QNX® Momentics® 6.3.0

Driver Development Kit

Graphics Devices

For targets running QNX® Neutrino® 6.3.0 or later

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Technical support options

If you have any questions, comments, or problems with a QNX product, please contact Technical Support. For more information, see the How to Get Help chapter of the *Welcome to QNX Momentics* guide or visit our website, **`www.qnx.com`**.

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☞ You must use this DDK with QNX Neutrino 6.3.0 or later.

Assumptions

We assume you have a basic familiarity with graphics cards, concepts, and terminology (e.g. pixels, spans, blitting, alpha-blending, chroma-keying, and raster operations).

You'll also need sufficient hardware documentation for your graphics chip in order to be able to program all the registers. A working knowledge of the C programming language is essential.

Building DDKs

You can compile the DDK from the IDE or the command line.

- To compile the DDK from the IDE:

  Please refer to the Managing Source Code chapter, and "QNX Source Package" in the Common Wizards Reference chapter of the *IDE User's Guide*.

- To compile the DDK from the command line:

  Please refer to the release notes or the installation notes for information on the location of the DDK archives.

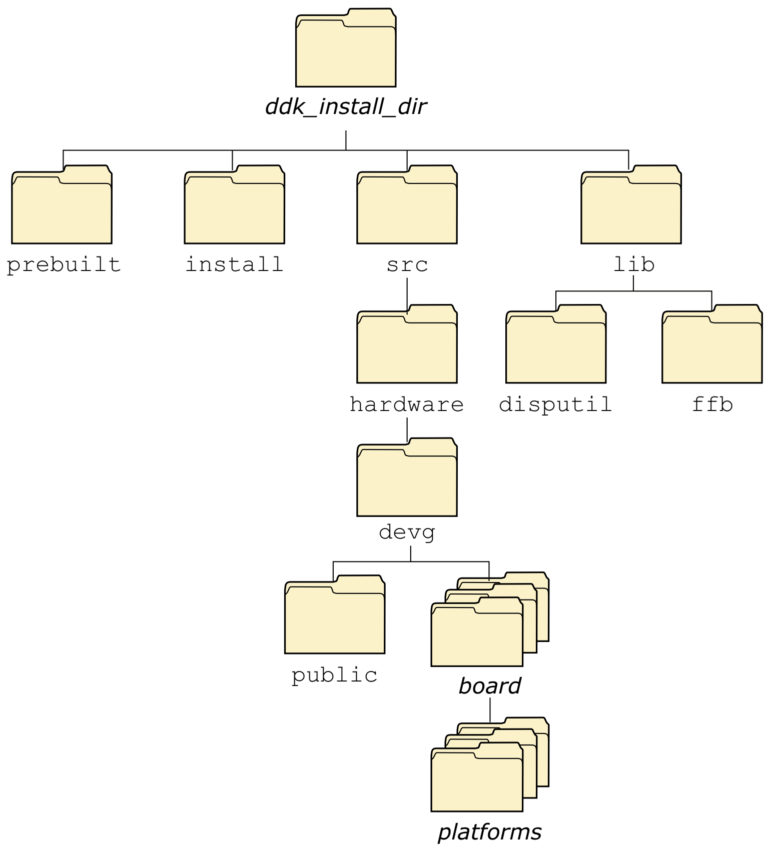
  DDKs are simple zipped archives, with no special requirements. You must manually expand their directory structure from the archive. You can install them into whichever directory you choose, assuming you have write permissions for the chosen directory.

  Historically, DDKs were placed in **/usr/src/ddk_VERSION** directory, e.g. **/usr/src/ddk-6.2.1.** This method is no longer required, as each DDK archive is completely self-contained.

  The following example indicates how you create a directory and unzip the archive file:

  ```
  # cd ~
  # mkdir my_DDK
  # cd my_DDK
  # unzip /path_to_ddks/ddk-device_type.zip
  ```

  The top-level directory structure for the DDK looks like this:



Directory structure for this DDK.

☞

You must run:

```
. ./setenv.sh
```

before running **make**, or **make install**.

Additionally, on Windows hosts you'll need to run the **Bash** shell (**bash.exe**) before you run the **. ./setenv.sh** command.

If you fail to run the **. ./setenv.sh** shell script prior to building the DDK, you can overwrite existing binaries or libs that are installed in **$QNX_TARGET**.

Each time you start a new shell, run the **. ./setenv.sh** command. The shell needs to be initialized before you can compile the archive.

The script will be located in the same directory where you unzipped the archive file. It must be run in such a way that it modifies the current shell's environment, not a sub-shell environment.

In **ksh** and **bash** shells, All shell scripts are executed in a sub-shell by default. Therefore, it's important that you use the syntax

```
. <script>
```

which will prevent a sub-shell from being used.

Each DDK is rooted in whatever directory you copy it to. If you type **make** within this directory, you'll generate all of the buildable entities within that DDK no matter where you move the directory.

all binaries are placed in a scratch area within the DDK directory that mimics the layout of a target system.

When you build a DDK, everything it needs, aside from standard system headers, is pulled in from within its own directory. Nothing that's built is installed outside of the DDK's directory. The makefiles shipped with the DDKs copy the contents of the **prebuilt** directory into the **install** directory. The binaries are built from the source using include files and link libraries in the **install** directory.

Chapter 1

Introduction to Graphics Drivers

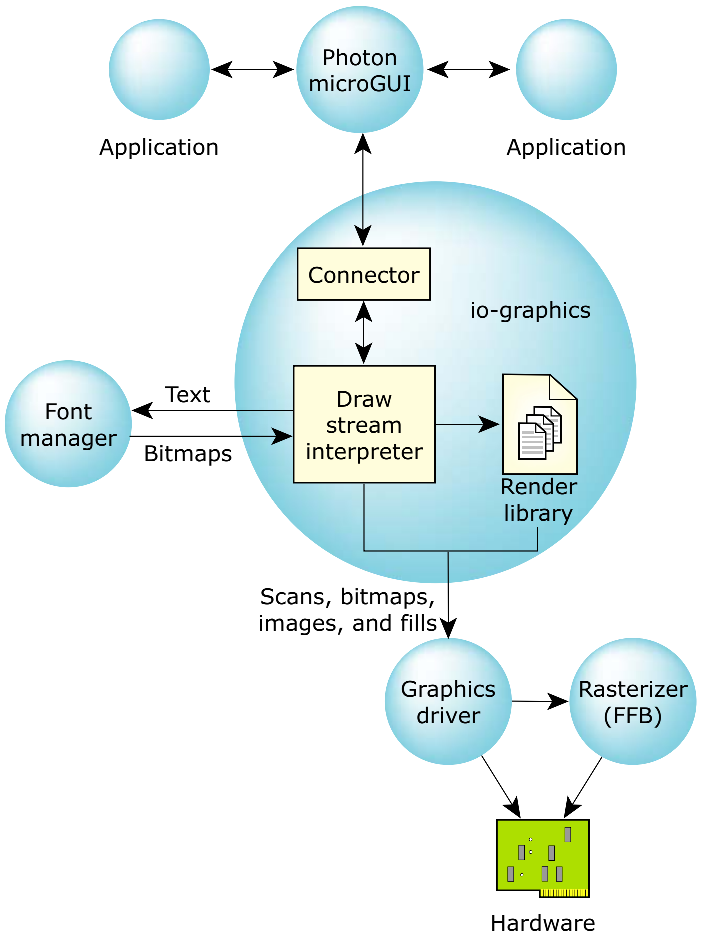
In this chapter. . .

Graphics drivers

The graphics drivers are independent of the Photon microGUI; the driver that you supply is implemented as one or more shared objects (your choice) that can be used by Photon or by any other application requiring the services of a graphics driver.

You provide a set of well defined entry points, and the appropriate graphics system dynamically loads your driver and calls the entry points.

By way of example, this is how your driver interacts with Photon and the graphics driver subsystem, **`io-graphics`**, under QNX Neutrino:



How a driver interacts with Photon.

As you can see from the above diagram, a set of Photon infrastructure components are responsible for the interface to Photon:

Connector	Presents the graphical region to Photon. This is the area that's defined to be shown on the graphical screen.

Draw stream interpreter	Interprets Photon’s *draw stream* and decodes the graphical commands into scans, bitmaps, images, and fills, and passes them to the graphics driver. The interpreter also converts the draw stream from whatever endian format it’s in to native-endian format.
Render library	Converts complex shapes (such as circles) into lower-level drawing primitives (scans, bitmaps, images, and fills) that the graphics driver can handle.
Font manager	Converts textual information into bitmaps.
Rasterizer (FFB)	Converts lower-level drawing primitives into a raster format, using the Flat Frame Buffer (FFB) library.
Graphics driver	Your graphics driver, supplied as one or more shared objects.

Chapter 2

Writing a Graphics Driver

In this chapter. . .

This chapter describes how to write a graphics driver.

Overview

Before looking at the data structures and functions, it's important to understand the "big picture" for the Photon Graphics Driver Development Kit.

The purpose of the Graphics DDK is to allow third parties to write accelerated drivers without requiring QNX Software Systems to become involved in doing the work.

Sample drivers

The Graphics DDK includes these sample drivers:

- a driver for IBM VGA-compatible adapters
- a driver for banked Super VGA adapters
- a generic VESA 2.00 linear frame buffer driver

The Professional Edition also includes:

- an accelerated driver for 3dfx VooDoo Banshee and VooDoo3 chipsets
- an accelerated driver for Intel 82810 (i810) chipsets
- an accelerated driver for Chips and Technologies 655xx, 690xx chipsets.

The 3dfx, Intel, and Chips and Technologies chipsets were chosen as the basis for the examples because the register-level programming documentation is available to anyone without signing a non-disclosure agreement.

These examples provide a good starting point for nearly any modern card. To write a new driver, you typically start with an existing driver (whichever is closest in terms of functionality to the chipset that you are targeting) and then modify the hardware-dependent pieces of the driver to drive your hardware.

Note that the driver framework includes a library called the FFB (Flat Frame Buffer). This library serves these main purposes:

- It provides a software fallback for drawing routines that can't be accelerated in hardware.
- It serves as reference when implementing an accelerated draw function in your driver.

For every 2D drawing entry point in a graphics driver, there's an equivalent software version in the FFB that takes identical parameters. Thus your driver isn't required to provide *any* functions. When the graphics framework asks your driver to supply its 2D drawing functions, the driver can return a mixture of its own accelerated functions and software-implemented FFB functions.

For more information, see "FFB library — 2D software fallback routines" in the Libraries chapter.

The modules

Photon graphics drivers are implemented in a modular fashion. Graphics driver functionality is broken down into various groups. A graphics driver's shared object may supply one or more groups of functionality. The shared object contains one module per functional group that it implements.

A graphics driver exposes its functionality by supplying a well-known entry point per module.

The modules currently defined are:

- Modeswitcher / mode enumerator
- 2D drawing module
- Offscreen memory manager
- Video overlay / scaler module
- Video capture / TV tuner module

Future modules can be implemented by defining a new well known entry point.

Because a graphics driver consists of one or more modules, it's possible to package a complete driver solution that consists of multiple shared objects. For example:

- One shared object could contain an overlay scaler module for an external video scaler device, while another shared object could contain the 2D graphics driver and modeswitcher for the desktop display device. Photon could use the scaler and desktop devices together, with a separate shared object supplied to control each device. However, a single shared object typically controls a single integrated device with desktop graphics and video scaler functionality.
- If you want to write a generic modeswitcher (e.g a modeswitcher to support any adapter with a VESA compliant BIOS), you could build the VESA BIOS modeswitcher as a single shared object and use it in conjunction with a shared object with a 2D module for a specific chipset, which might, or might not, have its own built-in modeswitcher.

It's possible to load multiple shared objects such that there's more than one instance of a given module type. In this case, the order in which to load the shared objects can be specified to the graphics subsystem; modules found in later-loaded shared objects are used in preference to those in earlier-loaded shared objects.

The graphics driver subsystem

With QNX Neutrino, the graphics driver subsystem consists of a main application and multiple shared objects. The main application is called **`io-graphics`** under QNX Neutrino, and is responsible for:

- connecting to the appropriate Photon server
- locating the correct set of shared objects to use for a particular set of hardware

- loading those shared objects and using them to fulfill the instructions encoded into the Photon draw stream.

For more information about starting **`io-graphics`**, see the QNX Neutrino *Utilities Reference*.

Although the current implementation of **`io-graphics`** is limited to driving a single Photon graphical region, eventually it will simultaneously handle an arbitrary number of graphical regions and Photon servers.

Font manager and render library

There are many operations defined in the Photon high-level API that are extremely unlikely to be handled by any kind of graphics hardware. For example, a graphics card is unlikely to handle circles and scaled fonts. Even if a graphics card *could* handle them, it would probably draw them in a card-dependent way that would be inconsistent with other cards.

The **`io-graphics`** subsystem solves these problems by using the render library and the font manager to turn high-level entities into lower-level primitives that all hardware can draw consistently.

The font manager is obviously used for rendering any sort of text objects. It's currently designed to return raster style output that the driver draws as bitmaps or images, but eventually it will be enhanced to return vector information that future drivers could use directly.

The render library is used to simplify operations (other than fonts) that are defined in the Photon API, but that make little sense to implement in chipset-specific code. These operations include drawing circles as well as things like thick dashed lines.

The current implementation of the render library breaks down its output into scanlines, rectangles, bitmaps and images, but future plans call for it to be upgraded to return other kinds of data, such as lists of vertices representing a polygonal area to fill.

To this end, extra draw commands will be added to the 2D driver specification, but the main thing to remember is that you should have to worry only about implementing the routines currently described in this guide.

Modeswitching and enumeration

Enumeration is the process of discovering what kind of video card you have, what its capabilities are. *Modeswitching* is the process of putting the video card into one of its supported modes.

With a standard installation of Photon for QNX Neutrino, cards are detected with the help of a generic utility called the enumerator (**`enum-devices`**). This utility uses a mapping file to detect video chips by their PCI or AGP vendor and device IDs. Depending on what video hardware it recognizes, if any, it builds an intermediate file that's used by the **`crttrap`** utility, which is normally invoked when Photon is started, and performs the secondary phase of hardware detection. For more information about **`enum-devices`** and **`crttrap`**, see the QNX Neutrino *Utilities Reference*.

At the driver level, enumeration of the video modes supported by a card roughly corresponds to the VESA BIOS model. A list of numbers is returned corresponding to the modes the card can do, and a function is called for each of the mode numbers, returning information about that mode.

Switching to a given mode is accomplished by calling a driver entry point with one of the supported mode numbers.

2D drawing

2D drawing routines are the functions that actually produce or manipulate a two-dimensional image.

Operations that fall into this category include:

- filled rectangle routines
- scanline operation routines
- BLIT (BLock Image Transfer) routines
- hardware cursor routines

BLIT routines include operations that render an image that's in system RAM into the framebuffer and routines that move a rectangular portion of the screen from one place to another.

Offscreen memory manager

Offscreen memory management routines are the code that allows **`io-graphics`** to manage multiple 2D objects, or surfaces, and to use the graphics driver to draw into various surfaces, whether the surfaces are on the visible display, or not.

Offscreen memory is the most important new API feature in Photon, and is what allows applications to take advantage of more advanced hardware features.

Most modern video cards have far more memory than is actually needed for the display. Most of them also allow the graphics hardware to draw into this unused memory, and then copy the offscreen object onto the visible screen, and vice-versa.

The offscreen management module deals with managing this memory. The routines in this module deal with allocating and deallocating 2D surfaces.

Video overlay control

Video overlay control routines manage the process of initializing and using video overlay hardware to do things like show MPEG content.

A video overlay scaler is a hardware feature that allows a rectangular area of the visible screen to be replaced by a scaled version of a different image. The prescaled video frames are typically stored in offscreen memory, and are fetched from memory and overlaid on top of the desktop display image in real time, by the overlay scaler.

Chroma keying is used to control what parts of the video frame are visible. Typically, the application picks a color to be the chroma-key color and draws a rectangle of this color where video content is to appear. When another application's window is placed on top of the video playback application, the chroma-colored rectangle is obscured. Since the video hardware is programmed to display video content only where the chroma-key color is drawn, video doesn't show through where the chroma-colored rectangle is obscured.

Most of the routines in this module deal with letting applications know what kind of features the particular hardware supports and then setting the overlay up to cover a specific area of the screen and to accept an input stream of a particular size.

The rest of the overlay routines deal with implementing a protocol so that the application knows when a given frame has been dealt with and when it can send new frames to be displayed.

Layer control

Some display controllers allow you to transparently overlay multiple "screens" on a single display. Each overlay is called a *layer*. Layers can be used to combine independent display elements. Because overlaying is performed by the graphics hardware, this can be more efficient than rendering all of the display elements onto a single memory surface. For example, a fast navigational display can be implemented with the scrolling navigational map on a background layer and pop-up GUI elements, such as menus or a web browser, on the foreground layer.

Layer capabilities vary, depending on the display controller and the driver. Some display controllers don't support layers. Different layers on the same display may have different capabilities. Layers are indexed per display, starting from 0, from back to front in the default overlay order.

Surfaces

The image on a layer is fetched from one or more offscreen contexts, also called *surfaces*. The layer format determines the number of surfaces needed by a layer. For excample, a layer whose format is DISP_LAYER_FORMAT_ARGB888 requires one surface, while a layer whose format is DISP_LAYER_FORMAT_YUV420 requires three surfaces for a complete image.

Viewports

The source viewport defines a rectangular window into the surface data. This window is used to extract a portion of the surface data for display by the layer. The destination viewport defines a rectangular window on the display. This window defines where the layer displays its image. Scrolling and scaling (if supported by the layer) can be implemented by adjusting these viewports.

Binding your driver to the graphics framework

You must include the file **`<display.h>`**, which contains structures that you use to bind your driver to the graphics framework.

The graphics framework binds your graphics driver by calling *dlopen()* to load your driver, and then finding your entry point(s). The name of the entry point depends on which functional module(s) your shared object is providing; a single shared object can provide more than one functional block, hence the names are unique. The following table applies:

Functional block	**Name of function**
Core 2D drawing functions	*devg_get_corefuncs()*
Context 2D drawing functions	*devg_get_contextfuncs()*
Miscellaneous 2D drawing functions	*devg_get_miscfuncs()*
Modeswitcher and layer control	*devg_get_modefuncs()*
Memory manager / frame buffer	*devg_get_memfuncs()*
Video overlay	*devg_get_vidfuncs()*
Video capture	*devg_get_vcapfuncs()*

☞ The three functions, *devg_get_miscfuncs()*, *devg_get_corefuncs()*, and *devg_get_contextfuncs()* must be supplied in the same shared object — they constitute one group.

All the functions in the table have a similar structure: the graphics framework passes to each a pointer to a **`disp_adapter_t`** structure, a pointer to a set of functions (the type of which depends on the function being called), and a table size in *tabsize* (plus other arguments as appropriate).

The **`disp_adapter_t`** structure is the main "glue" that the graphics framework uses to hold everything together. It describes the adapter for the graphics hardware.

Your function is expected to fill the function table with all the available functions — this is how the graphics framework finds out about the functions supported by each functional block module.

Finally, the table size (*tabsize*) parameter indicates the size of the structure, in bytes. This is so that your initialization function doesn't overwrite the area provided. You should use the *DISP_ADD_FUNC()* macro (defined in **`<display.h>`**) to add function pointers to the tables; it automatically checks the *tabsize* parameter.

The idea is that newer drivers that supply more functions will run properly with older versions of Photon that supply smaller function tables.

For more information, see the Graphics Driver API chapter.

Calling sequence

The graphics framework calls your driver's functions as follows:

```
modeswitch->init ();
    modeswitch->set_mode ();
    mem->init ();
        misc->init ();
            ...
            // graphics functions get called here
            ...
            // user requests a new mode; shut everything down
        misc->fini ();
    mem->fini ();
    // at this point no more graphics functions will be called

    modeswitch->set_mode ();
    mem->init ();
        misc->init ();
            ...
            // graphics functions get called here
            ...
            // shutdown of graphics drivers requested here
        misc->fini ();
    mem->fini ();
    // at this point no more graphics functions will be called
modeswitch->fini ();
```

☞ You can call the *devg_get_** functions at any time.

Conventions

Before looking at the function descriptions, there are some conventions that you should be aware of.

Colors

RGB colors that are passed to 2D drawing functions are in the same pixel format as the surface that's the target of the rendering operation.

However, chroma-key colors are passed with the 24-bit true-color value stored in the least significant three bytes. However, if the target of the draw operation is a palette-based surface, the palette index that corresponds to the color-key value is also stored in the most significant byte.

Coordinate system

The coordinate (0, 0) is the top left of the displayed area. Coordinates extend to the bottom right of the displayed area. For example, if your graphics card has a resolution of 1280 (horizontal) by 1024 (vertical), the coordinates are (0, 0) for the top left corner, through to (1279, 1023), for the bottom right.

Order

The graphics framework passes only sorted coordinates to your driver. For example, if a draw-span function is called to draw a horizontal line from (*x1*, *y*) to (*x2*, *y*), the graphics framework always passes the coordinates such that $x1 \leq x2$; it *never* passes them such that $x1$ **>** $x2$.

Inclusiveness

All coordinates given are *inclusive*, meaning, for example, that a call to draw a line from (5, 12) to (7, 12) shall produce *three* pixels (that is, (5, 12), (6, 12), and (7, 12)) in the image, and not two. Be careful to avoid this common coding mistake:

```
...

// WRONG!
for (x = x1; x < x2; x++) {
...
```

and instead use:

```
...

// CORRECT!
for (x = x1; x <= x2; x++) {
...
```

Core vs. context 2D functions

Core 2D drawing functions are typically expected to perform very simple operations. With the exception of pattern information, and information regarding the surface that's being drawn to, the core functions can ignore most of the information in the draw context structure.

Context 2D drawing functions are expected to be able to handle more complex operations, such as chroma-keying, alpha-blending, and complex raster operations.

Core functions may be coded to handle a single pixel format. However, context functions must be prepared to handle drawing to any of the possible drawable surface types.

Another difference is that the context functions are allowed to make calls to core drawing functions, but not the other way around. The draw state structure contains a pointer to the function table that contains pointers to the core functions, which allows the context functions access to the core functions.

Since context functions can be expected to perform complex operations, it often makes sense to perform the operation in multiple stages. Future optimizations in the FFB may entail having the FFB versions of the context functions making calls to the core functions.

Context information

The graphics framework passes to every function, as its first argument, a pointer to a **`disp_draw_context_t`** structure that gives the function access to the draw state context block.

☞ If your functions modify any of the context blocks during their operation, they *must* restore them before they return.

If the graphics framework modifies the context blocks between calls to the draw functions, it then calls the appropriate *update_*()* function to inform you which parts of the context data have been modified. The graphics framework doesn't modify the context blocks while your function is running.

Supplying draw functions and software fallback

When a 2D draw function (i.e. a function that's been supplied by the driver in either the **`disp_draw_corefuncs_t`** or the **`disp_draw_contextfuncs_t`** structure) is called, it's expected to perform the draw operation correctly before returning (i.e. it may not fail).

The FFB (Flat Frame Buffer) library serves as a reference as to how 2D primitives are to be rendered. The draw functions that your driver supplies in its *devg_get_corefuncs()* and *devg_get_contextfuncs()* entry points are expected to carry out the draw operation as the FFB does.

With typical graphics hardware, not all primitives can be rendered using hardware, while producing the same resulting pixels in the targeted draw surface as the FFB does. In order to perform the draw operation correctly, it's often necessary to call the FFB library functions to carry out a draw operation. This is called *falling back* on software.

Falling back on software can be achieved in these ways:

- Supply direct pointers to FFB functions in the **`disp_draw_corefuncs_t`** and **`disp_draw_contextfuncs_t`** structures. This is possible because, for each drawing entry point that your driver is expected to supply, there's an equivalent version of the function in the FFB.

  This has pleasant implications for the driver writer: it means that none of the draw functions are mandatory, that is, the driver implementor can simply supply only FFB functions. Obviously this would lead to a far-from-optimal driver, since none of the draw functions would be taking advantage any hardware acceleration features.

  Or:

- Supply function pointers to one or more of your driver's internal 2D rendering functions. When asked to perform a draw operation, the driver checks the contents of the draw context structure to determine whether or not it needs to fall back on the FFB functions.

Typically, the *devg_get_corefuncs()* and *devg_get_contextfuncs()* routines function as follows:

1. Retrieve the software versions of the rendering functions by calling *ffb_get_corefuncs()* or *ffb_get_contextfuncs()* as appropriate.
2. Overwrite the function pointers within the function table with pointers to accelerated routines, using the *DISP_ADD_FUNC()* macro.

Using the above method makes your driver forward-compatible with future versions of the driver framework. If more draw functions are added to the specification, **io-graphics** will pass in a larger structure, and an updated FFB library will fill in software versions of the new functions. The graphics driver doesn't need to be rebuilt or reshipped. At your discretion, you can update the graphics driver to supply accelerated versions of the new functions.

When a driver function is called to perform a draw operation, it typically checks members of the draw context structure, in order to determine if it needs to fallback on software. However, note that anytime the framework changes the draw context structure, it notifies the driver by means of one of the update-notification entry points.

As an optimization, your driver can perform these checks in its *update()* function (e.g. the **disp_draw_contextfuncs_t**'s *update_rop3()* function) and set flags to itself (in its private context structure) that indicate whether or not it can render various graphics primitives without falling back on software. This saves each and every context function from having to perform this work at runtime; it just checks the flags in a single test.

Patterns

Patterns are stored as a monochrome 8×8 array. Since many of the driver routines work with patterns, they're passed in 8-bit chunks (an **unsigned char**), with each bit representing one pixel. The most significant bit (MSB) represents the leftmost pixel, through to the least significant bit (LSB) representing the rightmost pixel. If a bit is on (1), the pixel is considered *active*, whereas if the bit is off (0), the pixel is considered *inactive*. The specific definitions of active and inactive, however, depend on the context where the pattern is used.

As an example, the binary pattern **11000001** (hex **0xC1**) indicates three active pixels: the leftmost, the second leftmost, and the rightmost.

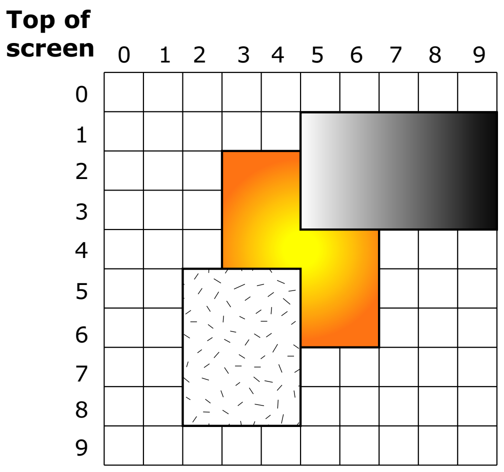
Note that functions that have **8x1** in their function names deal with a single byte of pattern data (one horizontal line), whereas functions that have **`8x8`** in their function names deal with an 8 by 8 array (eight horizontal lines).

The pattern is *circular*, meaning that if additional bits are required of the pattern past the end of the pattern definition (for that line) the beginning of the pattern (for that line) is reused. For example, if the pattern is **`11110000`** and 15 bits of pattern are required, then the first eight bits come from the pattern (i.e. **`11110000`**) and the next 7 bits once again come from the beginning of the pattern (i.e. **`1111000`**) for a total pattern of **`111100001111000`**. See "Pattern rotation," below for more details about the initial offset into the pattern buffer.

A similar discussion applies to the vertical direction: if an 8-byte pattern is used and more pattern definitions are required past the bottom of the pattern buffer, the pattern starts again at the top.

Pattern rotation on a filled surface

In order to ensure a consistent look to anything that's drawn with a pattern, you need to understand the relationships among the x and y coordinates of the beginning of the object to be drawn, the origin of the screen, and the *pat_xoff* and *pat_yoff* members of the **`disp_draw_contextfuncs_t`** context structure.



Three surfaces.

The diagram above shows three overlapping rectangles, representing three separate regions (for example, three **`pterm`** windows). If an application draws three rectangles within one Photon region, it's up to the *application* to draw the three rectangles in the appropriate order — the discussion here about clipping applies only to separate regions managed by Photon.

If only the middle rectangle is present (i.e. there are no other rectangles obscuring it), your function to draw a rectangle with a pattern (e.g. *draw_rect_pat8x8()*), is called once, with the following parameters:

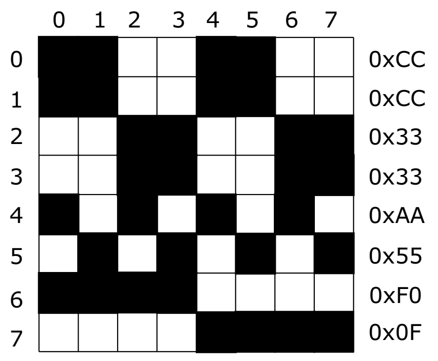
Parameter	Value
x1	3
y1	2
x2	6

continued. . .

Parameter	Value
y2	6
pat_xoff	0
pat_yoff	0

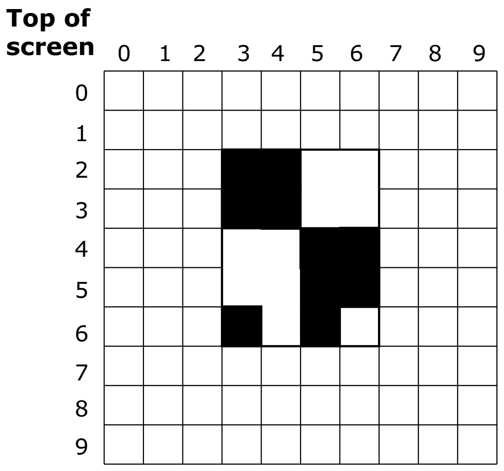
Note that the *x1*, *y1*, *x2* and *y2* parameters are passed to the function call itself, while the *pat_xoff* and *pat_yoff* parameters are part of a data structure that the function has access to.

The values for *x1*, *y1*, *x2* and *y2* are reasonably self-explanatory; draw a rectangle from (*x1*, *y1*) to (*x2*, *y2*). The *pat_xoff* and *pat_yoff* values are both zero. This indicates that you should begin drawing with the very first bit of the very first byte of the pattern. If the pattern looks like this:



Typical pattern.

then the rectangle drawn looks like this:



Pattern filling a surface.

If the values of the *pat_xoff* and *pat_yoff* arguments are anything *other than* zero (specifically, if these variables are functions of the location of the rectangle) then the pattern appears to creep along with the change of the location.

In the case where the other two rectangles are partially obscuring the rectangle of interest, Photon automatically transforms the single middle rectangle into a set of three rectangles, corresponding to the area that's still visible (this is called *clipping*):

- (3, 2) to (4, 3)
- (3, 4) to (6, 4)
- (5, 5) to (6, 6)

This means that *draw_rect_pat8x8()* is called three times with these parameters:

Parameter	**First call**	**Second**	**Third**
x1	3	3	5
y1	2	4	5
x2	4	6	6
y2	3	4	6
pat_xoff	0	0	2
pat_yoff	0	2	2

Notice how the *pat_xoff* and *pat_yoff* pattern offset values are different in each call (first (0, 0), then (0, 2) and finally (2, 2)) in order to present the same window on the pattern regardless of where the rectangle being drawn begins. This is called *pattern rotation*.

Pattern rotation on an image

To find the right bit in the pattern for a rectangle at point (*X*, *Y*):

```
x_index = (x + pat_xoff) % 8;
y_index = (y + pat_yoff) % 8;
```

The BLIT functions take a *dx* and *dy* parameter, so you should substitute that in the equations above.

Pixel formats

The pixel formats are defined below.

☞ You *aren't* expected to be able to render into the formats tagged with an asterisk (*) — these can only act as sources for operations, not as destinations. Therefore, these formats are never specified as parameters to *devg_get_corefuncs()*.

In any case, if you receive a *pixel_format* that you don't know what to do with (or don't want to handle yourself), simply call *ffb_get_corefuncs()* to populate the function table with software rendering routines.

For RGB formats, the name indicates the layout of the color components. For example, for DISP_SURFACE_FORMAT_ARGB1555, the Alpha bit is stored in the most significant bit of the pixel, and the Blue component is stored in the least significant 5 bits.

DISP_SURFACE_FORMAT_MONO (*)

Each pixel has 1 bit (monochrome).

DISP_SURFACE_FORMAT_PAL8

Each pixel has 8 bits, and is selected from a palette of 256 (8-bit) colors.

DISP_SURFACE_FORMAT_ARGB1555

Each pixel has 16 bits, and the color components for red, green, and blue are 5 bits each (the top bit, **`0x80`** will be used for alpha operations in the future).

DISP_SURFACE_FORMAT_RGB565

Each pixel has 16 bits, and the color components for red and blue are 5 bits each, while green is 6 bits.

DISP_SURFACE_FORMAT_RGB888

Each pixel has 24 bits, and the color components for red, green, and blue are 8 bits each.

DISP_SURFACE_FORMAT_ARGB8888

Each pixel has 32 bits, and the color components for red, green, and blue are 8 bits each, with the other 8 bits to be used for alpha operations in the future.

DISP_SURFACE_FORMAT_PACKEDYUV_UYVY (*)

Effectively 16 bits per pixel, organized as UYVY, two pixels packed per 32-bit quantity.

DISP_SURFACE_FORMAT_PACKEDYUV_YUY2 (*)

Effectively 16 bits per pixel, organized as YUYV, two pixels packed per 32-bit quantity.

DISP_SURFACE_FORMAT_PACKEDYUV_YVYU (*)

Effectively 16 bits per pixel, organized as YVYU, two pixels packed per 32-bit quantity.

DISP_SURFACE_FORMAT_PACKEDYUV_V422 (*)

Same as YUY2, above.

DISP_SURFACE_FORMAT_YPLANE (*)

Surface contains the Y component of planar YUV data.

DISP_SURFACE_FORMAT_UPLANE (*)

Surface contains the U component of planar YUV data.

DISP_SURFACE_FORMAT_VPLANE (*)

Surface contains the V component of planar YUV data.

DISP_SURFACE_FORMAT_BYTES (*)

Surface is a collection of bytes with no defined format (for example, unallocated frame buffer memory).

You can use the *DISP_BITS_PER_PIXEL()* and *DISP_BYTES_PER_PIXEL()* macros in **`<display.h>`** to determine the number of bits or bytes of a packed surface format, including packed RBG and packed YUV format.

☞ These macros don't work for planar formats. Before using them, you should examine their definitions in **`<display.h>`** to see exactly what they do!

Pixel formats for layers

The pixel formats for layers are defined below.

DISP_LAYER_FORMAT_PAL8

Each pixel has 8 bits.

DISP_LAYER_FORMAT_ARGB1555

Each pixel has 16 bits, with 1 bit for alpha, and 5 bits for red, green, and blue.

DISP_LAYER_FORMAT_RGB565

Each pixel has 16 bits, with 5 bits of red, 6 bits of green, and 5 bits of blue.

DISP_LAYER_FORMAT_RGB888

Each pixel has 24 bits, with 8 bits each of red, green, and blue.

DISP_LAYER_FORMAT_ARGB8888

Each pixel has 32 bits, with 8 bits of alpha, and 8 bits each of red, green, and blue.

DISP_LAYER_FORMAT_YUY2

Each pixel has 16 bits. Every 4 bytes of YUV colorspace data is arranged as YUYV. While the Y data uses one byte of data per pixel, the U and V subsampled data uses one byte of data each, shared between two pixels.

DISP_LAYER_FORMAT_UYVY

Each pixel has 16 bits. Every 4 bytes of YUV colorspace data is arranged as UYVY. While the Y data uses one byte of data per pixel, the U and V subsampled data uses one byte of data each, shared between two pixels.

DISP_LAYER_FORMAT_YVYU

Each pixel has 16 bits. Every 4 bytes of YUV colorspace data is arranged as YVYU. While the Y data uses one byte of data per pixel, the U and V subsampled data uses one byte of data each, shared between two pixels.

DISP_LAYER_FORMAT_V422

Each pixel has 16 bits. Every 4 bytes of YUV colorspace data is organized as VYUY. While the Y data uses one byte of data per pixel, the U and V subsampled data uses one byte of data each, shared between two pixels.

DISP_LAYER_FORMAT_YVU9

Three memory surfaces (the Y, U, and V planes) are needed to make a valid image. The Y plane index is 0, the U plane index is 1, and the V plane index is 2. The U and V planes are one quarter the width and height of the Y plane. One byte of U data and one byte of V data is subsampled across a 4x4 (16 pixel) grid. For every 16 pixels, 144 associated bits of data are created. This averages out to 9 bits per pixel.

DISP_LAYER_FORMAT_YV12

Three memory surfaces (the Y, U, and V planes) are needed to make a valid image. The Y plane index is 0, the U plane index is 1, and the V plane index is 2. The U and V planes are one half the width and height of the Y plane. One byte of U data and one byte of V data is subsampled across a 2x2 (4 pixel) grid. For every 4 pixels, 48 associated bits of data are created. This averages out to 12 bits per pixel.

DISP_LAYER_FORMAT_YUV420

Three memory surfaces (the Y, U, and V planes) are needed to make a valid image. The Y plane index is 0, the U plane index is 1, and the V plane index is 2. The U and V planes are one half the width of the Y plane. One byte of U data and one byte of V data is subsampled for every adjacent pair of Y samples. For every 2 pixels, 32 associated bits of data are created. This averages out to 16 bits per pixel.

Chapter 3

Debugging a Graphics Driver

In this chapter. . .

A simple setup

Let's assume you have two machines: a remote debug terminal (Machine A) and your QNX Neutrino target (Machine B).

The remote debug terminal, Machine A, can be running QNX Neutrino or any system that supports a **telnet** connection into Machine B. (Some prefer to run QNX Neutrino on Machine A as well.)

☞ In order to support a **telnet** session on Machine B, be sure to run the **inetd** services (e.g. as **root**, type: **inetd &**).

Once you have a **telnet** session, you should be able to login to Machine B from Machine A and get a shell prompt.

As an alternative to **telnet**, you could use **qtalk** to communicate to both machines over a serial link.

☞ Unless noted otherwise, you should run all the commands described in the following sections *on Machine B, your QNX Neutrino target system*.

Location of the Graphics DDK

The Graphics Driver Development Kit as downloaded (version 1.00) is in the form of a *package*, which should install to *ddk_install_dir***ddk-graphics**.

Compiling shared objects

After installation, you'll first need to compile the shared objects needed by the graphics driver.

1 **cd** to the *ddk_install_dir***/ddk-graphics** directory.

2 Type:

```
make
```

You can individually go in to each subdirectory (**ffb**, **disputil**, etc.) and make from the lowest level if you choose.

Building for a particular OS or architecture

You can easily specify the hardware platform (e.g. x86):

To build for:	Use this command:
x86 only	**CPULIST=x86 make**
PPC only	**CPULIST=ppc make**

☞ The **libdisputil.so** and **libffb.so** objects that we created have slightly different symbol information than the original ones that exist in **/usr/lib**.

Note also that you need to add the extension "**.2**" to the files **libdisputil.so** and **libffb.so** in order for the loader to locate them.

In order to run our debug driver, we'll need these newer libraries that we just compiled. We'll need to compile against them as well as have them available in our library path so that they're loaded in when we start our driver.

We recommend that you make a backup of the original **libdisputil.so** and **libffb.so** objects and then copy the newly compiled ones on top of the existing versions. For example:

```
cd /usr/lib
cp libdisputil.so.1 libdisputil_orig.so.1
cp libffb.so.1 libffb_orig.so.1

cp ddk_working_dir/prebuilt/cpu variant/libdisputil.so  /usr/lib/libdisputil.so.1
cp ddk_working_dir/prebuilt/cpu variant/lib/ffb/nto/x86/so/libffb.so  /usr/lib/libffb.so.1
```

☞ Note that the make environment used for the Graphics DDK is the same as the recursive make as described in the Conventions for Makefiles and Directories in appendix of the QNX Neutrino *Programmer's Guide*.

Shipping modified libs with your product

If you wish to ship modified versions of the **ffb** or **disputil** libraries with your product, you should rename them so that they're not confused with the QNX-supplied libraries.

You'll also need to modify your driver's **common.mk**, so that it's linked against the renamed library. Generally, however, you link and test your driver against the QNX-supplied library binaries.

Setting the LD_LIBRARY_PATH environment variable

To make sure the loader can find all the binaries when Photon and the driver are started, you should set the **LD_LIBRARY_PATH** variable to point at their location. (Or, you could simply install them in **/lib/dll**, but using the environment variable is probably better for testing purposes).

For example, before starting Photon, type:

```
export LD_LIBRARY_PATH=/home/barney/test_drivers
```

Now, running **crttrap trap** should create a trap file with the entries required to have Photon use the sample drivers.

☞ The command at the top line of the trap file is the command that's run to start the graphics driver. In order to specify which mode is used when Photon starts, you may select a line for a different mode and place it at the top of the trap file.

The `graphics` file

Another important file is **/etc/system/enum/devices/graphics**. The system determines which particular driver to use with a particular chip, using the mappings in this **graphics** file.

If you want to add a new driver to the system, you need to add an entry to this file.

Making a debug version of a driver

In this example, we'll make a debug version of the **devg-banshee** driver.

1. **cd** to the **devg/banshee/nto/x86** directory. You'll see a **dll** directory.
2. Make a **dll.g** directory at the same level as the **dll** directory.
3. Copy the Makefile from inside the **dll** directory to the **dll.g** directory.

☞ Both **dll** and **dll.g** use the very same Makefile — the directory-naming convention is what tells **make** to compile with the **-g** debugging option.

4. **cd** to **dll.g** and type:
   ```
   make
   ```
   This should create a **devg-banshee_g.so** shared object.

☞ We recommend that you copy the debug object to the same spot on disk as the non-debug object. This is okay because they have different names, and you'll invoke them differently.

5. Copy the debug object:
   ```
   cp devg-banshee_g.so /lib/dll
   ```
   The **gdb** debug example assumes that the debug object resides under the **/lib/dll** directory.

Running the debug driver and setting a breakpoint

Now let's try to run your debug driver (**devg-banshee_g.so**) and set a breakpoint on *banshee_init()*, which is a function within the **devg-banshee_g.so** shared object.

There's a slight complication here: we can't set the breakpoint under **gdb** until after the banshee DLL is loaded. What we want to do is freeze **io-graphics** after it has loaded **devg-banshee_g.so**, but before *banshee_init()* has been called.

Note how **io-graphics** gets the address of the *banshee_init()* function before it can call it: it obtains it via the *devg_get_modefuncs()* entry point. This means that *devg_get_modefuncs()* has to get called before *banshee_init()* (or any other modeswitcher entry point for that matter).

So in order to gain control under **gdb** before any of the modeswitcher entry points get called, we can add the following line of code to the *devg_get_modefuncs()* function:

```
kill(0, SIGSTOP);
```

What we're doing here is dropping a "stop" signal on our own process, **io-graphics**. Once **io-graphics** is in a stopped state, we can attach to it with **gdb**.

Now we're ready to start Photon.

If you're starting Photon manually, or via a custom script, you could launch **io-graphics** with the following command:

```
io-graphics -g1024x768x32 -dldevg-banshee_g.so -I0 -d0x121a,0x5 -R75
```

If you're using the **ph** script (which launches **io-graphics** via **crttrap**) you could place the above line at the top of the file **/etc/system/config/graphics-modes**.

When **io-graphics** runs, it loads your debug driver, but when it hits the *kill()* function in *devg_get_modefuncs()*, it goes into a stopped state.

From a **telnet** or serial session, type:

```
pidin | grep io-graphics
```

to find the process ID of **io-graphics**, so that we can attach to it with **gdb**.

☞ You need to ensure that **gdb** looks in the same location for your driver shared object as the run timer loader (otherwise the symbol table in **gdb** won't match the binary you're trying to debug!)

You can do this by setting the **solib-search-path** variable inside **gdb**. Here's an example for an x86 target:

```
(gdb) set solib-search-path /x86/lib:/x86/usr/lib:/x86/usr/dll:/home/barney/test_drivers
```

You could place the above command line in your **.gdbinit** file (note the leading period) so that it's automatically executed when **gdb** starts. This file is located in your home directory.

Now we can start **gdb**, attach to **io-graphics** using the process ID that we got from **pidin**, load the symbol table from the debug driver, and set a breakpoint:

```
(gdb) attach 123456
(gdb) shared
(gdb) break banshee_init
(gdb) cont
```

The **gdb** debugger should regain control when **io-graphics** hits the breakpoint in *banshee_init()*.

Chapter 4

Graphics Driver API

This chapter includes reference pages for the entry points your driver must provide, as well as for the macros and data structures you'll use when writing a graphics driver:

devg_get_contextfuncs()	Get a table of your driver's context drawing functions
devg_get_corefuncs()	Get a table of your driver's core 2D drawing functions
devg_get_memfuncs()	Get a table of your driver's video memory-management functions
devg_get_miscfuncs()	Get a table of your driver's miscellaneous drawing functions
devg_get_modefuncs()	Get a table of your driver's modeswitcher functions
devg_get_vcapfuncs()	Get a table of your driver's video capture functions
devg_get_vidfuncs()	Get a table of your driver's video-overlay functions
`disp_2d_caps_t`	Description of your driver's 2D capabilities
`disp_adapter_t`	Description of the graphics hardware's adapter
DISP_ADD_FUNC()	Add a function pointer to a table
`disp_crtc_settings_t`	CRT Controller settings

`disp_draw_context_t`
: Draw context for a graphics driver

`disp_draw_contextfuncs_t`
: Table of a driver's context drawing functions

`disp_draw_corefuncs_t`
: Table of a driver's core drawing functions

`disp_draw_miscfuncs_t`
: Table of miscellaneous drawing functions

`disp_layer_query_t`
: Query the capabilities of a given layer

`disp_memfuncs_t`
: Table of memory-management functions

`disp_mode_info_t`
: Information for a display mode

`disp_modefuncs_t`
: Table of your driver's modeswitcher functions

`disp_module_info_t`
: Driver module information

`disp_surface_t`
: Description of a two-dimensional surface

`disp_vcap_channel_caps_t`
: General capabilities of a video capture unit

`disp_vcap_channel_props_t`
: Configurable properties of a video capture unit

`disp_vcap_channel_status_t`
: Status of a video capture unit

`disp_vcapfuncs_t`
: Table of video capture functions

`disp_vid_alpha_t`
: A region of the video viewport to be blended with the desktop

`disp_vid_channel_caps_t`
: General capabilities of a video scaler

`disp_vid_channel_props_t`
: Configurable properties of a video scaler channel

`disp_vidfuncs_t`
: Table of video overlay functions

devg_get_contextfuncs()

Get a table of your driver's context 2D drawing functions

Synopsis:

```
int devg_get_contextfuncs (
        disp_adapter_t *ctx,
        disp_draw_contextfuncs_t *fns,
        int tabsize);
```

Description:

A 2D driver must provide an entry point called *devg_get_contextfuncs()*. The graphics framework calls this function to get a table of your driver's context 2D drawing functions.

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
fns	A pointer to a **disp_draw_contextfuncs_t** structure that this function must fill with pointers to your driver's context drawing functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_corefuncs(), *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_draw_contextfuncs_t`**

devg_get_corefuncs()

Get a table of your driver's core 2D drawing functions

Synopsis:

```
int devg_get_corefuncs (disp_adapter_t *ctx,
                        unsigned pixel_format,
                        disp_draw_corefuncs_t *fns,
                        int tabsize);
```

Description:

A 2D driver must provide an entry point called *devg_get_corefuncs()*. The graphics framework calls it to get a table of your driver's core 2D drawing functions for a particular pixel format.

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
pixel_format	The required pixel format. For more information, see "Pixel formats" in the Writing a Graphics Driver chapter.
fns	A pointer to a **disp_draw_corefuncs_t** structure that your driver must fill with pointers to its core 2D drawing functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	The driver doesn't support the given pixel format, or an error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_draw_corefuncs_t`**

devg_get_memfuncs()

Get a table of your driver's video memory management functions

Synopsis:

```
int devg_get_memfuncs (disp_adapter_t *ctx,
                       disp_memfuncs_t *funcs,
                       int tabsize);
```

Description:

A driver that contains a memory-management module must provide an entry point called *devg_get_memfuncs()*. The graphics framework calls it to get a table of your driver's video memory management functions.

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
funcs	A pointer to a **disp_memfuncs_t** structure that your driver must fill with pointers to its video memory management functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

The video driver is responsible for keeping track of the allocation of video memory. The framework requests the allocation of 2D surfaces, and asks the driver to free them when they're no longer in use. The onus is on the framework to free all surfaces; that is, for each surface that's allocated, the framework explicitly asks the driver to free the surface at some point before the driver is unloaded.

In general, you don't need to deal with all the complexities of writing a memory manager. Library routines in the DISPUTIL library can perform the bulk of the work. For more information, see the Libraries chapter.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_memfuncs_t`**

devg_get_miscfuncs()

Get a table of your driver's miscellaneous 2D drawing functions

Synopsis:

```
int devg_get_miscfuncs (disp_adapter_t *ctx,
                        disp_draw_miscfuncs_t *fns,
                        int tabsize);
```

Description:

A 2D driver must provide an entry point called *devg_get_miscfuncs()*. The graphics framework calls it to get a table of your driver's miscellaneous 2D drawing functions.

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
fns	A pointer to a **disp_draw_miscfuncs_t** structure that your driver must fill with pointers to its miscellaneous drawing functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_memfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_draw_miscfuncs_t`**

devg_get_modefuncs()

Get a table of your driver's modeswitcher functions

Synopsis:

```
int devg_get_modefuncs (disp_adapter_t *ctx,
                        disp_modefuncs_t *fns,
                        int tabsize);
```

Description:

A driver that contains a modeswitcher module must provide an entry point called *devg_get_modefuncs()*. The graphics framework calls it to get a table of your driver's modeswitcher functions.

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
fns	A pointer to a **disp_modefuncs_t** structure that your driver must fill with pointers to its modeswitcher functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_modefuncs_t`**

devg_get_vcapfuncs()

Get a table of your driver's video capture functions

Synopsis:

```
int devg_get_vcapfuncs (disp_adapter_t *ctx,
                        disp_vcapfuncs_t *funcs,
                        int tabsize);
```

Arguments:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
fns	A pointer to a **disp_vcapfuncs_t** structure that your driver must fill with pointers to its video capture functions.
tabsize	The size of the table, in bytes.

Description:

A driver that contains a video capture module must provide an entry point called *devg_get_vcapfuncs()*. The graphics framework calls it to get a table of your driver's video capture functions.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable

continued...

Safety	
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vidfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_vcapfuncs_t`**

devg_get_vidfuncs()

Get a table of your driver's video overlay functions

Synopsis:

```
int devg_get_vidfuncs (disp_adapter_t *ctx,
                       disp_vidfuncs_t *funcs,
                       int tabsize);
```

Description:

A driver that contains a video overlay module must provide an entry point called *devg_get_vidfuncs()*. The graphics framework calls it to get a table of your driver's video overlay functions:

The arguments are:

ctx	A pointer to the **disp_adapter_t** structure that describes the graphics adapter.
fns	A pointer to a **disp_vidfuncs_t** structure that your driver must fill with pointers to its video overlay functions.
tabsize	The size of the table, in bytes.

Use the *DISP_ADD_FUNC()* macro to add function pointers to the table. It checks the *tabsize* argument and adds a function pointer only if there's space for it in the table.

Returns:

0	Success.
-1	An error occurred.

Classification:

Photon

Safety	
Interrupt handler	Not applicable
Signal handler	Not applicable
Thread	Not applicable

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, **`disp_adapter_t`**, *DISP_ADD_FUNC()*, **`disp_vidfuncs_t`**

disp_2d_caps_t

Description of your driver's 2D capabilities

Synopsis:

```
#include <draw.h>

typedef struct disp_2d_caps {
    int         size;
    unsigned    accel_flags;
    unsigned    flags;
    int         min_stride;
    int         max_stride;
    int         stride_gran;
} disp_2d_caps_t;
```

Description:

The **disp_2d_caps_t** structure describes a driver's 2D capabilities. Your driver fills it in when the graphics framework calls the *get_2d_caps()* function defined in **disp_draw_miscfuncs_t**.

The **disp_2d_caps_t** structure includes the following members:

size
: The size of this structure, in bytes.

accel_flags
: Flags (defined in **<draw.h>**) describing which draw operations are performed with hardware acceleration:

- DISP_2D_ACCEL_OPAQUE_BLIT — simple, opaque blit operations
- DISP_2D_ACCEL_OPAQUE_FILL — simple, opaque fill operations
- DISP_2D_ACCEL_MONO_PAT — simple draw operations with two colors and a pattern
- DISP_2D_ACCEL_TRANS_PAT — simple draw operations with a transparency pattern
- DISP_2D_ACCEL_SIMPLE_ROPS — copy, XOR, AND and OR with a pattern
- DISP_2D_ACCEL_COMPLEX_ROPS — all 256 rop3 codes are accelerated

- DISP_2D_ACCEL_SRCALPHA_BLEND_GLOBAL — alpha blending with a global source factor is supported
- DISP_2D_ACCEL_SRCALPHA_BLEND_PIXEL — alpha blending with a per-pixel source factor is supported
- DISP_2D_ACCEL_SRCALPHA_BLEND_MAP — alpha blending with an alpha map as source is supported
- DISP_2D_ACCEL_DSTALPHA_BLEND_GLOBAL — alpha blending with a global destination factor
- DISP_2D_ACCEL_DSTALPHA_BLEND_PIXEL — alpha blending with a per-pixel destination factor
- DISP_2D_ACCEL_SRC_CHROMA — source image chroma keying is supported
- DISP_2D_ACCEL_DST_CHROMA — destination image chroma keying is supported

flags Flags (also defined in **`<draw.h>`**) describing miscellaneous properties of the 2D renderer:

- DISP_2D_SRC_DST_STRIDE_EQUAL — separate source and destination strides can't be specified

min_stride The minimum stride that a 2D surface can be.

max_stride The maximum stride that a 2D surface can be.

stride_gran A value that the stride of the 2D surface must be a multiple of.

Classification:

Photon

See also:

disp_draw_miscfuncs_t

Description of the graphics hardware's adapter

Synopsis:

```
#include <display.h>

typedef struct disp_adapter {
    ⋮
} disp_adapter_t;
```

Description:

This structure describes the graphics hardware's adapter. There's one instance of this structure for each device.

☞ The **disp_adapter_t** structure includes some members that aren't described here; don't use or change any undocumented members.

Each driver module has its own context block — these are the members whose name ends with **_ctx**. Your driver can use these context blocks to store any data it requires.

The structures pointed to by the *modefuncs* and *memfuncs* structures contain the entry points of the memory manager and modeswitcher modules. Through these, it's possible for one module to call functions within another. Since all entry points have access to the **disp_adapter_t** structure, each module's entry point is always able to find its own private data structures.

The members of **disp_adapter_t** include:

int *size*	Size of this structure.
**void ****gd_ctx*	Context block for graphics (2D) drivers.
**void ****ms_ctx*	Context block for the modeswitch function group.
**void ****mm_ctx*	Context block for the memory manager function group.
**void ****vid_ctx*	Context block for the video overlay function group.

void ***vcap_ctx** Context block for the video capture function group.

int *bus_type* Identifies the type of bus interface that connects the device to the rest of the system:

- DISP_BUS_TYPE_UNKNOWN — the driver can't determine the type of bus to which the device is connected, or the bus type isn't one of the following.
- DISP_BUS_TYPE_PCI — the device is connected to a PCI bus.
- DISP_BUS_TYPE_AGP — the device is connected to an AGP bus.
- DISP_BUS_TYPE_ISA — device is connected to an ISA bus.
- DISP_BUS_TYPE_VL — device is connected to a VESA local bus.

uintptr_t *bus.pci.base*[6]

An array of up to six physical base addresses that correspond to the device's (PCI) aperture bases. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP.

uintptr_t *bus.pci.apsize*[6]

An array of up to six aperture sizes that correspond to the device's (PCI) aperture bases. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP.

unsigned short *bus.pci.pci_vendor_id*

The PCI Vendor Identification number of the device that the driver interfaces with. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP.

unsigned short *bus.pci.pci_device_id*

The PCI Device Identification number of the device that the driver interfaces with. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP.

short *bus.pci.pci_index*

The PCI Index of the device that the driver interfaces with. Together, the three fields *pci_vendor_id*, *pci_device_id*, and *pci_index* uniquely identify a hardware device in the system. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP.

**struct pci_dev_info ****bus.pci.pci_devinfo*

A pointer to a structure containing extra PCI device information. For more details, see *pci_attach_device()* in the QNX Neutrino *Library Reference*. This value is defined only if the *bus_type* is DISP_BUS_TYPE_PCI or DISP_BUS_TYPE_AGP, and is present only under QNX Neutrino.

unsigned *caps*

Capabilities; a bitmap of the following values:

- DISP_CAP_MULTI_MONITOR_SAFE — the card can work with other VGA cards in the same system
- DISP_CAP_2D_ACCEL — the device provides 2D driver acceleration
- DISP_CAP_3D_ACCEL — the device provides 3D driver acceleration

The modeswitcher ORs in the multimonitor safe flag, if appropriate, and the other modules OR in their own capability flags if supported.

**FILE ****dbgfile*

A file pointer that indicates to which file debugging output is to be sent. The *disp_perror()*

and *disp_printf()* functions send their output to this file, unless its value is NULL.

struct disp_modefuncs **modefuncs*
: A pointer to a **disp_modefuncs_t** table containing the modeswitcher's entry points. This member lets the 2D driver invoke certain modeswitcher functionality.

struct disp_memfuncs **memfuncs*
: A pointer to a **disp_memfuncs_t** table containing the memory manager's entry points. This member lets the 2D driver allocate and free memory surfaces.

☞ The 2D driver is responsible for freeing any surfaces that it allocates on its own behalf. If the graphics framework asks the 2D driver to allocate any surfaces, the framework explicitly asks the driver to free them.

int *adapter_ram* The amount of video RAM on the card, in bytes.

struct vbios_context **vbios*
: The handle set by *vbios_register()* that you need to pass to the other *vbios_** functions. For more information, see the Libraries chapter.

Classification:

Photon

See also:

disp_memfuncs_t, **disp_modefuncs_t**

Synopsis:

```
#include <display.h>

#define DISP_ADD_FUNC(tabletype, table, entry, func, limit) ...
```

Description:

When the graphics framework calls your driver's entry points:

- *devg_get_contextfuncs()*
- *devg_get_corefuncs()*
- *devg_get_memfuncs()*
- *devg_get_miscfuncs()*
- *devg_get_modefuncs()*
- *devg_get_vcapfuncs()*
- *devg_get_vidfuncs()*

use the *DISP_ADD_FUNC()* macro to add your driver's functions to the appropriate table:

- **disp_draw_contextfuncs_t**
- **disp_draw_corefuncs_t**
- **disp_draw_miscfuncs_t**
- **disp_memfuncs_t**
- **disp_modefuncs_t**
- **disp_vcapfuncs_t**
- **disp_vidfuncs_t**

The *DISP_ADD_FUNC()* macro adds the function only if there's room for it in the table. If you use this macro, newer drivers that supply more functions will run properly with older versions of Photon that supply smaller function tables.

The arguments are:

tabletype	The data type for the table (e.g. **`disp_draw_contextfuncs_t`**).
table	A pointer to the instance of the table that you want to add the function to.
entry	The name of the entry you want to set in the table (e.g. *draw_span*).
func	A pointer to the function that your driver provides.
limit	The size of the table, in bytes.

Examples:

```
DISP_ADD_FUNC (disp_draw_corefuncs_t,
               &my_contextfuncs, blit1,
               &my_blit1_fn, tabsize);
```

Classification:

Photon

Safety	
Interrupt handler	No
Signal handler	No
Thread	No

See also:

devg_get_contextfuncs(), *devg_get_corefuncs()*, *devg_get_memfuncs()*, *devg_get_miscfuncs()*, *devg_get_modefuncs()*, *devg_get_vcapfuncs()*, *devg_get_vidfuncs()*, **`disp_draw_contextfuncs_t`**, **`disp_draw_corefuncs_t`**, **`disp_draw_miscfuncs_t`**, **`disp_memfuncs_t`**, **`disp_modefuncs_t`**, **`disp_vcapfuncs_t`**, **`disp_vidfuncs_t`**

disp_crtc_settings_t

CRT Controller settings

Synopsis:

```
#include <mode.h>

typedef struct disp_crtc_settings {
    short       xres;
    short       yres;
    short       refresh;
    unsigned    pixel_clock;

    uint8_t     sync_polarity;

    uint8_t     h_granularity;
    uint8_t     v_granularity;

    short       h_total;
    short       h_blank_start;
    short       h_blank_len;
    short       h_sync_start;
    short       h_sync_len;

    short       v_total;
    short       v_blank_start;
    short       v_blank_len;
    short       v_sync_start;
    short       v_sync_len;

    unsigned    flags;
} disp_crtc_settings_t;
```

Description:

The **disp_crtc_settings_t** structure contains the CRT Controller (CRTC) settings.

☞ These members are used in conjunction with generic modes only (with the *refresh* member applicable to both generic and fixed modes):

- *h_granularity*
- *v_granularity*
- *pixel_clock*
- *sync_polarity*
- *h_total*
- *h_blank_start*
- *h_blank_len*
- *h_sync_start*
- *h_sync_len*
- *v_total*
- *v_blank_start*
- *v_blank_len*
- *v_sync_start*
- *v_sync_len*

For more information, see the *get_modelist()* function in the description of **`disp_modefuncs_t`**.

The members include:

xres, *yres*	The horizontal and vertical resolution, in pixels.
refresh	The refresh rate (in Hz)
pixel_clock	The pixel clock rate (in kHz)

sync_polarity Any combination of the following bits:

- DISP_SYNC_POLARITY_V_POS — vertical synchronization is indicated by a positive signal if this bit is on, else negative.
- DISP_SYNC_POLARITY_H_POS — horizontal synchronization is indicated by a positive signal if this bit is on, else negative.

Or, you can use the following manifest constants (composed of the bits from the above):

- DISP_SYNC_POLARITY_NN — both synchronization signals are negative.
- DISP_SYNC_POLARITY_NP — horizontal negative, vertical positive.
- DISP_SYNC_POLARITY_PN — horizontal positive, vertical negative.
- DISP_SYNC_POLARITY_PP — both synchronization signals are positive.

h_granularity, *v_granularity*
The horizontal and vertical granularity; the values of the other *h_** and *v_** members must be multiples of these.

h_total, *h_blank_start*, *h_blank_len*, *h_sync_start*, *h_sync_len*
Detailed monitor timings indicating the horizontal total, blanking start, length of blanking, horizontal sync start and length, given in units of *h_granularity*.

v_total, *v_blank_start*, *v_blank_len*, *v_sync_start*, *v_sync_len*
Detailed monitor timings indicating the vertical total, blanking start, length of blanking, horizontal sync start and length; given in units of lines.

flags There are currently no flags defined.

Classification:

Photon

See also:

`disp_modefuncs_t`

disp_draw_context_t

Draw context for a graphics driver

Synopsis:

```
#include <draw.h>

typedef struct disp_draw_context {
    int                size;
    disp_adapter_t     *adapter;
    void               *gd_ctx;
    struct disp_draw_corefuncs *cfuncs;
    unsigned           flags;
    disp_color_t       fgcolor;
    disp_color_t       bgcolor;
    uint8_t            *pat;
    unsigned short     pat_xoff;
    unsigned short     pat_yoff;
    unsigned short     pattern_format;
    unsigned short     rop3;
    unsigned short     chroma_mode;
    disp_color_t       chroma_color0;
    disp_color_t       chroma_color1;
    disp_color_t       chroma_mask;
    unsigned           alpha_mode;
    unsigned           s_alpha;
    unsigned           d_alpha;
    unsigned           alpha_map_width;
    unsigned           alpha_map_height;
    unsigned           alpha_map_xoff;
    unsigned           alpha_map_yoff;
    unsigned char      *alpha_map;
    disp_surface_t     *dsurf
    char               *sysram_workspace;
    int                sysram_workspace_size;
} disp_draw_context_t;
```

Description:

The **disp_draw_context_t** structure defines the graphics driver's draw context. The graphics framework passes this structure to of all the 2D drawing entry points.

The members include:

size	The size of the structure, in bytes.
adapter	A pointer to the **disp_adapter_t** structure.
gd_ctx	The 2D module's private context structure.
cfuncs	A pointer to the **disp_draw_corefuncs_t** structure that lists the core functions for rendering into the currently targeted draw surface. This surface is of the type specified by the *dsurf* structure's *pixel_format* member.
flags	Flags that indicate what kind of operations should be performed in all subsequent "context draw" functions. Selected from one or more of the following (bitmap): ● DISP_DRAW_FLAG_SIMPLE_ROP ● DISP_DRAW_FLAG_COMPLEX_ROP ● DISP_DRAW_FLAG_USE_ALPHA ● DISP_DRAW_FLAG_USE_CHROMA ● DISP_DRAW_FLAG_MONO_PATTERN ● DISP_DRAW_FLAG_TRANS_PATTERN
fgcolor	The foreground color.
bgcolor	The background color.
pat	Pattern buffer; see the description in "Patterns" (in the "Conventions" section of the Writing a Graphics Driver chapter), as well as the context functions *draw_rect_pat8x8()*, and *draw_rect_trans8x8()*.
pat_xoff, *pat_yoff*	Horizontal and vertical offsets for the pattern to cause it to be shifted. For more information, see "Patterns" in the Writing a Graphics Driver chapter.

pattern_format	One of DISP_PATTERN_FORMAT_MONO_8x1 or DISP_PATTERN_FORMAT_MONO_8x8 (from **draw.h**).
rop3	Bitmapped raster operations, range between 0 and 255 inclusive. See the **memcpy_x.c** file in the flat framebuffer library source for a sample implementation.
chroma_mode	Selected from the following, see "Chroma mode bits," below: either DISP_CHROMA_OP_SRC_MATCH or DISP_CHROMA_OP_DST_MATCH, and/or either DISP_CHROMA_OP_DRAW or DISP_CHROMA_OP_NO_DRAW. (In other words, SRC and DST are mutually exclusive, as are DRAW and NO_DRAW.)
chroma_color0	The chroma key; indicates the color to test on.
chroma_color1, *chroma_mask*	Reserved; don't examine or modify.
alpha_mode	A bitmask indicating alpha blending operations, see "Alpha mode bits," below. For unrecognized alpha operations, call the supplied flat frame buffer functions.
s_alpha	The source alpha blending factor. For layers' blending configurations, multiplier 1, (*M1*), is the global alpha multiplier equivalent to *s_alpha*.
d_alpha	The destination alpha blending factor. For layers' blending configuration, multiplier 2 *M2*, is the global alpha multiplier equivalent to *d_alpha*.
alpha_map_width, *alpha_map_height*	The width and height of the alpha map (below) in pixels.

alpha_map_xoff, *alpha_map_yoff*
: The X and Y offset of the alpha map (below). See the discussion above in “Patterns” for more information.

alpha_map
: The alpha mapping grid, whose size is determined by *alpha_map_width* and *alpha_map_height* (above). Each element of the map is one byte, corresponding to one pixel. If this member is NULL, there’s no alpha map. The stride here is equal to the width, i.e. one byte per element.

dsurf
: A pointer to a **`disp_surface_t`** structure that contains the definition of the currently targeted draw surface. All draw operations target this surface by default, unless parameters to the draw function explicitly override this.

sysram_workspace
: A “scratch” area that the 2D driver and FFB library routines may use for temporary storage.

sysram_workspace_size
: The size of the workspace, in bytes. If the driver wishes, it may reallocate the workspace in order to increase its size. This member should be updated to reflect the change in size. The driver should never decrease the size of the workspace.

When using an alpha map, blending factors come from the *alpha_map*, and not from the *s_alpha* or *d_alpha* members.

Chroma mode bits

The following bits apply to the chroma mode flag *mode*, which performs a per-pixel test:

DISP_CHROMA_OP_SRC_MATCH
: Perform match on source image.

DISP_CHROMA_OP_DST_MATCH

Perform match on destination image.

DISP_CHROMA_OP_DRAW

If match, draw pixel.

DISP_CHROMA_OP_NO_DRAW

If match, don't draw pixel.

Note that DISP_CHROMA_OP_SRC_MATCH and DISP_CHROMA_OP_DST_MATCH are mutually exclusive, as are DISP_CHROMA_OP_DRAW and DISP_CHROMA_OP_NO_DRAW.

Alpha mode bits (*alpha_mode*)

The (Group 1) alpha modes are:

DISP_ALPHA_M1_SRC_PIXEL_ALPHA

Use the *M1* multiplier for the Alpha component of the source pixels.

DISP_ALPHA_M1_DST_PIXEL_ALPHA

Use the *M1* multiplier for the Alpha component of the destination pixels.

DISP_ALPHA_M1_GLOBAL

Use global blend factor from the *M1*multiplier.

The (Group 2) alpha modes are:

DISP_ALPHA_M2_SRC_PIXEL_ALPHA

Use the M2 multiplier for the Alpha component of the source pixels.

DISP_ALPHA_M2_DST_PIXEL_ALPHA

Use the M2 multiplier for the Alpha component of the destination pixels.

DISP_ALPHA_M2_GLOBAL

Use global destination blend factor from the *M2* multiplier.

Alpha mode blending (source) operation

The (Group 3) *alpha_mode* source operations are:

DISP_BLEND_SRC_M1_ALPHA

Ms = *M1*

DISP_BLEND_SRC_ONE_MINUS_M1_ALPHA

Ms = 1 -*M1*

DISP_BLEND_SRC_M2_ALPHA

Ms = *M2*

DISP_BLEND_SRC_ONE_MINUS_M2_ALPHA

Ms = 1 - *M2*

Alpha mode blending (destination) operation

The (Group 4) *alpha_mode* destination operations are:

DISP_BLEND_DST_M1_ALPHA

Md =*M1*

DISP_BLEND_DST_ONE_MINUS_M1_ALPHA

Md = 1 -*M1*

DISP_BLEND_DST_M2_ALPHA

Md = *M2*

DISP_BLEND_DST_ONE_MINUS_M2_ALPHA

Md = 1 -*M2*

☞ For each pixel, the value of the blended pixel is derived by combining the source and the destination pixels with the multipliers, as shown in the following equation: $Pd = Ps * Ms + Pd * Md$, where *Pd* is the destination pixel value, and *Ps* is the source pixel value.

Classification:

Photon

See also:

`disp_adapter_t`, **`disp_draw_corefuncs_t`**, **`disp_surface_t`**

disp_draw_contextfuncs_t

Table of a driver's context 2D drawing functions

Synopsis:

```
#include <draw.h>

typedef struct disp_draw_contextfuncs {
    void (*draw_span) (...);
    void (*draw_span_list) (...);
    void (*draw_rect) (...);

    void (*blit) (...);

    void (*update_general) (...);
    void (*update_color) (...);
    void (*update_rop3) (...);
    void (*update_chroma) (...);
    void (*update_alpha) (...);
} disp_draw_contextfuncs_t;
```

Description:

The **disp_draw_contextfuncs_t** structure is a table that your driver uses to define the context 2D drawing functions that it provides to the graphics framework. Your driver's *devg_get_contextfuncs()* entry point must fill in this structure.

All functions in the context drawing structure must obey the members of the **disp_draw_context_t** structure (e.g. the current foreground color, and the alpha- and chroma-related members); check the *flags* to see which members of the context structure need to be obeyed. Note also that the core functions *update_pattern()* and *update_draw_surface()* affect the operation of these (the context) functions.

draw_span()

The graphics framework calls this function to draw a single, horizontal line from (*x1*, *y*) to (*x2*, *y*). The prototype is:

```
void (*draw_span) (disp_draw_context_t *context,
                   int x1,
                   int x2,
                   int y)
```

Fallback function: *ffb_ctx_draw_span()*

draw_span_list()

The graphics framework calls this function to draw *count* number of horizontal lines as given by the arrays *x1*, *x2*, and *y*. The prototype is:

```
void (*draw_span_list) (
         disp_draw_context_t *context,
         int count,
         int *x1,
         int *x2,
         int *y)
```

Fallback function: *ffb_ctx_draw_span_list()*

draw_rect()

The graphics framework calls this function to draw a rectangle from (*x1*, *y1*) to (*x2*, *y2*). The prototype is:

```
void (*draw_rect) (disp_draw_context_t *context,
                    int x1,
                    int y1,
                    int x2,
                    int y2)
```

Fallback function: *ffb_ctx_draw_rect()*

blit()

The graphics framework calls this function to perform a blit. The prototype is:

```
void (*blit) (disp_draw_context_t *context,
              disp_surface_t *src,
              disp_surface_t *dst,
              int sx,
              int sy,
              int dx,
              int dy,
              int width,
              int height)
```

This function should move the pixels from the source surface (*src*) specified by the rectangle beginning at (*sx*, *sy*) for the specified size (*length* and *height*) to the destination surface beginning with the rectangle at (*dx*, *dy*) for the same size.

☞ The **disp_surface_t** structures pointed to by *src* and *dst* may actually describe the same 2D surface. In this case, the driver must be prepared to handle the case where the source and destination areas intersect (i.e. this function must handle overlapping blits).

Fallback function: *ffb_ctx_blit()*

update_general()

The graphics framework calls this function to notify the driver that potentially all the members of the *context* structure have changed. The prototype is:

```
void (*update_general) (
         disp_draw_context_t *context)
```

Fallback function: *ffb_ctx_update_general()*

update_color()

The graphics framework calls this function to notify the driver that the *fg_color* and *bg_color* members of the *context* structure could have changed. The prototype is:

```
void (*update_color) (disp_draw_context_t *context)
```

Fallback function: *ffb_ctx_update_color()*

update_rop3()

The graphics framework calls this function to notify the driver that the *rop3* member of the *context* structure could have changed. The prototype is:

```
void (*update_rop3) (disp_draw_context_t *context)
```

Fallback function: *ffb_ctx_update_rop3()*

update_chroma()

The graphics framework calls this function to notify the driver that the chroma-related members of the *context* structure could have changed. This includes the *flags*, *chroma_mode* and *chroma_color0* members. The prototype is:

```
void (*update_chroma) (
        disp_draw_context_t *context)
```

Fallback function: *ffb_ctx_update_chroma()*

update_alpha()

The graphics framework calls this function to notify the driver that the alpha-related members of the *context* structure could have changed. This includes the *flags*, *alpha_mode*, *d_alpha*, *alpha_map_width*, *alpha_map_height*, *alpha_map_xoff*, *alpha_map_yoff*, and *alpha_map* members. The prototype is:

```
void (*update_alpha) (disp_draw_context_t *context)
```

Fallback function: *ffb_ctx_update_alpha()*

Classification:

Photon

See also:

disp_draw_context_t, **disp_surface_t**

"FFB library — 2D software fallback routines" in the Libraries chapter

disp_draw_corefuncs_t

Table of a driver's core drawing functions

Synopsis:

```
#include <draw.h>

typedef struct disp_draw_corefuncs {
    void (*wait_idle) (...);
    void (*hw_idle) (...);

    void (*draw_span) (...);
    void (*draw_span_list) (...);
    void (*draw_solid_rect) (...);
    void (*draw_line_pat8x1) (...);
    void (*draw_line_trans8x1) (...);
    void (*draw_rect_pat8x8) (...);
    void (*draw_rect_trans8x8) (...);

    void (*blit1) (...);
    void (*blit2) (...);
    void (*draw_bitmap) (...);

    void (*update_draw_surface) (...);
    void (*update_pattern) (...);
} disp_draw_corefuncs_t;
```

Description:

The **disp_draw_corefuncs_t** structure is a table that your driver uses to define the core 2D drawing functions that it provides to the graphics framework. Your driver's *devg_get_corefuncs()* entry point must fill in this structure.

The core functions need to obey only the target information from the **disp_draw_context_t** structure, unless otherwise noted.

wait_idle()

The graphics framework calls this function when it needs to wait for the hardware to become idle. The prototype is:

```
void (*wait_idle) (disp_draw_context_t *context);
```

This function must not return until the hardware is idle. It's safe to directly access the draw target surface after this function returns.

Fallback function: *ffb_wait_idle()*

hw_idle()

The graphics framework calls this function to determine whether or not the 2D hardware is idle. The prototype is:

```
void (*hw_idle) (disp_adapter_t *context,
                 void *ignored )
```

This function should return a nonzero value if the 2D hardware is idle, in which case it's safe to directly access the draw target surface. If the hardware isn't idle, this function should return 0.

Fallback function: *ffb_hw_idle()*

draw_span()

The graphics framework calls this function to draw a single line. The prototype is:

```
void (*draw_span) (disp_draw_context_t *context,
                   disp_color_t color,
                   int x1,
                   int x2,
                   int y)
```

This function should draw a solid, opaque, horizontal line with the given color from (*x1*, *y*) to (*x2*, *y*). It doesn't use any pattern information — the line is a single, solid color.

Fallback functions: *ffb_draw_span_8()*, *ffb_draw_span_16()*, *ffb_draw_span_24()*, *ffb_draw_span_32()*

draw_span_list()

The graphics framework calls this function to draw a list of lines. The prototype is:

```
void (*draw_span_list) (
         disp_draw_context_t *context,
          int count,
          disp_color_t color,
          int *x1,
          int *x2,
          int *y)
```

It's identical to *draw_span()* above, except a list of lines is passed, with *count* indicating how many elements are present in the *x1*, *x2*, and *y* arrays.

Fallback functions: *ffb_draw_span_list_8()*, *ffb_draw_span_list_16()*, *ffb_draw_span_list_24()*, *ffb_draw_span_list_32()*

draw_solid_rect()

The graphics framework calls this function to draw a solid rectangle. The prototype is:

```
void (*draw_solid_rect) (
          disp_draw_context_t *context,
          disp_color_t color,
          int x1,
          int y1,
          int x2,
          int y2)
```

It draws a solid, opaque rectangle with the given color (in *color*), from (*x1*, *y1*) to (*x2*, *y2*). It doesn't use any pattern information — the rectangle is a single, solid color.

Fallback functions: *ffb_draw_solid_rect_8()*, *ffb_draw_solid_rect_16()*, *ffb_draw_solid_rect_24()*, *ffb_draw_solid_rect_32()*

draw_line_pat8x1()

The graphics framework calls this function to draw an opaque, patterned line. The prototype is:

```
void (*draw_line_pat8x1) (
          disp_draw_context_t *context,
          disp_color_t bgcolor,
          disp_color_t fgcolor,
          int x1,
          int x2,
          int y,
          uint8_t pattern)
```

It uses the *pattern* argument to determine the color to use for each pixel. An active bit (1) is drawn with the *fgcolor* color, and an inactive bit (0) is drawn with the *bgcolor* color. The pattern is consumed from left to right, with the most significant bit of the pattern being using for the first pixel drawn.

For more information, see "Patterns" in the Writing a Graphics Driver chapter.

Fallback functions: *ffb_draw_line_pat8x1_8()*, *ffb_draw_line_pat8x1_16()*, *ffb_draw_line_pat8x1_24()*, *ffb_draw_line_pat8x1_32()*

draw_line_trans8x1()

The graphics framework calls this function to draw a transparent, patterned line. The prototype is:

```
void (*draw_line_trans8x1) (
         disp_draw_context_t *context,
         disp_color_t color,
         int x1,
         int x2,
         int y,
         uint8_t pattern)
```

It uses the passed *pattern* to determine which pixels to draw. An active bit (1) is drawn with the *color* color, and an inactive bit (0) doesn't affect existing pixels. The pattern is consumed from left to right, with the most significant bit of the pattern being using for the first pixel drawn.

Fallback functions: *ffb_draw_line_trans8x1_8()*, *ffb_draw_line_trans8x1_16()*, *ffb_draw_line_trans8x1_24()*, *ffb_draw_line_trans8x1_32()*

draw_rect_pat8x8()

The graphics framework calls this function to draw an opaque, patterned rectangle. The prototype is:

```
void (*draw_rect_pat8x8) (
        disp_draw_context_t *context,
        disp_color_t fgcolor,
        disp_color_t bgcolor,
        int x1,
        int y1,
        int x2,
        int y2)
```

It uses the draw context structure's members *pat*, *pat_xoff*, *pat_yoff*, (but not *pattern_format* as it's already defined implicitly by virtue of this function being called). The pattern is used as described in the "Patterns" section of "Conventions," in the Writing a Graphics Driver chapter. An active bit is drawn with the *fgcolor* color, and an inactive bit is drawn with the *bgcolor* color.

Fallback functions: *ffb_draw_rect_pat8x8_8()*, *ffb_draw_rect_pat8x8_16()*, *ffb_draw_rect_pat8x8_24()*, *ffb_draw_rect_pat8x8_32()*

draw_rect_trans8x8()

The graphics framework calls this function to draw a transparent, patterned rectangle. The prototype is:

```
void (*draw_rect_trans8x8) (
        disp_draw_context_t *context,
        disp_color_t color,
        int x1,
        int y1,
        int x2,
        int y2)
```

It uses the context structure's members *pat*, *pat_xoff*, *pat_yoff*, (but not *pattern_format* as it's already defined implicitly by virtue of this function being called). The pattern is used as described in the "Patterns" section of "Conventions," in the Writing a Graphics Driver chapter. An active bit is drawn with the *color* color, and an inactive bit doesn't affect existing pixels.

Fallback functions: *ffb_draw_rect_trans8x8_8()*, *ffb_draw_rect_trans8x8_16()*, *ffb_draw_rect_trans8x8_24()*, *ffb_draw_rect_trans8x8_32()*

blit1()

The graphics framework calls this function to blit an area within a surface. The prototype is:

```
void (*blit1) (disp_draw_context_t *context,
               int sx,
               int sy,
               int dx,
               int dy,
               int width,
               int height)
```

It blits within the surface defined by the context structure's *dsurf* member (i.e., the source and destination are within the same surface). The contents of the area defined by the coordinates (*sx*, *sy*) for width *width* and height *height* are copied to the same-sized area defined by the coordinates (*dx*, *dy*).

☞ This function must be able to deal with overlapping blits, i.e. where the source area intersects with the destination area.

Fallback function: *ffb_core_blit1()*

blit2()

The graphics framework calls this function to blit an area from one surface to another. The prototype is:

```
void (*blit2) (disp_draw_context_t *context,
               disp_surface_t *src,
               disp_surface_t *dst,
               int sx,
               int sy,
               int dx,
               int dy,
               int width,
               int height)
```

This function blits from the source surface specified by the **disp_surface_t** structure pointed to by *src* to the destination surface specified by *dst*. The contents of the area defined by the coordinates (*sx*, *sy*) for width *width* and height *height*, within the source surface, are transferred to the same-sized area defined by the coordinates (*dx*, *dy*), within the destination surface.

☞ The *src* and *dst* surfaces are guaranteed to be different, whereas in *blit1()*, the operation takes place on the *same* surface (as implied by the lack of a destination surface parameter). Your driver may need to check the surface flags to see where the *src* and *dst* images are (either in system memory or video memory) before performing the operation, since the draw engine may not be able to copy the image directly from system RAM.

Fallback function: *ffb_core_blit2()*

draw_bitmap()

The graphics framework calls this function to draw an image in the destination surface by expanding the monochrome bitmap data in the buffer pointed to by "image". The prototype is:

```
void (*draw_bitmap) (disp_draw_context_t *context,
                     uint8_t *image,
                     int sstride,
                     int bit0_offset,
                     disp_color_t fgcolor,
                     disp_color_t bgcolor,
                     int transparent,
                     int dx,
                     int dy,
                     int width,
                     int height)
```

The *sstride* argument specifies the stride of the source bitmap image, in bytes. The *bit0_offset* specifies an index into the first byte of the source bitmap. For each scanline of the bitmap that's drawn, this index specifies the bit within the first byte of the scanline's source data that corresponds to the first pixel of the scanline that's drawn.

The *fgcolor* specifies the color to use when drawing a pixel when the corresponding bit in the source image is a 1. The *bgcolor* argument specifies the color to use when drawing a pixel when the corresponding bit in the source image is a 0, and the image is monochrome (as opposed to transparent).

For the *transparent* argument, a value of 0 specifies that the bitmap is a monochrome bitmap. Otherwise, the bitmap is a transparent bitmap. For transparent bitmaps, a bit value of 0 in the source image means that the corresponding pixel shouldn't be drawn. For monochrome bitmaps, a bit value of 0 in the source image means that the corresponding pixel should be drawn using the color specified by *bgcolor*.

The point (*dx*, *dy*) specifies the pixel offset within the draw surface where the image is to be drawn, and the *width* and *height* arguments specify the size of the bitmap, in pixels.

Fallback functions: *ffb_draw_bitmap_8()*, *ffb_draw_bitmap_16()*, *ffb_draw_bitmap_24()*, *ffb_draw_bitmap_32()*

update_draw_surface()

The graphics framework calls this function whenever the members of the structure pointed to by the *dsurf* member of the *context* structure have changed. The prototype is:

```
void (*update_draw_surface) (
         disp_draw_context_t *context)
```

All subsequent 2D drawing operations should be performed on the surface specified by *dsurf* (except for functions where the target surfaces are specified explicitly by parameters to the function).

Fallback function: *ffb_update_draw_surface()*

update_pattern()

The graphics framework calls this function whenever pattern information in the *context* structure has changed. The prototype is:

```
void (*update_pattern) (
         disp_draw_context_t *context)
```

This information includes the *flags*, *pat*, *pat_xoff*, *pat_yoff* and *pattern_format* members.

Fallback function: *ffb_update_pattern()*

Classification:

Photon

See also:

devg_get_corefuncs(), **`disp_draw_context_t`**, **`disp_surface_t`**

"FFB library — 2D software fallback routines" in the Libraries chapter

disp_draw_miscfuncs_t

Table of miscellaneous drawing functions

Synopsis:

```
#include <draw.h>

typedef struct disp_draw_miscfuncs {
    int  (*init) (...);
    void (*fini) (...);
    void (*module_info) (...);

    void (*set_palette) (...);

    int  (*set_hw_cursor) (...);
    void (*enable_hw_cursor) (...);
    void (*disable_hw_cursor) (...);
    void (*set_hw_cursor_pos) (...);

    void (*flushrect) (...);

    void (*get_2d_caps) (...);
    int  (*get_corefuncs_sw) (...);
    int  (*get_contextfuncs_sw) (...);
} disp_draw_miscfuncs_t;
```

Description:

The **disp_draw_miscfuncs_t** structure is a table that your driver uses to define the miscellaneous drawing functions that it provides to the graphics framework. Your driver's *devg_get_miscfuncs()* entry point must fill in this structure.

☞ Note that if the driver doesn't support hardware cursors, it should set *all* of the hardware cursor entry points in this structure to NULL. If any one of the hardware cursor entry points is non-NULL, your driver must provide *all* the hardware cursor entry points.

init()

The graphics framework calls this function to initialize the drawing hardware, allocate resources, and so on. The prototype is:

```
int (*init) (disp_adapter_t *adapter,
             char *optstring )
```

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

fini()

The graphics framework calls this function to shut down the driver by shutting off hardware, freeing resources, and so on. The prototype is:

```
void (*fini) (disp_adapter_t *adapter)
```

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

module_info()

The graphics framework calls this function to get information about the 2D driver module. The prototype is:

```
void (*module_info) (
         disp_adapter_t *adapter,
         disp_module_info_t *module_info)
```

This function must fill in the **`disp_module_info_t`** structure pointed to by *module_info*.

set_palette()

The graphics framework calls this function to set the palette. The prototype is:

```
void (*set_palette) (disp_adapter_t *ctx,
                     int index,
                     int count,
                     disp_color_t *pal)
```

☞ If the modeswitcher version of this function (**disp_modefuncs->***set_palette*) is present, it's called instead (i.e. the modeswitcher function overrides this one).

set_hw_cursor()

The graphics framework calls this function to set the attributes of the hardware cursor. The prototype is:

```
int (*set_hw_cursor) (disp_adapter_t *ctx,
                      uint8_t *bmp0,
                      uint8_t *bmp1,
                      unsigned color0,
                      unsigned color1,
                      int hotspot_x,
                      int hotspot_y,
                      int size_x,
                      int size_y,
                      int bmp_stride)
```

☞ The *hotspot* represents the "active" point of the cursor (e.g. the tip of the arrow in case of an arrow cursor, or the center of the crosshairs in case of a crosshair cursor).

If the cursor can't be displayed properly, this function should return -1, which causes the framework to show a software cursor instead. For example, if *sizex* or *sizey* is too big for the hardware to handle, this function should return -1.

The cursor image itself is defined by two bitmaps. The two colors, *color0* and *color1* apply to the two bitmaps *bmp0* and *bmp1*. Both bitmaps have the same width (*size_x*), height (*size_y*), and stride (*bmp_stride*) values.

For a given pixel within the cursor image, a 0 in both bitmap locations means this pixel is transparent. A 1 in *bmp0* means draw the corresponding pixel using the color given by *color0*. A 1 in *bmp1* means draw the corresponding pixel using the color given by *color1*. If there's a 1 in *both* bitmaps, then *color1* is to be used.

enable_hw_cursor()

The graphics framework calls this function to make the cursor visible. The prototype is:

```
void (*enable_hw_cursor) (disp_adapter_t *ctx)
```

disable_hw_cursor()

The graphics framework calls this function to make the cursor invisible. The prototype is:

```
void (*disable_hw_cursor) (disp_adapter_t *ctx)
```

set_hw_cursor_pos()

The graphics framework calls this function to set the position of the hardware cursor. The prototype is:

```
void (*set_hw_cursor_pos) (disp_adapter_t *ctx,
                           int x,
                           int y)
```

Position the cursor such that the hotspot is located at (*x*, *y*) in screen coordinates.

flushrect()

The graphics framework calls this function to flush a modified area to the draw surface. The prototype is:

```
void (*flushrect) (disp_draw_context_t *ctx,
                   int x1,
                   int y1,
                   int x2,
                   int y2)
```

The area defined by (*x1*, *y1*), (*x2*, *y2*) has been modified. Higher level software keeps track of which parts of the screen have been modified (or "dirtied"), since the last call to this function, and this function is called to flush the dirtied area to the targeted draw surface.

This function is optional; supply it only if you wish to implement a "dirty rectangle" driver. The sample VGA driver provided with the DDK is a good example of a dirty rectangle driver.

Even though the frame buffer organization is non-linear, the VGA driver is still able to use the standard rendering functions from the FFB lib. It does this by keeping a "shadow" copy of the frame buffer in system RAM. The format of the shadow buffer is linear (8-bit palette format). The FFB renders into the shadow buffer, then this function is used to flush the appropriate area of the shadow buffer out to the planar VGA frame buffer, by converting the data from linear to planar format.

get_2d_caps()

The graphics framework calls this function to get information about the 2D capabilities of the graphics hardware's accelerator. The prototype is:

```
void (*get_2d_caps) (disp_adapter_t *ctx,
                     disp_surface_t *surface,
                     disp_2d_caps_t *caps)
```

The *surface* argument points to a **disp_surface_t** structure that describes a targetable 2D surface. Your driver must fill in the **disp_2d_caps_t** structure pointed to by *caps* with information about how 2D drawing to that surface is to be performed.

get_corefuncs_sw()

The graphics framework calls this function to get your driver's core 2D drawing functions. The prototype is:

```
int (*get_corefuncs_sw)(
        disp_adapter_t *adapter,
        unsigned pixel_format,
        disp_draw_corefuncs_t *fns,
        int tabsize );
```

This function should be similar to *devg_get_corefuncs()*, but *get_corefuncs_sw()* should get only the ones that are guaranteed to render into system RAM.

get_contextfuncs_sw()

The graphics framework calls this function to get your driver's context 2D drawing functions. The prototype is:

```
int (*get_contextfuncs_sw)(
        disp_adapter_t *adapter,
        disp_draw_contextfuncs_t *fns,
        int tabsize );
```

This function should be similar to *devg_get_contextfuncs()*, but *get_contextfuncs_sw()* should get only the ones that are guaranteed to render into system RAM.

Classification:

Photon

See also:

devg_get_miscfuncs(), **disp_2d_caps_t**, **disp_adapter_t**, **disp_modefuncs_t**, **disp_module_info_t**, **disp_surface_t**

disp_layer_query_t

Query capabilities of a given layer

Synopsis:

```
#include <display.h>

typedef struct {
    int                 size;
    unsigned            pixel_format;
    unsigned            caps;
    unsigned            alpha_valid_flags;
    unsigned            alpha_combinations;
    unsigned            chromakey_caps;

    int                 src_max_height;
    int                 src_max_width;
    int                 src_max_viewport_height;
    int                 src_max_viewport_width;

    int                 dst_max_height;
    int                 dst_max_width;
    int                 dst_min_height;
    int                 dst_min_width;

    int                 max_scaleup_x;
    int                 max_scaleup_y;

    int                 max_scaledown_x;
    int                 max_scaledown_y;

} disp_layer_query_t *info;
```

Description:

The **disp_layer_query_t** structure defines the graphics driver's capabilities. The graphics framework passes this structure to the layer query entry point.

The members of *disp_layer_query_t* include:

size	The sizeof **disp_surface_info_t** structure.

format
: The pixel format; see "Pixel formats for layers" in the Writing a Graphics Driver chapter.

caps
: The flags that describe the capabilities of a layer for a given format:

- DISP_LAYER_CAP_FILTER — the layer can apply a filtering technique to the image as it's being displayed in order to produce a smoother image. Filtering techniques may be used to reduce artifacts when scaling images.
- DISP_LAYER_CAP_SCALE_REPLICATE — a simple pixel replication scaling technique is available for a source image that's scaled *before* it's displayed in the destination viewport.
- DISP_LAYER_CAP_PAN_SOURCE — the source viewpoint can be moved within the source image for this layer. If this flag isn't set, the viewport can be located only at the top left corner of the image.
- DISP_LAYER_CAP_PAN_DEST — the destination viewpoint can be moved within the display area for this layer. If this flag isn't set, the viewport can be located only at the top left corner of the image.
- DISP_LAYER_CAP_EDGE_CLAMP — if the image being displayed isn't large enough to fill the destination viewport, the unfilled right and bottom portions of the viewport can be filled. The last pixel that was displayed can be replicated to the edge of the viewport.
- DISP_LAYER_CAP_EDGE_WRAP — if the image being displayed isn't large enough to fill the destination viewport, the unfilled right and bottom portions of the viewport can be filled. The right and bottom portions can be wrapped around to the top left portions of the image.

- DISP_LAYER_CAP_DISABLE — you can disable this layer and make it invisible. This layer can also be enabled.
- DISP_LAYER_CAP_SET_BRIGHTNESS — you can adjust the intensity of the displayed image.
- DISP_LAYER_CAP_SET_CONTRAST — you can adjust the contrast of the displayed image.
- DISP_LAYER_CAP_SET_SATURATION — you can adjust the color saturation of the displayed image.
- DISP_LAYER_CAP_ALPHA_WITH_CHROMA — chroma-keying and alpha-blending operations can be used simultaneously when you combine this layer with other layers.
- DISP_LAYER_CAP_MAIN_DISPLAY — according to the mode-switcher, this layer is the "main" layer. Mode-switcher calls such as **`set_display_offset()`** that don't target a specific layer affect this layer. Typically, a driver for a "main" layer only reports that a single pixel format is available. This format is the same as the format that was selected when **`set_mode()`** was called.

alpha_valid_flags These are the flags that may be specified in the *alpha_mode* parameter to **`layer_set_blending()`**.

alpha_combinations

alpha_combinations are used to define some capabilities of the alpha-blending hardware for this layer. Defined values are:

- DISP_ALPHA_BLEND_CAP_SPP_WITH_GLOBAL — source per-pixel alpha blending can be used in conjunction with a global alpha multiplier.

- DISP_ALPHA_BLEND_CAP_GLOBAL_WITH_DPP — destination per-pixel blending can be used in conjunction with a global alpha multiplier.
- DISP_ALPHA_BLEND_CAP_SPP_WITH_DPP — source per-pixel alpha blending can be used in conjunction with destination per-pixel alpha blending.

chromakey_caps These flags define some capabilites of the chroma-key hardware for this layer. Defined values are:

- DISP_LAYER_CHROMAKEY_CAP_SRC_SINGLE — chroma-keying based on an exact match between the source-pixel value and a single key color is supported.
- DISP_LAYER_CHROMAKEY_CAP_DST_SINGLE — chroma-keying based on an exact match between the destination-pixel value and a single key color is supported.
- DISP_LAYER_CHROMAKEY_CAP_SHOWTHROUGH — a layer can be configured so that when a chroma-key comparison is made, and the colors match, the pixel displayed comes from the behind the layer. When the colors don't match, the pixel that appears comes from the layer displayed.
- DISP_LAYER_CHROMAKEY_CAP_BLOCK — a layer can be configured so that when a chroma-key comparison is made, and the colors match, the pixel displayed comes from the layer displayed. When the colors don't

match, the pixel that appears comes from behind the layer.

src_max_height The maximum height of the source image that can be displayed. The surface to be displayed may be taller than this value. When this is the case, it isn't possible to display part of the image at the bottom of the surface.

src_max_width The maximum width of the source image that can be displayed. The surface to be displayed may be wider than this value. When this is the case, it isn't possible to display part of the image at the right of the surface.

src_max_viewport_height

Maximum height of the viewport into the source image. The layer isn't capable of fetching an image area for a display that's taller than this value.

src_max_viewport_width

Maximum width of the viewport into the source image. The layer isn't capable of fetching an image area for a display that's wider than this value.

dst_max_height Maximum height of the destination viewport on the display.

dst_max_width Maximum width of the destination viewport on the display.

dst_min_height Minimum height of the destination viewport on the display.

dst_min_width Minimum width of the destination viewport on the display.

max_scaleup_x	Maximum scaling factor for image upscaling in the horizontal direction. A value of 1 means upscaling can't be performed. A value **<** 1 is invalid. A value **>** 1 means that the destination viewport width can be up to *max_scaleup_x* times the source viewport width.
max_scaleup_y	Maximum scaling factor for image upscaling in the vertical direction. A value of 1 means upscaling can't be performed. A value **<** 1 is invalid. A value **>** 1 means that the destination viewport height can be up to *max_scaleup_y* times the source viewport height.
max_scaledown_x	Maximum scaling factor for image downscaling in the horizontal direction. A value of 1 means downscaling can't be performed. A value **<** 1 is invalid. A value **>** 1 means that the source viewport width can be up to *max_scaledown_x* times the destination viewport width.
max_scaledown_y	Maximum scaling factor for image downscaling in the vertical direction. A value of 1 means downscaling can't be performed. A value **<** 1 is invalid. A value **>** 1 means that the source viewport height can be up to *max_scaledown_x* times the destination viewport height.

Classification:

Photon

disp_memfuncs_t

Table of memory management functions

Synopsis:

```
#include <vmem.h>

typedef struct disp_memfuncs {
    int  (*init) (...);
    void (*fini) (...);
    void (*module_info) (...);
    int  (*reset) (...);
    int  (*alloc_surface) (...);
    int  (*alloc_layer_surface) (...);
    int  (*free_surface) (...);
    int  (*mem_avail) (...);
} disp_memfuncs_t;
```

Description:

The **disp_memfuncs_t** structure is a table that your driver uses to define the memory management functions that it provides to the graphics framework. Your driver's *devg_get_memfuncs()* entry point must fill in this structure.

init()

The graphics framework calls this function to initialize the memory manager. The prototype is:

```
int (*init) (disp_adapter_t *adapter,
             char *optstring)
```

The graphics framework calls this function before any of the other functions in the **disp_memfuncs_t** structure. For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

fini()

The graphics framework calls this function to shut down the memory management module, freeing any resources that it allocated. The prototype is:

```
int (*fini) (disp_adapter_t *adapter)
```

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

module_info()

The prototype is:

```
int (*module_info) (disp_adapter_t *adapter,
                    disp_module_info_t *info)
```

This function must fill in the **disp_module_info_t** structure pointed to by *module_info*.

reset()

The graphics framework calls this function to reset the memory management module to its initial state. The prototype is:

```
int (*reset) (
        disp_adapter_t *adapter,
        disp_surface_t *surf  )
```

alloc_surface()

The graphics framework calls this function to allocate video memory to contain a 2D surface. The prototype is:

```
disp_surface_t * (*alloc_surface) (
                     disp_adapter_t *adapter,
                     int width,
                     int height,
                     unsigned format,
                     unsigned flags,
                     unsigned user_flags)
```

The size of the surface is *width* pixels by *height* scanlines. This function must allocate a **disp_surface_t** structure and initialize it to describe the allocated surface memory. Set the structure's *adapter* member to point to the driver's **disp_adapter_t** structure.

☞ If there isn't enough video RAM, your driver can allocate the surface from system RAM, but when the driver works with surfaces, it must use the flags defined for **disp_surface_t** to determine where the surfaces are defined. The driver must also be able to work with surfaces that aren't all in video RAM.

The function must return a pointer to the allocated **disp_surface_t** and must ensure that the memory it allocates conforms to the surface properties requested by the *flags* parameter. This implies that when the function returns, any flags set in *flags* are also set in the *flags* member of the returned surface.

There are currently no user flags defined; your driver should ignore the *user_flags* argument.

alloc_layer_surface()

The graphics framework calls this function to allocate video memory to a layer surface. The prototype is:

```
disp_surface_t * (*alloc_layer_surface) (
                      disp_adapter_t *adapter,
                      int dispno,
                      int width,
                      int height,
                      unsigned sflags,
                      unsigned hint_flags,
                      int layer_idx,
                      unsigned fmt_idx,
                      unsigned surface_idx );
```

The size of the buffer to be allocated is specified in pixels, by the *width* and *height* arguments. This function must allocate a **disp_surface_t** structure and initialize it to describe the allocated memory surface. Set the structure's *adapter* member to point to the driver's **disp_adapter_t** structure.

In the case of planar YUV data, the width and height argument would be the same, regardless of whether a Y, a U, or a V plane were being allocated for a given image. It is up to the driver to know how big the actual buffer size which needs to be allocated, should be.

The function must return a pointer to the allocated **disp_surface_t** and must ensure that the memory it allocates conforms to the surface properties requested by the *sflags* parameter. This implies that when the function returns, any flags set in *sflags* are also set in the *flags* member of the returned surface.

The *sflags* argument is one of the surface flags as defined in the **disp_surface_t** section. However, the following flags have no meaning here:

- DISP_SURFACE_DISPLAYABLE
- DISP_SURFACE_SCALER_DISPLAYABLE

The *fmt_idx* and *surface_idx* arguments select the data format of the surface. Some layer formats split the image components across multiple buffers. A planar YUV surface, for example, requires three buffers to store a valid image. The *surface_idx* argument specifies whether a Y, U, or V buffer gets allocated.

The *fmt_idx* argument selects the data format of the memory to be allocated.

This function should return a pointer to a structure describing the allocated memory surface, or NULL to indicate failure.

The only valid value for *hint_flags* is 0.

free_surface()

The graphics framework calls this function to free the video memory associated with the **disp_surface_t** structure that *surf* points to, as well as freeing the structure itself. The prototype is:

```
int (*free_surface) (disp_adapter_t *adapter,
                     disp_surface_t *surface)
```

mem_avail()

The graphics framework calls this function to determine how much memory is available. The prototype is:

```
int (*mem_avail) (disp_adapter_t *adapter,
                  unsigned sflags)
```

This function returns the amount of video memory available, in bytes. However, the memory that's reported as being available must conform to the surface properties specified by *sflags*.

Classification:

Photon

See also:

devg_get_memfuncs(), **disp_adapter_t**, **disp_mode_info_t**, **disp_surface_t**

disp_mode_info_t

Information for a display mode

Synopsis:

```
#include <mode.h>

typedef struct disp_mode_info {
   short         size;
   disp_mode_t   mode;
   int           xres, yres;
   unsigned      pixel_format;
   unsigned      flags;
   unsigned      crtc_start_gran;
   unsigned      caps;
   union {
       struct {
          short     refresh [DISP_MODE_NUM_REFRESH];
       } fixed;
       struct {
          int       min_vfreq, max_vfreq;
          int       min_hfreq, max_hfreq;
          int       min_pixel_clock;
          int       max_pixel_clock;
          uint8_t   h_granularity;
          uint8_t   v_granularity;
          uint8_t   sync_polarity;
       } generic;
   } u;
   int        num_colors;
   unsigned   crtc_pitch_gran;
} disp_mode_info_t;
```

Description:

The **disp_mode_info_t** structure holds information about a display mode. Your driver fills in this structure when the graphics framework calls the *get_modeinfo* function defined in the **disp_modefuncs_t** structure.

The members of **disp_mode_info_t** include:

size	The size of this structure.

mode	The unique mode ID; see the *get_modelist* function defined in the **`disp_modefuncs_t`** structure.
xres, *yres*	The display dimensions, in pixels.
pixel_format	The frame buffer's pixel format. For more information, see "Pixel formats" in the Writing a Graphics Driver chapter.
flags	Flags that specify various attributes of this mode, selected from the following:

- DISP_MODE_TVOUT — this mode drives a TV, and not a monitor.
- DISP_MODE_TVOUT_OR_MONITOR — this mode can drive a TV or a monitor, but not both simultaneously.
- DISP_MODE_TVOUT_WITH_MONITOR — this mode can drive a TV and a monitor simultaneously.
- DISP_MODE_TVOUT_OVERSCAN — the overscan goes beyond the edge of the TV (i.e. there are no borders at the edges).
- DISP_MODE_TVOUT_NTSC — this mode generates NTSC format video signal.
- DISP_MODE_TVOUT_PAL — this mode generates PAL format video signal.
- DISP_MODE_TVOUT_SECAM — this mode generates SECAM format video signal.
- DISP_MODE_GENERIC — this mode is a generic mode. That is, the mode has a given *pixel_format* but can handle any resolution or refresh rate, within certain constraints. If this flag is set, the members of the *u.generic* structure are defined. Otherwise, the members of the *u.fixed* structure are defined.

Note that there's a macro, *DISP_TVOUT_STANDARD()* that returns just the type of output (PAL, NTSC, SECAM).

crtc_start_gran
: The granularity of the frame buffer base address. Values passed in the *offset* parameter to the *set_display_offset()* function in the **`disp_modefuncs_t`** structure are multiples of this value.

caps
: The list of available features:

- DISP_MCAP_SET_DISPLAY_OFFSET — the display controller can point to different areas of the video RAM. This indicates that its offset into video RAM isn't hard-coded, meaning that it can perform double-buffering operations.
- DISP_MCAP_DPMS_SUPPORTED — the display supports DPMS (if this bit set), else no support.
- DISP_MCAP_VIRTUAL_PANNING — the display supports virtual resolutions that are larger than the physical display, and supports "panning" of the physical viewport into the virtual display.

u.fixed.refresh
: An array of possible refresh rates (in Hz) for this mode. The size of this array is given by DISP_MODE_NUM_REFRESH (i.e. it's the maximum number of refresh rates that can be supported for a given mode).

u.generic.min_vfreq, *u.generic.max_vfreq*
: The monitor vertical frequency limits, in Hz.

u.generic.min_hfreq, *u.generic.max_hfreq*
: The monitor horizontal frequency limits, in kHz.

u.generic.min_pixel_clock, *u.generic.max_pixel_clock*
: The pixel clock limits, in kHz.

u.generic.h_granularity	The horizontal granularity; X resolution must be a multiple of this.
u.generic.v_granularity	The vertical granularity; Y resolution must be a multiple of this.
num_colors	Defined only if the display format is palette-based. It specifies the maximum palette index that the display can handle. For example, the example 16-color VGA driver sets this to 16.

Classification:

Photon

See also:

`disp_modefuncs_t`

Synopsis:

```
#include <mode.h>

typedef struct disp_modefuncs {
    int  (*init) (...);
    void (*fini) (...);
    void (*module_info) (...);
    int  (*get_modeinfo) (...);
    void (*get_modelist) (...);
    int  (*set_mode) (...);
    int  (*wait_vsync) (...);
    int  (*set_dpms_mode) (...);
    int  (*set_display_offset) (...);
    int  (*set_palette) (...);
    void (*set_scroll_position (...);
    int  (*layer_query (...);
    int  (*layer_select_format  (...);
    int  (*layer_enable  (...);
    int  (*layer_disable  (...);
    int  (*layer_set_surface  (...);
    int  (*layer_set_source_viewport  (...);
    int  (*layer_set_dest_viewport  (...);
    int  (*layer_set_blending  (...);
    int  (*layer_set_chromakey  (...);
    int  (*layer_set_brightness  (...);
    int  (*layer_set_saturation  (...);
    int  (*layer_set_contrast  (...);
    int  (*layer_set_flags  (...);
    void (*layer_update_begin  (...);
    void (*layer_update_end  (...);
    void (*layer_reset  (...);


} disp_modefuncs_t;
```

Description:

The **disp_modefuncs_t** structure is a table that your driver uses to define the modeswitcher functions that it provides to the graphics framework. Your driver's *devg_get_modefuncs()* entry point must fill in this structure.

init()

The graphics framework calls this function to initialize your hardware. The prototype is:

```
int (*init) (disp_adapter_t *ctx,
             char *optstring)
```

This function should return the number of displays that this modeswitcher controls, or -1 to indicate an error. For example, if a display card controls both a flat-panel and a monitor simultaneously, this function should return 2.

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

fini()

The graphics framework calls this function to return your hardware to the uninitialized state, deallocate resources, and so on. The prototype is:

```
void (*fini) (disp_adapter_t *ctx)
```

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

module_info()

The graphics framework calls this function to get information about the module, such as its description and revision numbers. The prototype is:

```
void (*module_info) (disp_adapter_t *adapter,
                     disp_module_info_t *info);
```

This function should fill in the **disp_module_info_t** structure pointed to by *info*.

get_modeinfo()

The graphics framework calls this function to get mode information. The prototype is:

```
int (*get_modeinfo) (disp_adapter_t *ctx,
                     int dispno,
                     unsigned mode,
                     disp_mode_info_t *info)
```

This function should populate the **disp_module_info_t** structure pointed to by *info* with information pertaining to the mode specified in *mode* for the display referenced by *dispno*. See the note about modes in *get_modelist()* below for more information.

get_modelist()

The graphics framework calls this function to get a list of the modes that your driver supports. The prototype is:

```
void (*get_modelist) (disp_adapter_t *ctx,
                      int dispno,
                      disp_mode_t *list,
                      int index,
                      int size)
```

This function should place a maximum of *size* modes into the array *list*, starting at the index *index*, for the display referenced by *dispno*. The *index* parameter is in place to allow multiple calls to the *get_modelist()* function in case there are more modes than will fit into the *list* array on any given call.

The list of modes is terminated with the constant DISP_MODE_LISTEND — don't return this as a valid mode. The list of modes must be returned in the exact same order each time, but there's no requirement to arrange the list by any sorting criteria.

☞ It's the *mode number* (the *content* of the *list* array) that's important for subsequent calls, and *not* the mode index itself.

For example, if your driver returns the following array:

```
list [0] = 0x1234;
list [1] = 0x070B;
list [2] = 0x4321;
list [3] = DISP_MODE_LISTEND; // terminate list
```

then your *get_modeinfo()* and *set_mode()* functions are called with, for example, **0x4321** and *not* the index 2.

☞ The driver should use only the 15 least significant bits of the **disp_mode_t** type. Thus each entry in *list* must be less than or equal to **0x7fff**.

set_mode()

The graphics framework calls this function to set the hardware for the display referenced by *dispno* to the mode specified by *mode*. The prototype is:

```
int (*set_mode) (disp_adapter_t *ctx,
                 int dispno,
                 unsigned mode,
                 disp_crtc_settings_t *settings,
                 disp_surface_t *surf,
                 unsigned flags)
```

See the note about modes in *get_modelist()* above for more information.

The *settings* parameter is valid *only* if the mode is a generic mode, which means that the framework can pass an arbitrary X and Y resolution and refresh rate. The driver advertises that it can support generic modes by setting the appropriate flag in the **disp_mode_info_t** structure when *get_modeinfo()* is called.

If your driver supports virtual panning, the virtual screen might be larger than the physical screen resolution of the requested mode. The virtual x and y resolutions are passed in *surf*->*width* and *surf*->*height*. The *surf*->*stride* member specifies the stride, in bytes, that the driver should use to program the CRTC controller.

For more information on where this function fits into the general flow, see "Calling sequence" in the Writing a Graphics Driver chapter.

wait_vsync()

This function must wait until the display controller for the display referenced by *dispno* enters the vertical-retrace period. The prototype is:

```
int  (*wait_vsync) (disp_adapter_t *adapter,
                    int dispno);
```

set_dpms_mode()

The graphics framework calls this function to set the DPMS mode. mode. The prototype is:

```
void (*set_dpms_mode) (disp_adapter_t *ctx,
                       int dispno,
                       int mode)
```

Select a DPMS mode for the display referenced by *dispno* as follows:

Mode	Meaning
0	On
1	Standby
2	Suspend
4 (not a typo)	Off

set_display_offset()

The graphics framework calls this function to set the frame buffer base of the visible display for the display controller referenced by *dispno*. The prototype is:

```
void (*set_display_offset) (disp_adapter_t *ctx,
                            int dispno,
                            unsigned offset,
                            int wait_vsync)
```

☞ The *offset* member must be a multiple of the *crtc_start_gran* member of the **disp_mode_info_t** structure.

If *wait_vsync* is nonzero, your driver should wait for the next vertical retrace period before returning from this function.

set_palette()

The graphics framework calls this function to set the palette for the display referenced by *dispno*. The prototype is:

```
void (*set_palette) (disp_adapter_t *ctx,
                     int dispno,
                     int index,
                     int count,
                     disp_color_t *pal)
```

One or more entries in the palette can be set at a time with this function call. The *index* indicates the starting palette index, and *count* indicates the number of entries being set. Finally, *pal* contains an array of color values, one per entry, to set.

☞ If this function is specified (i.e. not NULL in the function pointer *set_palette*), then it's called regardless of whether or not the *set_palette()* function in the miscellaneous callouts structure, **disp_draw_miscfuncs_t**, has been supplied:

```
if (disp_modefuncs -> set_palette) {
    (*disp_modefuncs -> set_palette) (...);
} else if (disp_draw_miscfuncs -> set_palette) {
    (*disp_draw_miscfuncs -> set_palette (...);
}
```

set_scroll_position()

The graphics framework calls this function to scroll, or pan around a virtual desktop when the virtual display surface is bigger than the physical display. If your driver supports Virtual Panning, you must provide this function. The prototype is:

```
void (*set_scroll_position) (
        disp_adapter_t *adapter,
        int dispno,
        int xoff,
        int yoff )
```

This function should set the physical viewport into the virtual display surface such that the point (*xoff*, *yoff*) within the virtual display appears at the upper left corner of the physical display.

layer_query()

The graphics framework calls this function to query the capabilities of a given layer. The prototype is:

```
int (*layer_query) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int fmt_idx,
disp_layer_query_t  *info);
```

The arguments to *layer_query* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer being queried. Layers are indexed starting at 0.
fmt_idx	The index that pertains to the data format that's returned. Formats are indexed starting at 0.
info	A pointer to a structure that the driver fills in based on the selected layer and data format. The information returned for a layer can vary for different pixel formats. For more information on pixel formats for layers, see "Pixel formats for layers" in the Writing a Graphics Driver chapter.

If the *layer_idx* or *fmt_idx* indexes are out of range, this function should return -1, otherwise it should return 0.

layer_select_format()

The graphics framework calls this function to select the pixel format of the the layer specified by *layer_idx*. The prototype is:

```
int (*layer_select_format) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int fmt_idx )
```

The format specified by *fmt_idx* corresponds to the *fmt_idx* that was passed to *layer_query*.

The arguments to *layer_select_format* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.

layer_idx	The index of the layer that corresponds to the pixel format selected. Layers are indexed starting at 0.
fmt_idx	The index that pertains to the pixel format selected. Formats are indexed starting at 0.

If the *dispno*, *layer_idx*, or *fmt_idx* indexes are out of range, this function should return -1 to indicate an error, otherwise it should return 0.

layer_enable()

The graphics framework calls this function to make the layer specified by *layer_idx* visible. The prototype is:

```
int (*layer_enable) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx )
```

The arguments to *layer_enable* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer that *layer_idx* makes visible. Layers are indexed starting at 0.

If the *dispno* or *layer_idx* indexes are out of range, or the layer can't be disabled or reenabled, this function should return -1 to indicate an error, otherwise it should return 0.

layer_disable()

The graphics framework calls this function to make the layer specified by *layer_idx* invisible. The prototype is:

```
int (*layer_enable) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx )
```

The arguments to *layer_disable* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer that *layer_idx* makes invisible. Layers are indexed starting at 0.

If the *dispno*, or *layer_idx* indexes are out of range, or the layer can't be disabled or re-enabled, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_surface()

The graphics framework calls this function to associate a memory surface with the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_surface) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int surface_idx,
        disp_surface_t *surf )
```

The arguments to *layer_set_surface* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer associated with the memory surface. Layers are indexed starting at 0.
surface_idx	The meaning of this argument depends on the layer image format selected by *layer_select_format*. Some layer formats split the image components across multiple buffers. A planar YUV surface, for

	example, requires three buffers to store a valid image. In this case, the *surface_idx* argument specifies whether a Y, U, or V buffer gets allocated.
surf	A pointer to the surface created by **`disp_surface_t`**.

The memory surface was created by the driver's *alloc_layer_surface()* management entry point. The *layer_select_format* entry point is called *before* this entry point.

If the *dispno* or *layer_idx* indexes are out of range, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_source_viewport()

The graphics framework calls this function to set the size of the source viewport for the layer that *layer_idx* specifies. The prototype is:

```
int (*layer_set_source_viewport) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int x1, y1,
        int x2, y2 )
```

The arguments to *layer_set_source_viewport* are:

adapter	A pointer to the **`disp_adapter_t`** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer that corresponds to the source viewport. Layers are indexed starting at 0.
x1, *y1*	The location of the top-left edge of the source viewport.
x2, *y2*	The location of the bottom-right edge of the source viewport.

This function should return -1 if:

- indexes are out of range

  Or:

- viewport width is outside range

  Or:

- viewport size is outside range

Otherwise the function should return 0.

layer_set_dest_viewport()

The graphics framework calls this function to set the size of the destination viewport for the layer that *layer_idx* specifies. The prototype is:

```
int (*layer_set_dest_viewport) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int x1, y1,
        int x2, y2 )
```

The arguments to *layer_set_dest_viewport* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of the layer that corresponds to the destination viewport. Layers are indexed starting at 0.
x1, *y1*	The location of the top-left edge of the destination viewport.
x2, *y2*	The location of the bottom-right edge of the destination viewport.

If the *dispno* or *layer_idx* indexes are out of range, or the viewport width for the capabilities structure for this layer is outside the ranges specified by *dst_max_height*, *dst_min_height*, *dst_max_width*, and *dst_min_width*, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_blending()

The graphics framework calls this function to set the layer's blending configuration for the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_blending) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        unsigned alpha_mode,
        int m1,
        int m2 )
```

The arguments to *layer_set_blending* are:

adapter	A pointer to the **`disp_adapter_t`** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index of layer to blend. Layers are indexed starting at 0.
alpha_mode	The logical OR of up to four different flags. Four groups of flags are available, and either zero or one flags can be selected from each group. When a value of **`0`** is passed for *alpha_mode*, alpha blending is disabled.
m1	A primary alpha multiplier that's used when there's a request for blending using global alpha multipliers.
m2	A secondary alpha multiplier that's used when there's a request for blending using global alpha multipliers.

If the *dispno* or *layer_idx* indexes are out of range, this function should return -1 to indicate an error, otherwise it should return 0.

If the layer selected by *layer_idx* doesn't support the combination of flags specified by *alpha_mode*, this function should return -1, otherwise it should return 0.

For more information on global alpha multipliers, and the currently defined flags, see "Alpha mode bits."

layer_set_chromakey()

The graphics framework calls this function to set the layer's chroma-key configuration for the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_chromakey) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        unsigned chroma_mode,
        disp_color_t color0,
        disp_color_t color1,
        disp_color_t mask );
```

The arguments to *layer_set_chromakey* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the chroma-key configuration.
chroma_mode	Selected from: *DISP_CHROMA_OP_SRC_MATCH*, *DISP_CHROMA_OP_DST_MATCH*, *DISP_CHROMA_OP_DRAW*, *DISP_CHROMA_OP_NO_DRAW* *DISP_CHROMA_OP_SRC_MATCH* and *DISP_CHROMA_OP_DST_MATCH* are mutually exclusive.

	DISP_CHROMA_OP_DRAW and *DISP_CHROMA_OP_NO_DRAW* are also mutually exclusive. If 0 is passed for *chroma-mode*, chroma-keying is disabled. For more information on chroma key mode bits, see "Chroma mode bits"
color0	The color to test on.
color1	Reserved; ignore this argument.
mask	Reserved; ignore this argument.

If the layer selected by *layer_idx* doesn't support the combination of flags specified by *chroma_mode*, this function should return -1, otherwise it should return 0.

layer_set_brightness()

The graphics framework calls this function to set the brightness attribute of the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_brightness) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int brightness );
```

The arguments to *layer_set_brightness* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the brightness adjustment. Layers are indexed starting at 0.

brightness	The brightness value, in the range from **127** to **-128**, where **127** is brightest, and **-128** is darkest. A value of **0** is normal brightness.

If the selected layer doesn't support brightness adjustment, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_saturation()

The graphics framework calls this function to set the color saturation attribute of the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_saturation) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int saturation );
```

The arguments to *layer_set_saturation* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the saturation adjustment. Layers are indexed starting at 0.
saturation	The saturation value, in the range from **127** to **-128**, where **127** is most saturated, and **-128** is least saturated. A value of **0** is normal saturation.

If the selected layer doesn't support saturation adjustment, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_contrast()

The graphics framework calls this function to set the contrast attribute of the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_contrast) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        int contrast );
```

The arguments to *layer_set_contrast* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the contrast adjustment. Layers are indexed starting at 0.
contrast	The contrast value, in the range from **127** to **-128**, where **127** is the highest contrast, and **-128** is the lowest contrast. A value of **0** is normal contrast.

If the selected layer doesn't support contrast adjustment, this function should return -1 to indicate an error, otherwise it should return 0.

layer_set_flags()

The graphics framework calls this function to set various attributes of the layer specified by *layer_idx*. The prototype is:

```
int (*layer_set_flags) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx,
        unsigned flag_mask
        unsigned flag_values );
```

The arguments to *layer_set_flags* are:

adapter	A pointer to the **`disp_adapter_t`** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the attributes that are set. Layers are indexed starting at 0.
flag_mask	The bits whose values are to be changed. If a bit isn't set in *flag_mask*, the corresponding flag isn't affected.
flag_values	The new settings that correspond to the bits set in *flag_mask*.

The following flags are supported:

DISP_LAYER_FLAG_DISABLE_FILTERING

Disable any filtering algorthims that are applied to the image data before the image is displayed. When scaling is in effect, pixel replication is used instead of filtering to produce the scaled image, if pixel replication is supported.

DISP_LAYER_FLAG_EDGE_CLAMP

If the image being displayed isn't large enough to fill the destination viewport, then the unfilled right and bottom portions of the viewport are filled by replicating the last pixel that was displayed to the edge of the viewport.

DISP_LAYER_FLAG_EDGE_WRAP

If the image being displayed isn't large enough to fill the destination viewport, then the unfilled right and bottom portions of the viewport are filled by wrapping around to the top, left portions of the image.

If the selected layer isn't supported by one or more of the flags specified by *flag_mask*, this function should return -1 to indicate an error, otherwise it should return 0.

layer_update_begin()

This function *must* be called before you make any adjustments to the layer configuration. The driver should attempt to make multiple adjustments atomic, by having the adjustments take effect at the time *layer_update_end()* is called. The prototype is:

```
void  (*layer_update_begin) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx );
```

The arguments to *layer_update_begin* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the updates. Layers are indexed starting at 0.

layer_update_end()

The prototype is:

```
void  (*layer_update_end) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx );
```

The arguments to *layer_update_end* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The layer index for the updates. Layers are indexed starting at 0.

Before any calls are made that affect the layer configuration, *layer_update_begin()* is called, and subsequently *layer_update_end()* makes the changes effective.

This function runs after adjustments are made to the layer configuration. Any adjustments made since *layer_update_begin()* was called, will now take effect.

☞ The *layer_query()* function doesn't affect the layer configuration and is therefore an exception to this rule.

layer_reset()

The prototype is:

```
void  (*layer_reset) (
        disp_adapter_t *adapter,
        int dispno,
        int layer_idx );
```

The arguments to *layer_reset* are:

adapter	A pointer to the **disp_adapter_t** structure.
dispno	The display associated with the layer selected by *layer_idx*.
layer_idx	The index for the reset layers. Layers are indexed starting at 0.

This function resets the specified layer to its initial state.

A layer should be reset to its initial state after a modeswitch.

The initial state is defined as one where:

- a layer that can be disabled, is disabled (i.e. made invisible)
- the brightness, contrast, and color saturation of the layer are all set to **0**

- all the flags that can be set using *layer_set_flags()* are set to **0**
- the chroma-key state, the alpha-blending state, and the size and position of the source and destination viewports are undefined.

Classification:

Photon

See also:

devg_get_modefuncs(), **disp_adapter_t**, **disp_crtc_settings_t**, **disp_mode_info_t**, **disp_module_info_t**, **disp_surface_t**

disp_module_info_t

Driver module information

Synopsis:

```
#include <display.h>

typedef struct disp_module_info {
    uint8_t     ddk_version_major;
    uint8_t     ddk_version_minor;
    uint8_t     ddk_rev;
    uint8_t     driver_rev;
    char        *description;
    unsigned    reserved[16];
} disp_module_info_t;
```

Description:

The **disp_module_info_t** structure stores module information about your driver. Your driver must fill in this structure when the graphics framework calls the *module_info()* function that your driver defines in these structures:

- **disp_draw_miscfuncs_t**
- **disp_memfuncs_t**
- **disp_modefuncs_t**
- **disp_vidfuncs_t**

The members of the **disp_module_info_t** structure include:

ddk_version_major
: The major version number of the Graphics DDK that you used to build your driver. Set this to DDK_VERSION_MAJOR.

ddk_version_minor
: The minor version number of the DDK; set it to DDK_VERSION_MINOR.

ddk_rev
: The revision number of the DDK; set it to DDK_REVISION.

driver_rev	The revision of the driver; use this member as you see fit.
description	A string that describes the driver module. The recommended format is the driver name, followed by a space, a hyphen, another space, and then a generic description of the hardware that the driver should support. For example, **`vga - driver for VGA-compatible devices`**.

Classification:

Photon

See also:

disp_draw_miscfuncs_t, **disp_memfuncs_t**, **disp_modefuncs_t**, **disp_vidfuncs_t**

disp_surface_t

Description of a two-dimensional surface

Synopsis:

```
#include <display.h>

typedef struct disp_surface {
    int               size;
    unsigned          pixel_format;
    unsigned          offset;
    unsigned char     *vidptr;
    uintptr_t         paddr;
    unsigned          stride;
    unsigned          flags;
    int               width;
    int               height;
    disp_color_t      *palette;
    int               palette_valid_entries;
    disp_adapter_t    *adapter;
    unsigned          reserved;
} disp_surface_t;
```

Description:

The **disp_surface_t** structure describes a two-dimensional surface. It's used as an argument to several functions, and is also used within other structures, such as **disp_draw_context_t**.

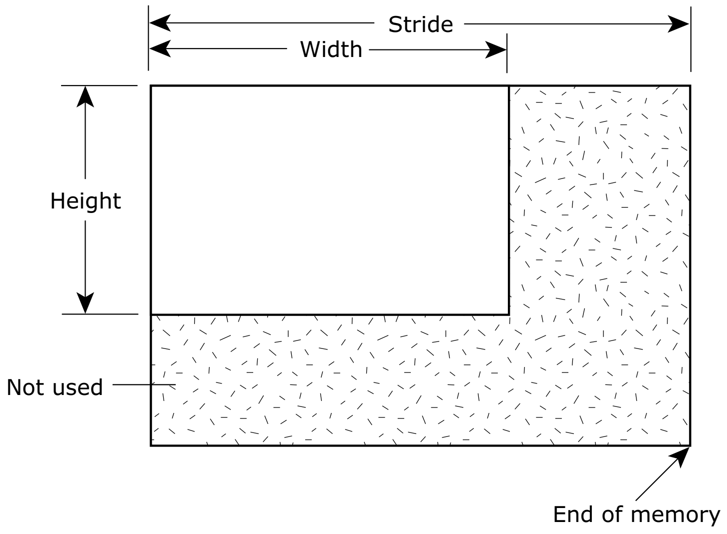
The members include:

size	The size of this structure. Any time a driver creates a structure of this type, it should set this member to **sizeof (disp_surface_t)**.
pixel_format	The pixel format. For more information, see "Pixel formats" in the Writing a Graphics Driver chapter.
offset	A device-dependent address that points to the start of the surface data.
vidptr	The virtual (CPU) address that points to the start of the surface data.

paddr	The physical (bus) address that points to the start of the surface data.
stride	The number of bytes from the beginning of one scanline to the beginning of the next (see diagram below).
flags	Surface flags, defined below.
width	The width of the surface, in pixels (see diagram below).
height	The height of the surface, in scan lines (see diagram below).
pal_ptr	A pointer to the palette for this surface. If not a palette type, this pointer is NULL.
pal_valid_entries	The number of entries that are valid in the *pal_ptr* palette. For palette-based surface data, pixel values in the data shouldn't exceed this value, otherwise they might reference past the end of the palette array.
adapter	A pointer to the **`disp_adapter_t`** structure for the device that created this surface (if any).

Relationship of *stride*, *height*, and *width*

The three members, *stride*, *height*, and *width* are used to define a surface as follows:



Memory layout.

The entire content of the box represents the total memory area available, and the unshaded portions represent the memory area that's actually used for the surface.

☞ Don't overwrite the "not used" areas; it might be used to store other surfaces.

flags

The *flags* member is a bitmap of the following values:

DISP_SURFACE_DISPLAYABLE
: The surface can be displayed via CRT controller.

DISP_SURFACE_CPU_LINEAR_READABLE
: The CPU can read this surface directly.

DISP_SURFACE_CPU_LINEAR_WRITEABLE
: The CPU can write to this surface directly.

DISP_SURFACE_2D_TARGETABLE

The 2D engine can render into this surface.

DISP_SURFACE_2D_READABLE

The surface is read-accessible by 2D engine.

DISP_SURFACE_3D_TARGETABLE

The 3D engine can render into surface.

DISP_SURFACE_3D_READABLE

The surface is read-accessible by 3D engine.

DISP_SURFACE_SCALER_DISPLAYABLE

The surface can be displayed via video overlay scaler.

DISP_SURFACE_VMI_TARGETABLE

Video capture hardware can write frames into this surface.

DISP_SURFACE_DMA_SAFE

The DMA engine can treat the surface memory as one contiguous block.

DISP_SURFACE_PAGE_ALIGNED

Surface memory starts on a page boundary.

DISP_SURFACE_OTHER_ENDIAN

Surface memory accesses by CPU are byte-swapped; the device on which the memory resides in the opposite "endian" from the CPU.

DISP_SURFACE_NON_CACHEABLE

The CPU shouldn't map the surface memory as cacheable.

DISP_SURFACE_PHYS_CONTIG

The surface memory is physically contiguous, from a bus master device's perspective.

Classification:

Photon

See also:

disp_adapter_t, **disp_draw_context_t**, **disp_draw_contextfuncs_t**, **disp_draw_corefuncs_t**, **disp_draw_miscfuncs_t**, **disp_memfuncs_t**, **disp_modefuncs_t**, **disp_vidfuncs_t**

Synopsis:

```
typedef struct {
    unsigned    flags;

    unsigned    input_format;
    int     frame_width;
    int     frame_height;
    int     frame_rate;

    unsigned    output_format;

    unsigned    reserved[10];
} disp_vcap_channel_caps_t;
```

Description:

The **disp_vcap_channel_caps_t** structure describes the capabilities of a video capture unit. The members include:

flags Flags that describe the capabilities:

- DISP_VCAP_CAP_SOURCE_TUNER — can capture video from a TV tuner.
- DISP_VCAP_CAP_SOURCE_SVIDEO — can capture video from an S-Video connector.
- DISP_VCAP_CAP_SOURCE_COMPOSITE — can capture video from an Composite video connector.
- DISP_VCAP_CAP_BRIGHTNESS_ADJUST — brightness can be adjusted.
- DISP_VCAP_CAP_CONTRAST_ADJUST — contrast can be adjusted.
- DISP_VCAP_CAP_SATURATION_ADJUST — saturation can be adjusted.
- DISP_VCAP_CAP_HUE_ADJUST — green Hue can be adjusted.

- DISP_VCAP_CAP_AUDIO_SOURCE_MUTE — audio can be muted.
- DISP_VCAP_CAP_AUDIO_SOURCE_TUNER — audio can be routed from a TV tuner through the capture unit.
- DISP_VCAP_CAP_AUDIO_SOURCE_EXTERNAL — audio can be routed from an external line in through the capture unit.
- DISP_VCAP_CAP_DOWNSCALING — the capture unit can scale video frames downwards.
- DISP_VCAP_CAP_UPSCALING — the capture unit can scale video frames upwards.
- DISP_VCAP_CAP_CROPPING — the capture unit can crop frames prior to scaling.
- DISP_VCAP_CAP_DOUBLE_BUFFER — the capture unit can alternate its output between two buffers.

input_format The format of the incoming video signal; one of:

- DISP_TV_SIGNAL_NTSC
- DISP_TV_SIGNAL_NTSC_JAPAN
- DISP_TV_SIGNAL_PAL
- DISP_TV_SIGNAL_PAL_M
- DISP_TV_SIGNAL_PAL_N
- DISP_TV_SIGNAL_PAL_N_COMBO
- DISP_TV_SIGNAL_SECAM

frame_width The width of the output frames, in pixels, prior to scaling.

frame_height The height of the output frames, in scanlines, prior to scaling.

frame_rate The frequency of frames output, in Hz (e.g. 30 for NTSC).

output_format	The data format of the frames output by the scaler unit; see “Pixel formats” in the Writing a Graphics Driver chapter.

Classification:

Photon

See also:

`disp_vcapfuncs_t`

disp_vcap_channel_props_t

Configurable properties of a video capture unit

Synopsis:

```
typedef struct {
    unsigned    size;
    unsigned    flags;
    unsigned    video_source;
    unsigned    audio_source;
    unsigned    input_format;
    unsigned    output_format;
    int         tuner_channel;
    int         Fif;
    short       dst_width;
    short       dst_height;
    short       crop_top;
    short       crop_bottom;
    short       crop_left;
    short       crop_right;
    short       brightness;
    short       contrast;
    short       u_saturation;
    short       v_saturation;
    short       hue;
    short       reserved;
    unsigned    update_flags;
    int         scaler_index;
    unsigned    reserved2[6];
} disp_vcap_channel_props_t;
```

Description:

The **disp_vcap_channel_props_t** describes the configurable properties of a video capture unit. The members include:

size Filled in with **sizeof (disp_vcap_channel_props_t)** on instantiation.

flags Valid flags are:

- DISP_VCAP_FLAG_AFT_ON — enable Auto Fine Tuning. After the driver programs the TV tuner to the requested frequency and band, the driver can use feedback from the tuner hardware in order to adjust the frequency to improve signal quality.

- DISP_VCAP_FLAG_RUNNING — the driver should enable streaming of incoming video frames only if this flag is set.
- DISP_VCAP_FLAG_DOUBLE_BUFFER — enable double buffering of the incoming video frames. The driver should direct each alternate frame of data to the alternate memory buffer.
- DISP_VCAP_FLAG_SYNC_WITH_SCALER — valid when DISP_VCAP_FLAG_DOUBLE_BUFFER is also specified. The driver should attempt to configure the hardware such that whenever a complete frame of data arrives, the scaler is automatically set to display the new frame.

  Note that the scaler hardware is already configured up when the *set_channel_props()* function defined in the **disp_vcapfuncs_t** structure is called. If the driver can't synchronize the capture unit with the scaler specified by the *scaler_index* member of the **disp_vcap_channel_props_t** structure in this manner, this function should simply act as if this flag hadn't been specified.

video_source The source of the video signal to be captured:

- DISP_VCAP_SOURCE_TUNER — capture from the output of the TV tuner.
- DISP_VCAP_SOURCE_SVIDEO — capture from the SVideo connector.
- DISP_VCAP_SOURCE_COMPOSITE — capture from the Composite video connector.

If something other than one of the above is specified, the driver should default to something reasonable.

audio_source
: The source of the audio signal that's routed through the capture unit:

- DISP_VCAP_AUDIO_SOURCE_MUTE — mute the audio output from the capture unit.
- DISP_VCAP_AUDIO_SOURCE_TUNER — route the audio signal from the TV tuner through the capture unit.
- DISP_VCAP_AUDIO_SOURCE_EXTERNAL — route the audio signal from the external line in through the capture unit.

input_format
: The encoding of the incoming signal to be captured:

- DISP_TV_SIGNAL_NTSC
- DISP_TV_SIGNAL_NTSC_JAPAN
- DISP_TV_SIGNAL_PAL
- DISP_TV_SIGNAL_PAL_M
- DISP_TV_SIGNAL_PAL_N
- DISP_TV_SIGNAL_PAL_N_COMBO
- DISP_TV_SIGNAL_SECAM

output_format
: The format of the data output by the capture unit; see "Pixel formats" in the Writing a Graphics Driver chapter.

tuner_channel
: The tuner frequency, in Hertz, to which the TV tuner should be programmed.

Fif
: The Intermediate Frequency, in Hertz, to be used when programming the TV tuner.

dst_width
: The output width of the frames after scaling.

dst_height	The output height of the frames after scaling.
crop_top	The number of lines to crop off the top of the captured before scaling.
crop_bottom	The number of lines to crop off the bottom of the captured before scaling.
crop_left	The number of lines to crop off the left of the captured before scaling.
crop_right	The number of lines to crop off the right of the captured before scaling.
brightness	The luminance adjustment to captured video. This is a signed value, where 0 means no adjustment, 32767 is the maximum brightness, and -32768 is the darkest.
contrast	The contrast adjustment to captured video. This is a signed value, where 0 means normal contrast, 32767 is the maximum contrast, and -32768 is the minimum.
u_saturation	The saturation level of the Cr chroma component of captured video. This is a signed value, where 0 means normal saturation, 32767 is the maximum saturation, and -32768 is the minimum.
v_saturation	The saturation level of the Cb chroma component of captured video. This is a signed value, where 0 means normal saturation, 32767 is the maximum saturation, and -32768 is the minimum.
hue	The level of green hue adjustment to captured video. This is a signed value, where 0 means no adjustment, 32767 is the maximum hue, and -32768 is the minimum.
update_flags	Flags that indicate which members of the **`disp_vcap_channel_props_t`** structure contain

valid data that should be used to program the capture unit:

Flag	Valid member(s)
DISP_VCAP_UPDATE_VIDEO_SOURCE	*video_source*
DISP_VCAP_UPDATE_AUDIO_SOURCE	*audio_source*
DISP_VCAP_UPDATE_INPUT_FORMAT	*input_format*
DISP_VCAP_UPDATE_OUTPUT_FORMAT	*output_format*
DISP_VCAP_UPDATE_TUNER	*tuner_channel*, *Fif*
DISP_VCAP_UPDATE_OUTPUT_SIZE	*dst_width*, *dst_height*, *crop_top*, *crop_bottom*, *crop_left*, *crop_right*
DISP_VCAP_UPDATE_BRIGHTNESS	*brightness*
DISP_VCAP_UPDATE_CONTRAST	*contrast*
DISP_VCAP_UPDATE_SATURATION	*u_saturation*, *v_saturation*
DISP_VCAP_UPDATE_HUE	*hue*
DISP_VCAP_UPDATE_OUTPUT_TARGET	One or more of the **plane** parameters is valid, and one or more of the buffers described by the **plane** parameters has changed since the last time this function was called.

Classification:

Photon

See also:

`disp_vcapfuncs_t`

disp_vcap_channel_status_t

Status of a video capture unit

Synopsis:

```
typedef struct {
unsigned  size;
unsigned flags;
unsigned reserved[8];
} disp_vcap_channel_status_t;
```

Description:

The **disp_vcap_channel_status_t** structure describes the status of a video capture unit. The members include:

size Filled in with **sizeof (disp_vcap_channel_status_t)** on instantiation.

flags Currently defined flags:

- DISP_VCAP_STATUS_TUNED — the TV tuner hardware has stabilized.
- DISP_VCAP_STATUS_CHANNEL_PRESENT — a good signal has been detected on the currently tuned channel.
- DISP_VCAP_STATUS_VIDEO_PRESENT — a video signal has been detected on the current channel.
- DISP_VCAP_STATUS_STEREO — stereo audio has been detected on the current channel.

Classification:

Photon

See also:

disp_vcapfuncs_t

disp_vcapfuncs_t

Table of video capture functions

Synopsis:

```
#include <vid.h>

typedef struct disp_vcapfuncs {
    int  (*init) (...);
    void (*fini) (...);
    void (*module_info) (...);
    int  (*get_channel_caps) (...);
    int  (*get_channel_status) (...);
    int  (*set_channel_props) (...);
    int  (*close_channel) (...);
} disp_vcapfuncs_t;
```

Description:

The **disp_vcapfuncs_t** structure is a table that your driver uses to define the video capture functions that it provides to the graphics framework. Your driver's *devg_get_vcapfuncs()* entry point must fill in this structure.

init()

The graphics framework calls this function to initialize the modeswitcher. The prototype is:

```
int (*init) (disp_adapter_t *adapter,
             char *optstring)
```

This function should return the number of capture units available.

fini()

The graphics framework calls this function to free resources and disable all scalers (making them invisible). The prototype is:

```
void (*fini) (disp_adapter_t *adapter)
```

This function must free any offscreen memory that was allocated for frame data.

module_info()

The graphics framework calls this function to get information about the module. The prototype is:

```
void (*module_info) (disp_adapter_t *adapter,
                     disp_module_info_t *info)
```

This function must fill the given **disp_module_info_t** structure.

get_channel_caps()

The graphics framework calls this function to get the scaler capabilities for a given pixel format. The prototype is:

```
int (*get_channel_caps) (
        disp_adapter_t *adapter,
        int channel,
        int input_fmt_index,
        int output_fmt_index,
        disp_vcap_channel_caps_t *caps)
```

This function should fill in the **disp_vcap_channel_caps_t** structure pointed to by *caps*.

The video capture module is responsible for controlling video capture hardware, which takes a video stream from a source such as a TV tuner, and turns it into a sequence of video frames. Currently, the interface defined here is mainly intended to support devices that stream data into the video frame buffer, especially into buffers whose contents can be displayed by the video scaler.

Currently, viewing of TV or live video in a window can be supported by higher level software, but full video capture (e.g. capture to disk) isn't yet supported.

A hardware device may integrate zero or more video capture units. The *channel* argument is a zero-based index that represents the device for which the device capabilities should be returned.

A video capture unit captures a video stream of a particular format (e.g. an analog NTSC signal) and converts it to a sequence of video frames that are of a particular format (e.g. packed YUV 422).

A capture unit may support one or more input formats, and one or more output formats. The *input_fmt_index* and *output_fmt_index* arguments are zero-based indexes that represent the input and output formats for which to provide information.

If *input_fmt_index* is greater than or equal to the number of input formats supported, or if *output_fmt_index* is greater than or equal to the number of output formats supported, this function should return -1, otherwise it should return 0.

get_channel_status()

The graphics framework calls this function to get the channel status. The prototype is:

```
int (*get_channel_status) (
        disp_adapter_t *adapter,
        int channel,
        disp_vcap_channel_status_t *caps );
```

This function should fill in the **disp_vcap_channel_status_t** structure pointed to by *caps* with status information for the capture unit specified by *channel*.

The *get_channel_status()* function should return 0 on success, or -1 on failure.

set_channel_props()

The graphics framework calls this function to set the scaler capabilities. The prototype is:

```
int (*set_channel_props) (
        disp_adapter_t *adapter,
        int channel,
        disp_vcap_channel_props_t *props,
        disp_surface_t *yplane1,
        disp_surface_t *yplane2,
        disp_surface_t *uplane1,
        disp_surface_t *uplane2,
        disp_surface_t *vplane1,
        disp_surface_t *vplane2)
```

This function should configure the the capture unit specified by *channel*, based on the contents of the **disp_vcap_channel_props_t** structure pointed to by *props*. The **plane** arguments describe the buffers where the incoming video is to be streamed. Depending on the properties specified by *props*, *set_channel_props()* may ignore some of the **plane** structures:

- When single-buffering, you should ignore the **plane2* arguments.
- For non-planar formats, you should ignore the *uplane** and *vplane** arguments.

In the case of packed RGB data, *yplane1* (and *yplane2*, if double buffering) specify where the data is to be streamed.

The *set_channel_props()* function should return 0 on success, or -1 on failure.

close_channel()

The graphics framework calls this function to close a channel. The prototype is:

```
int (*close_channel) (disp_adapter_t *adapter,
                      int channel)
```

This function should halt the video capture unit specified by *channel*, and free any system resources that were associated with it.

Classification:

Photon

See also:

devg_get_vcapfuncs(), **disp_adapter_t**, **disp_module_info_t**, **disp_surface_t**, **disp_vcap_channel_caps_t**, **disp_vcap_channel_props_t**, **disp_vcap_channel_status_t**

disp_vid_alpha_t

A region of the video viewport to be blended with the desktop

Synopsis:

```
#include <vid.h>

typedef struct {
    unsigned char    src_alpha;
    unsigned char    dst_alpha;
    unsigned         alpha_mode;
    unsigned short   x1;
    unsigned short   x2;
    unsigned short   y1;
    unsigned short   y2;
} disp_vid_alpha_t;
```

Description:

The **disp_vid_alpha_t** structure describes a region of the video viewport to be blended with desktop. The members include:

src_alpha	The source alpha blending factor.
dst_alpha	The destination alpha blending factor.
alpha_mode	The alpha blending mode. The description of this field is the same as for the *alpha_mode* member of the **disp_draw_context_t** structure.
x1	The offset of the left hand side of the region to be blended, in pixels, relative to the left hand side of the scaler viewport.
y1	The offset of the top scanline of the region to be blended, in pixels, relative to the top of the scaler viewport.
x2	The offset of the right-hand side of the region to be blended, in pixels, relative to the left hand side of the scaler viewport.

y2	The offset of the bottom scanline of the region to be blended, in pixels, relative to the top of the scaler viewport.

Classification:

Photon

See also:

disp_draw_context_t, **disp_vidfuncs_t**, **disp_vid_channel_props_t**

Synopsis:

```
#include <vid.h>

typedef struct {
    unsigned short size;
    unsigned short reserved0;
    unsigned       flags;
    unsigned       format;
    int            src_max_x;
    int            src_max_y;
    int            max_mag_factor_x;
    int            max_mag_factor_y;
    int            max_shrink_factor_x;
    int            max_shrink_factor_y;
    unsigned       reserved [8];
} disp_vid_channel_caps_t;
```

Description:

The **disp_vid_channel_caps_t** structure describes the general capabilities of a video scaler for a given format. The members include:

size The size of this structure.

reserved0, reserved

Reserved, don't examine or modify.

flags Flags that indicate the capabilities:

- DISP_VID_CAP_SRC_CHROMA_KEY — the video viewport supports chroma-keying on frame data.
- DISP_VID_CAP_DST_CHROMA_KEY — the video viewport supports chroma-keying on desktop data.
- DISP_VID_CAP_BUSMASTER — the scaler device can bus-master the data from system RAM.
- DISP_VID_CAP_DOUBLE_BUFFER — the scaler channel can be double-buffered.

- DISP_VID_CAP_BRIGHTNESS_ADJUST — the brightness of the video viewport can be adjusted.
- DISP_VID_CAP_CONTRAST_ADJUST — the contrast of the video viewport can be adjusted.

format The pixel format; see "Pixel formats" in the Writing a Graphics Driver chapter.

src_max_x, *src_max_y*

The maximum width and height of source frames.

max_mag_factor_x, *max_mag_factor_y*

The magnification — -1 means cannot scale upwards.

max_shrink_factor_x, *max_shrink_factor_y*

1 means cannot scale downwards.

Classification:

Photon

See also:

disp_vidfuncs_t

Synopsis:

```
#include <vid.h>

typedef struct {
    unsigned short    size;
    unsigned short    reserved0;
    unsigned          flags;
    unsigned          format;
    disp_color_t      chroma_key0;
    unsigned          reserved1;
    unsigned          chroma_flags;
    disp_color_t      chroma_key_mask;
    disp_color_t      chroma_mode;
    int               x1, y1;
    int               x2, y2;
    int               src_width, src_height;
    unsigned          fmt_index;
    short             brightness;
    short             contrast;
    disp_vid_alpha_t  alpha [DISP_VID_MAX_ALPHA];
    unsigned          reserved [8];
} disp_vid_channel_props_t;
```

Description:

The **disp_vid_channel_props_t** structure describes the configurable properties of a video scaler channel. The members include:

size The size of this structure.

reserved0, *reserved1*, *reserved*

Reserved, don't examine or modify.

flags A combination of the following bits:

- DISP_VID_FLAG_ENABLE — enable the video viewport.

- DISP_VID_FLAG_CHROMA_ENABLE — perform chroma-keying.
- DISP_VID_FLAG_DOUBLE_BUFFER — perform double-buffering.

format	The format of the frame data.
chroma_key0	The chroma-key color.
chroma_flags	The chroma-key comparison operation.
chroma_key_mask	Colors are masked with this before chroma comparison.
chroma_mode	The type of chroma key match to perform: • DISP_VID_CHROMA_FLAG_DST — perform chroma test on desktop data. • DISP_VID_CHROMA_FLAG_SRC — perform chroma test on video frame data.
x1, y1	The top left corner of video viewport in display coordinates.
x2, y2	The bottom right corner of video viewport in display coordinates.
src_width, src_height	The dimensions of the video source data.
fmt_index	Selects the format of the source frame data.
brightness	Brightness adjustment, where **`0x7fff`** is normal, 0 the darkest, and **`0xffff`** the brightest.
contrast	Contrast adjustment, where **`0x7fff`** is normal, 0 the minimum, and **`0xffff`** the maximum.
alpha	An array of regions of the video viewport to be blended with desktop. For more information, see **`disp_vid_alpha_t`**.

Classification:

Photon

See also:

`disp_vid_alpha_t`, **`disp_vidfuncs_t`**

disp_vidfuncs_t

Table of video overlay functions

Synopsis:

```
#include <vid.h>

typedef struct disp_vidfuncs {
    int  (*init) (...);
    void (*fini) (...);
    void (*module_info) (...);
    int  (*get_channel_caps) (...);
    int  (*set_channel_props) (...);
    int  (*next_frame) (...);
    int  (*close_channel) (...);
} disp_vidfuncs_t;
```

Description:

The **disp_vidfuncs_t** structure is a table that your driver uses to define the video overlay functions that it provides to the graphics framework. Your driver's *devg_get_vidfuncs()* entry point must fill in this structure.

init()

The graphics framework calls this function to initialize the modeswitcher. The prototype is:

```
int (*init) (disp_adapter_t *adapter,
             char *optstring)
```

This function should return the number of scalers available (functions similarly to the way the modeswitcher's *init()* function returns the number of display controllers available).

fini()

The graphics framework calls this function to free resources and disable all scalers (making them invisible). The prototype is:

```
void (*fini) (disp_adapter_t *adapter)
```

This function must free any offscreen memory that was allocated for frame data.

module_info()

The graphics framework calls this function to get information about the module. The prototype is:

```
void (*module_info) (disp_adapter_t *adapter,
                     disp_module_info_t *info)
```

This function must fill the given **disp_module_info_t** structure.

get_channel_caps()

The graphics framework calls this function to get the scaler capabilities for a given pixel format. The prototype is:

```
int (*get_channel_caps) (
        disp_adapter_t *adapter,
        int channel,
        int fmt_index,
        disp_vid_channel_caps_t *caps)
```

This function should fill in the **disp_vid_channel_caps_t** structure pointed to by *caps*.

The overlay scaler module is responsible for controlling scaler hardware, which is typically used for motion video (e.g. MPEG) acceleration. A hardware device may integrate zero or more scalers. Each scaler provides a “channel” for a video output stream.

The driver framework starts with a *fmt_index* of 0, and keeps calling *get_channel_caps()*, increasing *fmt_index* until this function returns -1. Thus, the framework can retrieve information on each format supported by the scaler denoted by *channel*. Channels are 0-based, i.e. if *init()* indicates that there are 3 channels, the valid channel numbers are 0, 1, and 2.

set_channel_props()

The graphics framework calls this function to set the scaler capabilities. The prototype is:

```
int (*set_channel_props) (
        disp_adapter_t *adapter,
        int channel,
        disp_vid_channel_props_t *props,
        disp_surface_t **yplane1,
        disp_surface_t **yplane2,
        disp_surface_t **uplane1,
        disp_surface_t **uplane2,
        disp_surface_t **vplane1,
        disp_surface_t **vplane2)
```

This function should configure the scaler channel *channel*, according to the contents of the **disp_vid_channel_props_t** structure pointed to by *props*. Typically, the driver allocates video memory surfaces to store the video frame data when this routine is called.

Each of the **plane** parameters it the address of a pointer to a **disp_surface_t** structure that describes a surface. Depending on the properties requested by *props*, the driver is required to return one or more surface pointers via the **plane** pointers. Unless the DISP_VID_FLAG_DOUBLE_BUFFER flag is set, your driver should ignore the **plane2* arguments. Unless the frame data format is planar (more than one surface needed), your driver should ignore the *uplane** and *vplane** arguments.

This function returns -1 on failure. Otherwise, it must return 1 if any of the attributes of the surfaces associated with the channel (e.g. the size or location of the surface memory) has been modified. If the state of the channel's surfaces hasn't been modified, *set_channel_props()* returns 0. Thus higher-level software can determine whether or not it's necessary to remap any of the frame data buffers.

(Note that the scaler may also support RGB or other non-YUV formats, in which case *yplane** points to the data).

next_frame()

The graphics framework calls this function every time the higher-level software has finished preparing a new frame for display. The prototype is:

```
int (*next_frame)(disp_adapter_t *adapter,
                   int channel)
```

When double buffering, the driver typically moves the scaler's frame base pointer, so that the scaler displays the new video frame during the next display refresh cycle.

This function should return the frame index (0 or 1) if double buffering, to specify whether the data for the next frame should be copied to the **plane1* surface set, or the **plane2* surface set that was returned by *set_channel_props()*. In all other cases, this function should return 0.

close_channel()

The graphics framework calls this function to close a channel. The prototype is:

```
int (*close_channel) (disp_adapter_t *adapter,
                      int channel)
```

Disable the scaler specified by *channel*. You should free up any offscreen memory that you may have allocated for the frame data on this channel.

Classification:

Photon

See also:

devg_get_vidfuncs(), **disp_adapter_t**, **disp_module_info_t**, **disp_surface_t**, **disp_vid_channel_caps_t**, **disp_vid_channel_props_t**

Chapter 5

Libraries

In this chapter. . .

This chapter describes the functions provided in the following libraries:

- DISPUTIL library — utility functions
- FFB library — 2D software fallback routines

DISPUTIL library — utility functions

The **disputil** (display utilities) library provides miscellaneous functions that can be useful when writing graphics drivers:

- Miscellaneous display driver functions
- PCI configuration access functions
- Virtual memory management functions
- Video memory management functions
- Video BIOS services (x86 only)

Miscellaneous display driver functions

The display driver utilities set includes:

- *disp_register_adapter()*
- *disp_unregister_adapter()*
- *disp_crtc_calc()*
- *disp_acquire_vga_resources()*
- *disp_release_vga_resources()*
- *disp_perror()*
- *disp_printf()*
- *disp_wait_condition()*
- *disp_usecspin()*

- *disp_get_rom_image()*
- *disp_vga_save_state()*
- *disp_vga_restore_state()*

disp_register_adapter()

This function registers your driver with the display utilities libraries. The prototype is:

```
int disp_register_adapter (disp_adapter_t *adapter)
```

☞ Call this function before calling any other *disp_** functions. If your driver uses the video BIOS functions, it must call *vbios_register()* before calling *disp_register_adapter()*.

disp_unregister_adapter()

This function frees any resources allocated by *disp_register_adapter()*. The prototype is:

```
int disp_unregister_adapter (
       disp_adapter_t *adapter)
```

Your driver should call this function when it no longer requires the services of the DISPUTIL lib. Typically, one of the driver's *fini()* routines calls *disp_unregister_adapter()*.

disp_crtc_calc()

This function calculates the CRT controller settings. The prototype is:

```
int disp_crtc_calc (disp_crtc_settings_t *display)
```

It uses the *xres*, *yres*, *refresh*, *h_granularity*, and *v_granularity* members of the **disp_crtc_settings_t** structure pointed to by *display* and computes the remaining members, according to the VESA GTF (Generalized Timing Formula).

disp_acquire_vga_resources()

This function acquires access to the VGA registers. The prototype is:

```
int disp_acquire_vga_resources (
       disp_adapter_t *adapter)
```

☞ You must call this function *before* activating any of the VGA registers.

Drivers that can't deactivate their legacy VGA registers shouldn't set the DISP_CAP_MULTI_MONITOR_SAFE flag in the *caps* member of the **disp_adapter_t** structure. At initialization time, the driver should ensure that the device doesn't respond to I/O or memory cycles to legacy VGA addresses (e.g. the memory aperture from **0xa0000** to **0xbffff**, or VGA I/O ports within in the **0x3b4** to **0x3d5** range). If the driver needs to activate the VGA legacy registers, and it has set the DISP_CAP_MULTI_MONITOR_SAFE flags, it should call this function before activating the registers.

For non-x86 architectures, VGA register conflicts aren't a concern, and this function has no effect.

disp_release_vga_resources()

This function is the opposite of *disp_acquire_vga_resources()*; call it when you're done with the VGA registers. The prototype is:

```
int disp_release_vga_resources (
       disp_adapter_t *adapter)
```

☞ You must deactivate the card's response to legacy VGA cycles before calling this function.

For non-x86 architectures, VGA register conflicts aren't a concern, and this function has no effect.

disp_perror()

This function is similar to the standard C library's *perror()* function. The prototype is:

```
void disp_perror (disp_adapter_t *adapter,
                  char *what)
```

It outputs the string given by *what* along with the string interpretation of the global *errno* to the graphics framework's debug stream (as given in the *dbgfile* member of the **disp_adapter_t** structure).

disp_printf()

This function is similar to the standard C library's *printf()* and *fprintf()* functions. The prototype is:

```
void disp_printf (disp_adapter_t *adapter,
                  const char *fmt, ...)
```

It outputs the given string (starting with the *fmt* parameter and any additional parameters specified) to the graphics framework's debug stream (as given in the *dbgfile* member of the **disp_adapter_t** structure).

disp_wait_condition()

This function provides a mechanism for waiting for a condition, while allowing other processes to be scheduled in the meantime. The prototype is:

```
void disp_wait_condition (disp_adapter_t *adapter,
                          int (*check)(disp_adapter_t *,
                                        void *arg),
                          void *arg)
```

This is better than polling, or busy-waiting, since it allows other processes to access the CPU, instead of wasting CPU cycles. The *check* function is a callback that indicates whether or not the condition has occurred yet. The *check* function should return 0 if the condition hasn't yet occurred, or nonzero if the condition has occurred. The *arg* parameter is passed as the *arg* parameter to the callback function.

disp_usecspin()

This function busy waits for at least *usecs* microseconds. The prototype is:

```
void disp_usecspin (unsigned usecs)
```

While polling is generally discouraged, sometimes the hardware demands that registers be accessed only after a certain (small) delay. If longer delays are necessary, use the *disp_wait_condition* function, which allows other processes to be scheduled, instead of wasting CPU cycles.

disp_get_rom_image()

This function gets the adapter's ROM image, if present. The prototype is:

```
void disp_get_rom_image (disp_adapter_t *adapter,
                         int code_type,
                         int *size,
                         int map_pci_base_index,
                         int map_offset)
```

For PCI devices, this function first attempts to fetch the ROM from the PCI ROM aperture. Note that the ROM image in the PCI aperture may be different on x86 systems from the image that typically shows up at physical address **0xc0000**. This is because the POST (Power On Self Test) process may modify and shrink the ROM image. See the PCI specification for more details. If the ROM can't be found in the PCI aperture, then, (x86 systems only) the function looks for a ROM image at physical address **0xc0000**.

The *code_type* parameter specifies the type of ROM image to fetch from the ROM aperture. The PCI specification defines the ROM types, and allows multiple ROM images to be present in the PCI ROM aperture, in order to allow multiple platforms to be supported. A value of 0 for *rom_type* specifies an x86 ROM image.

On some systems, the BIOS doesn't set up the bridge chips correctly, such that it isn't possible to map the ROM aperture. To work around this, a trick is used, whereby the ROM is mapped inside of one of the device's memory apertures (usually the frame buffer). The *map_pci_base* argument specifies in which of the six pci apertures the ROM should be mapped. The *map_map_offset* argument specifies the offset into this aperture at which the ROM should be mapped.

If *size* is non-NULL, *disp_get_rom_image()* sets **size* to the size of the ROM, in bytes.

disp_vga_save_state()

This function reads the values of the generic VGA registers and saves them in the **disp_vga_state_t** structure pointed to by *state*. The prototype is:

```
void disp_vga_save_state( disp_adapter_t *ctx,
                          disp_vga_state_t *state);
```

disp_vga_restore_state()

This function restores the state of the VGA registers from the values saved in the **disp_vga_state_t** structure pointed to by *state*. The prototype is:

```
void disp_vga_restore_state(
        disp_adapter_t *ctx,
        disp_vga_state_t *state);
```

disp_vga_state_t

This structure is used to save the state of the VGA registers:

```
typedef struct {
    uint8_t misc_out;
    uint8_t seq[5];
    uint8_t crtc[25];
    uint8_t gc[9];
    uint8_t attr[21];
    uint8_t pal[64*3];
} disp_vga_state_t;
```

PCI configuration access functions

The PCI configuration access utilities set includes:

- *disp_pci_init()*
- *disp_pci_shutdown()*
- *disp_pci_read_config()*
- *disp_pci_write_config()*
- *disp_pci_dev_find()*
- *disp_pci_dev_read_config()*
- *disp_pci_dev_write_config()*
- *disp_pci_info()*

disp_pci_init()

This function attaches the driver to a PCI device. The prototype is:

```
int disp_pci_init (disp_adapter_t *adapter,
                   unsigned flags)
```

It attaches the driver to the PCI device specified by the *pci_vendor_id*, *pci_device_id*, and *pci_index* members of the *adapter* structure.

The *flags* argument may be one of:

DISP_PCI_INIT_IRQ	Allocate an IRQ for the device.
DISP_PCI_BASE[0-5]	Allocate a memory range and initialize the corresponding PCI apertures.
DISP_PCI_BASES	Allocate memory ranges and initialize all PCI apertures that are implemented on the device.

DISP_PCI_ALL	Allocate memory ranges and initialize all PCI apertures that are implemented on the device. Also allocate a ROM aperture, and an IRQ, if implemented by the device.

If successful, *disp_pci_init()* sets *adapter->bus_type* to DISP_BUS_PCI, initializes the *adapter->bus.pci.base*, *adapter->bus.pci.apsize*, and *adapter->irq* members, and returns 0. Otherwise, this function returns -1.

☞ Call this function before calling any other PCI-related functions in the disputil library.

disp_pci_shutdown()

This function detaches the driver from the device and releases the resources from a previous *disp_pci_init()* call. The prototype is:

```
int disp_pci_shutdown (disp_adapter_t *adapter)
```

disp_pci_read_config()

This function reads a PCI configuration register. The prototype is:

```
int disp_pci_read_config (disp_adapter_t *adapter,
                          unsigned offset,
                          unsigned count,
                          size_t size,
                          void *bufptr)
```

PCI configuration registers can be byte, word, or double-word. This function reads a PCI configuration register (or registers if *count* is greater than one), as given by *offset* and *size*, into the data area given by *bufptr*. For details on the return values, see *pci_read_config()* in the QNX Neutrino *Library Reference*.

disp_pci_write_config()

This function writes a PCI configuration register. The prototype is:

```
int disp_pci_write_config (disp_adapter_t *adapter,
                           unsigned offset,
                           unsigned count,
                           size_t size,
                           void *bufptr)
```

It writes a PCI configuration register (or registers if *count* is greater than one), as given by *offset* and *size*, from the data area given by *bufptr*. For details on the return values, see *pci_write_config()* in the QNX Neutrino *Library Reference*.

disp_pci_dev_find()

This function is similar to *pci_find_device()*. The prototype is:

```
int disp_pci_dev_find (unsigned devid,
                       unsigned venid,
                       unsigned index,
                       unsigned *bus,
                       unsigned *devfunc)
```

It discovers a device's *bus* and *devfunc* values in order to let a driver talk to a PCI device other than the one specified in the **disp_adapter_t** structure.

disp_pci_dev_read_config()

This function reads a PCI configuration register. The prototype is:

```
int disp_pci_dev_read_config (unsigned bus,
                              unsigned devfunc,
                              unsigned offset,
                              unsigned cnt,
                              size_t size,
                              void *bufptr)
```

This function reads a PCI configuration register (like *disp_pci_read_config()*, above), but from a specific *bus* and device (*devfunc*). Error return codes are documented in *pci_read_config()*.

disp_pci_dev_write_config()

This function writes a PCI configuration register. The prototype is:

```
int disp_pci_dev_write_config (unsigned bus,
                               unsigned devfunc,
                               unsigned offset,
                               unsigned cnt,
                               size_t size,
                               void *bufptr)
```

This function writes a PCI configuration register (like *disp_pci_write_config()*, above), but to a specific *bus* and device (*devfunc*). Error return codes are documented in *pci_write_config()*.

disp_pci_info()

This function is a cover function for *pci_present()*. The prototype is:

```
int disp_pci_info (unsigned *lastbus,
                   unsigned *version,
                   unsigned *hardware)
```

Memory manager functions

The memory-manager utilities set includes:

- *disp_mmap_device_memory()*
- *disp_mmap_device_io()*
- *disp_munmap_device_memory()*
- *disp_phys_addr()*
- *disp_getmem()*
- *disp_freemem()*

disp_mmap_device_memory()

The prototype is:

```
void *disp_mmap_device_memory (paddr_t base,
                               size_t len,
                               int prot,
                               int flags)
```

It creates a virtual address space pointer to the physical address given in *base*, which is *len* bytes in length. The *prot* parameter is selected from one or more of the following bitmapped flags:

DISP_PROT_READ
: Allow read access.

DISP_PROT_WRITE
: Allow write access.

DISP_PROT_NOCACHE
: Don't cache the memory (useful for register access, for example).

The *flags* parameter is selected from one or more of the following bitmapped flags:

DISP_MAP_LAZY
: Allows the CPU to delay writes and combine them into burst writes for performance. It's ideal for mapping frame buffers (Intel calls it write combining, some other vendors call it write gathering). On CPUs that don't support this feature, the flag is ignored.

disp_mmap_device_io()

This function creates either a virtual address space pointer (like *disp_mmap_device_memory()*, above), or returns its argument *base*. The prototype is:

```
unsigned long disp_mmap_device_io (size_t len,
                                   paddr_t base)
```

On non-x86 architectures, this function returns a virtual address space pointer (because these don't have a separate I/O space), whereas for x86 architectures it returns the argument *base* unmodified. Regardless of the architecture, the return value can be used with functions such as *in8()* and *out8()*.

disp_munmap_device_memory()

This function releases any resources that were acquired by *disp_mmap_device_memory()*. The prototype is:

```
void disp_munmap_device_memory (void *addr,
                                size_t len)
```

It invalidates (unmaps) the virtual address pointer in *addr*.

disp_phys_addr()

This function returns the physical address corresponding to the virtual address passed in *addr*. The prototype is:

```
paddr_t disp_phys_addr (void *addr)
```

This call is useful with devices that use DMA (which must be programmed with the physical address of the transfer area), under architectures (e.g. x86) where device I/O and memory cycles aren't translated by the MMU.

Note that the **paddr_t** physical address is valid only for a maximum of __PAGESIZE bytes (i.e. from the physical address corresponding to the passed virtual address up to and including the end of the page boundary), unless the memory is physically contiguous.

For example, if __PAGESIZE is 4096 (**0x1000**), and the virtual address translated to a physical address of **0x7B000100**, then only the physical address range **0x7B000100** through to **0x7B000FFF** (inclusive) is valid.

disp_getmem()

This function allocates memory. The prototype is:

```
void *disp_getmem (int size,
                   unsigned prot,
                   unsigned flags)
```

It allocates *size* bytes of memory that conform to the *prot* and *flags* parameters.

☞ Allocations are rounded up to be a multiple of __PAGESIZE. For example, even if *size* is 1, __PAGESIZE bytes of system memory are used up.

The *size*, *prot* and *flags* arguments are the same as those passed to *disp_mmap_device_memory()* above, with the following additional bits for *flags*:

DISP_MAP_PHYS

Pages of memory allocated are physically contiguous. That is, the memory is a contiguous block, from both the device's and CPU's perspectives.

DISP_MAP_BELOW_16M

The memory allocated is located below the physical address **`0x1000000`**. This flag is useful for certain legacy x86 devices.

Note that you don't supply a *base* parameter as with the other mapping function; instead, *disp_getmem()* finds a free block of memory (called anonymous memory) and allocates it.

This function returns a pointer (virtual address) to the memory, or NULL if the memory couldn't be allocated.

disp_freemem()

This function invalidates the virtual address pointer in *addr* and deallocates the memory. The prototype is:

```
void disp_freemem (void *addr,
                   int size)
```

Video memory management functions

The video memory management utilities set includes:

- *disp_vm_create_pool()*
- *disp_vm_destroy_pool()*
- *disp_vm_alloc_surface()*
- *disp_vm_free_surface()*
- *disp_vm_mem_avail()*

These functions are primarily intended to be called from your driver's Video Memory Manager module. A simple Video Memory Manager is little more than a wrapper for these functions.

disp_vm_create_pool()

This function creates a new memory pool for the memory manager. The prototype is:

```
disp_vm_pool_t *disp_vm_create_pool (
                   disp_adapter_t *adapter,
                   disp_surface_t *surf,
                   int bytealign)
```

Pass the *adapter* associated with this memory pool, a pointer to the surface in *surf*, and a byte alignment parameter, *bytealign*. The *bytealign* argument indicates the alignment for the memory manager — all chunks of memory returned by the memory manager for this pool are aligned to the number of bytes specified.

The *surf* argument describes the block of memory that the driver wants to have managed. The driver should set the *vidptr*, *offset* and *paddr* (if appropriate) members of the surface structure. When the libraries' memory management routines are used to allocate a surface, the library uses these initial values to calculate the corresponding values for the allocated surface.

The *pixel_format* member of *surf* is typically set to DISP_SURFACE_FORMAT_BYTES, since the unallocated memory doesn't have any particular pixel format. The *stride* and *height* members should be set such that *stride*×*height* is equal to the size of the memory block. For example, the height could be set to 1 and the stride set to the size of the memory block.

Set the *flags* member to describe the characteristics of the video RAM.

A driver can create multiple pools, for example, if there are multiple regions of memory that have different characteristics. This is the case if not all of the devices RAM are addressable by the display controller. In this case, the driver might create a pool of CRTC-addressable memory, and a pool of non-CRTC-addressable memory. When the driver is asked to allocate some memory, it tries to obtain the memory from the non-CRTC-addressable pool first (assuming the framework hasn't explicitly requested displayable memory via the DISP_SURFACE_DISPLAYABLE flag). If the allocation from the non-CRTC-addressable pool fails, the driver then tries to obtain the memory from the CRTC-addressable pool.

The return value is a **`pool_handle_t`** that's passed to subsequent *disp_vm_*()* function calls.

disp_vm_destroy_pool()

This function deallocates all surfaces that were allocated from the pool and releases the resources associated with tracking the pool allocation. The prototype is:

```
int disp_vm_destroy_pool (disp_adapter_t *adapter,
                          disp_vm_pool_t *pool)
```

disp_vm_alloc_surface()

This function allocates a surface from the memory pool specified by *pool*. The prototype is:

```
disp_surface_t *disp_vm_alloc_surface (
                   pool_handle_t *pool,
                   int width,
                   int height,
                   int stride,
                   unsigned format,
                   unsigned flags)
```

The *flags* parameter is selected from the set of manifest constants defined in the *flags* argument for the **disp_surface_t** data type. This specifies the characteristics of the memory that's being requested. If there's no memory available with the specified characteristics, the function should return NULL. Otherwise, this function returns a pointer to a **disp_surface_t** structure, which describes the allocated memory.

The *width*, *height* and *stride* parameters define the area and stride of the surface to be allocated.

The *pixel_format* member of the **disp_surface_t** structure is set to the value specified by the *pixel_format* argument.

The *format* parameter is selected from the set of manifest constants beginning with DISP_SURFACE_FORMAT_*. For more information, see "Pixel formats," under the description for *devg_get_corefuncs()* in the Writing a Graphics Driver chapter.

disp_vm_free_surface()

This function releases the surface memory identified by *surf* back into the surface memory manager's pool. It also frees the *surf* structure. The prototype is:

```
int disp_vm_free_surface (disp_adapter_t *adapter,
                          disp_surface_t surf)
```

This function returns 0, or -1 if an error occurred.

disp_vm_mem_avail()

This function returns how much memory is available in the pool identified by *pool*, in bytes. The prototype is:

```
unsigned long disp_vm_mem_avail (
                 disp_vm_pool_t *pool,
                 unsigned sflags)
```

It should report only memory that has at least the characteristics specified by *sflags*.

Video BIOS services (x86 only)

The video BIOS services include:

- *vbios_register()*
- *vbios_unregister()*
- *vbios_int()*
- *vbios_call()*
- *vbios_dowarmboot()*
- *vbios_get_realptr()*
- **vbios_context_t**

The *vbios_** routines provide drivers with the ability to make calls to the VGA / VESA BIOS. These calls are often referred to as Int 10 calls, since the Video BIOS is generally accessed via vector **0x10** in the Real Mode Interrupt Vector table.

These services are available only on x86 platforms; this section isn't relevant to non-x86 architectures or to drivers that are targeted toward machines that don't have a Video BIOS.

Typically, graphics drivers that use the Video BIOS use only the VESA / VGA Modeswitching services, performing other functions, such as drawing, by directly programming the hardware. Often, using the BIOS can be the most reliable method of writing a modeswitcher, since the BIOS on the video card is tailor-made for the device to which it is attached.

One of the main drawbacks of using the BIOS to switch modes is that the BIOS might not provide a method of selecting a video refresh rate. However, some vendors do provide a way to set a specific refresh rate using the BIOS. If the BIOS for a particular device doesn't have refresh-rate support, you need to write a direct modeswitcher to program the hardware directly, in order to provide refresh rate support.

Video BIOSes are generally implemented with real 8086 code. Hence special support is required to allow execution of the BIOS under a memory-protected operating system.

Under QNX Neutrino, there's special support in the kernel that allows the Video BIOS to be executed in the x86 processor's Virtual 8086 mode.

vbios_register()

This function registers your driver with the VBIOS services. You should call this function before calling any of the other *vbios_** routines. The prototype is:

```
int vbios_register( disp_adapter_t *adp,
                    unsigned flags );
```

The *adp* argument is a pointer to your driver's **`disp_adapter_t`** structure. There are currently no flags defined; pass 0 for the *flags* argument.

☞ If your driver uses the video BIOS functions as well as the *disp_** functions, it must call *vbios_register()* before calling *disp_register_adapter()*.

This function stores a pointer to a **`vbios_context_t`** structure in the *vbios* member of the structure pointed to by *adp*. This pointer is to be used in subsequent calls to *vbios_** functions.

This function initializes the *xfer_area_seg*, *xfer_area_off*, and *xfer_area_ptr* members of the **vbios_context_t** structure. These members point to a communications area that's used to supply data to and retrieve data from the BIOS code. The *xfer_area_ptr* member points to the communications area in the driver's address space. Together, *xfer_area_seg* and *xfer_area_off* specify the real-mode address that the BIOS code can use to address the communications area.

vbios_unregister()

You driver should call this function when it no longer requires VBIOS services. The prototype is:

```
void vbios_unregister( vbios_context_t *ctx );
```

The *ctx* argument is a pointer to the **vbios_context_t** structure that *vbios_register()* stored in the *vbios* member of the driver's **disp_adapter_t** structure.

vbios_int()

This function makes a BIOS call. The prototype is:

```
int vbios_int( vbios_context_t *ctx,
               int inum,
               vbios_regs_t *regs,
               int xfer_size );
```

The arguments are:

ctx	A pointer to the **vbios_context_t** structure that *vbios_register()* stored in the *vbios* member of the driver's **disp_adapter_t** structure.
inum	The interrupt vector number; to call the Video BIOS, specify **0x10**.
regs	The contents of the CPU's registers on entry to the call.

xfer_size	The number of bytes to transfer from the communications area. The specified number of bytes are copied from the driver's address space to the real-mode communications area before the call, and the same number of bytes are copied back into the driver's address space after the call.

The driver accesses the communications area data via the *xfer_area_ptr* member of *ctx*, whereas the BIOS code accesses it using the real-mode address specified by *xfer_area_seg* and *xfer_area_off*.

vbios_call()

This function makes a real-mode call. The prototype is:

```
int vbios_call( vbios_context_t *ctx,
                int seg,
                int offs,
                vbios_regs_t *regs,
                int xfer_size );
```

The *ctx* argument is a pointer to the **vbios_context_t** structure that *vbios_register()* stored in the *vbios* member of the driver's **disp_adapter_t** structure.

The *seg* and *offs* arguments specify the real-mode address of the routine to call. This function is similar to *vbios_int()*, except that the address of the routine to execute is passed directly, rather than coming from the real-mode Interrupt Vector Table.

vbios_dowarmboot()

The prototype is:

```
int vbios_dowarmboot( vbios_context_t *ctx,
                      unsigned ax_val,
                      unsigned char *biosptr,
                      int bios_size );
```

In the event that there's more than one video card in the system, it may be necessary to perform a warm boot of the non-primary cards.

At boot time, the system BIOS selects one of the adapters to be the BIOS primary. The system then calls the BIOS of this card in order to initialize the card and put it into text mode. Meanwhile, other graphics devices stay dormant.

Many drivers don't duplicate the code that's present in the BIOS, and which performs this device initialization; they rely on the fact that the BIOS has already performed basic device initialization. In fact, it often isn't possible to perform this initialization, since the driver may lack certain knowledge that's necessary to initialize the device (e.g. what type of memory is present on the adapter).

However, on devices that are compliant to PCI 2.1 (or greater), it's possible to perform the BIOS warm boot sequence for one of the nonprimary cards. This involves disabling the active VGA device and performing an initialization sequence similar to the sequence performed by the POST (Power On Self Test) on the primary VGA device, at boot time.

If your driver can't initialize the graphics device from scratch, you should call this routine. It determines whether or not the device has already been warm booted, and performs the BIOS POST sequence, if necessary.

The arguments to *vbios_dowarmboot()* are:

ctx	A pointer to the **`vbios_context_t`** structure that *vbios_register()* stored in the *vbios* member of the driver's **`disp_adapter_t`** structure.
ax_val	The value to be put into the AX register; see the PCI specification.
biosptr	A pointer to the BIOS image, which you can get by calling *disp_get_rom_image()*.
bios_size	The size of the BIOS image, in bytes.

vbios_get_realptr()

The prototype is:

```
void *vbios_get_realptr( vbios_context_t *ctx,
                         unsigned seg,
                         unsigned off );
```

This function takes the real-mode address specified via the segment *seg* and the offset *off*, and returns a pointer to this memory within the driver's address space.

The *ctx* argument is a pointer to the **vbios_context_t** structure that *vbios_register()* stored in the *vbios* member of the driver's **disp_adapter_t** structure.

Since not all addresses within the real-mode address range (**0x00** - **0x10ffff**) are usable by the driver or by the BIOS, this function can return NULL. Generally, the address specified by *seg*:*off* should reside either within the first 4K of memory, or within the range **0xa0000** - **0x100fff** (640K to 1Meg + 4K).

vbios_context_t

This structure stores the Video BIOS context information; *vbios_register()* stores a pointer to this structure in the *vbios* member of the driver's **disp_adapter_t** structure.

```
typedef struct vbios_context {
    disp_adapter_t *adp;
    unsigned        xfer_area_seg;
    unsigned        xfer_area_off;
    unsigned char  *xfer_area_ptr;
} vbios_context_t;
```

adp	A pointer to the device's adapter structure.
xfer_area_seg:*xfer_area_off*	The real-mode address of the communications area.
xfer_area_ptr	The virtual address of the communications area.

FFB library — 2D software fallback routines

The FFB (Flat Frame Buffer) library includes:

Core functions that you can fall back on in **`disp_draw_corefuncs_t`**:

- *ffb_core_blit1()*
- *ffb_core_blit2()*
- *ffb_draw_span_8()*, *ffb_draw_span_16()*, *ffb_draw_span_24()*, and *ffb_draw_span_32()*
- *ffb_draw_span_list_8()*, *ffb_draw_span_list_16()*, *ffb_draw_span_list_24()*, and *ffb_draw_span_list_32()*
- *ffb_draw_solid_rect_8()*, *ffb_draw_solid_rect_16()*, *ffb_draw_solid_rect_24()*, and *ffb_draw_solid_rect_32()*
- *ffb_draw_line_pat8x1_8()*, *ffb_draw_line_pat8x1_16()*, *ffb_draw_line_pat8x1_24()*, and *ffb_draw_line_pat8x1_32()*
- *ffb_draw_line_trans8x1_8()*, *ffb_draw_line_trans8x1_16()*, *ffb_draw_line_trans8x1_24()*, and *ffb_draw_line_trans8x1_32()*
- *ffb_draw_rect_pat8x8_8()*, *ffb_draw_rect_pat8x8_16()*, *ffb_draw_rect_pat8x8_24()*, and *ffb_draw_rect_pat8x8_32()*
- *ffb_draw_rect_trans8x8_8()*, *ffb_draw_rect_trans8x8_16()*, *ffb_draw_rect_trans8x8_24()*, and *ffb_draw_rect_trans8x8_32()*

Context functions that you can fall back on in **`disp_draw_contextfuncs_t`**:

- *ffb_ctx_draw_span()*
- *ffb_ctx_draw_span_list()*
- *ffb_ctx_draw_rect()*
- *ffb_ctx_blit()*

Draw state update notify functions:

- *ffb_update_draw_surface()*
- *ffb_update_pattern()*
- *ffb_ctx_update_general()*
- *ffb_ctx_update_color()*
- *ffb_ctx_update_rop3()*
- *ffb_ctx_update_chroma()*
- *ffb_ctx_update_alpha()*

Color space conversion utility:

- *ffb_color_translate()*

Miscellaneous:

- *ffb_hw_idle()*
- *ffb_wait_idle()*

Draw function retrieval routines:

- *ffb_get_corefuncs()*
- *ffb_get_contextfuncs()*

You can use these functions when you create your driver. For example, you may start out with a driver that doesn't actually do very much, and instead relies upon the functionality of these routines to perform the work. As you progress in your development cycle, you can take over more and more functionality from these functions and do them in a card-specific manner (e.g. using the hardware acceleration).

In general, this can be done quite simply by taking the function table pointer that's passed to you in your initialization function, and calling the appropriate function (*ffb_get_corefuncs()* or *ffb_get_contextfuncs()*)

to populate your function table array with the defaults from this library. Note, however, that *all* functions in the library are exposed; you don't have to bind to them by way of the *ffb_get_*()* functions; you can just simply link against them.

The next step in the development cycle is to take over some of the functions, and follow the outlines discussed above for each of them. If you find that you're able to support a given operation in a card-specific manner, demultiplex that case out of the function call and handle it, while relying on the library routines to perform functions that your hardware doesn't support or that you don't wish to write the code for right at that point. Since the supplied libraries are hardware-independent (i.e. everything is implemented in software), they're likely to be much slower than your hardware-accelerated versions.

Another advantage of the way that the library and graphics framework are structured is that in case your driver becomes out-of-date (i.e. a newer version of the graphics framework has been released that has more functions), the shared library that's supplied with the newer version will know how to handle the extra functions, without any additional intervention on your part. You may then release a new version of your driver that supports accelerated versions of the extra function(s) at your convenience.

☞ There are four sets of functions for some of the core functions supplied, optimized based on the pixel depth. For example, instead of the expected single function *ffb_draw_span()*, there are in fact four of them:

1. *ffb_draw_span_8()*
2. *ffb_draw_span_16()*
3. *ffb_draw_span_24()*
4. *ffb_draw_span_32()*

Use the *pixel_format* argument passed to *ffb_get_corefuncs()* to determine which function to bind to the *draw_span* entry in the **disp_draw_corefuncs_t** function table.

The other functions (that aren't listed as having 8/16/24/32 bit pixel-depth variants) support all pixel depths.

The impact on your driver is that you may choose to call the *ffb_get_corefuncs()* four times, (once for each color depth), and fill four separate arrays, or you may choose to call it whenever *your get_corefuncs()* call-in is called, so that you can dynamically bind the appropriate library routines. The *get_corefuncs()* call-in gets called very infrequently (only during initialization and modeswitch operations) so efficiency isn't of paramount importance in this case.

ffb_get_corefuncs()

This function populates the function table pointed to by *funcs* with the core functions from the Flat Frame Buffer library. The prototype is:

```
int ffb_get_corefuncs (
       disp_adapter_t *context,
       unsigned pixel_format,
       disp_draw_corefuncs_t *funcs,
       int tabsize)
```

This function returns 0 on success, or -1 if an error occurred (e.g. the pixel format is invalid).

ffb_get_contextfuncs()

This function populates the function table pointed to by *funcs* with the context functions from the Flat Frame Buffer library. The prototype is:

```
int ffb_get_contextfuncs (
       disp_adapter_t *context,
       disp_draw_contextfuncs_t *funcs,
       int tabsize)
```

This function returns 0 on success, or -1 if an error occurred.

ffb_color_translate()

This function takes the *color* that corresponds to the surface type specified by *srcformat*, and returns a **disp_color_t** that corresponds to the same (or closest available) color in the surface type specified by *dstformat*. The prototype is:

```
disp_color_t ffb_color_translate (
                disp_draw_context_t *context,
                int srcformat,
                int dstformat,
                disp_color_t color)
```

For more information about the surface types, see “Pixel formats” in the Writing a Graphics Driver chapter.

Note that this function doesn’t yet handle a palette-based format for *dstformat*.

Glossary

AGP

Accelerated Graphics Port; a high-performance bus designed specifically for graphical devices.

alpha-blending

A technique of portraying transparency when drawing an object. It combines the color of an object to be drawn (the source) and the color of whatever the object is to be drawn on top of (the destination). The higher the blending factor of the source object, the more opaque the object looks.

Mathematically, a blending factor is a real number between 0 and 1, inclusive. A 32-bit color is made up of four 8-bit **channels**: alpha, red, green, and blue. These channels are represented as (A, R, G, B). When referring to the source, the channels are denoted as As, Rs, Gs, and Bs; for the destination, they're Ad, Rd, Gd, and Bd.

BIOS

Basic Input/Output System; standard ROM services that are available on x86 platforms.

blitting

BLock Image Transfer; copying an image from one place on the screen to another.

chroma keying

A method of masking out pixel data during a rendering operation (blits, image rendering, etc.) based on a key color value.

CRTC

Cathode-Ray Tube Controller.

DPMS

Display Power Management System; a system that reduces the amount of energy consumed by a monitor when it's idle.

falling back on software

Using software to perform operations that the graphics hardware doesn't support.

FFB

Flat Frame Buffer

PCI

Peripheral Components Interface; a general-purpose system bus that's found in most modern PCs.

pixel

A picture element, one of the dots that make up an image on the screen.

raster operations (ROP)

A per-pixel operation to be performed when rendering an object. A raster operation may involve up to three input parameters (source, pattern, and destination) that are combined in accordance with the raster operation that's currently in effect. The resulting pixel value is written to the destination.

ROP3

A set of 256 raster operations, as defined by MicroSoft.

stride

The number of bytes from the beginning of one scanline to the beginning of the next.

surface

A two-dimensional area.

ternary raster operation

A raster operation involving 3 input parameters.

VESA

Video Electronics Standards Association.

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