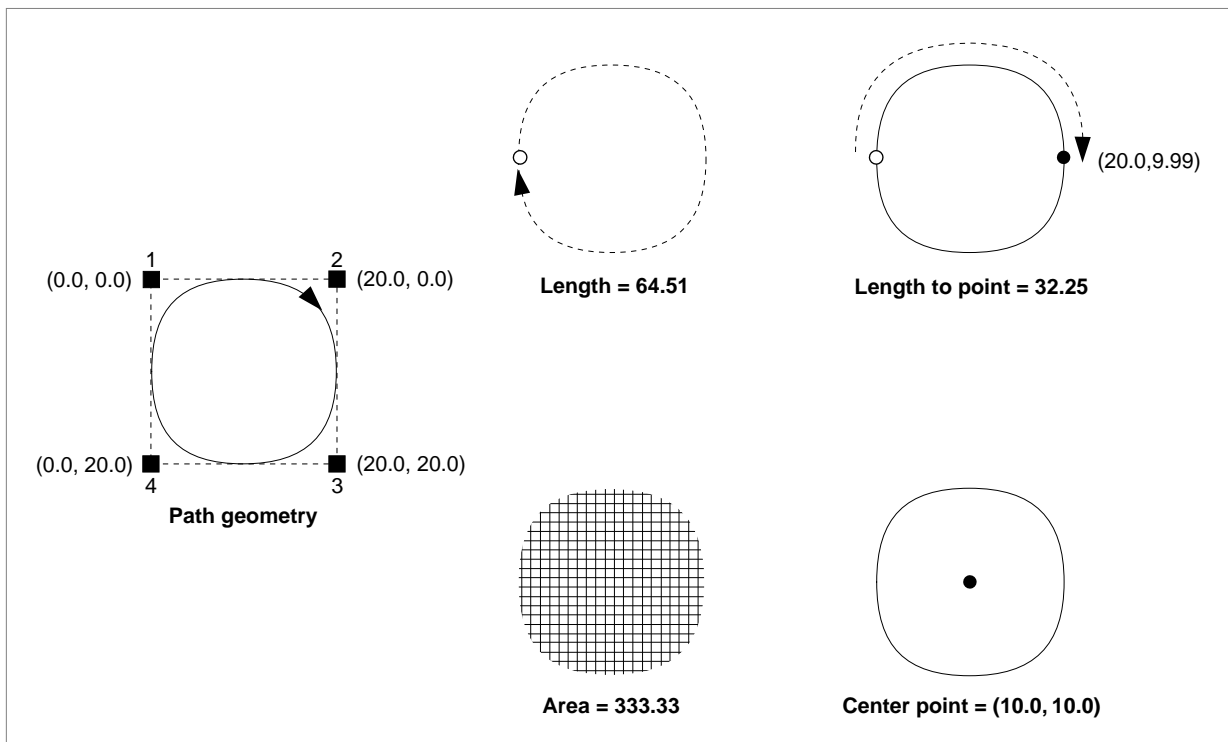
Figure 1-8 An example of simplifying a shape



As Figure 1-8 shows, simplifying the polygon geometry splits it into two contours: an upper triangular contour with three geometric points, and a lower triangular contour with three geometric points. Although the simplified geometry contains more geometric points and more contours than the original, it does not contain any crossed edges.

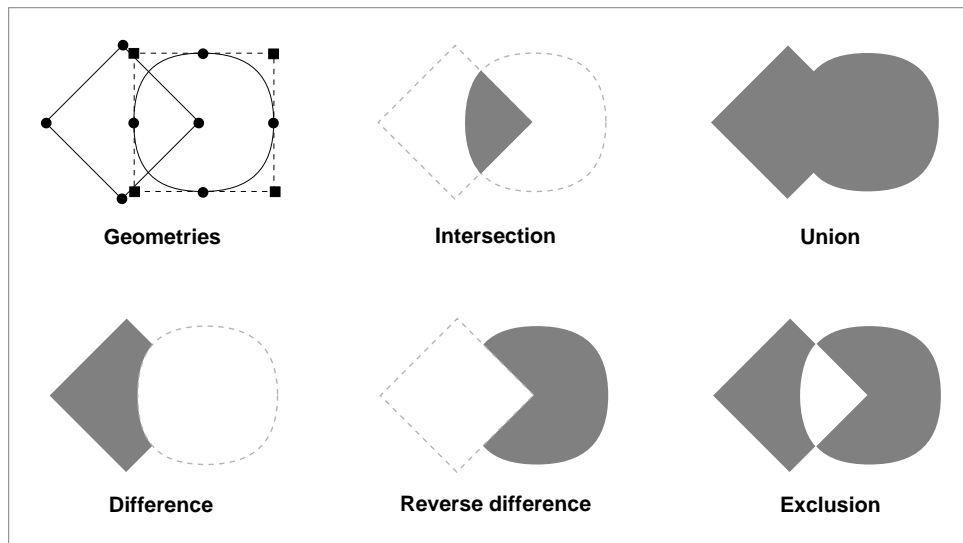
You can find more about reducing and simplifying shape geometries in the chapter “Geometric Operations” in this book. That chapter also describes many functions that allow you to obtain information about geometric shapes and perform geometric arithmetic on them. Figure 1-9 shows some examples of the different types of geometric information that QuickDraw GX calculates for you.

Figure 1-9 Some examples of the geometric information available about a shape



You can find more about geometric information in the “Geometric Operations” chapter of this book.

Another important type of geometric operation is geometric arithmetic. Figure 1-10 shows examples of intersection, union, difference, reverse difference, and exclusion operations, which each return a result calculated by combining the geometries of two shapes in different ways.

Figure 1-10 Some examples of the geometric arithmetic you can perform with shapes

Other geometric operations provided by QuickDraw GX allow you to

- alter the order of the geometric points specified in a shape's geometry
- break a single shape contour into multiple contours
- calculate whether two shapes intersect
- calculate whether one shape contains another shape
- inset the geometric points of a shape's geometry
- scale the shape to fit in a new bounding rectangle
- invert the geometry of a shape

These geometric operations are all discussed in the chapter "Geometric Operations" in this book.

The chapter "Transform Objects" in *Inside Macintosh: QuickDraw GX Objects* describes a related set of functions you can use to perform geometric modifications to a shape's geometry. These functions allow you to

- move a shape
- rotate a shape
- scale a shape
- skew a shape
- perform any arbitrary mapping on a shape

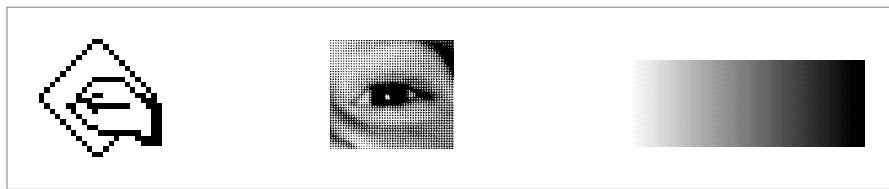
Depending on the setting of a shape's map-transform shape attribute, these functions either modify the mapping matrix contained in the shape's transform object or recalculate the geometric points contained in the shape's geometry directly.

Bitmap Shapes

Bitmap shapes allow you to create images for which you specify the color value of each pixel. Geometric shapes create images with more flexibility—they can be rendered by QuickDraw GX accurately at any output device resolution. However, you might still want to use bitmap shapes for a number of reasons. For example, if you know the resolution of an output device, you can create a bitmap shape to use as an offscreen graphics buffer. As another example, since bitmaps allow you to specify multiple colors within a single shape, you can use bitmaps to create gradients, or ramps—shapes that fade from one color to another.

Figure 1-11 shows some sample bitmaps.

Figure 1-11 Sample bitmap shapes



Although there are many types of geometric shapes—points, lines, curves, and so on—there is only one type of bitmap shape. Bitmap shapes make extensive use of their geometry property. In fact, most of the information useful to bitmap shapes is stored in their geometry—the values of the bitmap’s pixels, the dimensions of the bitmap, and the color information used by the bitmap.

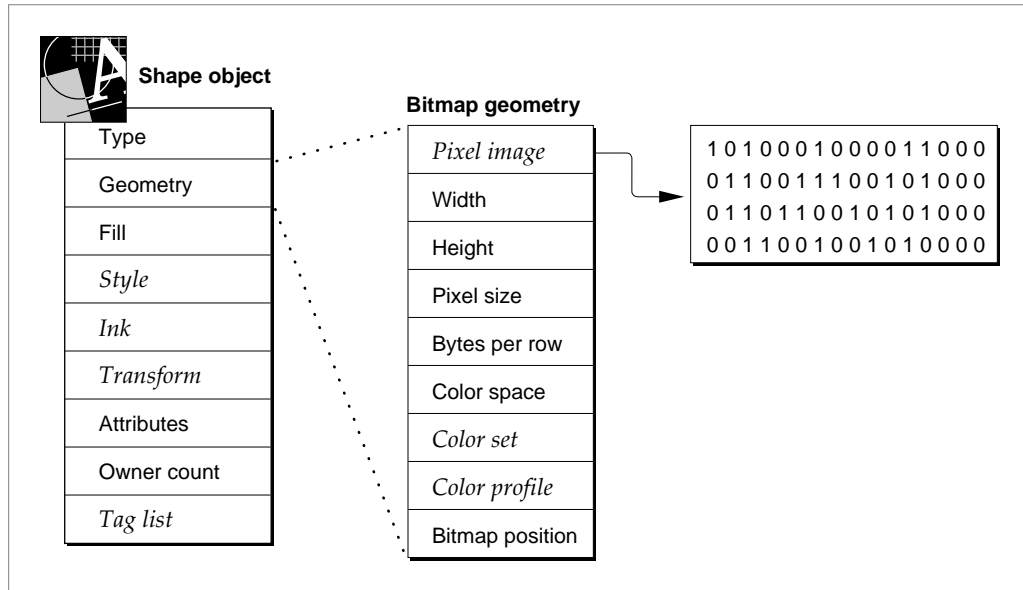
Bitmap shapes don’t make much use of their shape fill property, and they use very little of their associated style object. In fact, the only pieces of information in a style object used by bitmap shapes are the style attributes that determine whether the upper-left corner of the bitmap should be constrained to an integer grid position.

Because bitmap shapes store their own color information in their geometries, they don’t use the color property of their ink object. They do, however, use the transfer mode property of their ink objects.

Bitmap shapes make full use of their transform objects. For example, you can scale, skew, rotate, and clip bitmap shapes. You can also hit-test bitmap shapes, but you cannot hit-test parts of a bitmap shape as you can for other types of shapes. For more information about transform objects and hit-testing, see the chapter “Transform Objects” and the chapter “Shape Objects” of *Inside Macintosh: QuickDraw GX Objects*.

Figure 1-12 shows a bitmap shape object and bitmap geometry.

Figure 1-12 A bitmap shape



As Figure 1-12 shows, a bitmap geometry contains a reference to a **pixel image**, which contains the color values of each pixel in the bitmap. QuickDraw GX allows pixel images to be stored in three locations:

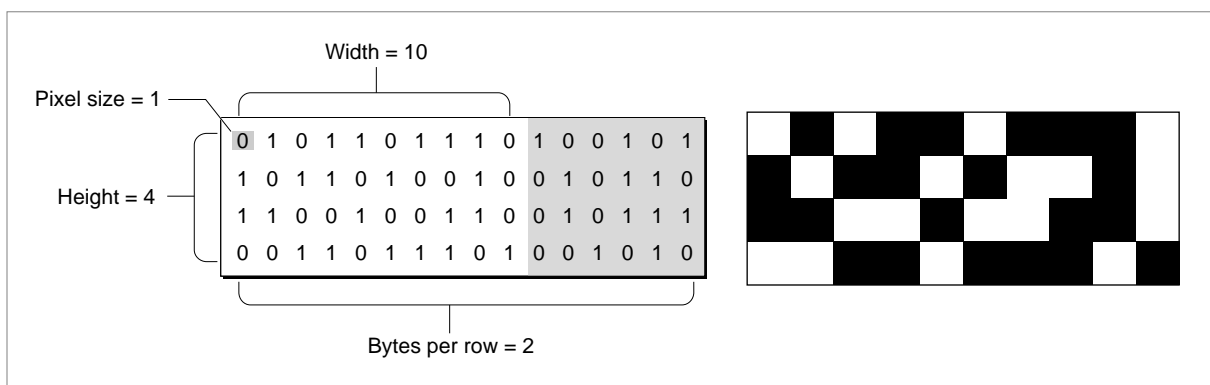
- in memory allocated by your application
- in memory allocated and managed by QuickDraw GX
- in a disk file

Each of these options presents different advantages and disadvantages. For example, storing a pixel image in a disk file allows you to have large bitmaps without keeping the entire pixel image in memory. However, QuickDraw GX provides only limited access to this type of pixel image: it can read the image, but cannot make changes to it.

Different bitmap shapes may reference the same pixel image. You might want to use this feature to draw the same pixel image with two different transfer modes, for example, or to draw the same pixel image in two different color spaces.

The other fields of a bitmap geometry define the dimensions, color information, and position of the bitmap's pixel image. Figure 1-13 shows a sample bitmap geometry that uses one bit to represent each pixel, and has four rows and ten columns. Since each row of the pixel image requires only ten bits, the pixel image is padded so that each row is represented by an even number of bytes.

Figure 1-13 Elements of a bitmap geometry



The color space and color set fields of the bitmap geometry allow you to specify how QuickDraw GX should interpret the pixel values. In this example, pixel values of 0 represent white pixels and pixel values of 1 represent black pixels.

The color profile field specifies color-matching information. See the chapter “Color-Related Objects” in *Inside Macintosh: QuickDraw GX Objects* for more information about color values, color spaces, color sets, and color matching.

For more information about bitmap shapes, see the chapter “Bitmap Shapes” in this book.

Picture Shapes

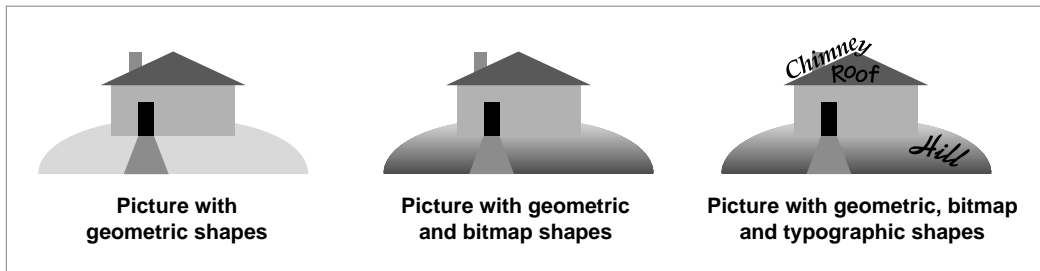
Picture shapes contain collections of other shapes. They allow you to gather disparate elements together inside a single shape.

You can use picture shapes for many reasons, including to group a page of shapes together for printing, to provide a grouping feature in a graphics application, or to simplify your programming by gathering a number of shapes together and applying modifications to the group as a whole.

Figure 1-14 shows three sample picture shapes:

- The first picture shape combines a number of geometric shapes—rectangles, polygons, and paths—into one picture.
- The second picture shape includes a bitmap shape as well—the lawn is a gradient, or ramp, which fades from dark to light.
- The third picture shape includes typographic shapes in the picture as well.

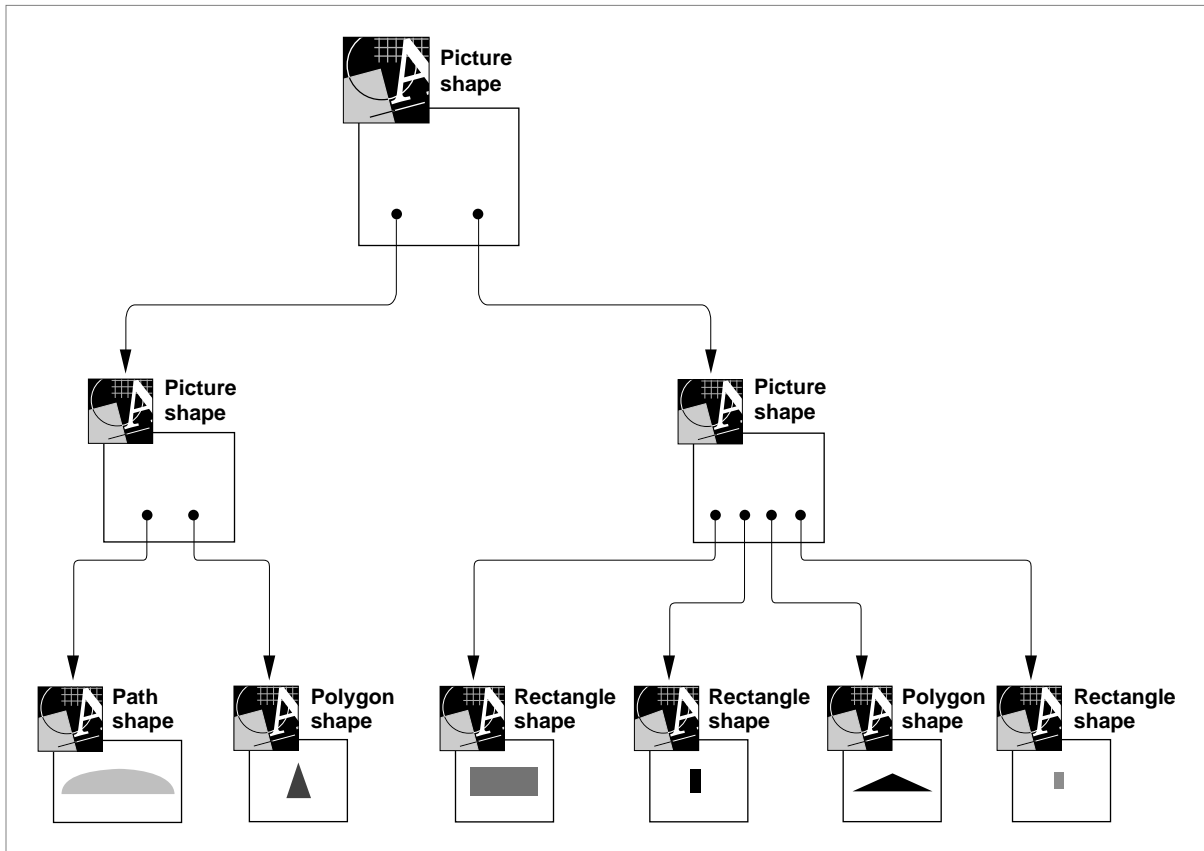
Figure 1-14 Sample picture shapes



Like bitmap shapes, picture shapes make extensive use of their geometry property. A picture shape uses its geometry property to store a list of references to the shapes to be included in the picture. Although each of these shapes has its own style, ink, and transform object, picture shapes allow you to provide an overriding style, ink, and transform object to use for each of these shapes.

Figure 1-15 shows a hierarchical view of the first picture shape shown in Figure 1-14. The picture contains two items: each of which is a picture shape itself. The first item is a picture that contains two items: the lawn and the walkway. The second item is a picture that contains four items: the chimney, the house, the door, and the roof.

Figure 1-15 A picture hierarchy



Notice that the order the shapes appear in the geometry is the order in which QuickDraw GX draws them, from back to front.

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Since picture shapes contain other shapes, they don't make much use of their shape fill property, although you can specify a no-fill shape fill if you don't want the picture to appear when drawn.

Picture shapes also don't make much use of their associated style or ink objects, since each shape in the picture has its own style object and ink object, and, potentially, an overriding style and ink object.

Picture shapes do make full use of their transform objects, however. For example, you can scale, skew, rotate, and clip picture shapes as a whole, as well as separately for each individual shape in the picture. QuickDraw GX also provides powerful tools for hit-testing picture shapes.

For more information about picture shapes, see the chapter "Picture Shapes" in this book.