

TECHNOTE: QuickDraw GX OffscreenLibrary.c in Detail: Description, Uses & Limitations

By Cary Clark
cary@artemis.com
Apple Emeritus

This Technote discusses `OffscreenLibrary.c` from the QuickDraw GX Libraries.

This Note is intended for Macintosh QuickDraw GX developers who implement flickerless drawing or double buffering using `OffscreenLibrary.c` or who are considering using it for their QuickDraw GX graphics applications.

About the GX Libraries

For better or worse, the development of QuickDraw GX took seven years from conception to initial release. During that time, there were many requests for

feature enhancements and interface improvements that, if implemented, might have taken seven more years to complete. As it turns out, some of these enhancements could readily be built on existing services, but there was no time to test or document these services with the rigor required to make them fully part of the released system.

The GX Libraries fill this gap by providing services built on top of the rest of GX in source form. This Technote and others documents these services. Since GX libraries are provided as source, it is reasonable for developers to modify them to meet their specific needs. Care was taken for the libraries not to depend on the implementation details of GX so that future versions of GX should not invalidate them, in original or modified form.

The libraries are likely to evolve to take advantage of improved algorithms, new Macintosh or GX services; if you modify one for your application's specific needs, it's worth occasionally reviewing the GX library provided by Apple to stay synchronized with any improvements.

What are Offscreens?

Slick graphics applications attempt to draw animations seamlessly to the screen, without flashing or flickering. QuickDraw GX provides a number of strategies that change these distractions into attractions. The most popular method to eliminate flickering is double buffering; the application draws into one bitmap while the computer displays a second bitmap. The bitmap receiving the drawing that will be displayed momentarily is called an offscreen.

What is in OffscreenLibrary.c?

The GX Library, `OffscreenLibrary.c`, provides utility functions to implement double buffering; it creates bitmaps that in turn are imaged by GX Graphics. It was written primarily by Oliver Steele, with contributions from the rest of the GX Graphics team.

`OffscreenLibrary.c` has two distinct groups of functions. The simpler revolves around the offscreen struct, and provide a single bitmap for back buffering. The other set uses a `viewPortBuffer` to support multiple offscreens that correspond to the portions of a window that spans multiple monitors of different depths.

Using OffscreenLibrary.c

The One Shot Solution: Struct offscreen

The meat of `OffscreenLibrary.c` is this struct:

```
struct offscreen {
    gxShape      draw; /* a bitmap which, when drawn, transfers the
                       offscreen to the display */
    gxTransform  xform; /* this causes shapes owning it to draw
                       offscreen. */
    gxViewDevice device; /* the offscreen device whose colorSpace,
                       etc. you may change */
    gxViewPort   port; /* the offscreen port which may be put in
                       any transform's viewPort list */
    gxViewGroup  group; /* the global space in which the viewPort
                       and viewDevice exist */
};
```

and these functions:

```
void CreateOffscreen(offscreen *target, gxShape bitmapShape);
```

Use `CreateOffscreen` to fill in the offscreen struct, given the bitmap shape to back up.

```
void DisposeOffscreen(offscreen *target);
```

When you're through with the offscreen, use `DisposeOffscreen` to get rid of the pieces.

```
void CopyToBitmaps(gxShape target, gxShape source);
```

To copy one bitmap to another, use `CopyToBitmaps`.

GX makes it pretty darn easy to create an offscreen. For instance, you can create a bitmap that contains a diagonal line with these calls:

```
gxLine aLine = {ff(20), ff(40), ff(60), ff(80)};
gxShape lineBits = GXNewLine(&aLine);
GXSetShapeType(lineBits, gxBitmapType);
```

Then, to create an offscreen from the line bitmap:

```
offscreen offLine;
CreateOffscreen(offLine, lineBits);
```

You can draw the line bitmap with:

```
GXDrawShape(offLine.draw);
```

To add a rectangle to the line bitmap, first create a rectangle:

```
gxRectangle aRect = {ff(50), ff(50), ff(60), ff(60)};
gxShape rectToAdd = GXNewRectangle(&aRect);
```

Then change the rectangle to the transform in the offscreen:

```
GXSetShapeTransform(rectToAdd, offLine.xform);
GXDrawShape(rectToAdd);
```

Now, drawing the line bitmap will draw both the line and the rectangle:

```
GXDrawShape(lineBits);
```

Once you're done, you can use `DisposeOffscreen` to get rid of it:

```
DisposeOffscreen(&offLine);
```

The function `CopyToBitmaps` uses the offscreen structure internally to copy one bitmap onto another. The name is somewhat misleading, since the shape to be copied can be any shape type, not necessarily a bitmap. For instance, you can use it to create a bitmap that has a specific bit depth from a picture:

```
static gxShape Create8BitPicture(gxShape myPicture)
{
    gxRectangle bounds;
    // get the bounding box of the picture
    GXGetShapeBounds(myPicture, 0, &bounds);
```

```

// move the picture so that it's upper left corner is at (0, 0)
    GXMoveShape(myPicture, -bounds.left, -bounds.top);
// create a bitmap big enough to hold the picture
    gxShape bitmap = {nil, FixRound(bounds.right - bounds.left),
        FixRound(bounds.bottom - bounds.top), 0, 8, nil, nil, nil};
// copy the picture to the bitmap
    CopyToBitmaps(bitmap, myPicture);
// move the bitmap to the picture's original position
    GXMoveShape(myPicture, bounds.left, bounds.top);
// restore the picture's original position
    GXMoveShape(bitmap, bounds.left, bounds.top);
    return bitmap;
}

```

The ViewPortBuffer Multiple Offscreen Scheme

The Macintosh is relatively unique among computers in that it allows windows to straddle two or more monitors at the same time. QuickDraw GX fully embraces this capability, and takes it to the logical extreme; not only can viewPorts cross multiple viewDevices, but the viewDevices themselves can overlap each other.

This makes allocating an offscreen bitmap a challenge, since there may be no single best depth that allows drawing to contain the correct amount of color and draw as quickly as possible. The solution provided by a `viewPortBuffer` creates a picture containing an array of offscreens that match the desired multiple viewDevices.

Here's the interface to `viewPortBuffer`.

```
typedef struct viewPortBufferRecord **viewPortBuffer;
```

The `viewPortBuffer` is a blind handle that points to the internals kept by these routines. It is never necessary to directly access the fields pointed to by this handle.

```
viewPortBuffer NewViewPortBuffer(gxViewPort originalPort);
```

To create an offscreen for a window that may cross multiple monitors, call `NewViewPortBuffer`. It takes the window's `viewPort`, returns a reference to the

internal structure. The window's viewPort can be retrieved from `GXGetWindowViewPort`.

```
void DisposeViewPortBuffer(viewPortBuffer target);
```

When the window is closed, call `DisposeViewPortBuffer` to get deallocate the internal objects allocated by the `viewPortBuffer`.

```
gxViewPort GetViewPortBufferViewPort(viewPortBuffer source);
```

To draw shapes into the offscreen, first call `GetViewPortBufferViewPort`. `GetViewPortBufferViewPort` returns a viewPort that references the multiple offscreens. Drawing into this viewPort draws into as many offscreen bitmaps as is appropriate. To attach this viewPort to a single shape, use the library routine `SetShapeViewPort`. To change all shapes of a given type, try `SetTransformViewPort(GXGetDefaultTransform(theType))`;

```
gxShape GetViewPortBufferShape(viewPortBuffer source);
```

To draw the offscreens, call `GetViewPortBufferShape` to get the shape to draw. Drawing the returned shape transfers the offscreen bitmaps to the viewDevices pointed to by the original viewPort, typically the window's viewPort.

```
Boolean ValidViewPortBuffer(viewPortBuffer target);
```

The user may foul things up by changing the monitors depth or the window's position. After a window-altering event, call `ValidViewPortBuffer` to see if the `viewPortBuffer` needs to be recomputed.

```
Boolean UpdateViewPortBuffer(viewPortBuffer target);
```

If the `viewPortBuffer` is out of date, `UpdateViewPortBuffer` will put things right again. It returns true if the `viewPortBuffer` was already valid.

Here's a convoluted example that builds the offscreens and draws a shape.

```
static void BufferDraw(gxShape shape, WindowPtr window)
{
// create the viewPortBuffer from the viewPort associated with the window
    viewPortBuffer buffer =
        NewViewPortBuffer(GXGetWindowViewPort(window));
// retrieve the viewPort created that allows drawing into the offscreen
```

```
    viewport offscreenPort = GetViewportBufferViewport(buffer);
// point the shape to that offscreen
    SetShapeViewport(shape, offscreenPort);
// draw the shape into the offscreen
    GXDrawShape(shape);
// draw the offscreen into the window
    GXDrawShape(GetViewportBufferShape(buffer));
// throw the offscreen away
    DisposeViewportBuffer(buffer);
}
```

How the ViewPortBuffer Works

Since the `viewportBuffer` is implemented as a library, you can read the code yourself; you'll find it is pretty straight-forward.

The implementation is split into a few steps:

1. Figure out which devices the window / viewport crosses.
2. For each device, figure out the coordinates for the viewport on that device.
3. Create a bitmap that has the same pixel depth, color set, color profile and color space as the corresponding device.
4. Keep track of the allocations and object references so that closing the window (or disposing the device) doesn't leave any dangling references or pointers.

Summary

GX Libraries contain a wealth of information and show how to use QuickDraw GX to solve real problems. `OffscreenLibrary.c` shows how to use GX to construct flickerless drawing by implementing double buffering on a single device or on multiple devices.

Further Reference

- MacOS SDK CD, Development Kits (Disc 1): QuickDraw GX: Programming Stuff: GX Libraries:

- Inside Macintosh: QuickDraw GX Objects
- Inside Macintosh: QuickDraw GX Environment and Utilities

Acknowledgements

Thanks to Tom Dowdy, Rob Johnson and Ingrid Kelly for reviewing this Technote. Special thanks to Michael Fairman for proving that graphics is more than what you can draw.