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A Whirlwind Tour of WinG

If you’re like me, the first time you saw Microsoft Windows 3.0 and its program manager, you went straight for the Games program group. Like me, you probably expected to find a game as different from DOS games as Windows is different from DOS itself. Instead, you found Solitaire. Not a bad version of Solitaire, but Solitaire nonetheless. If you waited until 3.1 to check out Windows, you also found Minesweeper—a bit more exciting, but you wouldn’t call it “high-performance.”

Expectations for Windows games have been very low. When Microsoft released a set of games called Arcade last year, reviewers were shocked. They couldn’t believe games of Arcade’s quality could be done on Windows. Arcade is a great set of games, but we are talking about 1970s technology on 1990s computers! Their enthusiasm was unfounded: Arcade is nothing compared to the games you find on DOS. A Pentium probably has more on-chip cache than the original Asteroids game had main memory.

Sure, operating systems of today do more than they did back then (did they even have operating systems back then?), and I can play Asteroids while simultaneously running other applications on the same desktop, but is this all we can expect from our brand new machines running Windows? On the same hardware, DOS games have consistently pushed the performance envelope with the current crop doing full-screen texture-mapped worlds at 30 frames per second. What’s the crucial difference between DOS games and Windows games? Graphics performance.

Finally there’s help: WinG. WinG is a library that eliminates the performance difference between DOS games and Windows games. It gives Windows games graphics performance at or above their DOS counterparts on the same hardware.

Current Windows Graphics—Slow?

We’re interested in raw blt (bit level transfer) performance: transferring pixels to the screen in blocks. Most high-performance games try to achieve smooth animation by hiding the rendering and only allow the player to see the resulting frame. These games compose images into buffers, then quickly update the display. While the composition phase is usually application-
specific (each game renders using its own special algorithms), only a few popular techniques for updating the display exist.

Update techniques fall into two groups: blitting and page flipping. The trade-offs between the two techniques on current PC hardware are far too complex to cover here, but suffice it to say that high-performance DOS games use both techniques (for example, System Shock and Ultima Underworld I and II blt, while Doom page flips). It is fairly easy to move a game from blting to page flipping or vice versa.

Windows does not currently allow page flipping, so we will deal with blt performance. Although we've said graphics speed (or lack thereof) is the major impediment to high-performance Windows games, if you time the BitBlt function, you will find the bandwidth comparable to what you find under DOS for the same resolutions. The catch is BitBlt transfers pixels from objects called HBITMAPs, not from memory the application owns.

Applications are not allowed to touch the bits of an HBITMAP directly, they must use Windows Graphics Device Interface (GDI) functions, like LineTo, SetPixel, and Rectangle. GDI provides a rich set of two-dimensional graphics functions that are perfect for applications like spreadsheets and word processors, but you will not find a TextureMapPolygon function anywhere in the Windows API documentation. For this reason, games need to render directly to memory, and GDI does not allow them this luxury with HBITMAPs.

Windows does provide objects called Device Independent Bitmaps (DIBs), which applications can access directly, but the APIs for transferring DIBs to the screen (StretchDIBits and SetDIBitsToDevice) are typically three to 20 times slower than BitBlt and therefore not competitive with DOS blt bandwidth.

WinGBitmaps—a Hybrid

WinG introduces a new kind of object: the WinGBitmap. WinGBitmaps are both DIBs and HBITMAPs. Applications get a pointer to the bits like a DIB, and like an HBITMAP, WinG will transfer them to the screen quickly. How quickly? At the 1994 Game Developer's Conference, we demonstrated a Windows version of Doom, WinDoom, running at about the same speed under Windows as the DOS version on the same hardware. Better yet, it only took a weekend to do the port.

Porting a DOS Game to WinG

I don't have space in this article to develop a DOS game and then port it to Windows and WinG, but I will describe a typical DOS game's architecture and discuss how to move it to WinG. Let's assume our game has five major parts:

• Setup
• Get input events
• Run the simulation
• Render into a buffer
• Blt the buffer to the screen.

During Setup, the program allocates the off-screen buffer, creates the palette, and initializes the simulator. Next, it gets any user input and uses that information to run the simulator for a single time slice. The results of the simulation are rendered into a buffer, and the buffer is blted to the screen. We're ignoring synchronization, sound, networking, user interface, and
whatnot, but you get the idea.

Under Windows, the setup phase needs to initialize Windows-specific elements, like the application window, but most of the setup code stays the same. One interesting difference is that, unlike the DOS version where your application allocates the buffer memory, you must call WinCreateBitmap with BITMAPINFO (a structure describing the size and format of the WinBitmap) to allocate the buffer, and WinG will return the memory pointer. The application uses this pointer to draw on the WinBitmap surface directly.

The application will also need to use GDI palette APIs to create and realize the game's palette. GDI realizes a palette when it copies the description of the palette colors into the video hardware. Because multiple applications can share the hardware palette, this can get a bit tricky, but there is plenty of palette sample code in the WinG development kit to illuminate matters.

User input is slightly more difficult. Well-behaved Windows applications must yield control to the system fairly often in case the user wants to switch away to another application. Normal applications like word processors call the GetMessage API to process their user input messages. If there are no messages so the game can continue the simulation. The subtleties of PeekMessage in particular and event-driven architectures in general are beyond the scope of this article, but I will provide you with an appropriate reference.

The game simulation code should work unchanged on Windows. Once the user input is translated from Windows messages to the application-specific format, the simulation should run normally. Your game's rendering code should also work unchanged. The only caveat is that WinBitmap scanlines are word aligned, so if for some reason you need a 201-wide bitmap, you'll need to know the start of the next scanline is actually 204 bytes from the current scanline, not 201 bytes.

Once composition is complete, you bit the buffer to the screen with WinBitBlt or WinGStretchBlt. As its name implies, WinGStretchBlt will stretch or compress the WinBitmap as it bits, where WinBitBlt simply transfers the WinBitmap to the screen. Once you have your game running on Windows, it's time to make it run fast. You'll also want to take advantage of the benefits of running in a windowed environment, so we'll talk about some of those issues as well.

### Setup

Our naive port called WinCreateBitmap with the description of the WinBitmap we wanted. To achieve maximum bit performance during the screen update phase, we'll ask WinG for a little help during our optimized setup. Although WinG is fast under almost any circumstances, there will always be a particular WinBitmap format that is the absolute fastest to bit on the current display, and the WinGRecommendDIBFormat API will tell us what that format is at run time.

The most important difference between the DIB formats that we'll get back from WinGRecommendDIBFormat is the DIB orientation. There are two DIB orientations: bottom-up and top-down, illustrated in Figure 1. Both kinds of DIBs consist of a BITMAPINFO structure and a pointer to the bits. The BITMAPINFO contains information such as the width, height, number of bits per pixel, and the color table of the DIB. For bottom-up DIBs, the bits pointer points to the bottom-most scanline in the DIB.

Increasing memory addresses means going up the DIB image, hence the term bottom-up. This is probably the exact opposite of the memory bitmaps you've dealt with before and is the opposite of most video displays (notably mode 13h VGA, for example). Top-down DIBs are more familiar: the bits pointer points to the top-most scanline, and increasing memory addresses go down the image. Life gets interesting because WinG might recommend either DIB format at runtime, and high-performance games should be able to deal with both. This isn't as hard as it sounds. I'll go over the details in the section on rendering.

Once we have the recommended DIB format, we pass the information to WinCreateBitmap and go on to our palette setup. For optimal performance, a WinG application should have an "identity palette mapping." An identity palette mapping means the color table in the WinBitmap and the palette in the display hardware match exactly. In this case, WinG can block-transfer the pixels in the WinBitmap to the screen without translating them. If the palette mapping is not identity, WinG needs to translate each

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**Figure 1. DIB Orientations**

Bottom-up DIB

Top-down DIB
pixel as it is blted, which is slow. We'll cover this briefly, and if you still don't get it, there is plenty of excruciatingly detailed documentation and sample code in the WinG development kit.

Windows runs multiple applications at the same time. There is only one hardware palette—something has to give. The compromise is that each application requests the hardware palette (called the system palette) by calling `RealizePalette`. Windows may or may not let the application have the entire system palette depending on a number of factors, like whether the application is in the foreground, whether there are other palette applications around, and so on.

Even if Windows does give the application the system palette, the system tries to minimize the palette entries used by each application by collapsing any duplicate colors into the first instance of that color. In addition, each `WinGBitmap` has an application-defined color table associated with it, and the color table must match the system palette for the mapping to be identity. If all this sounds complicated, it is, but once you understand it, you'll be able to charge outlandish consulting fees to other game developers, so it's worth your time to learn. Besides, your bits will go from mediocre to blazing once you get an identity palette mapping.

WinG can help in your quest for an identity mapping by spitting out debugging information. You can set two flags in the win.ini configuration file to direct WinG to tell you what is going on. The `Debug` flag makes WinG tell you if you have an identity palette mapping, and the `DebugPalette` flag makes it tell you how each color table index in your `WinGBitmap` maps to the current system palette if that mapping is not identity. So, if you can't figure out why you don't have an identity palette, you can turn on `DebugPalette` and see messages like:

```
WinG: Palette mapping is not identity.
WinG: Color table index 123 maps to system palette entry 5.
```

You can take this information and see exactly why you aren't getting an identity mapping.

As soon as you've figured out the intricacies of identity palettes, you'll need to make a user interface decision: `SYSPAL_STATIC` mode or `SYSPAL_NOSTATIC` mode. Windows normally reserves 20 colors in the system palette and does not let applications overwrite them. This keeps a single palette application from making all other applications look horrible—other applications always have at least those 20 colors, called the static colors, to map to, even if an application realizes an all-black palette. As with most things in Windows, there's a way around the static colors: `SetSystemPaletteUse`. If you call `SetSystemPaletteUse` with `SYSPAL_NOSTATIC`, Windows will let you overwrite 18 of the 20 static colors, leaving only black at entry 0 and white at entry 255.

`SYSPAL_NOSTATIC` applications make the Windows desktop look gross, while `SYSPAL_STATIC` applications only get 236 colors out of a possible 256. You'll need to
choose which mode to use as you develop your game. It is possible to use SYSPOP_MOS- TATIC when you have a maximized window (users won’t be able to see the off-colored desktop anyway) and SYSPOP_STATIC when you’re windowed (and users can see the program manager and other applications), but your game must do the extra work.

Rendering

High-performance games have optimized rendering algorithms, and most of this code can be left alone, although your rendering code will need to deal with top-down and bottom-up DIBs for best performance. The impact this has on most rendering code is minimal. When you step from scanline to scanline, you need to use a signed number. For example, let’s say this is your rendering loop for a 320 byte wide buffer:

```assembly
; edi points to destination scanline
mov edi,pBits
loop_top:
    ; draw some pixels
    mov [edi],ThisValue
    mov [edi+4],ThatValue
    mov [edi+8],TheOtherValue
    add edi,320 ; point to ext scanline
```

Although simple, this type of loop is the core of most scanline renderers. After changing two lines, this code can handle both DIB orientations at run time:

```assembly
 ; if we’re not done, do it again
jnz loop_top
```

```assembly
dec ScansLeft
```

Other Issues

It’s been said that the best and worst thing about Windows is that it runs on an incredible variety of hardware. To make the best of this variety, your game will need to configure itself to the run-time platform, like WinG does at startup with the display performance test. Is it faster to stretch or render? The answer will change depending on the user’s hardware and software configuration, so be prepared. Is it faster to update dirty rectangles or blt the whole buffer? Again, this can change from machine to machine. Time it and you’ll never go wrong.

This has been a whirlwind tour of WinG game development, but we’ve touched on the major issues. Once you are seriously into Windows programming, get the WinG development kit for yourself and play with the sample applications to get first-hand experience, then port your game to Windows in no time flat.