

**Khronos Native Platform Graphics Interface
(EGL Version 1.5 - August 27, 2014)**

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Chapter 1

Overview

This document describes EGL, an interface between rendering APIs such as OpenCL, OpenGL, OpenGL ES or OpenVG (referred to collectively as *client APIs*) and one or more underlying *platforms* (typically window systems such as X11). It refers to concepts discussed in the specifications for these client APIs, and should be read together with those specifications. EGL uses OpenGL ES conventions for naming entry points and macros.

EGL provides mechanisms for creating rendering surfaces onto which client APIs can draw, creating graphics contexts for client APIs, and synchronizing drawing by client APIs as well as platform rendering APIs. EGL does not explicitly support remote or *indirect* rendering, unlike the similar GLX API.

Chapter 2

EGL Operation

2.1 Native Platforms and Rendering APIs

EGL is intended to be implementable on multiple operating systems (such as Android, Unix, and Windows) and platforms¹ (including window systems such as X11 and Microsoft Windows, and platforms supporting rendering without a display, such as GBM). Implementations may also choose to allow rendering into specific types of EGL *surfaces* via *native rendering APIs* specific to a platform, such as Xlib or GDI. Native rendering is described in more detail in section 2.2.3.

To the extent possible, EGL itself is independent of definitions and concepts specific to any platform or rendering API. However, there are a few places where native concepts must be mapped into EGL-specific concepts, including the definition of the *display* on which graphics are drawn, and the definition of native windows and pixmaps which can also support client API rendering.

This specification does not define the set of platforms that may be supported by the EGL implementation, nor does it specify behavior specific to any platform. The set of supported platforms and their behavior is defined by extensions. To detect if a particular platform is supported, clients should query the `EGL_EXTENSIONS` string of `EGL_NO_DISPLAY` using `eglQueryString` (see section 3.3).

2.1.1 EGL Types

`EGLBoolean` is an integral type representing a boolean value, and should only take on the values `EGL_TRUE` (1) and `EGL_FALSE` (0). If boolean parameters

¹ Platforms were previously referred to as “native window systems”, but EGL 1.5 now supports both rendering without a display, and multiple runtime platforms.

passed to EGL take on other values, behavior is undefined, although typically any non-zero value will be interpreted as `EGL_TRUE`.

`EGLint` is an integral type, normally the same size as a native platform `int`. Legal attribute values whose type is boolean, bitmask, enumerant, or integer can be passed in `EGLint` attribute lists, but handle and pointer values may not be representable in such attribute lists².

`EGLAttrib` is an integral type defined to be equivalent to the ISO C `intptr_t` type. It is used in the commands `eglCreateImage`, `eglCreateSync`, `eglCreatePlatformWindowSurface`, `eglCreatePlatformPixmapSurface`, `eglGetPlatformDisplay`, and `eglGetSyncAttrib`, and will be used for all similar commands in the future which take attribute lists or return attribute values, since such commands might at some point need to represent handle and pointer values in attribute lists as well as other integral types³.

`EGLContext` is an opaque type representing a client API context. The definition of contexts depends on the client API, but usually represents the state vector of an abstract machine describing the client API and allows executing client API commands with respect to that state vector.

`EGLImage` is an opaque type representing handles to `EGLImage` objects (see section 2.5).

`EGLSurface` is an opaque type representing a drawing surface which client APIs can render content into.

`EGLSync` is an opaque type representing handles to sync objects (see section 3.8.1).

`EGLTime` is a 64-bit unsigned integer type representing a timeout interval in nanoseconds for `eglClientWaitSync` (see section 3.8.1.3).

2.1.2 Displays

Most EGL calls include an `EGLDisplay` parameter. This represents the abstract display on which graphics are drawn. In most environments a display corresponds

² This is a functionality regression relative to earlier versions of EGL, first adopted in the November, 2013 EGL 1.4 update. It was adopted because EGL implementations on some 64-bit platforms chose their `EGLint` type to be a 32-bit integer type, and changing the definition would break their ABIs in a way considered to be too disruptive to their application base. The `EGL_KHR_cl_event2` and `EGL_KHR_lock_surface3` extensions replace similar earlier extensions allowing pointers in attribute lists, and work around this regression by providing new interfaces using attribute types which **are** guaranteed to be sufficiently large. New commands in EGL 1.5 taking attribute lists and returning attribute values use the `EGLAttrib` type (see below).

³ New interfaces using the new `EGLAttrib` type are not defined for older functionality such as creating puffers, since there is no current or expected requirement for pointer/handle-sized attributes in those interfaces.

to a single physical screen. The initialization routines described in section 3.2 include a method for querying a *default display*, and platform-specific EGL extensions may be defined to obtain other displays.

All EGL objects are associated with an `EGLDisplay`, and exist in a namespace defined by that display. Objects are always specified by the combination of an `EGLDisplay` parameter with a parameter representing the handle of the object.

2.2 Rendering Contexts and Drawing Surfaces

The client API specifications are intentionally vague on how a *rendering context* (e.g. the state machine defined by a client API) is created. One of the purposes of EGL is to provide a means to create client API rendering contexts (henceforth simply referred to as *contexts*), and associate them with drawing surfaces.

EGL defines several types of drawing surfaces collectively referred to as `EGLSurfaces`. These include *windows*, used for onscreen rendering; *pbuffers*, used for offscreen rendering; and *pixmap*s, used for offscreen rendering into buffers that may be accessed through native APIs. EGL windows and pixmaps are tied to platform windows and pixmaps.

`EGLSurfaces` are created with respect to an `EGLConfig`. The `EGLConfig` describes the depth of the color buffer components and the types, quantities and sizes of the *ancillary buffers* (i.e., the depth, multisample, and stencil buffers).

Ancillary buffers are associated with an `EGLSurface`, not with a context. If several contexts are all writing to the same surface, they will share those buffers. Rendering operations to one window never affect the unobscured pixels of another window, or the corresponding pixels of ancillary buffers of that window.

Contexts for different client APIs all share the color buffer of a surface, but ancillary buffers are not necessarily meaningful for every client API. In particular, depth, multisample, and stencil buffers are currently used only by OpenGL and OpenGL ES.

A context can be used with any `EGLSurface` that it is *compatible* with (subject to the restrictions discussed in the section on address space). A surface and context are compatible if:

- They support the same type of color buffer (RGB or luminance).
- They have color buffers and ancillary buffers of the same depth.

Depth is measured per-component. For example, color buffers in RGB565 and RGBA4444 formats have the same aggregate depth of 16 bits/pixel, but are not compatible because their per-component depths are different.

Ancillary buffers not meaningful to a client API do not affect compatibility; for example, a surface with both color and stencil buffers will be compatible with an OpenVG context so long as the color buffers associated with the contexts are of the same depth. The stencil buffer is irrelevant because OpenVG does not use it.

- The surface was created with respect to an `EGLConfig` supporting client API rendering of the same type as the API type of the context (in environments supporting multiple client APIs).
- They were created with respect to the same `EGLDisplay` (in environments supporting multiple displays).

As long as the compatibility constraint and the address space requirement are satisfied, clients can render into the same `EGLSurface` using different contexts. It is also possible to use a single context to render into multiple `EGLSurfaces`.

2.2.1 Using Rendering Contexts

OpenGL and OpenGL ES define both client state and server state. Thus an OpenGL or OpenGL ES context consists of two parts: one to hold the client state and one to hold the server state. OpenVG does not separate client and server state.

The OpenGL, OpenGL ES, and OpenVG client APIs rely on an *implicit* context used by all entry points, rather than passing an explicit context parameter. The implicit context for each API is set with EGL calls (see section 3.7.3). The implicit contexts used by these APIs are called *current contexts*.

Each thread can have at most one current rendering context for each supported client API; for example, there may be both a current OpenGL ES context and a current OpenVG context in an implementation supporting both of these APIs. In addition, a context can be current to only one thread at a time. The client is responsible for creating contexts and surfaces. Because OpenGL and OpenGL ES contexts share many entry points, additional restrictions on current contexts exists for these client APIs when both are supported (see section 3.7).

2.2.2 Rendering Models

EGL, OpenGL, and OpenGL ES support two rendering models: *back buffered* and *single buffered*.

Back buffered rendering is used by window and pbuffer surfaces. Memory for the color buffer used during rendering is allocated and owned by EGL. When the

client is finished drawing a frame, the back buffer may be copied to a visible window using **eglSwapBuffers**. Pbuffer surfaces have a back buffer but no associated window, so the back buffer need not be copied.

Single buffered rendering is used by pixmap surfaces. Memory for the color buffer is specified at surface creation time in the form of a native pixmap, and client APIs are required to use that memory during rendering. When the client is finished drawing a frame, the native pixmap contains the final image. Pixmap surfaces typically do not support multisampling, since the native pixmap used as the color buffer is unlikely to provide space to store multisample information.

Some client APIs, such as OpenGL and OpenVG, also support single buffered rendering to window surfaces. This behavior can be selected when creating the window surface, as defined in section 3.5.1. When mixing use of client APIs which do not support single buffered rendering into windows, like OpenGL ES, with client APIs which do support it, back color buffers and visible window contents must be kept consistent when binding window surfaces to contexts for each API type (see section 3.7.3).

Both back and single buffered surfaces may also be copied to a specified native pixmap using **eglCopyBuffers**.

2.2.2.1 Native Surface Coordinate Systems

The coordinate system for native windows and pixmaps in most platforms is inverted relative to the OpenGL, OpenGL ES, and OpenVG client API coordinate systems. In such systems, native windows and pixmaps have (0, 0) in the upper left of the pixmap, while the client APIs have (0, 0) in the lower left. To accommodate this, client API rendering to window and pixmap surfaces must invert their own y coordinate when accessing the color buffer in the underlying native window or pixmap, so that the resulting images appear as intended by the application when the final image is displayed by **eglSwapBuffers** or copied from a pixmap to a visible window using native rendering APIs.

2.2.2.2 Window Resizing

EGL window surfaces need to be resized when their corresponding native window is resized. Implementations typically use hooks into the OS and platform to perform this resizing on demand, transparently to the client. Some implementations may instead define an EGL extension giving explicit control of surface resizing.

Implementations which cannot resize EGL window surfaces on demand must instead respond to native window size changes in **eglSwapBuffers** (see section 3.10.3).

2.2.3 Interaction With Native Rendering

Native rendering will always be supported by pixmap surfaces (to the extent that native rendering APIs can draw to native pixmaps). Pixmap surfaces are typically used when mixing native and client API rendering is desirable, since there is no need to move data between the back buffer visible to the client APIs and the native pixmap visible to native rendering APIs. However, pixmap surfaces may, for the same reason, have restricted capabilities and performance relative to window and pbuffer surfaces.

Native rendering will not be supported by pbuffer surfaces, since the color buffers of pbuffers are allocated internally by EGL and are not accessible through any other means.

Native rendering may be supported by window surfaces, but only if the platform has a compatible rendering model allowing it to share the back color buffer, or if single buffered rendering to the window surface is being done.

When both native rendering APIs and client APIs are drawing into the same underlying surface, no guarantees are placed on the relative order of completion of operations in the different rendering streams other than those provided by the synchronization primitives discussed in section 3.8.

Some state is shared between client APIs and the underlying platform and rendering APIs, including color buffer values in window and pixmap surfaces.

2.3 Direct Rendering and Address Spaces

EGL is assumed to support only *direct* rendering, unlike similar APIs such as GLX. EGL objects and related context state cannot be used outside of the *address space* in which they are created. In a single-threaded environment, each process has its own address space. In a multi-threaded environment, all threads may share the same virtual address space; however, this capability is not required, and implementations may choose to restrict their address space to be per-thread even in an environment supporting multiple application threads.

Context state, including both the client and server state of OpenGL and OpenGL ES contexts, exists in the client's address space; this state cannot be shared by a client in another process.

Support of indirect rendering (in those environments where this concept makes sense) may have the effect of relaxing these limits on sharing. However, such support is beyond the scope of this document.

2.4 Shared State

Most context state is small. However, some types of state are potentially large and/or expensive to copy, in which case it may be desirable for multiple contexts to share such state rather than replicating it in each context. Such state may only be shared between different contexts of the same API type (e.g. two OpenGL contexts, two OpenGL ES contexts, or two OpenVG contexts, but not a mixture).

EGL provides for sharing certain types of context state among contexts existing in a single address space. The types of client API objects that are shareable are defined by the corresponding client API specifications.

2.4.1 OpenGL and OpenGL ES Texture Objects

Texture state can be encapsulated in a named texture object. A texture object is created by binding an unused name to one of the supported texture targets (`GL_TEXTURE_2D`, `GL_TEXTURE_3D`, or `GL_TEXTURE_CUBE_MAP`) of OpenGL or OpenGL ES context. When a texture object is bound, operations on the target to which it is bound affect the bound texture object, and queries of the target to which it is bound return state from the bound texture object.

OpenGL and OpenGL ES makes no attempt to synchronize access to texture objects. If a texture object is bound to more than one context, then it is up to the programmer to ensure that the contents of the object are not being changed via one context while another context is using the texture object for rendering. The results of changing a texture object while another context is using it are undefined.

All modifications to shared context state as a result of executing **glBindTexture** are atomic. Also, a texture object will not be deleted while it is still bound to any context.

2.4.2 OpenGL and OpenGL ES Buffer Objects

If a OpenGL or OpenGL ES buffer object is bound to more than one context, then it is up to the programmer to ensure that the contents of the object are not being changed via one context while another context is using the buffer object for rendering. The results of changing a buffer object while another context is using it are undefined.

All modifications to shared context state as a result of executing **glBindBuffer** are atomic. Also, a buffer object will not be deleted while it is still bound to any context.

2.5 EGLImages

As described in section 2.4, EGL allows contexts of the same client API type to share significant amounts of state (such as OpenGL and OpenGL ES texture objects, or OpenVG paths); however, in some cases it may be desirable to share state between client APIs. An example is using a previously-rendered OpenVG image as an OpenGL ES texture object.

In order to facilitate these more complicated use-cases, EGL is capable of creating EGL resources that can be shared between contexts of different client APIs (called EGLImages) from client API resources such as texel arrays in OpenGL ES texture objects or OpenVG VGLImages. Collectively, the resources that are used to create EGLImages are referred to as *EGLImage sources*.

The EGL client APIs each provide mechanisms for creating appropriate resource types (such as complete texture arrays or OpenVG VGLImages) from EGLImages through API-specific mechanisms. Collectively, resources which are created from EGLImages within client APIs are referred to as *EGLImage targets*. Each EGLImage may have multiple associated EGLImage targets. Collectively, the EGLImage source and EGLImage targets associated with an EGLImage object are referred to as *EGLImage siblings*.

Commands to create, manage, and destroy EGLImages are described in section 3.9.

2.6 Multiple Threads

EGL and its client APIs must be threadsafe. Interrupt routines may not share a context with their main thread.

EGL guarantees sequentiality within a command stream for each of its client APIs, but not between these APIs and native APIs which may also be rendering into the same surface. It is possible, for example, that a native drawing command issued by a single threaded client after an OpenGL ES command might be executed before that OpenGL ES command.

Client API commands are not guaranteed to be atomic. Some such commands might otherwise impair interactive use of the platform by the user. For instance, rendering a large texture mapped polygon on a system with no graphics hardware, or drawing a large OpenGL ES vertex array, could prevent a user from popping up a menu soon enough to be usable.

Synchronization is in the hands of the client. It can be maintained at moderate cost with the judicious use of commands such as **glFinish**, **vgFinish**, **eglWaitClient**, and **eglWaitNative**, as well as (if they exist) synchronization commands

present in native rendering APIs. Client API and native rendering can be done in parallel so long as the client does not preclude it with explicit synchronization calls.

Some performance degradation may be experienced if needless switching between client APIs and native rendering is done.

2.7 Power Management

Power management events can occur asynchronously while an application is running. When the system returns from the power management event the `EGLContext` will be invalidated, and all subsequent client API calls will have no effect (as if no context is bound).

Errors

Following a power management event, calls to **`eglSwapBuffers`**, **`eglCopyBuffers`**, or **`eglMakeCurrent`** will indicate failure by returning `EGL_FALSE`. The error `EGL_CONTEXT_LOST` will be returned if a power management event has occurred.

On detection of this error, the application must destroy all contexts (by calling **`eglDestroyContext`** for each context). To continue rendering the application must recreate any contexts it requires, and subsequently restore any client API state and objects it wishes to use.

Any `EGLSurfaces` that the application has created need not be destroyed following a power management event, but their contents will be invalid.

Note that not all implementations can be made to generate power management events, and developers should continue to refer to platform-specific documentation in this area. We expected continued work in platform-specific extensions to enable more control over power management issues, including event detection, scope and nature of resource loss, behavior of EGL and client API calls under resource loss, and recommended techniques for recovering from events. Future versions of EGL may incorporate additional functionality in this area.

2.8 Extensions

EGL implementations may expose additional functionality beyond that described by this specification. Additional functionality may include new functions, new enumerant values, and extended behavior for existing functions. Implementations ad-

vertise such extensions to EGL by exposing *extension strings*, which are queryable with **eglQueryString**.

Each EGL extension belongs to exactly one of the following types:

Display Extension A *display extension* adds functionality to an individual `EGLDisplay`. Different instances of `EGLDisplay` may support different sets of display extensions.

Client Extension A *client extension* adds functionality that is independent of any display. In other words, it adds functionality to the EGL client library itself. In a given process, there exists exactly one set, possibly empty, of supported client extensions. When the client extension string is first queried, that set becomes immutable.

Chapter 3

EGL Functions and Errors

3.1 Errors

Where possible, when an EGL function fails it has no side effects.

EGL functions usually return an indicator of success or failure; either an `EGLBoolean` `EGL_TRUE` or `EGL_FALSE` value, or in the form of an out-of-band return value indicating failure, such as returning `EGL_NO_CONTEXT` instead of a requested context handle. Additional information about the success or failure of the **most recent** EGL function called in a specific thread¹, in the form of an error code, can be obtained by calling

```
EGLint eglGetError(void);
```

The error codes that may be returned from `eglGetError`, and their meanings, are:

`EGL_SUCCESS`

Function succeeded.

`EGL_NOT_INITIALIZED`

EGL is not initialized, or could not be initialized, for the specified display. Any command may generate this error.

`EGL_BAD_ACCESS`

EGL cannot access a requested resource (for example, a context is bound in

¹ Note that calling `eglGetError` twice without any other intervening EGL calls will always return `EGL_SUCCESS` on the second call, since `eglGetError` is itself an EGL function, and the second call is reporting the success or failure of the first call. In other words, error checking must always be performed immediately after an EGL function fails.

another thread). Any command accessing a named resource may generate this error.

EGL_BAD_ALLOC

EGL failed to allocate resources for the requested operation. Any command allocating resources may generate this error.

EGL_BAD_ATTRIBUTE

An unrecognized attribute or attribute value was passed in an attribute list. Any command taking an attribute parameter or attribute list may generate this error.

EGL_BAD_CONTEXT

An `EGLContext` argument does not name a valid `EGLContext`. Any command taking an `EGLContext` parameter may generate this error.

EGL_BAD_CONFIG

An `EGLConfig` argument does not name a valid `EGLConfig`. Any command taking an `EGLConfig` parameter may generate this error.

EGL_BAD_CURRENT_SURFACE

The current surface of the calling thread is a window, pbuffer, or pixmap that is no longer valid.

EGL_BAD_DISPLAY

An `EGLDisplay` argument does not name a valid `EGLDisplay`. Any command taking an `EGLDisplay` parameter may generate this error.

EGL_BAD_SURFACE

An `EGLSurface` argument does not name a valid surface (window, pbuffer, or pixmap) configured for rendering. Any command taking an `EGLSurface` parameter may generate this error.

EGL_BAD_MATCH

Arguments are inconsistent; for example, an otherwise valid context requires buffers (e.g. depth or stencil) not allocated by an otherwise valid surface.

EGL_BAD_PARAMETER

One or more argument values are invalid. Any command taking parameters may generate this error.

EGL_BAD_NATIVE_PIXMAP

An `EGLNativePixmapType` argument does not refer to a valid native

`pixmap`. Any command taking an `EGLNativePixmapType` parameter may generate this error.

`EGL_BAD_NATIVE_WINDOW`

An `EGLNativeWindowType` argument does not refer to a valid native window. Any command taking an `EGLNativeWindowType` parameter may generate this error.

`EGL_CONTEXT_LOST`

A power management event has occurred. The application must destroy all contexts and reinitialise client API state and objects to continue rendering, as described in section 2.7. Any command may generate this error.

When an EGL function could potentially generate several different errors (for example, when passed both a bad attribute name, and a bad attribute value for a legal attribute name), the implementation may choose to generate any one of the applicable errors.

When there is no status to return (in other words, when `eglGetError` is called as the first EGL call in a thread, or immediately after calling `eglReleaseThread`), `EGL_SUCCESS` will be returned.

3.1.1 Generic Errors Are Not Described Repeatedly

Some specific error codes that may be generated by a failed EGL function, and their meanings, are described together with each function. However, not all possible errors are described with each function. Errors whose meanings are identical across many functions (such as returning `EGL_BAD_DISPLAY` or `EGL_NOT_INITIALIZED` for an unsuitable `EGLDisplay` argument) may not be described repeatedly. Some of the error codes above describe a class of commands which may generate them. Such errors are not necessarily described repeatedly together with each such command in the class.

3.1.2 Parameter Validation

EGL normally checks the validity of objects passed into it, but detecting invalid native objects (pixmap, window, and display) may not always be possible. Specifying such invalid handles may result in undefined behavior, although implementations should generate `EGL_BAD_NATIVE_PIXMAP` and `EGL_BAD_NATIVE_WINDOW` errors if possible.

3.2 Initialization

A display can be obtained by calling

```
EGLDisplay eglGetPlatformDisplay(EGLenum platform,  
    void *native_display, const EGLAttrib  
    *attrib_list);
```

The resulting `EGLDisplay` belongs to the native platform specified by *platform*. This specification defines no valid values for *platform*. Any specification that does define a valid value for *platform* will also define requirements for the *native_display* parameter. For example, an extension specification that defines support for the X11 platform may require that *native_display* be a pointer to an X11 `Display`, and an extension specification that defines support for the Microsoft Windows platform may require that *native_display* be a pointer to a Windows `Device Context`.

All attribute names in *attrib_list* are immediately followed by the corresponding desired value. The list is terminated with `EGL_NONE`. The *attrib_list* is considered empty if either *attrib_list* is `NULL` or if its first element is `EGL_NONE`. This specification defines no valid attribute names for *attrib_list*.

Multiple calls made to **eglGetPlatformDisplay** with the same parameters will return the same `EGLDisplay` handle.

If *platform* is valid but no display matching *native_display* is available, then `EGL_NO_DISPLAY` is returned; no error condition is raised in this case.

Errors

eglGetPlatformDisplay returns `EGL_NO_DISPLAY` on failure.

An `EGL_BAD_PARAMETER` error is generated if *platform* has an invalid value.

A display can also be obtained by calling

```
EGLDisplay eglGetDisplay(EGLNativeDisplayType  
    display_id);
```

The behavior of **eglGetDisplay** is similar to that of **eglGetPlatformDisplay**, but is specified in terms of implementation-specific behavior rather than platform-specific extensions. As for **eglGetPlatformDisplay**, EGL considers the returned `EGLDisplay` as belonging to the same platform as *display_id*. However, the set of platforms to which *display_id* is permitted to belong, as well as the actual type of

display_id, are implementation-specific. If *display_id* is `EGL_DEFAULT_DISPLAY`, a *default display* is returned. Multiple calls made to **eglGetDisplay** with the same *display_id* will return the same `EGLDisplay` handle.

If no display matching *display_id* is available, `EGL_NO_DISPLAY` is returned; no error condition is raised in this case.

EGL may be initialized on a display by calling

```
EGLBoolean eglInitialize(EGLDisplay dpy, EGLint
    *major, EGLint *minor);
```

`EGL_TRUE` is returned on success, and *major* and *minor* are updated with the major and minor version numbers of the EGL implementation (for example, in an EGL 1.2 implementation, the values of *major* and *minor* would be 1 and 2, respectively). *major* and *minor* are not updated if they are specified as `NULL`.

Initializing an already-initialized display is allowed, but the only effect of such a call is to return `EGL_TRUE` and update the EGL version numbers. An initialized display may be used from other threads in the same address space without being initialized again in those threads.

Errors

eglInitialize returns `EGL_FALSE` on failure, and *major* and *minor* are not updated.

An `EGL_BAD_DISPLAY` error is generated if the *dpy* argument does not refer to a valid `EGLDisplay`.

An `EGL_NOT_INITIALIZED` error is generated if EGL cannot be initialized for an otherwise valid *dpy*.

To release resources associated with use of EGL and client APIs on a display, call

```
EGLBoolean eglTerminate(EGLDisplay dpy);
```

Termination marks **all** EGL-specific resources, such as contexts and surfaces, associated with the specified display for deletion. Handles to all such resources are invalid as soon as **eglTerminate** returns, but the *dpy* handle itself remains valid. Passing such handles to any other EGL command will generate `EGL_BAD_SURFACE` or `EGL_BAD_CONTEXT` errors. Applications should not try to perform useful work

with such resources following **eglTerminate**; only **eglMakeCurrent** or **eglReleaseThread** should be called, to complete deletion of these resources. ²

If contexts or surfaces, created with respect to *dpy* are *current* (see section 3.7.3) to any thread, then they are not actually destroyed while they remain current. If other resources created with respect to *dpy* are in use by any current context or surface, then they are also not destroyed until the corresponding context or surface is no longer current.

All such resources will be destroyed as soon as **eglReleaseThread** is called from the thread they are bound to, or **eglMakeCurrent** is called from that thread with the current rendering API (see section 3.7) set such that the current context is affected. Use of bound contexts and surfaces (that is, continuing to issue commands to a bound client API context) will not result in interruption or termination of applications, but rendering results are undefined, and client APIs may generate errors.

Errors

eglTerminate returns `EGL_FALSE` on failure.

If the *dpy* argument does not refer to a valid `EGLDisplay`, an `EGL_BAD_DISPLAY` error is generated.

Termination of a display that has already been terminated, or has not yet been initialized, is allowed, but the only effect of such a call is to return `EGL_TRUE`, since there are no EGL resources associated with the display to release. A terminated display may be re-initialized by calling **eglInitialize** again. When re-initializing a terminated display, resources which were marked for deletion as a result of the earlier termination remain so marked, and handles which previously referred to them remain invalid

At any point a display may either be initialized or uninitialized. All displays start out uninitialized. A display becomes initialized after **eglInitialize** is successfully called on it. A display becomes uninitialized after **eglTerminate** is successfully called on it. An uninitialized display may be passed to the functions **eglInitialize**, **eglTerminate**, and in some cases **eglMakeCurrent**. All other EGL functions which take a *display* argument will fail and generate an `EGL_NOT_`

² Immediately invalidating handles is a subtle behavior change. Prior to the January 13, 2009 release of the EGL 1.4 Specification, handles remained valid so long as the underlying surface was current. In the September 18, 2010 release, handle invalidation was explicitly extended to all EGL resources associated with *dpy*, not just contexts and surfaces.

INITIALIZED error when passed a valid but uninitialized display.³

3.3 EGL Queries

```
const char *eglQueryString(EGLDisplay dpy, EGLint
    name);
```

eglQueryString returns a pointer to a static, zero-terminated string describing some aspect of the EGL implementation running on the specified display. *name* may be one of `EGL_CLIENT_APIS`, `EGL_EXTENSIONS`, `EGL_VENDOR`, or `EGL_VERSION`.

The `EGL_CLIENT_APIS` string describes which client APIs are supported. It is zero-terminated and contains a space-separated list of API names, which must include at least one of `''OpenGL''`, `''OpenGL_ES''` or `''OpenVG''`.

The `EGL_EXTENSIONS` string describes the set of supported EGL extensions. The string is zero-terminated and contains a space-separated list of extension names; extension names themselves do not contain spaces. If there are no extensions, then the empty string is returned.

If *dpy* is `EGL_NO_DISPLAY`, then the `EGL_EXTENSIONS` string describes the set of supported client extensions. If *dpy* is a valid, initialized display, then the `EGL_EXTENSIONS` string describes the set of display extensions supported by that display. The set of supported client extensions is disjoint from the set of extensions supported by any given display (see section 2.8).

The format and contents of the `EGL_VENDOR` string is implementation dependent.

The format of the `EGL_VERSION` string is:

```
<major_version.minor_version><space><vendor_specific_info>
```

Both the major and minor portions of the version number are numeric. Their values must match the *major* and *minor* values returned by **eglInitialize** (see section 3.2). The vendor-specific information is optional; if present, its format and contents are implementation specific.

If *dpy* is `EGL_NO_DISPLAY`, then the `EGL_VERSION` string describes the supported client version. If *dpy* is a valid, initialized display, then the `EGL_VERSION` string describes the supported EGL version for *dpy*. The client version indicates

³ Note that once an `EGLDisplay` is created, the handle will necessarily remain valid for the lifetime of the application, although the corresponding display may be repeatedly initialized and terminated.

that all EGL entry points which are needed for the supported client APIs are available at runtime, while the display version indicates which EGL functionality is supported for a display.

Errors

On failure, `NULL` is returned.

An `EGL_BAD_DISPLAY` error is generated if *dpy* is not a valid display, unless *dpy* is `EGL_NO_DISPLAY` and *name* is `EGL_EXTENSIONS` or `EGL_VERSION`.

An `EGL_NOT_INITIALIZED` error is generated if *dpy* is a valid but uninitialized display.

An `EGL_BAD_PARAMETER` error is generated if *name* is not one of the values described above.

3.4 Configuration Management

An `EGLConfig` describes the format, type and size of the color buffers and ancillary buffers for an `EGLSurface`. If the `EGLSurface` is a window, then the `EGLConfig` describing it may have an associated native *visual type*.

Names of `EGLConfig` attributes are shown in table 3.1. These names may be passed to `eglChooseConfig` to specify required attribute properties.

`EGL_CONFIG_ID` is a unique integer identifying different `EGLConfigs`. Configuration IDs must be small positive integers starting at 1 and ID assignment should be compact; that is, if there are N `EGLConfigs` defined by the EGL implementation, their configuration IDs should be in the range $[1, N]$. Small gaps in the sequence are allowed, but should only occur when removing configurations defined in previous revisions of an EGL implementation.

Buffer Descriptions and Attributes

The various buffers that may be contained by an `EGLSurface`, and the `EGLConfig` attributes controlling their creation, are described below. Attribute values include the *depth* of these buffers, expressed in bits/pixel component. If the depth of a buffer in an `EGLConfig` is zero, then an `EGLSurface` created with respect to that `EGLConfig` will not contain the corresponding buffer.

Not all buffers are used or required by all client APIs. To conserve resources, implementations may delay creation of buffers until they are needed by EGL or a client API. For example, if an `EGLConfig` describes an alpha mask buffer with

Attribute	Type	Notes
EGL_BUFFER_SIZE	integer	total color component bits in the color buffer
EGL_RED_SIZE	integer	bits of Red in the color buffer
EGL_GREEN_SIZE	integer	bits of Green in the color buffer
EGL_BLUE_SIZE	integer	bits of Blue in the color buffer
EGL_LUMINANCE_SIZE	integer	bits of Luminance in the color buffer
EGL_ALPHA_SIZE	integer	bits of Alpha in the color buffer
EGL_ALPHA_MASK_SIZE	integer	bits of Alpha Mask in the mask buffer
EGL_BIND_TO_TEXTURE_RGB	boolean	True if bindable to RGB textures.
EGL_BIND_TO_TEXTURE_RGBA	boolean	True if bindable to RGBA textures.
EGL_COLOR_BUFFER_TYPE	enum	color buffer type
EGL_CONFIG_CAVEAT	enum	any caveats for the configuration
EGL_CONFIG_ID	integer	unique EGLConfig identifier
EGL_CONFORMANT	bitmask	whether contexts created with this config are conformant
EGL_DEPTH_SIZE	integer	bits of Z in the depth buffer
EGL_LEVEL	integer	frame buffer level
EGL_MAX_PBUFFER_WIDTH	integer	maximum width of pbuffer
EGL_MAX_PBUFFER_HEIGHT	integer	maximum height of pbuffer
EGL_MAX_PBUFFER_PIXELS	integer	maximum size of pbuffer
EGL_MAX_SWAP_INTERVAL	integer	maximum swap interval
EGL_MIN_SWAP_INTERVAL	integer	minimum swap interval
EGL_NATIVE_RENDERABLE	boolean	EGL_TRUE if native rendering APIs can render to surface
EGL_NATIVE_VISUAL_ID	integer	handle of corresponding native visual
EGL_NATIVE_VISUAL_TYPE	integer	native visual type of the associated visual
EGL_RENDERABLE_TYPE	bitmask	which client APIs are supported
EGL_SAMPLE_BUFFERS	integer	number of multisample buffers
EGL_SAMPLES	integer	number of samples per pixel
EGL_STENCIL_SIZE	integer	bits of Stencil in the stencil buffer
EGL_SURFACE_TYPE	bitmask	which types of EGL surfaces are supported.
EGL_TRANSPARENT_TYPE	enum	type of transparency supported
EGL_TRANSPARENT_RED_VALUE	integer	transparent red value
EGL_TRANSPARENT_GREEN_VALUE	integer	transparent green value
EGL_TRANSPARENT_BLUE_VALUE	integer	transparent blue value

Table 3.1: EGLConfig attributes.
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depth greater than zero, that buffer need not be allocated by a surface until an OpenVG context is bound to that surface.

The Color Buffer

The *color buffer* contains pixel color values, and is shared by all client APIs rendering to a surface.

`EGL_COLOR_BUFFER_TYPE` indicates the color buffer type, and must be either `EGL_RGB_BUFFER` for an RGB color buffer, or `EGL_LUMINANCE_BUFFER` for a luminance color buffer. For an RGB buffer, `EGL_RED_SIZE`, `EGL_GREEN_SIZE`, `EGL_BLUE_SIZE` must be non-zero, and `EGL_LUMINANCE_SIZE` must be zero. For a luminance buffer, `EGL_RED_SIZE`, `EGL_GREEN_SIZE`, `EGL_BLUE_SIZE` must be zero, and `EGL_LUMINANCE_SIZE` must be non-zero. For both RGB and luminance color buffers, `EGL_ALPHA_SIZE` may be zero or non-zero (the latter indicates the existence of a *destination alpha* buffer).

If OpenGL or OpenGL ES rendering is supported for a luminance color buffer (as described by the value of the `EGL_RENDERABLE_TYPE` attribute, described below), it is treated as RGB rendering with the value of `GL_RED_BITS` equal to `EGL_LUMINANCE_SIZE` and the values of `GL_GREEN_BITS` and `GL_BLUE_BITS` equal to zero. The red component of fragments is written to the luminance channel of the color buffer, the green and blue components are discarded, and the alpha component is written to the alpha channel of the color buffer (if present).

`EGL_BUFFER_SIZE` gives the total of the color component bits of the color buffer⁴. For an RGB color buffer, the total is the sum of `EGL_RED_SIZE`, `EGL_GREEN_SIZE`, `EGL_BLUE_SIZE`, and `EGL_ALPHA_SIZE`. For a luminance color buffer, the total is the sum of `EGL_LUMINANCE_SIZE` and `EGL_ALPHA_SIZE`.

The Alpha Mask Buffer

The *alpha mask buffer* is used only by OpenVG. `EGL_ALPHA_MASK_SIZE` indicates the depth of this buffer.

The Depth Buffer

The *depth buffer* is shared by OpenGL and OpenGL ES. It contains fragment depth (Z) information generated during rasterization. `EGL_DEPTH_SIZE` indicates the depth of this buffer in bits.

⁴ The value of `EGL_BUFFER_SIZE` does not include any padding bits that may be present in the pixel format, nor does it account for any alignment or padding constraints of surfaces, so it cannot be reliably used to compute the memory consumed by a surface. No such query exists in EGL 1.4.

The Stencil Buffer

The *stencil buffer* is shared by OpenGL and OpenGL ES. It contains fragment stencil information generated during rasterization. `EGL_STENCIL_SIZE` indicates the depth of this buffer in bits.

The Multisample Buffer

The *multisample buffer* may be shared by OpenGL, OpenGL ES and OpenVG, although such sharing cannot be guaranteed (see comments at the end of section 3.7.3.1 for more information about sharing the multisample buffer). It contains multisample information (color values, and possibly stencil and depth values) generated by multisample rasterization. The format of the multisample buffer is not specified, and its contents are not directly accessible. Only the existence of the multisample buffer, together with the number of samples it contains, are exposed by EGL.

Operations such as posting a surface with **eglSwapBuffers** (see section 3.10.1, copying a surface with **eglCopyBuffers** (see section 3.10.2), reading from the color buffer using client API commands, and binding a client API context to a surface (see section 3.7.3), may cause *resolution* of the multisample buffer to the color buffer.

Multisample resolution combines and filters per-sample information in the multisample buffer to create per-pixel colors stored in the color buffer. The details of this filtering process are normally chosen by the implementation, but under some circumstances may be controlled on a per-surface basis using **eglSurfaceAttrib** (see section 3.5.6).

`EGL_SAMPLE_BUFFERS` indicates the number of multisample buffers, which must be zero or one. `EGL_SAMPLES` gives the number of samples per pixel; if `EGL_SAMPLE_BUFFERS` is zero, then `EGL_SAMPLES` will also be zero. If `EGL_SAMPLE_BUFFERS` is one, then the number of color, depth, and stencil bits for each sample in the multisample buffer are as specified by the `EGL_*_SIZE` attributes.

There are no single-sample depth or stencil buffers for a multisample `EGLConfig`; the only depth and stencil buffers are those in the multisample buffer. If the color samples in the multisample buffer store fewer bits than are stored in the color buffers, this fact will not be reported accurately. Presumably a compression scheme is being employed, and is expected to maintain an aggregate resolution equal to that of the color buffers.

Other `EGLConfig` Attribute Descriptions

EGL Token Name	Description
EGL_WINDOW_BIT	EGLConfig supports windows
EGL_PIXMAP_BIT	EGLConfig supports pixmaps
EGL_PBUFFER_BIT	EGLConfig supports pbuffers
EGL_MULTISAMPLE_RESOLVE_BOX_BIT	EGLConfig supports box filtered multisample resolve
EGL_SWAP_BEHAVIOR_PRESERVED_BIT	EGLConfig supports setting swap behavior for color buffers
EGL_VG_COLORSPACE_LINEAR_BIT	EGLConfig supports OpenVG rendering in linear colorspace
EGL_VG_ALPHA_FORMAT_PRE_BIT	EGLConfig supports OpenVG rendering with premultiplied alpha

Table 3.2: Types of surfaces supported by an EGLConfig

EGL_SURFACE_TYPE is a mask indicating capabilities of surfaces that can be created with the corresponding EGLConfig (the config is said to *support* these surface types). The valid bit settings are shown in Table 3.2.

For example, an EGLConfig for which the value of the EGL_SURFACE_TYPE attribute is

```
EGL_WINDOW_BIT | EGL_PIXMAP_BIT | EGL_PBUFFER_BIT
```

can be used to create any type of EGL surface, while an EGLConfig for which this attribute value is EGL_WINDOW_BIT cannot be used to create a pbuffer or pixmap. EGL_SURFACE_TYPE is EGL_WINDOW_BIT.

If EGL_MULTISAMPLE_RESOLVE_BOX_BIT is set in EGL_SURFACE_TYPE, then the EGL_MULTISAMPLE_RESOLVE attribute of a surface can be specified as a box filter with **eglSurfaceAttrib** (see section 3.5.6).

If EGL_SWAP_BEHAVIOR_PRESERVED_BIT is set in EGL_SURFACE_TYPE, then the EGL_SWAP_BEHAVIOR attribute of a surface can be specified to preserve color buffer contents using **eglSurfaceAttrib** (see section 3.5.6).

If EGL_VG_COLORSPACE_LINEAR_BIT is set in EGL_SURFACE_TYPE, then the EGL_VG_COLORSPACE attribute may be set to EGL_VG_COLORSPACE_LINEAR when creating a window, pixmap, or pbuffer surface (see section 3.5).

If EGL_VG_ALPHA_FORMAT_PRE_BIT is set in EGL_SURFACE_TYPE, then the EGL_VG_ALPHA_FORMAT attribute may be set to EGL_VG_ALPHA_FORMAT_PRE when creating a window, pixmap, or pbuffer surface (see section 3.5).

EGL_RENDERABLE_TYPE is a mask indicating which client APIs can render into a surface created with respect to an EGLConfig. The valid bit settings are

EGL Token Name	Client API and Version Supported
EGL_OPENGL_BIT	OpenGL
EGL_OPENGL_ES_BIT	OpenGL ES 1.x
EGL_OPENGL_ES2_BIT	OpenGL ES 2.x
EGL_OPENGL_ES3_BIT	OpenGL ES 3.x
EGL_OPENVG_BIT	OpenVG 1.x

Table 3.3: Types of client APIs supported by an `EGLConfig`

shown in Table 3.3.

Creation of a client API context based on an `EGLConfig` will fail unless the `EGLConfig`'s `EGL_RENDERABLE_TYPE` attribute include the bit corresponding to that API and version.

`EGL_NATIVE_RENDERABLE` is an `EGLBoolean` indicating whether the platform can be used to render into a surface created with the `EGLConfig`. Constraints on native rendering are discussed in more detail in sections 2.2.2 and 2.2.3.

If an `EGLConfig` supports windows then it may have an associated native visual. `EGL_NATIVE_VISUAL_ID` specifies an identifier for this visual, and `EGL_NATIVE_VISUAL_TYPE` specifies its type. If an `EGLConfig` does not support windows, or if there is no associated native visual type, then querying `EGL_NATIVE_VISUAL_ID` will return 0 and querying `EGL_NATIVE_VISUAL_TYPE` will return `EGL_NONE`.

The interpretation of the native visual identifier and type is platform-dependent. For example, if the platform is X11, then the identifier will be the `XID` of an `XVisual`.

The `EGL_CONFIG_CAVEAT` attribute may be set to one of the following values: `EGL_NONE`, `EGL_SLOW_CONFIG` or `EGL_NON_CONFORMANT_CONFIG`. If the attribute is set to `EGL_NONE` then the configuration has no caveats; if it is set to `EGL_SLOW_CONFIG` then rendering to a surface with this configuration may run at reduced performance (for example, the hardware may not support the color buffer depths described by the configuration); if it is set to `EGL_NON_CONFORMANT_CONFIG` then rendering to a surface with this configuration will not pass the required OpenGL ES conformance tests (note that `EGL_NON_CONFORMANT_CONFIG` is obsolete, and the same information can be obtained from the `EGL_CONFORMANT` attribute on a per-client-API basis, not just for OpenGL ES).

API conformance requires that a set of `EGLConfigs` supporting certain defined minimum attributes (such as the number, type, and depth of supported buffers) be supplied by any conformant implementation. Those requirements are

documented only in the conformance specifications for client APIs.

`EGL_CONFORMANT` is a mask indicating if a client API context created with respect to the corresponding `EGLConfig` will pass the required conformance tests for that API. The valid bit settings are the same as for `EGL_RENDERABLE_TYPE`, as defined in table 3.3, but the presence or absence of each client API bit determines whether the corresponding context will be conformant or non-conformant.⁵

`EGL_LEVEL` is the framebuffer overlay or underlay level in which an `EGLSurface` created with respect to an on-screen native window (see section 3.5.1) will be placed. Level zero indicates the default layer. The behavior of windows placed in overlay and underlay levels depends on the underlying platform.

`EGL_TRANSPARENT_TYPE` indicates whether or not a configuration supports transparency. If the attribute is set to `EGL_NONE` then windows created with the `EGLConfig` will not have any transparent pixels. If the attribute is `EGL_TRANSPARENT_RGB`, then the `EGLConfig` supports transparency; a transparent pixel will be drawn when the red, green and blue values which are read from the framebuffer are equal to `EGL_TRANSPARENT_RED_VALUE`, `EGL_TRANSPARENT_GREEN_VALUE` and `EGL_TRANSPARENT_BLUE_VALUE`, respectively.

If `EGL_TRANSPARENT_TYPE` is `EGL_NONE`, then the values for `EGL_TRANSPARENT_RED_VALUE`, `EGL_TRANSPARENT_GREEN_VALUE`, and `EGL_TRANSPARENT_BLUE_VALUE` are undefined. Otherwise, they are interpreted as integer framebuffer values between 0 and the maximum framebuffer value for the component. For example, `EGL_TRANSPARENT_RED_VALUE` will range between 0 and $2^{\text{EGL_RED_SIZE}} - 1$.

`EGL_MAX_PBUFFER_WIDTH` and `EGL_MAX_PBUFFER_HEIGHT` indicate the maximum width and height that can be passed into `eglCreatePbufferSurface`, and `EGL_MAX_PBUFFER_PIXELS` indicates the maximum number of pixels (width times height) for a pbuffer surface. Note that an implementation may return a value for `EGL_MAX_PBUFFER_PIXELS` that is less than the maximum width times the maximum height. The value for `EGL_MAX_PBUFFER_PIXELS` is static and assumes that no other pbuffers or native resources are contending for the framebuffer memory. Thus it may not be possible to allocate a pbuffer of the size given by `EGL_MAX_PBUFFER_PIXELS`.

`EGL_MAX_SWAP_INTERVAL` is the maximum value that can be passed to `eglSwapInterval`, and indicates the number of swap intervals that will elapse before a buffer swap takes place after calling `eglSwapBuffers`. Larger values will be

⁵ Most `EGLConfigs` should be conformant for all supported client APIs. Conformance requirements limit the number of non-conformant configs that an implementation can define.

silently clamped to this value.

`EGL_MIN_SWAP_INTERVAL` is the minimum value that can be passed to **eglSwapInterval**, and indicates the number of swap intervals that will elapse before a buffer swap takes place after calling **eglSwapBuffers**. Smaller values will be silently clamped to this value.

`EGL_BIND_`-

`TO_TEXTURE_RGB` and `EGL_BIND_TO_TEXTURE_RGBA` are booleans indicating whether the color buffers of a pbuffer created with the `EGLConfig` can be bound to an OpenGL ES RGB or RGBA texture respectively. Currently only pbuffers can be bound as textures, so these attributes may only be `EGL_TRUE` if the value of the `EGL_SURFACE_TYPE` attribute includes `EGL_PBUFFER_BIT`. It is possible to bind a RGBA visual to a RGB texture, in which case the values in the alpha component of the visual are ignored when the color buffer is used as a RGB texture.

Implementations may choose not to support `EGL_BIND_TO_TEXTURE_RGB` for RGBA visuals.

Texture binding to OpenGL textures is not supported.

3.4.1 Querying Configurations

Use

```
EGLBoolean eglGetConfigs(EGLDisplay dpy,
    EGLConfig *configs, EGLint config_size,
    EGLint *num_config);
```

to get the list of all `EGLConfigs` that are available on the specified display. *configs* is a pointer to a buffer containing *config_size* elements. On success, `EGL_TRUE` is returned. The number of configurations is returned in *num_config*, and elements 0 through *num_config* - 1 of *configs* are filled in with the valid `EGLConfigs`. No more than *config_size* `EGLConfigs` will be returned even if more are available on the specified display. However, if **eglGetConfigs** is called with *configs* = `NULL`, then no configurations are returned, but the total number of configurations available will be returned in *num_config*.

Errors

On failure, `EGL_FALSE` is returned.

An `EGL_NOT_INITIALIZED` error is generated if EGL is not initialized on *dpy*.

An `EGL_BAD_PARAMETER` error is generated if *num_config* is `NULL`.

Use

```
EGLBoolean eglChooseConfig(EGLDisplay dpy, const
    EGLint *attrib_list, EGLConfig *configs,
    EGLint config_size, EGLint *num_config);
```

to get `EGLConfigs` that match a list of attributes. The return value and the meaning of `configs`, `config_size`, and `num_config` are the same as for `eglGetConfigs`. However, only configurations matching `attrib_list`, as discussed below, will be returned.

Errors

On failure, `EGL_FALSE` is returned.

An `EGL_BAD_ATTRIBUTE` error is generated if `attrib_list` contains an undefined EGL attribute or an attribute value that is unrecognized or out of range.

All attribute names in `attrib_list` are immediately followed by the corresponding desired value. The list is terminated with `EGL_NONE`. If an attribute is not specified in `attrib_list`, then the default value (shown in Table 3.4) is used (it is said to be specified implicitly). If `EGL_DONT_CARE` is specified as an attribute value, then the attribute will not be checked. `EGL_DONT_CARE` may be specified for all attributes except `EGL_LEVEL` and `EGL_MATCH_NATIVE_PIXMAP`. If `attrib_list` is `NULL` or empty (first attribute is `EGL_NONE`), then selection and sorting of `EGLConfigs` is done according to the default criteria in Tables 3.4 and 3.1, as described below in sections 3.4.1.1 and 3.4.1.2.

3.4.1.1 Selection of `EGLConfigs`

Attributes are matched in an attribute-specific manner, as shown in the "Selection Criteria" column of table 3.4. The criteria shown in the table have the following meanings:

AtLeast Only `EGLConfigs` with an attribute value that meets or exceeds the specified value are selected.

Exact Only `EGLConfigs` whose attribute value equals the specified value are matched.

Mask Only `EGLConfigs` for which the bits set in the attribute value include all the bits that are set in the specified value are selected (additional bits might

be set in the attribute value)⁶.

Special As described for the specific attribute.

Some of the attributes must match the specified value exactly; others, such as `EGL_RED_SIZE`, must meet or exceed the specified minimum values.

To retrieve an `EGLConfig` given its unique integer ID, use the `EGL_CONFIG_ID` attribute. When `EGL_CONFIG_ID` is specified, all other attributes are ignored, and only the `EGLConfig` with the given ID is returned.

If `EGL_MAX_PBUFFER_WIDTH`, `EGL_MAX_PBUFFER_HEIGHT`, `EGL_MAX_PBUFFER_PIXELS`, or `EGL_NATIVE_VISUAL_ID` are specified in *attrib_list*, then they are ignored (however, if present, these attributes must still be followed by an attribute value in *attrib_list*). If `EGL_SURFACE_TYPE` is specified in *attrib_list* and the mask that follows does not have `EGL_WINDOW_BIT` set, or if there are no native visual types, then the `EGL_NATIVE_VISUAL_TYPE` attribute is ignored.

If `EGL_TRANSPARENT_TYPE` is set to `EGL_NONE` in *attrib_list*, then the `EGL_TRANSPARENT_RED_VALUE`, `EGL_TRANSPARENT_GREEN_VALUE`, and `EGL_TRANSPARENT_BLUE_VALUE` attributes are ignored.

If `EGL_MATCH_NATIVE_PIXMAP` is specified in *attrib_list*, it must be followed by an attribute value which is the handle of a valid native pixmap. Only `EGLConfigs` which support rendering to that pixmap will match this attribute⁷.

If no `EGLConfig` matching the attribute list exists, then the call succeeds, but *num_config* is set to 0.

3.4.1.2 Sorting of `EGLConfigs`

If more than one matching `EGLConfig` is found, then a list of `EGLConfigs` is returned. The list is sorted by proceeding in ascending order of the "Sort Priority" column of table 3.4. That is, configurations that are not ordered by a lower numbered rule are sorted by the next higher numbered rule.

Sorting for each rule is either numerically *Smaller* or *Larger* as described in the "Sort Order" column, or a *Special* sort order as described for each sort rule below:

1. *Special*: by `EGL_CONFIG_CAVEAT` where the precedence is `EGL_NONE`, `EGL_SLOW_CONFIG`, `EGL_NON_CONFORMANT_CONFIG`.

⁶ Some readers have found this phrasing confusing. Another way to think of it to say that any bits present in the mask attribute must also be present in the `EGLConfig` attribute. Thus, setting a mask attribute value of zero means that all configs will match that value.

⁷ The special match criteria for `EGL_MATCH_NATIVE_PIXMAP` was introduced due to the difficulty of determining an `EGLConfig` equivalent to a native pixmap using only color component depths.

Attribute	Default	Selection Criteria	Sort Order	Sort Priority
EGL_BUFFER_SIZE	0	<i>AtLeast</i>	<i>Smaller</i>	4
EGL_RED_SIZE	0	<i>AtLeast</i>	<i>Special</i>	3
EGL_GREEN_SIZE	0	<i>AtLeast</i>	<i>Special</i>	3
EGL_BLUE_SIZE	0	<i>AtLeast</i>	<i>Special</i>	3
EGL_LUMINANCE_SIZE	0	<i>AtLeast</i>	<i>Special</i>	3
EGL_ALPHA_SIZE	0	<i>AtLeast</i>	<i>Special</i>	3
EGL_ALPHA_MASK_SIZE	0	<i>AtLeast</i>	<i>Smaller</i>	9
EGL_BIND_TO_TEXTURE_RGB	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_BIND_TO_TEXTURE_RGBA	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_COLOR_BUFFER_TYPE	EGL_RGB_BUFFER	<i>Exact</i>	<i>Special</i>	2
EGL_CONFIG_CAVEAT	EGL_DONT_CARE	<i>Exact</i>	<i>Special</i>	1
EGL_CONFIG_ID	EGL_DONT_CARE	<i>Special</i>	<i>Smaller</i>	11 (last)
EGL_CONFORMANT	0	<i>Mask</i>	<i>None</i>	
EGL_DEPTH_SIZE	0	<i>AtLeast</i>	<i>Smaller</i>	7
EGL_LEVEL	0	<i>Exact</i>	<i>None</i>	
EGL_MATCH_NATIVE_PIXMAP	EGL_NONE	<i>Special</i>	<i>None</i>	
EGL_MAX_SWAP_INTERVAL	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_MIN_SWAP_INTERVAL	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_NATIVE_RENDERABLE	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_NATIVE_VISUAL_TYPE	EGL_DONT_CARE	<i>Exact</i>	<i>Special</i>	10
EGL_RENDERABLE_TYPE	EGL_OPENGL_ES_BIT	<i>Mask</i>	<i>None</i>	
EGL_SAMPLE_BUFFERS	0	<i>AtLeast</i>	<i>Smaller</i>	5
EGL_SAMPLES	0	<i>AtLeast</i>	<i>Smaller</i>	6
EGL_STENCIL_SIZE	0	<i>AtLeast</i>	<i>Smaller</i>	8
EGL_SURFACE_TYPE	EGL_WINDOW_BIT	<i>Mask</i>	<i>None</i>	
EGL_TRANSPARENT_TYPE	EGL_NONE	<i>Exact</i>	<i>None</i>	
EGL_TRANSPARENT_RED_VALUE	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_TRANSPARENT_GREEN_VALUE	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	
EGL_TRANSPARENT_BLUE_VALUE	EGL_DONT_CARE	<i>Exact</i>	<i>None</i>	

Table 3.4: Default values and match criteria for EGLConfig attributes.

2. *Special*: by `EGL_COLOR_BUFFER_TYPE` where the precedence is `EGL_RGB_BUFFER`, `EGL_LUMINANCE_BUFFER`.
3. *Special*: by larger *total* number of color bits (for an RGB color buffer, this is the sum of `EGL_RED_SIZE`, `EGL_GREEN_SIZE`, `EGL_BLUE_SIZE`, and `EGL_ALPHA_SIZE`; for a luminance color buffer, the sum of `EGL_LUMINANCE_SIZE` and `EGL_ALPHA_SIZE`)⁸. If the requested number of bits in *attrib_list* for a particular color component is 0 or `EGL_DONT_CARE`, then the number of bits for that component is not considered.
4. *Smaller* `EGL_BUFFER_SIZE`.
5. *Smaller* `EGL_SAMPLE_BUFFERS`.
6. *Smaller* `EGL_SAMPLES`.
7. *Smaller* `EGL_DEPTH_SIZE`.
8. *Smaller* `EGL_STENCIL_SIZE`.
9. *Smaller* `EGL_ALPHA_MASK_SIZE`.
10. *Special*: by `EGL_NATIVE_VISUAL_TYPE` (the actual sort order is implementation-defined, depending on the meaning of native visual types).
11. *Smaller* `EGL_CONFIG_ID` (this is always the last sorting rule, and guarantees a unique ordering).

`EGLConfigs` are not sorted with respect to the parameters `EGL_BIND_TO_TEXTURE_RGB`, `EGL_BIND_TO_TEXTURE_RGBA`, `EGL_CONFORMANT`, `EGL_LEVEL`, `EGL_NATIVE_RENDERABLE`, `EGL_MAX_SWAP_INTERVAL`, `EGL_MIN_SWAP_INTERVAL`, `EGL_RENDERABLE_TYPE`, `EGL_SURFACE_TYPE`, `EGL_TRANSPARENT_TYPE`, `EGL_TRANSPARENT_RED_VALUE`, `EGL_TRANSPARENT_GREEN_VALUE`, and `EGL_TRANSPARENT_BLUE_VALUE`.

⁸ This rule places configs with deeper color buffers first in the list returned by `eglChooseConfig`. Applications may find this counterintuitive if they expect configs with smaller buffer sizes to be returned first. For example, if an implementation has two configs with RGBA depths of 8888 and 5650, and the application specifies RGBA sizes of 1110, the 8888 config will be returned first. To avoid this rule altogether, specify 0 or `EGL_DONT_CARE` for each component size. In this case this rule will be ignored, and rule 4, which prefers configs with a smaller `EGL_BUFFER_SIZE`, will apply.

3.4.2 Lifetime of Configurations

Configuration handles (`EGLConfigs`) returned by `eglGetConfigs` and `eglChooseConfig` remain valid so long as the `EGLDisplay` from which the handles were obtained is not terminated. Implementations supporting a large number of different configurations, where it might be burdensome to instantiate data structures for each configuration so queried (but never used), may choose to return handles encoding sufficient information to instantiate the corresponding configurations dynamically, when needed to create EGL resources or query configuration attributes.

3.4.3 Querying Configuration Attributes

To get the value of an `EGLConfig` attribute, use

```
EGLBoolean eglGetConfigAttrib(EGLDisplay dpy,  
                               EGLConfig config, EGLint attribute, EGLint  
                               *value);
```

If `eglGetConfigAttrib` succeeds then it returns `EGL_TRUE` and the value for the specified attribute is returned in *value*.

Errors

On failure `eglGetConfigAttrib` returns `EGL_FALSE`.
If *attribute* is not a valid attribute then `EGL_BAD_ATTRIBUTE` is generated.

attribute may be any of the EGL attributes shown in tables 3.1 and 3.4, with the exception of `EGL_MATCH_NATIVE_PIXMAP`.

3.5 Rendering Surfaces

3.5.1 Creating On-Screen Rendering Surfaces

To create an on-screen rendering surface, first create a native platform window whose pixel format corresponds to the format, type, and size of the color buffers required by *config*. On some implementations, the pixel format of the native win-

dow must match that of the `EGLConfig`⁹. Other implementations may allow any native window and *config* to correspond, even if their formats differ¹⁰.

The command

```
EGLSurface
    eglCreatePlatformWindowSurface(EGLDisplay dpy,
    EGLConfig config, void *native_window,
    const EGLAttrib *attrib_list);
```

creates an onscreen `EGLSurface` and returns a handle to it. Any EGL context created with a compatible `EGLConfig` can be used to render into this surface.

native_window must belong to the same platform as *dpy*, and EGL considers the returned `EGLSurface` as belonging to that same platform. The EGL extension that defines the platform to which *dpy* belongs also defines the requirements for the *native_window* parameter.

attrib_list specifies a list of attributes for the window. The list has the same structure as described for **eglChooseConfig**. Attributes that can be specified in *attrib_list* include `EGL_GL_COLORSPACE`, `EGL_RENDER_BUFFER`, `EGL_VG_COLORSPACE`, and `EGL_VG_ALPHA_FORMAT`.

It is possible that some platforms will define additional attributes specific to those environments, as an EGL extension.

attrib_list may be `NULL` or empty (first attribute is `EGL_NONE`), in which case all attributes assumes their default value as described below.

`EGL_RENDER_BUFFER` specifies which buffer should be used by default for client API rendering to the window, as described in section 2.2.2. If its value is `EGL_SINGLE_BUFFER`, then client APIs should render directly into the visible window. If its value is `EGL_BACK_BUFFER`, then all client APIs should render into the back buffer. The default value of `EGL_RENDER_BUFFER` is `EGL_BACK_BUFFER`.

Client APIs may not be able to respect the requested rendering buffer. To determine the actual buffer that a context will render to by default, call **eglQueryContext** with *attribute* `EGL_RENDER_BUFFER` (see section 3.7.4).

⁹ The exact definition of matching formats is implementation-dependent, but usually means the color format (which of R, G, B, and A components are present), type (EGL expects unsigned integer color components), and size (number of bits/component) are the same. For example, X11-based EGL implementations often require the native window to have an X visual ID whose format matches *config* in this fashion.

¹⁰ It may still be desirable for the native window and *config* to have matching formats, even if the implementation does not require this. Otherwise potentially costly operations such as format conversion during **eglSwapBuffers** may be required.

Some client APIs expose the ability to switch between rendering to the front or the back buffer. In this case **eglQueryContext** does not reflect such changes, and will report the buffer used as a render target when the context was first created, which may not be the same as the current render target for that buffer.

Some platforms may not allow rendering directly to the front buffer of a window surface. When such windows are made current to a context, the context will always have an `EGL_RENDER_BUFFER` attribute value of `EGL_BACK_BUFFER`. From the client API point of view these surfaces have only a back buffer and no front buffer, similar to pbuffer rendering (see section 2.2.2). Client APIs which generally have the ability to switch render target from back to front will not be able to do so when the platform does not allow this; from the point of view of the client API the front buffer for such windows does not exist.

`EGL_GL_COLORSPACE` specifies the color space used by OpenGL and OpenGL ES when rendering to the surface¹¹. If its value is `EGL_GL_COLORSPACE_sRGB`, then a non-linear, perceptually uniform color space is assumed, with a corresponding `GL_FRAMEBUFFER_ATTACHMENT_COLOR_ENCODING` value of `GL_sRGB`. If its value is `EGL_GL_COLORSPACE_LINEAR`, then a linear color space is assumed, with a corresponding `GL_FRAMEBUFFER_ATTACHMENT_COLOR_ENCODING` value of `GL_LINEAR`. The default value of `EGL_GL_COLORSPACE` is `EGL_GL_COLORSPACE_LINEAR`.

Note that the `EGL_GL_COLORSPACE` attribute is used only by OpenGL and OpenGL ES contexts supporting sRGB framebuffers. EGL itself does not distinguish multiple colorspace models. Refer to the “sRGB Conversion” sections of the OpenGL 4.4 and OpenGL ES 3.0 specifications for more information.

`EGL_VG_COLORSPACE` specifies the *color space* used by OpenVG when rendering to the surface. If its value is `EGL_VG_COLORSPACE_sRGB`, then a non-linear, perceptually uniform color space is assumed, with a corresponding `VGImageFormat` of form `VG_s*`. If its value is `EGL_VG_COLORSPACE_LINEAR`, then a linear color space is assumed, with a corresponding `VGImageFormat` of form `VG_l*`. The default value of `EGL_VG_COLORSPACE` is `EGL_VG_COLORSPACE_sRGB`.

`EGL_VG_ALPHA_FORMAT` specifies how alpha values are interpreted by OpenVG when rendering to the surface. If its value is `EGL_VG_ALPHA_FORMAT_NONPRE`, then alpha values are not premultiplied. If its value is `EGL_VG_ALPHA_`

¹¹ Only OpenGL and OpenGL ES contexts which support sRGB rendering must respect requests for `EGL_GL_COLORSPACE_sRGB`, and only to sRGB formats supported by the context (normally just SRGB8). Older versions not supporting sRGB rendering will ignore this surface attribute. Applications using OpenGL must additionally enable `GL_FRAMEBUFFER_SRGB` to perform sRGB rendering, even when an sRGB surface is bound; this enable is not required (or supported) for OpenGL ES.

FORMAT_PRE, then alpha values are premultiplied. The default value of EGL_VG_ALPHA_FORMAT is EGL_VG_ALPHA_FORMAT_NONPRE.

Note that the EGL_VG_COLORSPACE and EGL_VG_ALPHA_FORMAT attributes are used only by OpenVG. EGL itself does not distinguish multiple colorspace models. Refer to section 11.2 of the OpenVG 1.0 specification for more information.

Similarly, the EGL_VG_ALPHA_FORMAT attribute does **not** necessarily control or affect the platform's interpretation of alpha values, even when the platform makes use of alpha to composite surfaces at display time. The platform's use and interpretation of alpha values is outside the scope of EGL. However, the preferred behavior is for platforms to ignore the value of EGL_VG_ALPHA_FORMAT when compositing window surfaces.

If *dpy* and *native_window* do not belong to the same platform, then undefined behavior occurs (see section 3.1.2).

Errors

On failure **eglCreatePlatformWindowSurface** returns EGL_NO_SURFACE.

If the pixel format of *native_window* does not correspond to the format, type, and size of the color buffers required by *config*, as discussed above, then an EGL_BAD_MATCH error is generated.

If *config* does not support rendering to windows (the EGL_SURFACE_TYPE attribute does not contain EGL_WINDOW_BIT), an EGL_BAD_MATCH error is generated.

If *config* does not support the OpenVG colorspace or alpha format attributes specified in *attrib_list* (as defined for **eglCreatePlatformWindowSurface**), an EGL_BAD_MATCH error is generated.

If *config* is not a valid EGLConfig, an EGL_BAD_CONFIG error is generated.

If *native_window* is not a valid native window handle, then an EGL_BAD_NATIVE_WINDOW error should be generated.

If there is already an EGLSurface associated with *native_window* (as a result of a previous **eglCreatePlatformWindowSurface** call), then an EGL_BAD_ALLOC error is generated.

If the implementation cannot allocate resources for the new EGL window, an EGL_BAD_ALLOC error is generated.

An on-screen rendering surface may also be created by calling

```
EGLSurface eglCreateWindowSurface(EGLDisplay dpy,
    EGLConfig config, EGLNativeWindowType win,
    const EGLint *attrib_list);
```

The behavior of **eglCreateWindowSurface** is identical to that of **eglCreatePlatformWindowSurface** except that the set of platforms to which *dpy* is permitted to belong, as well as the actual type of *win*, are implementation specific.

3.5.2 Creating Off-Screen Rendering Surfaces

EGL supports off-screen rendering surfaces in pbuffers. Pbuffers differ from windows in the following ways:

1. Pbuffers are typically allocated in offscreen (non-visible) graphics memory and are intended only for accelerated offscreen rendering. Allocation can fail if there are insufficient graphics resources (implementations are not required to virtualize framebuffer memory). Clients should deallocate pbuffers when they are no longer in use, since graphics memory is often a scarce resource.
2. Pbuffers are EGL resources and have no associated native window or native window type. It may not be possible to render to pbuffers using native rendering APIs.

To create a pbuffer, call

```
EGLSurface eglCreatePbufferSurface(EGLDisplay dpy,
    EGLConfig config, const EGLint
    *attrib_list);
```

This creates a single pbuffer surface and returns a handle to it.

attrib_list specifies a list of attributes for the pbuffer. The list has the same structure as described for **eglChooseConfig**. Attributes that can be specified in *attrib_list* include `EGL_WIDTH`, `EGL_HEIGHT`, `EGL_LARGEST_PBUFFER`, `EGL_TEXTURE_FORMAT`, `EGL_TEXTURE_TARGET`, `EGL_MIPMAP_TEXTURE`, `EGL_GL_COLORSPACE`, `EGL_VG_COLORSPACE`, and `EGL_VG_ALPHA_FORMAT`.

It is possible that some platforms will define additional attributes specific to those environments, as an EGL extension.

attrib_list may be `NULL` or empty (first attribute is `EGL_NONE`), in which case all the attributes assume their default values as described below.

`EGL_WIDTH` and `EGL_HEIGHT` specify the pixel width and height of the rectangular pbuffer. If the value of EGLConfig attribute `EGL_TEXTURE_FORMAT` is

not `EGL_NO_TEXTURE`, then the pbuffer width and height specify the size of the level zero texture image. The default values for `EGL_WIDTH` and `EGL_HEIGHT` are zero.

`EGL_TEXTURE_FORMAT` specifies the format of the OpenGL ES texture that will be created when a pbuffer is bound to a texture map. It can be set to `EGL_TEXTURE_RGB`, `EGL_TEXTURE_RGBA`, or `EGL_NO_TEXTURE`. The default value of `EGL_TEXTURE_FORMAT` is `EGL_NO_TEXTURE`.

`EGL_TEXTURE_TARGET` specifies the target for the OpenGL ES texture that will be created when the pbuffer is created with a texture format of `EGL_TEXTURE_RGB` or `EGL_TEXTURE_RGBA`. The target can be set to `EGL_NO_TEXTURE` or `EGL_TEXTURE_2D`. The default value of `EGL_TEXTURE_TARGET` is `EGL_NO_TEXTURE`.

`EGL_MIPMAP_TEXTURE` indicates whether storage for OpenGL ES mipmaps should be allocated. Space for mipmaps will be set aside if the attribute value is `EGL_TRUE` and `EGL_TEXTURE_FORMAT` is not `EGL_NO_TEXTURE`. The default value for `EGL_MIPMAP_TEXTURE` is `EGL_FALSE`.

Use `EGL_LARGEST_PBUFFER` to get the largest available pbuffer when the allocation of the pbuffer would otherwise fail. The width and height of the allocated pbuffer will never exceed the values of `EGL_WIDTH` and `EGL_HEIGHT`, respectively. If the pbuffer will be used as a OpenGL ES texture (i.e., the value of `EGL_TEXTURE_TARGET` is `EGL_TEXTURE_2D`, and the value of `EGL_TEXTURE_FORMAT` is `EGL_TEXTURE_RGB` or `EGL_TEXTURE_RGBA`), then the aspect ratio will be preserved and the new width and height will be valid sizes for the texture target (e.g. if the underlying OpenGL ES implementation does not support non-power-of-two textures, both the width and height will be a power of 2). Use `eglQuerySurface` to retrieve the dimensions of the allocated pbuffer. The default value of `EGL_LARGEST_PBUFFER` is `EGL_FALSE`.

`EGL_GL_COLORSPACE`, `EGL_VG_COLORSPACE` and `EGL_VG_ALPHA_FORMAT` have the same meaning and default values as when used with `eglCreatePlatformWindowSurface`.

The resulting pbuffer will contain color buffers and ancillary buffers as specified by *config*.

The contents of the depth and stencil buffers may not be preserved when rendering an OpenGL ES texture to the pbuffer and switching which image of the texture is rendered to (e.g., switching from rendering one mipmap level to rendering another).

Errors

On failure `eglCreatePbufferSurface` returns `EGL_NO_SURFACE`.

If the pbuffer could not be created due to insufficient resources, then an `EGL_BAD_ALLOC` error is generated.

If *config* is not a valid `EGLConfig`, an `EGL_BAD_CONFIG` error is generated.

If the value specified for either `EGL_WIDTH` or `EGL_HEIGHT` is less than zero, an `EGL_BAD_PARAMETER` error is generated.

If *config* does not support pbuffers, an `EGL_BAD_MATCH` error is generated.

An `EGL_BAD_MATCH` error is generated if any of the following conditions are true:

- The `EGL_TEXTURE_FORMAT` attribute is not `EGL_NO_TEXTURE`, and `EGL_WIDTH` and/or `EGL_HEIGHT` specify an invalid size (e.g., the texture size is not a power of two, and the underlying OpenGL ES implementation does not support non-power-of-two textures).
- The `EGL_TEXTURE_FORMAT` attribute is `EGL_NO_TEXTURE`, and `EGL_TEXTURE_TARGET` is something other than `EGL_NO_TEXTURE`; or, `EGL_TEXTURE_FORMAT` is something other than `EGL_NO_TEXTURE`, and `EGL_TEXTURE_TARGET` is `EGL_NO_TEXTURE`.

Finally, an `EGL_BAD_ATTRIBUTE` error is generated if any of the `EGL_TEXTURE_FORMAT`, `EGL_TEXTURE_TARGET`, or `EGL_MIPMAP_TEXTURE` attributes are specified, but *config* does not support OpenGL ES rendering (e.g. the `EGL_RENDERABLE_TYPE` attribute does not include at least one of `EGL_OPENGL_ES_BIT`, `EGL_OPENGL_ES2_BIT`, or `EGL_OPENGL_ES3_BIT`,

3.5.3 Binding Off-Screen Rendering Surfaces To Client Buffers

Pbuffers may also be created by binding renderable buffers created in client APIs to EGL. Currently, the only client API resources which may be bound in this fashion are `OpenVGImage` objects.

To bind a client API renderable buffer to a pbuffer, call

```
EGLSurface eglCreatePbufferFromClient-
Buffer(EGLDisplay dpy, EGLenum buftype,
EGLClientBuffer buffer, EGLConfig config,
const EGLint *attrib_list);
```

This creates a single pbuffer surface bound to the specified *buffer* for part or all of its buffer storage, and returns a handle to it. The width and height of the pbuffer are determined by the width and height of *buffer*.

buftype specifies the type of buffer to be bound. The only allowed value of *buftype* is `EGL_OPENVG_IMAGE`.

buffer is a client API reference to the buffer to be bound. When *buftype* is `EGL_OPENVG_IMAGE`, *buffer* must be a valid `VGImage` handle, cast into the type `EGLClientBuffer`.

attrib_list specifies a list of attributes for the pbuffer. The list has the same structure as described for **`eglChooseConfig`**. Attributes that can be specified in *attrib_list* include `EGL_TEXTURE_FORMAT`, `EGL_TEXTURE_TARGET`, and `EGL_MIPMAP_TEXTURE`. The meaning of these attributes is as described above for **`eglCreatePbufferSurface`**. The `EGL_VG_COLORSPACE` and `EGL_VG_ALPHA_FORMAT` attributes of the surface are determined by the `VGImageFormat` of *buffer*.

attrib_list may be `NULL` or empty (first attribute is `EGL_NONE`), in which case all the attributes assume their default values as described above for **`eglCreatePbufferSurface`**.

The resulting pbuffer will contain color and ancillary buffers as specified by *config*. Buffers which are present in *buffer* (normally, just the color buffer) will be bound to EGL. Buffers which are not present in *buffer* (such as depth and stencil, if *config* includes those buffers) will be allocated by EGL in the same fashion as for a surface created with **`eglCreatePbufferSurface`**

Errors

On failure **`eglCreatePbufferFromClientBuffer`** returns `EGL_NO_SURFACE`.

In addition to the errors described above for **`eglCreatePbufferSurface`**, **`eglCreatePbufferFromClientBuffer`** may fail and generate errors for the following reasons:

If *buftype* is not a recognized client API resource type (e.g. is not `EGL_OPENVG_IMAGE`), an `EGL_BAD_PARAMETER` error is generated.

If *buffer* is not a valid handle or name of a client API resource of the specified *buftype* in the currently bound context corresponding to that type, an `EGL_BAD_PARAMETER` error is generated.

If the buffers contained in *buffer* do not correspond to a proper subset of the buffers described by *config*, and match the bit depths for those buffers specified in *config*, then an `EGL_BAD_MATCH` error is generated. For example, a `VGImage` with pixel format `VG_1RGBA_8888` corresponds to an `EGLConfig` with `EGL_RED_SIZE`, `EGL_GREEN_SIZE`, `EGL_BLUE_SIZE`, and `EGL_ALPHA_SIZE` values of 8.

If the buffers contained in *buffer* consist of any `EGLImage` siblings, an

EGL_BAD_ACCESS error is generated.

If no context corresponding to the specified *buftype* is current, an EGL_BAD_ACCESS error is generated.

There may be additional constraints on which types of buffers may be bound to EGL surfaces, as described in client API specifications. If those constraints are violated, then an EGL_BAD_MATCH error is generated^a.

If *buffer* is already bound to another pbuffer, or is in use by a client API as discussed below, an EGL_BAD_ACCESS error is generated.

^a An example of such an additional constraint is an implementation which cannot support an OpenVGImage being bound to a pbuffer which will be used as a mipmapped OpenGL ES texture (e.g. whose EGL_MIPMAP_TEXTURE attribute is EGL_TRUE).

3.5.3.1 Lifetime and Usage of Bound Buffers

Binding client API buffers to EGL pbuffers create the possibility of race conditions, and of buffers being deleted through one API while still in use in another API. To avoid these problems, a number of constraints apply to bound client API buffers:

- Bound buffers may be used exclusively by either EGL, or the client API that originally created them.

For example, if a VGImage is bound to a pbuffer, and that pbuffer is bound to any client API rendering context, then the VGImage may not be used as the explicit source or destination of any OpenVG operation. Errors resulting from such use are described in client API specifications.

Similarly, while a VGImage is in use by OpenVG, the pbuffer it is bound to may not be made current to any client API context, as described in section 3.7.3.

- Binding a buffer creates an additional reference to it, and implementations must respect outstanding references when destroying objects.

For example, if a VGImage is bound to a pbuffer, destroying the image with **vgDestroyImage** will not free the underlying buffer, because it is still in use by EGL. However, following **vgDestroyImage** the buffer may only be referred to via the EGL pbuffer handle, since the OpenVG handle to that buffer no longer exists.

Similarly, destroying the pbuffer with **eglDestroySurface** will not free the underlying buffer, because it is still in use by OpenVG. However, following **eglDestroySurface** the buffer may only be referred to via the OpenVGVGImage handle, since the EGL pbuffer handle no longer exists.

3.5.4 Creating Native Pixmap Rendering Surfaces

EGL also supports rendering surfaces whose color buffers are stored in native pixmaps. Pixmaps differ from windows in that they are typically allocated in off-screen (non-visible) graphics or CPU memory. Pixmaps differ from pbuffers in that they do have an associated native pixmap and native pixmap type, and it may be possible to render to pixmaps using APIs other than client APIs.

To create a pixmap rendering surface, first create a native platform pixmap, then select an `EGLConfig` matching the pixel format of that pixmap (calling **eglChooseConfig** with an attribute list including `EGL_MATCH_NATIVE_PIXMAP` returns only `EGLConfigs` matching the pixmap specified in the attribute list - see section 3.4.1).

The command

```
EGLSurface eglCreatePlatformPixmapSurface(EGLDisplay
    dpy, EGLConfig config, void *native_pixmap,
    const EGLAttrib *attrib_list);
```

creates an offscreen `EGLSurface` and returns a handle to it. Any EGL context created with a compatible `EGLConfig` can be used to render into this surface.

native_pixmap must belong to the same platform as *dpy*, and EGL considers the returned `EGLSurface` as belonging to that same platform. The extension that defines the platform to which *dpy* belongs also defines the requirements for the *native_pixmap* parameter.

attrib_list specifies a list of attributes for the pixmap. The list has the same structure as described for **eglChooseConfig**. Attributes that can be specified in *attrib_list* include `EGL_GL_COLORSPACE`, `EGL_VG_COLORSPACE` and `EGL_VG_ALPHA_FORMAT`.

It is possible that some platforms will define additional attributes specific to those environments, as an EGL extension.

attrib_list may be `NULL` or empty (first attribute is `EGL_NONE`), in which case all attributes assumes their default value.

`EGL_GL_COLORSPACE`, `EGL_VG_COLORSPACE` and `EGL_VG_ALPHA_FORMAT` have the same meaning and default values as when used with **eglCreatePlatformWindowSurface**.

The resulting pixmap surface will contain color and ancillary buffers as specified by *config*. Buffers which are present in *pixmap* (normally, just the color buffer) will be bound to EGL. Buffers which are not present in *pixmap* (such as depth and stencil, if *config* includes those buffers) will be allocated by EGL in the same fashion as for a surface created with **eglCreatePbufferSurface**.

If *dpy* and *native_pixmap* do not belong to the same platform, then undefined behavior occurs (see section 3.1.2).

Errors

On failure **eglCreatePlatformPixmapSurface** returns `EGL_NO_SURFACE`.

If the attributes of *pixmap* do not correspond to *config*, then an `EGL_BAD_MATCH` error is generated.

If *config* does not support rendering to pixmaps (the `EGL_SURFACE_TYPE` attribute does not contain `EGL_PIXMAP_BIT`), an `EGL_BAD_MATCH` error is generated.

If *config* does not support the colorspace or alpha format attributes specified in *attrib_list* (as defined for **eglCreatePlatformWindowSurface**), an `EGL_BAD_MATCH` error is generated.

If *config* is not a valid `EGLConfig`, an `EGL_BAD_CONFIG` error is generated.

If *pixmap* is not a valid native pixmap handle, then an `EGL_BAD_NATIVE_PIXMAP` error should be generated.

If there is already an `EGLSurface` associated with *pixmap* (as a result of a previous **eglCreatePlatformPixmapSurface** call), then a `EGL_BAD_ALLOC` error is generated.

Finally, if the implementation cannot allocate resources for the new `EGL` pixmap, an `EGL_BAD_ALLOC` error is generated.

An offscreen rendering surface may also be created by calling

```
EGLSurface eglCreatePixmapSurface(EGLDisplay dpy,
    EGLConfig config, EGLNativePixmapType
    pixmap, const EGLint *attrib_list);
```

The behavior of **eglCreatePixmapSurface** is identical to that of **eglCreatePlatformPixmapSurface** except that the set of platforms to which *dpy* is permitted to belong, as well as the actual type of *pixmap*, are implementation specific.

3.5.5 Destroying Rendering Surfaces

An `EGLSurface` of any type (window, pbuffer, or pixmap) is destroyed by calling

```
EGLBoolean eglDestroySurface(EGLDisplay dpy,
    EGLSurface surface);
```

All resources associated with *surface* which were allocated by EGL are marked for deletion as soon as possible. Following **eglDestroySurface**, the surface and the handle referring to it are treated in the same fashion as a surface destroyed by **eglTerminate** (see section 3.2).

Resources associated with *surface* but not allocated by EGL, such as native windows, native pixmaps, or client API buffers, are not affected when the surface is destroyed. Only storage actually allocated by EGL is marked for deletion.

Furthermore, resources associated with a pbuffer surface are not released until all color buffers of that pbuffer bound to a OpenGL ES texture object have been released.

Errors

eglDestroySurface returns `EGL_FALSE` on failure.

An `EGL_BAD_SURFACE` error is generated if *surface* is not a valid rendering surface.

3.5.6 Surface Attributes

To set an attribute for an `EGLSurface`, call

```
EGLBoolean eglSurfaceAttrib(EGLDisplay dpy,
    EGLSurface surface, EGLint attribute,
    EGLint value);
```

The specified *attribute* of *surface* is set to *value*. Attributes that can be specified are `EGL_MIPMAP_LEVEL`, `EGL_MULTISAMPLE_RESOLVE`, and `EGL_SWAP_BEHAVIOR`.

If *attribute* is `EGL_MIPMAP_LEVEL`, then *value* indicates which level of the OpenGL ES mipmap texture should be rendered. If the value of this attribute is outside the range of supported mipmap levels, the closest valid mipmap level is selected for rendering. The initial value of this attribute is 0.

If the value of pbuffer attribute `EGL_TEXTURE_FORMAT` is `EGL_NO_TEXTURE`, if the value of attribute `EGL_TEXTURE_TARGET` is `EGL_NO_TEXTURE`, or if *surface* is not a pbuffer, then attribute `EGL_MIPMAP_LEVEL` may be set, but has no effect.

If *attribute* is `EGL_MULTISAMPLE_RESOLVE`, then *value* specifies the filter to use when resolving the multisample buffer. A *value* of `EGL_MULTISAMPLE_RESOLVE_DEFAULT` chooses the default implementation-defined filtering method, while `EGL_MULTISAMPLE_RESOLVE_BOX` chooses a one-pixel wide box filter placing equal weighting on all multisample values.

If *value* is `EGL_MULTISAMPLE_RESOLVE_BOX`, and the `EGL_SURFACE_TYPE` attribute of the `EGLConfig` used to create *surface* does not contain `EGL_MULTISAMPLE_RESOLVE_BOX_BIT`, a `EGL_BAD_MATCH` error is generated.

The initial value of `EGL_MULTISAMPLE_RESOLVE` is `EGL_MULTISAMPLE_RESOLVE_DEFAULT`.

If *attribute* is `EGL_SWAP_BEHAVIOR`, then *value* specifies the effect on the color buffer of posting a surface with `eglSwapBuffers` (see section 3.10). A *value* of `EGL_BUFFER_PRESERVED` indicates that color buffer contents are unaffected, while `EGL_BUFFER_DESTROYED` indicates that color buffer contents may be destroyed or changed by the operation.

If *value* is `EGL_BUFFER_PRESERVED`, and the `EGL_SURFACE_TYPE` attribute of the `EGLConfig` used to create *surface* does not contain `EGL_SWAP_BEHAVIOR_PRESERVED_BIT`, a `EGL_BAD_MATCH` error is generated.

The initial value of `EGL_SWAP_BEHAVIOR` is chosen by the implementation.

Errors

`eglSurfaceAttrib` returns `EGL_FALSE` on failure.

If OpenGL ES rendering is not supported by *surface*, then trying to set `EGL_MIPMAP_LEVEL` will cause an `EGL_BAD_PARAMETER` error.

Other errors for specific attribute values are described above.

To query an attribute associated with an `EGLSurface` call:

```
EGLBoolean eglQuerySurface(EGLDisplay dpy,
                             EGLSurface surface, EGLint attribute,
                             EGLint *value);
```

`eglQuerySurface` returns in *value* the value of *attribute* for *surface*. *attribute* must be set to one of the attributes in table 3.5.

Querying `EGL_CONFIG_ID` returns the ID of the `EGLConfig` with respect to which the surface was created.

Querying `EGL_LARGEST_PBUFFER` for a pbuffer surface returns the same attribute value specified when the surface was created with `eglCreatePbufferSurface`. For a window or pixmap surface, the contents of *value* are not modified.

Querying `EGL_WIDTH` and `EGL_HEIGHT` returns respectively the width and height, in pixels, of the surface. For a window or pixmap surface, these values are initially equal to the width and height of the native window or pixmap with respect to which the surface was created. If a native window is resized, the corresponding window surface will eventually be resized by the implementation to match (as discussed in section 3.10.1). If there is a discrepancy because EGL has not yet resized

Attribute	Type	Description
EGL_GL_COLORSPACE	enum	Color space for OpenGL and OpenGL ES
EGL_VG_ALPHA_FORMAT	enum	Alpha format for OpenVG
EGL_VG_COLORSPACE	enum	Color space for OpenVG
EGL_CONFIG_ID	integer	ID of EGLConfig surface was created with
EGL_HEIGHT	integer	Height of surface
EGL_HORIZONTAL_RESOLUTION	integer	Horizontal dot pitch
EGL_LARGEST_PBUFFER	boolean	If true, create largest pbuffer possible
EGL_MIPMAP_TEXTURE	boolean	True if texture has mipmaps
EGL_MIPMAP_LEVEL	integer	Mipmap level to render to
EGL_MULTISAMPLE_RESOLVE	enum	Multisample resolve behavior
EGL_PIXEL_ASPECT_RATIO	integer	Display aspect ratio
EGL_RENDER_BUFFER	enum	Render buffer
EGL_SWAP_BEHAVIOR	enum	Buffer swap behavior
EGL_TEXTURE_FORMAT	enum	Format of texture: RGB, RGBA, or no texture
EGL_TEXTURE_TARGET	enum	Type of texture: 2D or no texture
EGL_VERTICAL_RESOLUTION	integer	Vertical dot pitch
EGL_WIDTH	integer	Width of surface

Table 3.5: Queryable surface attributes and types.

the window surface, the size returned by **eglQuerySurface** will always be that of the EGL surface, not the corresponding native window.

For a pbuffer, they will be the actual allocated size of the pbuffer (which may be less than the requested size if `EGL_LARGEST_PBUFFER` is `EGL_TRUE`).

Querying `EGL_HORIZONTAL_RESOLUTION` and `EGL_VERTICAL_RESOLUTION` returns respectively the horizontal and vertical dot pitch of the display on which a window surface is visible. The values returned are equal to the actual dot pitch, in pixels/meter, multiplied by the constant value `EGL_DISPLAY_SCALING` (10000)¹².

Querying `EGL_PIXEL_ASPECT_RATIO` returns the aspect ratio of an individual pixel (the ratio of a pixel's width to its height), multiplied by `EGL_DISPLAY_SCALING`. For almost all displays, the returned value will be `EGL_DISPLAY_SCALING`, indicating an aspect ratio of one (square pixels).

For an offscreen (pbuffer or pixmap) surface, or a surface whose pixel dot pitch or aspect ratio are unknown, querying `EGL_HORIZONTAL_RESOLUTION`, `EGL_VERTICAL_RESOLUTION`, and `EGL_PIXEL_ASPECT_RATIO` will return the constant value `EGL_UNKNOWN` (-1).

Querying `EGL_RENDER_BUFFER` returns the buffer which client API rendering is requested to use. For a window surface, this is the same attribute value specified when the surface was created. For a pbuffer surface, it is always `EGL_BACK_BUFFER`. For a pixmap surface, it is always `EGL_SINGLE_BUFFER`. To determine the actual buffer being rendered to by a context, call **eglQueryContext** (see section 3.7.4).

Querying `EGL_MULTISAMPLE_RESOLVE` returns the filtering method used when performing multisample buffer resolution. The filter may be either `EGL_MULTISAMPLE_RESOLVE_DEFAULT` or `EGL_MULTISAMPLE_RESOLVE_BOX`, as described above for **eglSurfaceAttrib**.

Querying `EGL_SWAP_BEHAVIOR` describes the effect on the color buffer when posting a surface with **eglSwapBuffers** (see section 3.10). Swap behavior may be either `EGL_BUFFER_PRESERVED` or `EGL_BUFFER_DESTROYED`, as described above for **eglSurfaceAttrib**.

Querying `EGL_TEXTURE_FORMAT`, `EGL_TEXTURE_TARGET`, `EGL_MIPMAP_TEXTURE`, or `EGL_MIPMAP_LEVEL` for a non-pbuffer surface is not an error, but *value* is not modified.

¹² `EGL_DISPLAY_SCALING` is used where EGL needs to return floating-point attribute values, which would normally be smaller than 1, as integers while still retaining sufficient precision to be meaningful.

Errors

eglQuerySurface returns `EGL_FALSE` on failure and *value* is not updated.

If *attribute* is not a valid EGL surface attribute, then an `EGL_BAD_ATTRIBUTE` error is generated.

If *surface* is not a valid `EGLSurface`, then an `EGL_BAD_SURFACE` error is generated.

3.6 Rendering to Textures

This section describes how to render to an OpenGL ES texture using a pbuffer surface configured for this operation.

Errors

If a pbuffer surface does not support OpenGL ES rendering, or if OpenGL ES is not implemented on a platform, then calling **eglBindTexImage** or **eglReleaseTexImage** will always generate `EGL_BAD_SURFACE` errors.

3.6.1 Binding a Surface to a OpenGL ES Texture

The command

```
EGLBoolean eglBindTexImage(EGLDisplay dpy,
                             EGLSurface surface, EGLint buffer);
```

defines a two-dimensional texture image. The texture image consists of the image data in *buffer* for the specified surface, and need not be copied. Currently the only value accepted for *buffer* is `EGL_BACK_BUFFER`, which indicates the buffer into which OpenGL ES rendering is taking place (this is true even when using a single-buffered surface, such as a pixmap). In future versions of EGL, additional *buffer* values may be allowed to bind textures to other buffers in an `EGLSurface`.

The texture target, the texture format and the size of the texture components are derived from attributes of the specified *surface*, which must be a pbuffer supporting one of the `EGL_BIND_TO_TEXTURE_RGB` or `EGL_BIND_TO_TEXTURE_RGBA` attributes.

Note that any existing images associated with the different mipmap levels of the texture object are freed (it is as if **glTexImage** was called with an image of zero width).

Texture Component	Size
R	EGL_RED_SIZE
G	EGL_GREEN_SIZE
B	EGL_BLUE_SIZE
A	EGL_ALPHA_SIZE

Table 3.6: Size of texture components

The `pbuffer` attribute `EGL_TEXTURE_FORMAT` determines the base internal format of the texture. The component sizes are also determined by `pbuffer` attributes as shown in table 3.6:

The texture target is derived from the `EGL_TEXTURE_TARGET` attribute of *surface*. If the attribute value is `EGL_TEXTURE_2D`, then *buffer* defines a texture for the two-dimensional texture object which is bound to the current context (hereafter referred to as the current texture object).

If *dpy* and *surface* are the display and surface for the calling thread's current context, **eglBindTexImage** performs an implicit **glFlush**. For other *surfaces*, **eglBindTexImage** waits for all effects from previously issued client API commands drawing to the surface to complete before defining the texture image, as though **glFinish** were called on the last context to which that surface were bound.

After **eglBindTexImage** is called, the specified *surface* is no longer available for reading or writing. Any read operation, such as **glReadPixels** or **eglCopyBuffers**, which reads values from any of the surface's color buffers or ancillary buffers will produce indeterminate results. In addition, draw operations that are done to the surface before its color buffer is released from the texture produce indeterminate results. Specifically, if the surface is current to a context and thread then rendering commands will be processed and the context state will be updated, but the surface may or may not be written. **eglSwapBuffers** has no effect if it is called on a bound surface.

Client APIs other than OpenGL ES may be used to render into a surface later bound as a texture. The effects of binding a surface as an OpenGL ES texture when the surface is current to a client API context other than OpenGL ES are generally similar those described above, but there may be additional restrictions. Applications using mixed-mode render-to-texture in this fashion should unbind surfaces from all client API contexts before binding those surfaces as OpenGL ES textures.

Note that the color buffer is bound to a texture object. If the texture object is shared between contexts, then the color buffer is also shared. If a texture object is deleted before **eglReleaseTexImage** is called, then the color buffer is released and

the surface is made available for reading and writing.

Texture mipmap levels are automatically generated when all of the following conditions are met while calling **eglBindTexImage**:

- The EGL_MIPMAP_TEXTURE attribute of the pbuffer being bound is EGL_TRUE.
- The OpenGL ES texture parameter GL_GENERATE_MIPMAP is GL_TRUE for the currently bound texture.
- The value of the EGL_MIPMAP_LEVEL attribute of the pbuffer being bound is equal to the value of the texture parameter GL_TEXTURE_BASE_LEVEL.

In this case, additional mipmap levels are generated as described in section 3.8 of the OpenGL ES 1.1 Specification.

It is not an error to call **glTexImage2D** or **glCopyTexImage2D** to replace an image of a texture object that has a color buffer bound to it. However, these calls will cause the color buffer to be released back to the surface and new memory will be allocated for the texture. Note that the color buffer is released even if the image that is being defined is a mipmap level that was not defined by the color buffer.

Errors

eglBindTexImage returns EGL_FALSE on failure.

If **eglBindTexImage** is called and the surface attribute EGL_TEXTURE_FORMAT is set to EGL_NO_TEXTURE, then an EGL_BAD_MATCH error is returned.

If *buffer* is already bound to a texture then an EGL_BAD_ACCESS error is returned.

If *buffer* is not a valid buffer, then an EGL_BAD_PARAMETER error is generated.

If *surface* is not a valid EGLSurface, or is not a pbuffer surface supporting texture binding, then an EGL_BAD_SURFACE error is generated.

eglBindTexImage is ignored if there is no current rendering context.

3.6.2 Releasing a Surface from an OpenGL ES Texture

To release a color buffer that is being used as a texture, call

```
EGLBoolean eglReleaseTexImage(EGLDisplay dpy,
                               EGLSurface surface, EGLint buffer);
```

The specified color buffer is released back to the surface. The surface is made available for reading and writing when it no longer has any color buffers bound as textures.

The contents of the color buffer are undefined when it is first released. In particular, there is no guarantee that the texture image is still present. However, the contents of other color buffers are unaffected by this call. Also, the contents of the depth and stencil buffers are not affected by **eglBindTexImage** and **eglReleaseTexImage**.

If the specified color buffer is no longer bound to a texture (e.g., because the texture object was deleted) then **eglReleaseTexImage** has no effect. No error is generated.

After a color buffer is released from a texture (either explicitly by calling **eglReleaseTexImage** or implicitly by calling a routine such as **glTexImage2D**), all texture images that were defined by the color buffer become NULL (it is as if **glTexImage** was called with an image of zero width).

Errors

If **eglReleaseTexImage** is called and the value of surface attribute `EGL_TEXTURE_FORMAT` is `EGL_NO_TEXTURE`, then an `EGL_BAD_MATCH` error is returned.

If *buffer* is not a valid buffer (currently only `EGL_BACK_BUFFER` may be specified), then an `EGL_BAD_PARAMETER` error is generated.

If *surface* is not a valid `EGLSurface`, or is not a bound pbuffer surface, then an `EGL_BAD_SURFACE` error is returned.

3.6.3 Implementation Caveats

Developers should note that conformant OpenGL ES implementations are not required to support render to texture; that is, there may be no `EGLConfigs` supporting the `EGL_BIND_TO_TEXTURE_RGB` or `EGL_BIND_TO_TEXTURE_RGBA` attributes. Render to texture is functionally subsumed by the newer framebuffer object extension to OpenGL ES, and may eventually be deprecated. Render to texture is not supported for OpenGL contexts.

3.7 Rendering Contexts

EGL provides functions to create and destroy rendering contexts for each supported client API; to query information about rendering contexts; and to bind rendering

contexts to surfaces, making them *current*.

At most one context for each supported client API may be current to a particular thread at a given time, and at most one context may be bound to a particular surface at a given time¹³. The minimum number of current contexts that must be supported by an EGL implementation is one for each supported client API¹⁴.

Only one OpenGL or OpenGL ES context may be current to a particular thread, even if the implementation supports OpenGL and one or more versions of OpenGL ES in the same runtime¹⁵. This restriction is enforced by **eglMakeCurrent** as described in section 3.7.3.

Some of the functions described in this section make use of the *current rendering API*, which is set on a per-thread basis¹⁶ by calling

```
EGLBoolean eglBindAPI(EGLenum api);
```

api must specify one of the supported client APIs, either `EGL_OPENGL_API`, `EGL_OPENGL_ES_API`, or `EGL_OPENVG_API`.

Applications using multiple client APIs are responsible for ensuring the current rendering API is correct before calling the functions **eglCreateContext**, **eglGetCurrentContext**, **eglGetCurrentDisplay**, **eglGetCurrentSurface**, **eglCopyBuffers**, **eglSwapBuffers**, **eglSwapInterval**, **eglMakeCurrent** (when its *ctx* parameter is `EGL_NO_CONTEXT`), **eglWaitClient**, or **eglWaitNative**.

`EGL_OPENGL_API` and `EGL_OPENGL_ES_API` are interchangeable for all purposes except **eglCreateContext**¹⁷.

¹³ Note that this implies that implementations must allow (for example) both an OpenGL ES and an OpenVG context to be current to the **same** thread, so long as they are drawing to **different** surfaces.

¹⁴ This constraint allows valid implementations which are restricted to supporting only one active rendering thread in a thread group. Such implementations may generate errors in **eglMakeCurrent**.

¹⁵ This restriction is necessary because many entry points are shared by OpenGL and both versions of OpenGL ES. Determining which library version to call into is based on properties of the current OpenGL or OpenGL ES context.

¹⁶ Note that the current rendering API is set on a per-thread basis, but not on a per-`EGLDisplay` basis. This is because current contexts are bound in the same manner.

¹⁷ This is a behavior change introduced in the February, 2013 EGL 1.4 specification update. Prior to this change, operations such as (for example) calling **eglGetCurrentContext** when an OpenGL ES context is current but the current rendering API is `EGL_OPENGL_API` would return `EGL_NO_CONTEXT` instead of the OpenGL ES context.

The change is subtle, unlikely to affect any existing applications, and intended as a convenience to the programmer. It is based on the restriction described above (that only one OpenGL or OpenGL ES context may be current to a particular thread). It is still necessary to distinguish between the two current rendering APIs when creating a context on an implementation which supports both OpenGL and OpenGL ES.

Errors

eglBindAPI returns `EGL_FALSE` on failure.

If *api* is not one of the values specified above, or if the client API specified by *api* is not supported by the implementation, an `EGL_BAD_PARAMETER` error is generated.

To obtain the value of the current rendering API, call

```
EGLenum eglQueryAPI(void);
```

The value returned will be one of the valid *api* parameters to **eglBindAPI**, or `EGL_NONE`.

The initial value of the current rendering API is `EGL_OPENGL_ES_API`, unless OpenGL ES is not supported by an implementation, in which case the initial value is `EGL_NONE`.

3.7.1 Creating Rendering Contexts

To create a rendering context for the current rendering API, call

```
EGLContext eglCreateContext(EGLDisplay dpy,
                             EGLConfig config, EGLContext share_context,
                             const EGLint *attrib_list);
```

If **eglCreateContext** succeeds, it initializes the context to the initial state defined for the current rendering API, and returns a handle to it. The context can be used to render to any compatible `EGLSurface`.

Although contexts are specific to a single client API, all contexts created in EGL exist in a single namespace. This allows many EGL calls which manage contexts to avoid use of the current rendering API.

If *share_context* is not `EGL_NO_CONTEXT`, then all shareable data, as defined by the client API (note that for OpenGL and OpenGL ES, shareable data excludes texture objects named 0) will be shared by *share_context*, all other contexts *share_context* already shares with, and the newly created context. An arbitrary number of `EGLContexts` can share data in this fashion. The OpenGL and OpenGL ES server context state for all sharing contexts must exist in a single address space.

attrib_list specifies a list of attributes for the context. The list has the same structure as described for **eglChooseConfig**. If an attribute is not specified in *attrib_list*, then the default value specified below is used instead. Most attributes are only meaningful for specific client APIs, and will generate an error when specified for other types of contexts.

3.7.1.1 OpenGL and OpenGL ES Context Versions

The values for attributes `EGL_CONTEXT_MAJOR_VERSION` and `EGL_CONTEXT_MINOR_VERSION` specify the requested client API version. They are only meaningful for OpenGL and OpenGL ES contexts, and specifying them for other types of contexts will generate an error.

When the current rendering API is `EGL_OPENGL_ES_API` or `EGL_OPENGL_API`, the values of `EGL_CONTEXT_MAJOR_VERSION`¹⁸ (the *major* version) and `EGL_CONTEXT_MINOR_VERSION` (the *minor* version) request creation of an OpenGL ES or OpenGL context, respectively, supporting the specified version *major.minor* of that client API. The context returned must be the specified version, or a later version which is *backwards compatible* with that version. Even if a later version is returned, the specified version must correspond to a defined version of the client API. Defined versions and backwards compatibility are determined as follows:

For an OpenGL ES context:

- Defined versions are 1.0, 1.1, 2.0, 3.0, and any later versions of OpenGL ES released by Khronos.
- If version 1.0 is requested, the context returned may implement either OpenGL ES 1.0 or OpenGL ES 1.1.
- If version 1.1 is requested, the context returned must implement OpenGL ES 1.1.
- If version 2.0, version 3.0, or a later version (when later versions are defined by Khronos) is requested, the context returned must implement the requested OpenGL ES version, or any later version which is backwards compatible with the requested version.

For an OpenGL context:

- Defined versions are 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 2.0, 2.1, 3.0, 3.1, 3.2, 4.0, 4.1, 4.2, 4.3, 4.4, and any later versions of OpenGL released by Khronos.
- If a version less than or equal to OpenGL 3.0 is requested, the context returned may implement any of the following versions:

– Any version no less than that requested and no greater than 3.0.

¹⁸ The EGL 1.4 token `EGL_CONTEXT_CLIENT_VERSION` is an alias for `EGL_CONTEXT_MAJOR_VERSION`, and the tokens may be used interchangeably.

- Version 3.1, if the `GL_ARB_compatibility` extension is also implemented.
 - The compatibility profile of version 3.2 or greater.
- If OpenGL 3.1 is requested, the context returned may implement any of the following versions:
 - Version 3.1. The `GL_ARB_compatibility` extension may or may not be implemented, as determined by the implementation.
 - The core profile of version 3.2 or greater.
 - If OpenGL 3.2 or greater is requested, the context returned may implement any of the following versions:
 - The requested profile (see attribute `EGL_CONTEXT_OPENGL_PROFILE_MASK` below) of the requested version.
 - The requested profile of any later version, so long as no features have been removed from that later version and profile.

Typically, the implementation will return the most recent version of OpenGL it supports which is backwards compatible with the requested version.

Querying the `GL_VERSION` string with **glGetString** in either OpenGL or OpenGL ES (or the `GL_MAJOR_VERSION` and `GL_MINOR_VERSION` values with **glGetIntegerv**, in an OpenGL 3.0 or later context) will return the actual version supported by a context.

The default values for `EGL_CONTEXT_MAJOR_VERSION` and `EGL_CONTEXT_MINOR_VERSION` are 1 and 0 respectively.

3.7.1.2 OpenGL Context Profiles

The value for attribute `EGL_CONTEXT_OPENGL_PROFILE_MASK` specifies a *profile* of the OpenGL API. This attribute is only meaningful for OpenGL contexts, and specifying it for other types of contexts, including OpenGL ES contexts, is an error.

When the current rendering API is `EGL_OPENGL_API`, the value of `EGL_CONTEXT_OPENGL_PROFILE_MASK` requests an OpenGL context supporting the corresponding profile. If the `EGL_CONTEXT_OPENGL_CORE_PROFILE_BIT` bit is set in the attribute value, then a context implementing the *core* profile of OpenGL is returned. If the `EGL_CONTEXT_OPENGL_COMPATIBILITY_PROFILE_BIT` bit is set, then a context implementing the *compatibility* profile is returned. If the

requested OpenGL version is less than 3.2, `EGL_CONTEXT_OPENGL_PROFILE_MASK` is ignored and the functionality of the context is determined solely by the requested version.

Querying the value of `GL_CONTEXT_PROFILE_MASK` with `glGetIntegerv` will return the profile mask used to create the context. This query is only supported in an OpenGL 3.2 or later context.

The default value for `EGL_CONTEXT_OPENGL_PROFILE_MASK` is `EGL_CONTEXT_OPENGL_CORE_PROFILE_BIT`. All OpenGL 3.2 and later implementations are required to implement the core profile, but implementation of the compatibility profile is optional.

If the core profile is requested, then the context returned cannot implement functionality defined only by the compatibility profile.

3.7.1.3 OpenGL and OpenGL ES Debug Contexts

If the `EGL_CONTEXT_OPENGL_DEBUG` attribute is set to `EGL_TRUE`, a *debug context* will be created. Debug contexts are intended for use during application development, to provide additional runtime checking, validation, and logging functionality while possibly incurring performance penalties. OpenGL and OpenGL ES implementations supporting the `GL_KHR_debug` extension, or equivalent core API functionality, are required to enable it when creating a debug context. Additional debug context functionality, if any, is determined by the implementation.

This attribute is supported only for OpenGL and OpenGL ES contexts. If the implementation does not support any additional debug functionality, context creation will not fail, but the resulting context will be identical to a non-debug context.

The default value for `EGL_CONTEXT_OPENGL_DEBUG` is `EGL_FALSE`.

3.7.1.4 OpenGL Forward Compatible Contexts

If the `EGL_CONTEXT_OPENGL_FORWARD_COMPATIBLE` attribute is set to `EGL_TRUE`, a *forward-compatible* context will be created. Forward-compatible contexts are defined only for OpenGL versions 3.0 and later. They must **not** support functionality marked as *deprecated* by that version of the API, while a non-forward-compatible context must support all functionality in that version, deprecated or not.

This attribute is supported only for OpenGL contexts. If a forward-compatible context is requested for OpenGL versions less than 3.0, or the implementation does not support forward-compatible contexts for later versions, context creation will fail.

The default value for `EGL_CONTEXT_FORWARD_COMPATIBLE` is `EGL_FALSE`.

3.7.1.5 OpenGL and OpenGL ES Robust Buffer Access

If the `EGL_CONTEXT_OPENGL_ROBUST_ACCESS` attribute is set to `EGL_TRUE`, a context supporting *robust buffer access* will be created. OpenGL contexts must support the `GL_ARB_robustness` extension, or equivalent core API functionality. OpenGL ES contexts must support the `GL_EXT_robustness` extension, or equivalent core API functionality.

This attribute is supported only for OpenGL and OpenGL ES contexts. If the implementation does not support robust buffer access, context creation will fail.

The default value of `EGL_CONTEXT_OPENGL_ROBUST_ACCESS` is `EGL_FALSE`.

3.7.1.6 OpenGL and OpenGL ES Reset Notification Strategy

The attribute `EGL_CONTEXT_OPENGL_RESET_NOTIFICATION_STRATEGY` specifies *reset notification behavior* for a context supporting robust buffer access. The attribute value may be either `EGL_NO_RESET_NOTIFICATION` or `EGL_LOSE_CONTEXT_ON_RESET`, which respectively result in reset notification behavior of `GL_NO_RESET_NOTIFICATION_ARB` and `GL_LOSE_CONTEXT_ON_RESET_ARB`, as described by the OpenGL `GL_ARB_robustness` extension, or by equivalent functionality¹⁹.

This attribute is supported only for OpenGL and OpenGL ES contexts. If the `EGL_CONTEXT_OPENGL_ROBUST_ACCESS` attribute is not set to `EGL_TRUE`, context creation will not fail, but the resulting context may not support robust buffer access, and therefore may not support the requested reset notification strategy.

The default value for `EGL_CONTEXT_OPENGL_RESET_NOTIFICATION_STRATEGY` is `EGL_NO_RESET_NOTIFICATION`.

Errors

On failure `eglCreateContext` returns `EGL_NO_CONTEXT`.

An `EGL_BAD_MATCH` error is generated if the current rendering api is `EGL_NONE` (this situation can only arise in an implementation which does not support OpenGL ES 1.x, and prior to the first call to `eglBindAPI`).

An `EGL_BAD_ATTRIBUTE` error is generated if an attribute is specified that is not supported for the client API type determined by the current rendering API.

An `EGL_BAD_ATTRIBUTE` error is generated if an attribute name or at-

¹⁹ An example of equivalent functionality for OpenGL ES is the vendor `GL_EXT_robustness` extension.

tribute value in *attrib_list* is not recognized (including undefined or unsupported bits in bitmask attributes),

An `EGL_BAD_CONTEXT` error is generated if *share_context* is neither `EGL_NO_CONTEXT` nor a valid context of the same client API type as the newly created context.

An `EGL_BAD_CONFIG` error is generated if *config* is not a valid `EGLConfig`.

An `EGL_BAD_MATCH` error is generated if *config* does not support the requested client API. This includes requesting creation of an OpenGL ES 1.x, 2.0, or 3.0 context when the `EGL_RENDERABLE_TYPE` attribute of *config* does not contain `EGL_OPENGL_ES_BIT`, `EGL_OPENGL_ES2_BIT`, or `EGL_OPENGL_ES3_BIT` respectively.

An `EGL_BAD_MATCH` error is generated if an OpenGL or OpenGL ES context is requested and any of:

- the server context state for *share_context* exists in an address space that cannot be shared with the newly created context
- *share_context* was created on a different display than the one referenced by *config*
- the reset notification behavior of *share_context* and the newly created context are different
- the contexts are otherwise incompatible (for example, one context being associated with a hardware device driver and the other with a software renderer).

An `EGL_BAD_MATCH` error is generated if an OpenGL or OpenGL ES context is requested and the specified version number is not a defined version of that client API.

An `EGL_BAD_MATCH` error is generated if an forward-compatible OpenGL context is requested and the **requested** OpenGL version is less than 3.0, or the implementation does not support a forward-compatible context of exactly the requested version. Because the purpose of forward-compatible contexts is to allow application development on a specific OpenGL version with the knowledge that the app will run on a future version, in this case context creation cannot result in a later, backwards-compatible version.

An `EGL_BAD_MATCH` error is generated if an OpenGL or OpenGL ES context is requested with robust buffer access, and the implementation does not support the corresponding OpenGL or OpenGL ES extension.

An `EGL_BAD_MATCH` error is generated if an OpenGL or OpenGL ES context is requested with robust buffer access and with a specified reset notifica-

tion behavior, and the implementation does not support that behavior.

An `EGL_BAD_MATCH` error is generated if an OpenGL context is requested, the requested version is 3.2 or greater, and any of:

- the context profile mask has no bits set
- the mask has any bits set other than `EGL_CONTEXT_OPENGL_CORE_PROFILE_BIT` and `EGL_CONTEXT_OPENGL_COMPATIBILITY_PROFILE_BIT`
- the mask has more than one of these bits set
- the implementation does not support the requested profile.

An `EGL_BAD_MATCH` error is generated if *config* does not support a context compatible with the requested API version and context attributes for reasons not enumerated above. It is difficult to enumerate all possible combinations of unsupported context version attributes, since this sometimes depends on properties of the implementation; this error allows such implementations to indicate they cannot satisfy a request.

If the server does not have enough resources to allocate the new context, then an `EGL_BAD_ALLOC` error is generated.

3.7.2 Destroying Rendering Contexts

A rendering context is destroyed by calling

```
EGLBoolean eglDestroyContext(EGLDisplay dpy,
                               EGLContext ctx);
```

All resources associated with *ctx* are marked for deletion as soon as possible. When multiple contexts share objects (see **eglCreateContext**), such shared objects are not deleted until after all contexts on the share list are destroyed, unless the objects are first explicitly deleted by the application. Following **eglDestroyContext**, the context and the handle referring to it are treated in the same fashion as a context destroyed by **eglTerminate** (see section 3.2).

Errors

eglDestroyContext returns `EGL_FALSE` on failure.

An `EGL_BAD_CONTEXT` error is generated if *ctx* is not a valid context.

3.7.3 Binding Contexts and Drawables

To make a context current, call

```
EGLBoolean eglMakeCurrent(EGLDisplay dpy,  
    EGLSurface draw, EGLSurface read,  
    EGLContext ctx);
```

eglMakeCurrent binds *ctx* to the current rendering thread and to the *draw* and *read* surfaces.

For an OpenGL or OpenGL ES context, *draw* is used for all operations except for any pixel data read back or copied, which is taken from the frame buffer values of *read*. Note that the same *EGLSurface* may be specified for both *draw* and *read*.

For an OpenVG context, the same *EGLSurface* **must** be specified for both *draw* and *read*.

If the calling thread already has a current context of the same client API type as *ctx*, then that context is flushed and marked as no longer current. *ctx* is then made the current context for the calling thread. For purposes of **eglMakeCurrent**, the client API type of all OpenGL ES and OpenGL contexts is considered the same. In other words, if any OpenGL ES context is currently bound and *ctx* is an OpenGL context, or if any OpenGL context is currently bound and *ctx* is an OpenGL ES context, the currently bound context will be made no longer current and *ctx* will be made current.

OpenGL and OpenGL ES buffer mappings created by e.g. **glMapBuffer** are not affected by **eglMakeCurrent**; they persist whether the context owning the buffer is current or not.

Errors

eglMakeCurrent returns `EGL_FALSE` on failure.

If *draw* or *read* are not compatible with *ctx*, then an `EGL_BAD_MATCH` error is generated.

If *ctx* is current to some other thread, or if either *draw* or *read* are bound to contexts in another thread, an `EGL_BAD_ACCESS` error is generated.

If binding *ctx* would exceed the number of current contexts of that client API type supported by the implementation, an `EGL_BAD_ACCESS` error is generated.

If either *draw* or *read* are pbuffers created with **eglCreatePbufferFromClientBuffer**, and the underlying bound client API buffers are in use by the client API that created them, an `EGL_BAD_ACCESS` error is generated.

If *ctx* is not a valid context and is not `EGL_NO_CONTEXT`, an `EGL_BAD_CONTEXT` error is generated.

If either *draw* or *read* are not valid EGL surfaces and are not `EGL_NO_SURFACE`, an `EGL_BAD_SURFACE` error is generated.

If *ctx* is `EGL_NO_CONTEXT` and either *draw* or *read* are not `EGL_NO_SURFACE`, an `EGL_BAD_MATCH` error is generated.

If either of *draw* or *read* is a valid surface and the other is `EGL_NO_SURFACE`, an `EGL_BAD_MATCH` error is generated.

If *ctx* does not support being bound without read and draw surfaces, and both *draw* and *read* are `EGL_NO_SURFACE`, an `EGL_BAD_MATCH` error is generated.

If a native window underlying either *draw* or *read* is no longer valid, an `EGL_BAD_NATIVE_WINDOW` error is generated.

If *draw* and *read* cannot fit into graphics memory simultaneously, an `EGL_BAD_MATCH` error is generated.

If the previous context of the calling thread has unflushed commands, and the previous surface is no longer valid, an `EGL_BAD_CURRENT_SURFACE` error is generated.

If the ancillary buffers for *draw* and *read* cannot be allocated, an `EGL_BAD_ALLOC` error is generated.

If a power management event has occurred, an `EGL_CONTEXT_LOST` error is generated.

As with other commands taking `EGLDisplay` parameters, if *dpy* is not a valid `EGLDisplay` handle, an `EGL_BAD_DISPLAY` error is generated^a.

Other errors may arise when the context state is inconsistent with the surface state, as described in the following paragraphs.

^a Some implementations have chosen to allow `EGL_NO_DISPLAY` as a valid *dpy* parameter for **`eglMakeCurrent`**. This behavior is not portable to all EGL implementations, and should be considered as an undocumented vendor extension.

If *draw* is destroyed after **`eglMakeCurrent`** is called, then subsequent rendering commands will be processed and the context state will be updated, but the surface contents become undefined. If *read* is destroyed after **`eglMakeCurrent`** then pixel values read from the framebuffer (e.g., as result of calling **`glReadPixels`**) are undefined. If a native window or pixmap underlying the *draw* or *read* surfaces is destroyed, rendering and readback are handled as above.

To release the current context without assigning a new one, set *ctx* to `EGL_NO_CONTEXT` and set *draw* and *read* to `EGL_NO_SURFACE`. The currently bound context for the client API specified by the current rendering API is flushed and marked as no longer current, and there will be no current context for that client API

after **eglMakeCurrent** returns. This is the only case in which **eglMakeCurrent** respects the current rendering API. In all other cases, the client API affected is determined by *ctx*. This is the only case where an uninitialized display may be passed to **eglMakeCurrent**.

If any of the following are true:

- *ctx* is not EGL_NO_CONTEXT
- *read* is not EGL_NO_SURFACE
- *draw* is not EGL_NO_SURFACE

then an EGL_NOT_INITIALIZED error is generated if *dpy* is a valid but uninitialized display.

If *ctx* is EGL_NO_CONTEXT, then *draw* and *read* must be EGL_NO_SURFACE.

If *ctx* is not EGL_NO_CONTEXT, then both *draw* and *read* must not be EGL_NO_SURFACE **unless** *ctx* is a context which supports being bound without read and draw surfaces. In this case the context is made current without a *default framebuffer*. The meaning of this is defined by the client API of the supporting context (see chapter 4 of the OpenGL 3.0 Specification, and the GL_OES_surfaceless_context OpenGL ES extension.).

The first time a OpenGL or OpenGL ES context is made current the viewport and scissor dimensions are set to the size of the *draw* surface (as though **glViewport(0,0,w,h)** and **glScissor(0,0,w,h)** were called, where *w* and *h* are the width and height of the surface, respectively). However, the viewport and scissor dimensions are not modified when *ctx* is subsequently made current. The client is responsible for resetting the viewport and scissor in this case.

The first time *ctx* is made current, if it is without a default framebuffer (e.g. both *draw* and *read* are EGL_NO_SURFACE), then the viewport and scissor regions are set as though **glViewport(0,0,0,0)** and **glScissor(0,0,0,0)** were called.

Implementations may delay allocation of auxiliary buffers for a surface until they are required by a context (which may result in the EGL_BAD_ALLOC error described above). Once allocated, however, auxiliary buffers and their contents persist until a surface is deleted.

3.7.3.1 Multisample Buffers and Multiple Rendering Streams

When rendering to a surface containing multisample buffers (created with respect to an EGLConfig whose EGL_SAMPLE_BUFFERS attribute has a value of one), switching rendering between client APIs may force resolution of the multisample buffer into the color buffer. This can occur for many reasons, such as client

APIs which do not share the same interpretation of the multisample information (for example, using different sample locations or weightings); client APIs which do not support multisample rendering; or applications which enable multisample rendering in one client API and disable it in another.

Repeated resolution of the multisample buffer may result in lower quality images. For this reason, applications mixing rendering by multiple client APIs onto the same surface should minimize switching between client APIs. Ideally, each client API rendering to a surface should be made current only once for each frame being rendered.

3.7.3.2 Order of Rendering Operations Between Contexts

EGL makes no guarantees on the rendering order between contexts, even within the same thread. For example, rendering operations performed by a thread while one context is current do not necessarily complete before rendering operations performed later in the same thread but with a different context current. It is the responsibility of the application to employ the correct synchronization when the drawing result of one context needs to be complete before another context accesses that result. Otherwise the result is undefined.

To achieve synchronization, an application can use client API-specific commands such as **glFinish** to wait for rendering operations to complete in one context before making the next current. Alternatively, synchronization objects can be used to order rendering operations between contexts, if supported by the underlying implementation. Synchronization objects are defined by the `EGL_KHR_fence_sync` and `EGL_KHR_wait_sync` EGL extensions, or alternatively, they may be available as a feature of the underlying client API. Use of synchronization objects may allow asynchronous execution of the rendering operations, achieving better performance than synchronous wait functions like **glFinish**.

3.7.4 Context Queries

Several queries exist to return information about contexts.

To get the current context for the current rendering API, call

```
EGLContext eglGetCurrentContext(void);
```

If there is no current context for the current rendering API, or if the current rendering API is `EGL_NONE`, then `EGL_NO_CONTEXT` is returned (this is not an error). If the current context has been marked for deletion as a result of calling **glTerminate** or **eglDestroyContext**, the handle returned by **eglGetCurrentContext** is not

valid, and cannot be passed successfully to any other EGL function, as discussed in section 3.2.

To get the surfaces used for rendering by a current context, call

```
EGLSurface eglGetCurrentSurface(EGLint readdraw);
```

readdraw is either `EGL_READ` or `EGL_DRAW`, to return respectively the read or draw surfaces bound to the current context in the calling thread, for the current rendering API.

If there is no current context for the current rendering API, then `EGL_NO_SURFACE` is returned (this is not an error).

Errors

eglGetCurrentContext returns `EGL_NO_SURFACE` on failure (but may also return it if no context is bound, as described above)

If *readdraw* is neither `EGL_READ` nor `EGL_DRAW`, an `EGL_BAD_PARAMETER` error is generated.

If a current surface has been marked for deletion as a result of calling **eglTerminate** or **eglDestroySurface**, the handle returned by **eglGetCurrentSurface** is not valid, and cannot be passed successfully to any other EGL function, as discussed in section 3.2.

To get the display associated with a current context, call

```
EGLDisplay eglGetCurrentDisplay(void);
```

The display for the current context in the calling thread, for the current rendering API, is returned. If there is no current context for the current rendering API, `EGL_NO_DISPLAY` is returned (this is not an error).

Note that `EGL_NO_DISPLAY` is used solely to represent an error condition, and is not a valid `EGLDisplay` handle.

Errors

Passing `EGL_NO_DISPLAY` to any command taking an `EGLDisplay` parameter will generate either an `EGL_BAD_DISPLAY` error if the EGL implementation validates `EGLDisplay` handles, or undefined behavior as described at the end of section 3.1. The only exception to this rule is that **eglQueryString** will accept an `EGLDisplay` parameter of `EGL_NO_DISPLAY`

when querying the client extension string (see section 3.3).

To obtain the value of context attributes, use

```
EGLBoolean eglQueryContext(EGLDisplay dpy,
    EGLContext ctx, EGLint attribute, EGLint
    *value);
```

eglQueryContext returns in *value* the value of *attribute* for *ctx*. *attribute* must be set to `EGL_CONFIG_ID`, `EGL_CONTEXT_CLIENT_TYPE`, `EGL_CONTEXT_CLIENT_VERSION`, or `EGL_RENDER_BUFFER`.

Querying `EGL_CONFIG_ID` returns the ID of the `EGLConfig` with respect to which the context was created.

Querying `EGL_CONTEXT_CLIENT_TYPE` returns the type of client API this context supports (the value of the *api* parameter to **eglBindAPI**).

Querying `EGL_CONTEXT_CLIENT_VERSION` returns the version of the client API this context actually supports (which may differ from the version specified at context creation time). The resulting value is only meaningful for an OpenGL ES context.

Querying `EGL_RENDER_BUFFER` returns the buffer which client API rendering via this context will use. The value returned depends on properties of both the context, and the draw surface to which the context is bound:

- If the context is bound to a pixmap surface, then `EGL_SINGLE_BUFFER` will be returned.
- If the context is bound to a pbuffer surface, then `EGL_BACK_BUFFER` will be returned.
- If the context is bound to a window surface, then either `EGL_BACK_BUFFER` or `EGL_SINGLE_BUFFER` may be returned. The value returned depends on both the buffer *requested* by the setting of the `EGL_RENDER_BUFFER` property of the *surface* (which may be queried by calling **eglQuerySurface** - see section 3.5.6), and on the client API (not all client APIs support single-buffer rendering to window surfaces). Some client APIs allow control of whether rendering goes to the front or back buffer. This client API-specific choice is not reflected in the returned value, which only describes the buffer that will be rendered to by default if not overridden by the client API.
- If the context is not bound to a surface, then `EGL_NONE` will be returned.

Errors

eglQueryContext returns `EGL_FALSE` on failure and *value* is not updated.

If *attribute* is not a valid EGL context attribute, then an `EGL_BAD_ATTRIBUTE` error is generated.

If *ctx* is invalid, an `EGL_BAD_CONTEXT` error is generated.

3.8 Synchronization Primitives

To prevent native rendering API functions from executing until any outstanding client API rendering affecting the same surface is complete, call

```
EGLBoolean eglWaitClient(void);
```

All rendering calls for the currently bound context, for the current rendering API, made prior to **eglWaitClient**, are guaranteed to be executed before native rendering calls made after **eglWaitClient** which affect the read or draw surfaces associated with that context.

The same result can be achieved using client API-specific calls such as **glFinish** or **vgFinish**.

Clients rendering to single buffered surfaces (e.g. pixmap surfaces) should call **eglWaitClient** before accessing the native pixmap from the client.

eglWaitClient returns `EGL_TRUE` on success. If there is no current context for the current rendering API, the function has no effect but still returns `EGL_TRUE`.

Errors

eglWaitClient returns `EGL_FALSE` on failure.

If a surface associated with the calling thread's current context is no longer valid, an `EGL_BAD_CURRENT_SURFACE` error is generated.

For backwards compatibility, the function

```
EGLBoolean eglWaitGL(void);
```

is equivalent to

```
EGLenum api = eglQueryAPI();
eglBindAPI(EGL_OPENGL_ES_API);
eglWaitClient();
```

```
eglBindAPI(api);
```

To prevent a client API command sequence from executing until any outstanding native rendering affecting the same surface is complete, call

```
EGLBoolean eglWaitNative(EGLint engine);
```

Native rendering calls made with the specified marking *engine*, and which affect the read or draw surfaces associated with the calling thread's current context, for the current rendering API, are guaranteed to be executed before client API rendering calls made after **eglWaitNative**. The same result may be (but is not necessarily) achievable using native synchronization calls.

engine denotes a particular *marking engine* (another drawing API, such as GDI or Xlib) to be waited on. Valid values of *engine* are defined by EGL extensions specific to implementations, but implementations will always recognize the symbolic constant `EGL_CORE_NATIVE_ENGINE`, which denotes the most commonly used marking engine other than a client API.

eglWaitNative returns `EGL_TRUE` on success. If there is no current context, the function has no effect but still returns `EGL_TRUE`. If a surface does not support native rendering (e.g. `pbuffer` and in most cases window surfaces), the function has no effect but still returns `EGL_TRUE`.

Errors

eglWaitNative returns `EGL_FALSE` on failure.

If the surface associated with the calling thread's current context is no longer valid, an `EGL_BAD_CURRENT_SURFACE` error is generated.

If *engine* does not denote a recognized marking engine, an `EGL_BAD_PARAMETER` error is generated.

3.8.1 Sync Objects

In addition to the aforementioned synchronization functions, which provide an efficient means of serializing client and native API operations within a thread, *sync objects* are provided to enable synchronization of client API operations between threads and/or between API contexts. Sync objects may be tested or waited upon by application threads.

Sync objects have a status with two possible states: *signaled* and *unsignaled*. Initially, sync objects are *unsignaled*. EGL may be asked to wait for a sync object to become *signaled*, or a sync object's status may be queried.

Depending on the type of a sync object, its status may be changed either by an external event, or by explicitly signaling and unsignaling the sync.

Sync objects are associated with an `EGLDisplay` when they are created, and have *attributes* defining additional aspects of the sync object. All sync objects include attributes for their type and their status. Additional attributes are discussed below for different types of sync objects.

Fence sync objects are created in association with a *fence command* in a client API. When the client API executes the fence command, an event is generated which signals the corresponding fence sync object. Fence sync objects may not be explicitly signaled, and may only change their status once, from the initial unsignaled status to signaled. Fence sync objects may be used to wait for partial completion of a client API command stream, as a more flexible form of **glFinish** or **vgFinish**.

A *OpenCL event sync object* reflects the status of a corresponding OpenCL event object to which the sync object is linked. This provides another method of coordinating sharing of images between EGL and OpenCL (see Chapter 9 of the OpenCL 1.0 Specification and the `cl_khr_egl_image` extension). Waiting on such a sync object is equivalent to waiting for completion of the linked OpenCL event object.

The command

```
EGLSync eglCreateSync(EGLDisplay dpy, EGLenum
    type, const EGLAttrib *attrib_list);
```

creates a sync object of the specified *type* associated with the specified display *dpy*, and returns a handle to the new object. *attrib_list* is an attribute-value list specifying other attributes of the sync object, terminated by an attribute entry `EGL_NONE`. Attributes not specified in the list will be assigned their default values.

Once the *condition* of the sync object is satisfied, the sync is signaled, causing any **eglClientWaitSync** or **eglWaitSync** commands (see below) blocking on *sync* to unblock.

3.8.1.1 Creating Fence Sync Objects

If *type* is `EGL_SYNC_FENCE`, a fence sync object is created. In this case *attrib_list* must be `NULL` or empty (containing only `EGL_NONE`). Attributes of the fence sync object are set as shown in table 3.7.

When a fence sync object is created, **eglCreateSync** also inserts a fence command into the command stream of the bound client API's current context (i.e., the context returned by **eglGetCurrentContext**), and associates it with the newly created sync object.

Attribute Name	Initial Attribute Value(s)
EGL_SYNC_TYPE	EGL_SYNC_FENCE
EGL_SYNC_STATUS	EGL_UNSIGNALED
EGL_SYNC_CONDITION	EGL_SYNC_PRIOR_COMMANDS_COMPLETE

Table 3.7: Fence sync attributes and initial values.

The only condition supported for fence sync objects is `EGL_SYNC_PRIOR_COMMANDS_COMPLETE`, which is satisfied by completion of the fence command corresponding to the sync object, and all preceding commands in the associated client API context's command stream. The sync object will not be signaled until all effects from these commands on the client API's internal and framebuffer state are fully realized. No other state is affected by execution of the fence command.

Creation of fence sync objects requires support from the bound client API, and will not succeed unless the client API satisfies one of the following properties. Note that `eglWaitSync` (see section 3.8.1.3) also requires satisfying these conditions.

- client API is OpenGL, and either the OpenGL version is 3.2 or greater, or the `GL_ARB_sync` extension is supported.
- client API is OpenGL ES, and either the OpenGL ES version is 3.0 or greater, or the `GL_OES_egl_sync` extension is supported.
- client API is OpenVG, and the `VG_KHR_egl_sync` extension is supported.

3.8.1.2 Creating OpenCL Event Sync Objects

If *type* is `EGL_SYNC_CL_EVENT`, an OpenCL event sync object is created. In this case *attrib_list* must contain the attribute `EGL_CL_EVENT_HANDLE`, set to a valid OpenCL event handle returned by a call to `clEnqueueReleaseGLObjects` or `clEnqueueReleaseEGLObjects`; other types of OpenCL event handles are not supported. Note that `EGL_CL_EVENT_HANDLE` is not a queryable property of a sync object. Attributes of the OpenCL event sync object are set as shown in table 3.8.

The status of such a sync object depends on *event*. When the status of *event* is `CL_QUEUED`, `CL_SUBMITTED`, or `CL_RUNNING`, the status of the linked sync object will be `EGL_UNSIGNALED`. When the status of *event* changes to `CL_COMPLETE`, the status of the linked sync object will become `EGL_SIGNALED`.

The only condition supported for OpenCL event sync objects is `EGL_SYNC_CL_EVENT_COMPLETE`, which is satisfied when the status of the OpenCL event associated with the sync object changes to `CL_COMPLETE`.

Attribute Name	Initial Attribute Value(s)
EGL_SYNC_TYPE	EGL_SYNC_CL_EVENT
EGL_SYNC_STATUS	Depends on status of <i>event</i>
EGL_SYNC_CONDITION	EGL_SYNC_CL_EVENT_COMPLETE

Table 3.8: OpenCL event sync attributes and initial values.

Creating a linked sync object places a reference on the linked OpenCL event object. When the sync object is deleted, the reference will be removed from the event object.

However, implementations are not required to validate the OpenCL event, and passing an invalid event handle in *attrib_list* may result in undefined behavior up to and including program termination.

Errors

eglCreateSync returns `EGL_NO_SYNC` on failure.

If *dpy* is not the name of a valid, initialized `EGLDisplay`, an `EGL_BAD_DISPLAY` error is generated.

If *attrib_list* contains an attribute name not defined for the type of sync object being created, an `EGL_BAD_ATTRIBUTE` error is generated.

If *type* is not a supported type of sync object, an `EGL_BAD_PARAMETER` error is generated.

If *type* is `EGL_SYNC_FENCE` and no context is current for the bound API (i.e., **eglGetCurrentContext** returns `EGL_NO_CONTEXT`), an `EGL_BAD_MATCH` error is generated.

If *type* is `EGL_SYNC_FENCE` and *dpy* does not match the `EGLDisplay` of the currently bound context for the currently bound client API (the `EGLDisplay` returned by **eglGetCurrentDisplay**), an `EGL_BAD_MATCH` error is generated.

If *type* is `EGL_SYNC_FENCE` and the current context for the currently bound client API does not support fence commands, an `EGL_BAD_MATCH` error is generated.

If *type* is `EGL_SYNC_CL_EVENT` and `EGL_CL_EVENT_HANDLE` is not specified in *attrib_list*, or its attribute value is not a valid OpenCL event handle as described above, then an `EGL_BAD_ATTRIBUTE` error is generated.

3.8.1.3 Waiting For Sync Objects

The command

```
EGLint eglClientWaitSync(EGLDisplay dpy, EGLSync
    sync, EGLint flags, EGLTime timeout);
```

blocks the calling thread until the specified sync object *sync* is signaled, or until *timeout* nanoseconds have passed.

More than one **eglClientWaitSync** may be outstanding on the same *sync* at any given time. When there are multiple threads blocked on the same *sync* and the sync object is signaled, all such threads are released, but the order in which they are released is not defined.

If the value of *timeout* is zero, then **eglClientWaitSync** simply tests the current status of *sync*. If the value of *timeout* is the special value `EGL_FOREVER`, then **eglClientWaitSync** does not time out. For all other values, *timeout* is adjusted to the closest value allowed by the implementation-dependent timeout accuracy, which may be substantially longer than one nanosecond.

eglClientWaitSync returns one of three status values describing the reason for returning. A return value of `EGL_TIMEOUT_EXPIRED` indicates that the specified timeout period expired before *sync* was signaled, or if *timeout* is zero, indicates that *sync* is not signaled. A return value of `EGL_CONDITION_SATISFIED` indicates that *sync* was signaled before the timeout expired, which includes the case when *sync* was already signaled when **eglClientWaitSync** was called. If an error occurs then an error is generated and `EGL_FALSE` is returned.

If the sync object being blocked upon will not be signaled in finite time (for example, by an associated fence command issued previously, but not yet flushed to the graphics pipeline), then **eglClientWaitSync** may wait forever. To help prevent this behavior²⁰, if the `EGL_SYNC_FLUSH_COMMANDS_BIT` bit is set in *flags*, and *sync* is unsignaled when **eglClientWaitSync** is called, then the equivalent of `Flush()` will be performed for the current API context (i.e., the context returned by **eglGetCurrentContext**) before blocking on *sync*. If no context is current for the bound API, the `EGL_SYNC_FLUSH_COMMANDS_BIT` bit is ignored.

Errors

eglClientWaitSync returns `EGL_FALSE` on failure.

²⁰ The simple `Flush` behavior defined by `EGL_SYNC_FLUSH_COMMANDS_BIT` will not help when waiting for a fence command issued in a different context's command stream. Applications which block on a fence sync object must take additional steps to ensure that the context from which the associated fence command was issued has flushed that command to the graphics pipeline.

If *sync* is not a valid sync object for *dpy*, an `EGL_BAD_PARAMETER` error is generated.

If *dpy* does not match the `EGLDisplay` passed to `eglCreateSync` when *sync* was created, the behaviour is undefined.

The command

```
EGLBoolean eglWaitSync(EGLDisplay dpy, EGLSync
    sync, EGLint flags);
```

is similar to `eglClientWaitSync`, but instead of blocking and not returning to the application until *sync* is signaled, `eglWaitSync` returns immediately. On success, `EGL_TRUE` is returned, and the server for the client API context²¹ will block until *sync* is signaled²².

sync has the same meaning as for `eglClientWaitSync`.

flags must be 0.

`eglWaitSync` requires support from the bound client API, and will not succeed unless the same client API properties described for creation of fence syncs in section 3.8.1.1 are satisfied.

Errors

`eglWaitSync` returns `EGL_FALSE` on failure, and does not cause the server for the client API context to block.

If the current context for the currently bound client API does not support server waits, an `EGL_BAD_MATCH` error is generated.

If no context is current for the currently bound client API (i.e., `eglGetCurrentContext` returns `EGL_NO_CONTEXT`), an `EGL_BAD_MATCH` error is generated.

If *dpy* does not match the `EGLDisplay` passed to `eglCreateSync` when *sync* was created, the behavior is undefined.

If *sync* is not a valid sync object for *dpy*, an `EGL_BAD_PARAMETER` error is generated.

If *flags* is not 0, an `EGL_BAD_PARAMETER` error is generated.

²¹ The server may choose to wait either in the CPU executing server-side code, or in the GPU hardware if it supports this operation.

²² `eglWaitSync` allows applications to continue to queue commands from the application in anticipation of the sync being signaled, potentially increasing parallelism between application, client API server code, and the GPU. The server only blocks execution of commands for the specific context on which `eglWaitSync` was issued; other contexts implemented by the same server are not affected.

Attribute	Description	Supported Sync Objects
EGL_SYNC_TYPE	Type of the sync object	All
EGL_SYNC_STATUS	Status of the sync object	All
EGL_SYNC_CONDITION	Signaling condition	EGL_SYNC_FENCE or EGL_SYNC_CL_EVENT

Table 3.9: Attributes accepted by `eglGetSyncAttrib`.

3.8.1.3.1 Multiple Waiters It is possible for the application thread calling a client API to be blocked on a sync object in a `eglClientWaitSync` command, the server for that client API context to be blocked as the result of a previous `eglWaitSync` command, and for additional `eglWaitSync` commands to be queued in the server, all for a single sync object. When the sync object is signaled in this situation, the client will be unblocked, the server will be unblocked, and all such queued `eglWaitSync` commands will continue immediately when they are reached.

Sync objects may be waited on or signaled from multiple contexts of different client API types in multiple threads simultaneously, although some client APIs may not support `eglWaitSync`. This support is determined by client API-specific extensions.

The command

3.8.1.4 Querying Sync Object Attributes

```
EGLBoolean eglGetSyncAttrib(EGLDisplay dpy,
                             EGLSync sync, EGLint attribute, EGLAttrib
                             *value);
```

is used to query attributes of the sync object `sync`. Legal values for `attribute` depend on the type of sync object, as shown in table 3.9. Assuming no errors are generated, `EGL_TRUE` is returned and the value of the queried attribute is returned in `*value`.

Errors

On failure, `eglGetSyncAttrib` returns `EGL_FALSE` and `*value` is not modified.

If `sync` is not a valid sync object for `dpy`, an `EGL_BAD_PARAMETER` error is generated.

If `attribute` is not one of the attributes in table 3.9, an `EGL_BAD_ATTRIBUTE` error is generated.

If *attribute* is not supported for the type of sync object passed in *sync*, an EGL_BAD_MATCH error is generated.

If *dpy* does not match the display passed to **eglCreateSync** when *sync* was created, behaviour is undefined.

The command

```
EGLBoolean eglDestroySync(EGLDisplay dpy, EGLSync
                             sync);
```

is used to destroy an existing sync object.

If any **eglClientWaitSync** or **eglWaitSync** commands are blocking on *sync* when **eglDestroySync** is called, *sync* is flagged for deletion and will be deleted when the associated fence command or OpenCL event object has completed, and *sync* is no longer blocking any such **egl*WaitSync** command. Otherwise, the sync object is destroyed immediately.

If no errors are generated, EGL_TRUE is returned, and *sync* will no longer be the handle of a valid sync object.

Errors

On failure, **eglDestroySync** returns EGL_FALSE.

If *sync* is not a valid sync object for *dpy*, EGL_FALSE is returned and an EGL_BAD_PARAMETER error is generated.

If *dpy* does not match the display passed to **eglCreateSync** when *sync* was created, the behaviour is undefined.

3.9 EGLImage Specification and Management

The command

```
EGLImage eglCreateImage(EGLDisplay dpy,
                          EGLContext ctx, EGLenum target,
                          EGLClientBuffer buffer, const EGLAttrib
                          *attrib_list);
```

is used to create an EGLImage from an existing image resource *buffer*. *dpy* specifies the EGL display used for this operation. *ctx* specifies the EGL client API context used for this operation, or EGL_NO_CONTEXT if a client API context is not required. *target* specifies the type of resource being used as the EGLImage source

(examples include two-dimensional textures in OpenGL ES contexts and VGImage objects in OpenVG contexts). *buffer* is the name (or handle) of a resource to be used as the EGLImage source, cast into the type `EGLClientBuffer`. *attrib_list* is a list of attribute-value pairs which is used to select sub-sections of *buffer* for use as the EGLImage source, such as mipmap levels for OpenGL ES texture map resources, as well as behavioral options, such as whether to preserve pixel data during creation. If *attrib_list* is non-NULL, the last attribute specified in the list must be `EGL_NONE`.

The resource specified by *dpy*, *ctx*, *target*, *buffer*, and *attrib_list* must not itself be an EGLImage sibling, or bound to a pbuffer `EGLSurface` resource (**`eglBindTexImage`**, **`eglCreatePbufferFromClientBuffer`**).

Values accepted for *target* are shown in table 3.10.

Attribute names accepted in *attrib_list* are shown in table 3.11, together with the *target* for which each attribute name is valid, and the default value used for each attribute if it is not included in *attrib_list*.

`eglCreateImage` returns an EGLImage object corresponding to the image data specified by *dpy*, *ctx*, *target*, *buffer* and *attrib_list* which may be referenced by client API operations.

If *target* is `EGL_GL_TEXTURE_2D`, `EGL_GL_TEXTURE_3D`, `EGL_GL_RENDERBUFFER`, `EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_X`, `EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_X`, `EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_Y`, `EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_Y`, `EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_Z`, or `EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_Z`, *dpy* must be a valid `EGLDisplay`, and *ctx* must be a valid OpenGL or OpenGL ES API context on that display.

If *target* is `EGL_GL_TEXTURE_2D`, *buffer* must be the name of a nonzero, `GL_TEXTURE_2D` target texture object, cast into the type `EGLClientBuffer`.

If *target* is one of the `EGL_GL_TEXTURE_CUBE_MAP_*` enumerants, *buffer* must be the name of a nonzero, `GL_TEXTURE_CUBE_MAP` (or equivalent in GL extensions) target texture object, cast into the type `EGLClientBuffer`.

If *target* is `EGL_GL_TEXTURE_3D`, *buffer* must be the name of a nonzero, `GL_TEXTURE_3D` (or equivalent in GL extensions) target texture object, cast into the type `EGLClientBuffer`.

attrib_list should specify the mipmap level (`EGL_GL_TEXTURE_LEVEL`) and, where applicable, z-offset (`EGL_GL_TEXTURE_ZOFFSET`) which will be used as the EGLImage source; If not specified, the default values listed in table 3.11 will be used instead. Additional values specified in are ignored.

There must exist some levels *x* and *y* such that the mipmap level requested lies between *x* and *y* (inclusive), the texture would be mipmap complete were *x* substituted for the base level and *y* substituted for the max level, and all levels less

<i>target</i>	Notes
EGL_GL_TEXTURE_2D	Used for GL 2D texture images
EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_X	Used for the +X face of GL cubemap texture images
EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_X	Used for the -X face of GL cubemap texture images
EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_Y	Used for the +Y face of GL cubemap texture images
EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_Y	Used for the -Y face of GL cubemap texture images
EGL_GL_TEXTURE_CUBE_MAP_POSITIVE_Z	Used for the +Z face of GL cubemap texture images
EGL_GL_TEXTURE_CUBE_MAP_NEGATIVE_Z	Used for the -Z face of GL cubemap texture images
EGL_GL_TEXTURE_3D	Used for GL 3D texture images
EGL_GL_RENDERBUFFER	Used for GL render-buffer images

Table 3.10: Legal values for **eglCreateImage** *target* parameter.

Attribute	Description	Valid <i>targets</i>	Default Value
EGL_NONE	Marks the end of the attribute-value list	All	N/A
EGL_GL_TEXTURE_LEVEL	Specifies the mipmap level used as the EGLImage source. Must be part of the complete texture object <i>buffer</i>	EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_* , EGL_GL_TEXTURE_3D	0
EGL_GL_TEXTURE_ZOFFSET	Specifies the depth offset of the image to use as the EGLImage source. Must be part of the complete texture object <i>buffer</i>	EGL_GL_TEXTURE_3D	0
EGL_IMAGE_PRESERVED	Whether to preserve pixel data	All	EGL_FALSE

Table 3.11: Legal attributes for **eglCreateImage** *attrib_list* parameter.

than x or greater than y are unspecified. For cubemaps a single pair x and y must apply to all faces. For three-dimensional textures, the specified z-offset must be smaller than the depth of the specified mipmap level.

If *target* is EGL_GL_RENDERBUFFER, *buffer* must be the name of a complete, nonzero, non-multisampled GL_RENDERBUFFER (or equivalent in extensions) target object, cast into the type EGLClientBuffer. Values specified in *attrib_list* are ignored.

If the value of attribute EGL_IMAGE_PRESERVED is EGL_FALSE (the default), then all pixel data values associated with *buffer* will be undefined after **eglCreateImage** returns.

If the value of attribute EGL_IMAGE_PRESERVED is EGL_TRUE, then all pixel data values associated with *buffer* are preserved.

Errors

eglCreateImage returns EGL_NO_IMAGE on failure. The contents of *buffer* will be unaffected.

If *dpy* is not the handle of a valid EGLDisplay object, the error EGL_BAD_DISPLAY is generated.

If *ctx* is neither the handle of a valid EGLContext object on *dpy* nor

EGL_NO_CONTEXT, the error EGL_BAD_CONTEXT is generated.

If *target* is not one of the values in table 3.10, the error EGL_BAD_PARAMETER is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_*, EGL_GL_RENDERBUFFER or EGL_GL_TEXTURE_3D, and *dpy* is not a valid EGLDisplay, the error EGL_BAD_DISPLAY is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_*, EGL_GL_RENDERBUFFER or EGL_GL_TEXTURE_3D, and *ctx* is not a valid EGLContext, the error EGL_BAD_CONTEXT is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_*, EGL_GL_RENDERBUFFER or EGL_GL_TEXTURE_3D, and *ctx* is not a valid GL context, or does not match the *dpy*, the error EGL_BAD_MATCH is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_* or EGL_GL_TEXTURE_3D and *buffer* is not the name of a texture object of type *target*, the error EGL_BAD_PARAMETER is generated.

If *target* is EGL_GL_RENDERBUFFER and *buffer* is not the name of a renderbuffer object, or if *buffer* is the name of a multisampled renderbuffer object, the error EGL_BAD_PARAMETER is generated.

If EGL_GL_TEXTURE_LEVEL is nonzero, *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_* or EGL_GL_TEXTURE_3D, and *buffer* is not the name of a complete GL texture object, the error EGL_BAD_PARAMETER is generated.

If EGL_GL_TEXTURE_LEVEL is 0, *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_* or EGL_GL_TEXTURE_3D, *buffer* is the name of an incomplete GL texture object, and any mipmap levels other than mipmap level 0 are specified, the error EGL_BAD_PARAMETER is generated.

If EGL_GL_TEXTURE_LEVEL is 0, *target* is EGL_GL_TEXTURE_2D or EGL_GL_TEXTURE_3D, *buffer* is not the name of a complete GL texture object, and mipmap level 0 is not specified, the error EGL_BAD_PARAMETER is generated.

If EGL_GL_TEXTURE_LEVEL is 0, *target* is EGL_GL_TEXTURE_CUBE_MAP_*, *buffer* is not the name of a complete GL texture object, and one or more faces do not have mipmap level 0 specified, the error EGL_BAD_PARAMETER is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_*, EGL_GL_RENDERBUFFER or EGL_GL_TEXTURE_3D and *buffer* refers to the default GL texture object (0) for the corresponding GL target, the error EGL_BAD_PARAMETER is generated.

If *target* is EGL_GL_TEXTURE_2D, EGL_GL_TEXTURE_CUBE_MAP_*, or EGL_GL_TEXTURE_3D, and the value specified in *attrib.list* for EGL_GL_*

TEXTURE_LEVEL is not a valid mipmap level for the specified GL texture object *buffer*, the error EGL_BAD_MATCH is generated.

If *target* is EGL_GL_TEXTURE_3D, and the value specified in *attrib_list* for EGL_GL_TEXTURE_ZOFFSET exceeds the depth of the specified mipmap level-of-detail in *buffer*, the error EGL_BAD_PARAMETER is generated.

If an attribute specified in *attrib_list* is not one of the attributes shown in table 3.11, the error EGL_BAD_PARAMETER is generated.

If an attribute specified in *attrib_list* is not a valid attribute for *target*, as shown in table 3.11, the error EGL_BAD_MATCH is generated.

If the resource specified by *dpy*, *ctx*, *target*, *buffer* and *attrib_list* has an off-screen buffer bound to it (e.g., by a previous call to **eglBindTexImage**), the error EGL_BAD_ACCESS is generated.

If the resource specified by *dpy*, *ctx*, *target*, *buffer* and *attrib_list* is bound to an off-screen buffer (e.g., by a previous call to **eglCreatePbufferFromClientBuffer**), the error EGL_BAD_ACCESS is generated.

If the resource specified by *dpy*, *ctx*, *target*, *buffer* and *attrib_list* is itself an EGLImage sibling, the error EGL_BAD_ACCESS is generated.

If insufficient memory is available to complete the specified operation, the error EGL_BAD_ALLOC is generated.

If the value specified in *attrib_list* for EGL_IMAGE_PRESERVED is EGL_TRUE, and an EGLImage handle cannot be created from the specified resource such that the pixel data values in *buffer* are preserved, the error EGL_BAD_ACCESS is generated.

Note that the success or failure of **eglCreateImage** should not affect the ability to use *buffer* in its original API context (or context share group) (although the pixel data values will be undefined if the command succeeds and the value of EGL_IMAGE_PRESERVED is not EGL_TRUE).

3.9.1 Lifetime and Usage of EGLImages

Once an EGLImage is created from an EGLImage source, the memory associated with the EGLImage source will remain allocated (and all EGLImage siblings in all client API contexts will be useable) as long as either of the following conditions is true:

- Any EGLImage siblings exist in any client API context
- The EGLImage object exists inside EGL

The semantics for specifying, deleting and using EGLImage siblings are client API-specific, and are described in the appropriate API specifications.

If an application specifies an EGLImage sibling as the destination for rendering and/or pixel download operations (e.g., as an OpenGL or OpenGL ES framebuffer object, **glTexSubImage2D**, etc.), the modified image results will be observed by all EGLImage siblings in all client API contexts. If multiple client API contexts access EGLImage sibling resources simultaneously, with one or more context modifying the image data, rendering results in all contexts accessing EGLImage siblings are undefined.

Respecification and/or deletion of any EGLImage sibling (i.e., both EGLImage source and EGLImage target resources) inside a client API context (by issuing a subsequent call to commands such as **glTexImage*** or **glDeleteTextures**, with the EGLImage sibling resource as the target of the operation) affects only that client API context and other contexts within its share group. For an OpenGL or OpenGL ES context, respecification always results in *orphaning* of the EGLImage, and may also include allocation of additional memory for the respecified resource and/or copying of the EGLImage pixel data²³.

Operations inside EGL or any client API context which may affect the lifetime of an EGLImage (or the memory allocated for the EGLImage), such as respecifying and/or deleting an EGLImage sibling inside a client API context, must be atomic.

Applications may create client API resources from an EGLImage using client API extensions outside the scope of this document (such as `GL_OES_EGL_image`, which creates OpenGL ES texture and renderbuffer objects). If the EGLImage used to create the client resource was created with the `EGL_IMAGE_PRESERVED` attribute set to `EGL_TRUE`, then the pixel data values associated with the image will be preserved after creating the client resource; otherwise, the pixel data values will be undefined. If the EGLImage was created with the `EGL_IMAGE_PRESERVED` attribute set to `EGL_TRUE`, and EGL is unable to create the client resource without modifying the pixel values, then creation will fail and the pixel data values will be preserved.

The command

```
EGLBoolean eglDestroyImage(EGLDisplay dpy,
                             EGLImage image);
```

is used to destroy the specified EGLImage object *image*. Once destroyed, *image* may not be used to create any additional EGLImage target resources within any client API contexts, although existing EGLImage siblings may continue to be used. `EGL_TRUE` is returned on success.

²³ Behavior of other types of client APIs generally follows the OpenGL and OpenGL ES behavior described here, although this is not mandated yet.

Errors

On failure, **eglDestroyImage** returns EGL_FALSE

If *dpy* is not the handle of a valid EGLDisplay object, the error EGL_BAD_DISPLAY is generated.

If *image* is not a valid EGLImage object created with respect to *dpy*, the error EGL_BAD_PARAMETER is generated.

3.10 Posting the Color Buffer

After completing rendering, the contents of the color buffer can be made visible in a native window, or copied to a native pixmap.

3.10.1 Posting to a Window

To post the color buffer to a window, call

```
EGLBoolean eglSwapBuffers(EGLDisplay dpy,
    EGLSurface surface);
```

If *surface* is a back-buffered window surface, then the color buffer is copied to the native window associated with that surface. If *surface* is a single-buffered window, pixmap, or pbuffer surface, **eglSwapBuffers** has no effect.

The contents of ancillary buffers are always undefined after calling **eglSwapBuffers**. The contents of the color buffer are undefined if the value of the EGL_SWAP_BEHAVIOR attribute of *surface* is not EGL_BUFFER_PRESERVED. The value of EGL_SWAP_BEHAVIOR can be set for some surfaces using **eglSurfaceAttrib**, as described in section 3.5.6. EGL_SWAP_BEHAVIOR applies only to the color buffer. EGL 1.5 has no way to specify or query whether or not ancillary buffers are preserved, and applications should not rely on this behavior.

3.10.1.1 Native Window Resizing

If the native window corresponding to *surface* has been resized prior to the swap, *surface* must be resized to match. *surface* will normally be resized by the EGL implementation at the time the native window is resized. If the implementation cannot do this transparently to the client, then **eglSwapBuffers** must detect the change and resize *surface* prior to copying its pixels to the native window.

If *surface* shrinks as a result of resizing, some rendered pixels are lost. If *surface* grows, the newly allocated buffer contents are undefined. The resizing

behavior described here only maintains consistency of EGL surfaces and native windows; clients are still responsible for detecting window size changes (using platform-specific means) and changing their viewport and scissor regions accordingly.

3.10.2 Copying to a Native Pixmap

To copy the color buffer to a native pixmap, call

```
EGLBoolean eglCopyBuffers(EGLDisplay dpy,
    EGLSurface surface, EGLNativePixmapType
    target);
```

The color buffer is copied to the specified *target*, which must be a valid native pixmap handle.

The mapping of pixels in the color buffer to pixels in the pixmap is platform-dependent, since the native platform pixel coordinate system may differ from that of client APIs.

The color buffer of *surface* is left unchanged after calling **eglCopyBuffers**.

3.10.3 Posting Semantics

surface must be bound to the draw surface of the calling thread's current context, for the current rendering API. This restriction may be lifted in future EGL revisions.

eglSwapBuffers and **eglCopyBuffers** perform an implicit flush operation on the context (**glFlush** for an OpenGL or OpenGL ES context, **vgFlush** for an OpenVG context). Subsequent client API commands can be issued immediately, but will not be executed until posting is completed.

The destination of a posting operation (a visible window, for **eglSwapBuffers**, or a native pixmap, for **eglCopyBuffers**) should have the same number of components and component sizes as the color buffer it's being copied from.

In the specific case of a luminance color buffer being posted to an RGB destination, the luminance component value will normally be replicated in each of the red, green, and blue components of the destination. Some implementations may use alternate color-space conversion algorithms to map luminance to red, green, and blue values, so long as the perceptual result is unchanged. Such alternate conversions should be documented by the implementation.

In other cases where this compatibility constraint is not met by the surface and posting destination, implementations may choose to relax the constraint by converting data to the destination format. If they do so, they should define an EGL

extension specifying which destination formats are supported, and specifying the conversion arithmetic used.

The function

```
EGLBoolean eglSwapInterval(EGLDisplay dpy, EGLint
    interval);
```

specifies the minimum number of video frame periods per buffer swap for the draw surface of the current context, for the current rendering API. The interval takes effect when **eglSwapBuffers** is first called subsequent to the **eglSwapInterval** call. The swap interval has no effect on **eglCopyBuffers**.

The parameter *interval* specifies the minimum number of video frames that are displayed before a buffer swap will occur. The *interval* specified by the function applies to the draw surface bound to the context that is current on the calling thread.

If *interval* is set to a value of 0, buffer swaps are not synchronized to a video frame, and the swap happens as soon as all rendering commands outstanding for the current context are complete. *interval* is silently clamped to minimum and maximum implementation dependent values before being stored; these values are defined by EGLConfig attributes EGL_MIN_SWAP_INTERVAL and EGL_MAX_SWAP_INTERVAL respectively.

The default swap interval is 1.

3.10.4 Posting Errors

Errors

eglSwapBuffers and **eglCopyBuffers** return EGL_FALSE on failure.

If *surface* is not a valid EGL surface, an EGL_BAD_SURFACE error is generated.

If *surface* is not bound to the draw surface of the calling thread's current context, an EGL_BAD_SURFACE error is generated.

If *target* is not a valid native pixmap handle, an EGL_BAD_NATIVE_PIXMAP error should be generated.

If the format of *target* is not compatible with the color buffer, or if the size of *target* is not the same as the size of the color buffer, and there is no defined conversion between the source and target formats, an EGL_BAD_MATCH error is generated.

If called after a power management event has occurred, a EGL_CONTEXT_LOST error is generated.

If **eglSwapBuffers** is called and the native window associated with *surface* is no longer valid, an EGL_BAD_NATIVE_WINDOW error is generated.

If **eglCopyBuffers** is called and the implementation does not support native pixmaps, an `EGL_BAD_NATIVE_PIXMAP` error is generated.

Errors

eglSwapInterval returns `EGL_FALSE` on failure.

If there is no current context on the calling thread, a `EGL_BAD_CONTEXT` error is generated.

If there is no surface bound to the current context, a `EGL_BAD_SURFACE` error is generated.

3.11 Obtaining Function Pointers

The client API and EGL functions which are available to a client may vary at runtime, depending on factors such as the rendering path being used (hardware or software), resources available to the implementation, or updated device drivers. Therefore, the address of client API and EGL functions may be queried at runtime. The function

```
void (*eglGetProcAddress(const char
    *procname)) (void);
```

returns the address of the function named by *procName*. *procName* must be a NULL-terminated string. The pointer returned should be cast to a function pointer matching the function's definition in the corresponding API or extension specification. A return value of `NULL` indicates that the specified function does not exist for the implementation.

A non-NULL return value for **eglGetProcAddress** does not guarantee that a function is actually supported at runtime. The client must also make a corresponding query, such as **glGetString**(`GL_EXTENSIONS`) for OpenGL and OpenGL ES extensions; **vgGetString**(`VG_EXTENSIONS`) for OpenVG extensions; or **eglQueryString**(*dpy*, `EGL_EXTENSIONS`) for EGL extensions; or query the EGL or client API version for non-extension functions, to determine if a function is supported by EGL or a specific client API context²⁴.

²⁴ If a function is not supported by EGL or a specific client API context, the preferred behavior of calling through the function pointer is to generate an error, such as `GL_INVALID_OPERATION` for OpenGL and OpenGL ES contexts. However, undefined behavior up to and including program termination is possible.

Client API function pointers returned by **eglGetProcAddress** are independent of the display and the currently bound client API context, and may be used by any client API context which supports the function.

eglGetProcAddress may be queried for all EGL and client API functions supported by the implementation (whether those functions are extensions or not, and whether they are supported by the current client API context or not).

For functions that are queryable with **eglGetProcAddress**, implementations may choose to also export those functions statically from the object libraries implementing those functions. However, portable clients cannot rely on this behavior.

3.12 Releasing Thread State

EGL maintains a small amount of per-thread state, including the error status returned by **eglGetError**, the currently bound rendering API defined by **eglBindAPI**, and the current contexts for each supported client API. The overhead of maintaining this state may be objectionable in applications which create and destroy many threads, but only call EGL or client APIs in a few of those threads at any given time.

To return EGL to its state at thread initialization, call

```
EGLBoolean eglReleaseThread(void);
```

EGL_TRUE is returned on success, and the following actions are taken:

- For each client API supported by EGL, if there is a currently bound context, that context is released. This is equivalent to calling **eglMakeCurrent** with *ctx* set to EGL_NO_CONTEXT and both *draw* and *read* set to EGL_NO_SURFACE (see section 3.7.3).
- The current rendering API is reset to its value at thread initialization (see section 3.7).
- Any additional implementation-dependent per-thread state maintained by EGL is marked for deletion as soon as possible.

eglReleaseThread may be called in any thread at any time, and may be called more than once in a single thread. The initialization status of EGL (see section 3.2) is **not** affected by releasing the thread; only per-thread state is affected.

Resources explicitly allocated by calls to EGL, such as contexts, surfaces, and configuration lists, are not affected by **eglReleaseThread**. Such resources belong not to the thread, but to the EGL implementation as a whole.

Applications may call other EGL routines from a thread following **eglReleaseThread**, but any such call may reallocate the EGL state previously released. In particular, calling **eglGetError** immediately following a successful call to **eglReleaseThread** should not be done. Such a call will return `EGL_SUCCESS` - but will also result in reallocating per-thread state.

Errors

eglReleaseThread returns `EGL_FALSE` on failure.

There are no defined conditions under which failure will occur. Even if EGL is not initialized on any `EGLDisplay`, **eglReleaseThread** should succeed. However, platform-dependent failures may be signaled through the value returned from **eglGetError**. Unless the platform-dependent behavior is known, a failed call to **eglReleaseThread** should be assumed to leave the current rendering API, and the currently bound contexts for each supported client API, in an unknown state.

Chapter 4

Extending EGL

EGL implementors may extend EGL by adding new commands or additional enumerated values for existing EGL commands.

New names for EGL functions and enumerated types must clearly indicate whether some particular feature is in the core EGL or is vendor specific. To make a vendor-specific name, append a company identifier (in upper case) and any additional vendor-specific tags (e.g. machine names). For instance, SGI might add new commands and manifest constants of the form **eglNewCommandSGI** and `EGL_NEW_DEFINITION_SGI`. If two or more vendors agree in good faith to implement the same extension, and to make the specification of that extension publicly available, the procedures and tokens that are defined by the extension can be suffixed by `EXT`. Extensions approved by supra-vendor organizations use similar identifiers, such as `KHR` for extensions approved by the Khronos Group).

It is critically important for interoperability that enumerants and entry point names be unique across vendors. The Khronos API Registrar maintains a registry of enumerants, and all shipping enumerant values must be determined by requesting blocks of enumerants from the registry. See

<http://www.khronos.org/registry/>

for more information on defining extensions.

Chapter 5

EGL Versions, Header Files, and Enumerants

Each version of EGL supports specified client API versions, and all prior versions of those APIs up to that version. For OpenGL ES 1.x, such support includes both Common and Common-Lite profiles. EGL implementations may also support later versions of client APIs or additional client APIs, but such support will usually depend on vendor extensions.

- EGL 1.0 supports OpenGL ES 1.0.
- EGL 1.1 adds support for OpenGL ES 1.1.
- EGL 1.2 adds support for OpenGL ES 2.0 and OpenVG 1.0.
- EGL 1.4 adds support for all versions of OpenGL.
- EGL 1.5 adds support for OpenGL ES 3.0, and for sharing events with OpenCL via sync objects.

Whether a particular client API is actually available at runtime may depend on additional factors. In most cases, EGL and each client API are provided in separate libraries, and applications must link to the EGL library and to each of the client APIs used by the application. However, details of this procedure vary, and developers must refer to platform-specific documentation.

5.1 Header Files

The EGL specification defines an ISO C language binding. This binding may also be used from C++ code. In these environments, the EGL header file

`<EGL/egl.h>` provides prototypes for all the EGL entry points, and C preprocessor symbols for all the EGL tokens. C and C++ source code should `#include <EGL/egl.h>` before using any EGL entry points or symbols¹

Languages other than C and C++ will define the EGL interfaces using other methods, not described in this specification.

The Khronos Implementers Guidelines describe recommended practice, outline platform-specific issues, and provide other recommendations to people writing EGL implementations. For more details refer to the developer area at:

<http://www.khronos.org/>

5.2 Compile-Time Version Detection

To allow code to be written portably against future EGL versions, the compile-time environment must make it possible to determine which EGL version interfaces are available. The details of such detection are language-specific and should be specified in the language binding documents for each language. For C and C++ code, the `<EGL/egl.h>` header defines C preprocessor symbols corresponding to all versions of EGL supported by the implementation:

```
#define EGL_VERSION_1_0 1
#define EGL_VERSION_1_1 1
#define EGL_VERSION_1_2 1
#define EGL_VERSION_1_3 1
#define EGL_VERSION_1_4 1
#define EGL_VERSION_1_5 1
```

Future versions of EGL will define additional preprocessor symbols corresponding to the major and minor numbers of those versions.

5.3 Enumerant Values and Header Portability

Enumerant values for EGL tokens are required to be common across all implementations. A reference version of the `egl.h` header file, including defined values for all EGL enumerants, accompanies this specification and can be downloaded from

<http://www.khronos.org/>

¹ For backwards compatibility, implementations supporting OpenGL ES 1.x must also support the EGL header on the path `<GLES/egl.h>`.

All platform-specific types, values, and macros used in `egl.h` are partitioned into a platform header, `eglplatform.h`, which is automatically included by `egl.h`. A copy of `eglplatform.h` providing definitions suitable for many platforms is included along with `egl.h`. Implementers should need to modify only `eglplatform.h`, never `egl.h`².

² Please submit any additions to `eglplatform.h` made to support new platforms for inclusion in the reference copy.

Chapter 6

Glossary

Address Space the set of objects or memory locations accessible through a single name space. In other words, it is a data region that one or more threads may share through pointers.

Client an application, which communicates with the underlying EGL implementation and underlying platform by some path. The application program is referred to as a client of the platform server. To the server, the client is the communication path itself. A program with multiple connections is viewed as multiple clients to the server. The resource lifetimes are controlled by the connection lifetimes, not the application program lifetimes.

Client API one of the rendering APIs supported by EGL. At present client APIs include OpenGL, OpenGL ES and OpenVG, but other clients are expected to be added in future versions of EGL. Context creation / management, rendering semantics, and interaction between client APIs are all well-defined by EGL. There is (considerably more limited) support for rendering to EGL surfaces by non-client (native) rendering APIs, and the semantics of such support are more implementation-dependent.

Compatible an OpenGL or OpenGL ES rendering context is compatible with (may be used to render into) a surface if they meet the constraints specified in section 2.2.

Connection a bidirectional byte stream that carries the X (and EGL) protocol between the client and the server. A client typically has only one connection to a server.

(Rendering) Context an OpenGL or OpenGL ES rendering context. This is a virtual machine. All OpenGL or OpenGL ES rendering is done with respect

to a context. The state maintained by one rendering context is not affected by another except in case of state that may be explicitly shared at context creation time, such as textures.

Current Context an implicit context used by OpenGL, OpenGL ES and OpenVG, rather than passing a context parameter to each API entry point. The current OpenGL, OpenGL ES and OpenVG contexts are set as defined in section 3.7.3.

EGLContext a handle to a rendering context. OpenGL and OpenGL ES rendering contexts consist of client side state and server side state. Other client APIs do not distinguish between the two types of state.

EGLImage An opaque handle to a shared resource created by EGL client APIs, presumably a 2D array of image data

EGLImage Source An object or sub-object originally created in a client API (such as a mipmap level of a texture object in OpenGL or OpenGL ES, or a `VGImage` in OpenVG) which is used as the *buffer* parameter in a call to `eglCreateImage`.

EGLImage Target An object created in a client API (such as a texture object in OpenGL ES or a `VGImage` in OpenVG) from a previously-created `EGLImage`

EGLImage Sibling The set of all `EGLImage` targets (in all client API contexts) which are created from the same `EGLImage` object, and the `EGLImage` source resource which was used to create that `EGLImage`.

Orphaning The process of respecifying and/or deleting an `EGLImage` sibling resource (inside a client API context) which does not result in deallocation of the memory associated with the `EGLImage` or affect rendering results using other `EGLImage` siblings.

Referencing The process of creating an `EGLImage` target resource (inside a client API context) from an `EGLImage`.

Respecification When the size, format, or other attributes of an `EGLImage` sibling are changed via client API calls such as `gl*TexImage*`. Respecification usually will result in orphaning the sibling. Note that changing the pixel values of the sibling (e.g. by rendering to it or by calling `gl*TexSubImage*`) does not constitute respecification.

(Drawing) Surface an onscreen or offscreen buffer where pixel values resulting from rendering through OpenGL ES or other APIs are written.

Thread one of a group of execution units all sharing the same address space. Typically, each thread will have its own program counter and stack pointer, but the text and data spaces are visible to each of the threads. A thread that is the only member of its group is equivalent to a process.

Appendix A

Version 1.0

EGL version 1.0, approved on July 23, 2003, is the original version of EGL. EGL was loosely based on GLX 1.3, generalized to be implementable on many different operating systems and window systems and simplified to reflect the needs of embedded devices running OpenGL ES.

A.1 Acknowledgements

EGL 1.0 is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a partial list of contributors, including the company that they represented at the time of their contribution:

Aaftab Munshi, ATI	Jon Leech, Silicon Graphics
Andy Methley, Panasonic	Justin Couch, Yumetech
Carl Korobkin, 3d4W	Kari Pulli, Nokia
Chris Hall, Seaweed Systems	Lane Roberts, Symbian
Claude Knaus, Silicon Graphics	Mark Callow, HI
David Blythe, 3d4W	Mark Tarlton, Motorola
Ed Plowman, ARM	Mike Olivarez, Motorola
Graham Connor, Imagination Technologies	Neil Trevett, 3Dlabs
Harri Holopainen, Hybrid Graphics	Phil Huxley, Tao Group
Jacob Ström, Ericsson	Tom Olson, Texas Instruments
Jani Vaarala, Nokia	Ville Miettinen, Hybrid Graphics

Appendix B

Version 1.1

EGL version 1.1, approved on August 5, 2004, is the second release of EGL. It adds power management and swap control functionality based on vendor extensions from Imagination Technologies, and optional render-to-texture functionality based on the `WGL_ARB_render_texture` extension defined by the OpenGL ARB for desktop OpenGL.

B.1 Revision 1.1.2

EGL version 1.1.2 (revision 2 of EGL 1.1), approved on November 10, 2004, clarified that vertex buffer objects are shared among contexts in the same fashion as texture objects.

B.2 Acknowledgements

EGL 1.1 is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a partial list of contributors, including the company that they represented at the time of their contribution:

Aaftab Munshi, ATI	Carlos Sarria, Imagination Technologies
Andy Methley, Panasonic	Chris Tremblay, Motorola
Axel Mamode, Sony	Claude Knaus, Esmertec
Barthold Lichtenbelt, 3Dlabs	Clay Montgomery, Nokia
Benji Bowman, Imagination Technologies	Dan Petersen, Sun
Borgar Ljosland, Falanx	Dan Rice, Sun
Brian Murray, Motorola	David Blythe, HI
Brian Johnstone, Texas Instruments	David Yoder, Motorola

Doug Twilleager, Sun	Mark Tarlton, Motorola
Ed Plowman, ARM	Mike Olivarez, Motorola
Graham Connor, Imagination Technologies	Neil Trevett, 3Dlabs
Greg Stoner, Motorola	Nick Triantos, Nvidia
Hannu Napari, Hybrid	Petri Kero, Hybrid
Harri Holopainen, Hybrid	Petri Nordlund, Bitboys
Jacob Ström, Ericsson	Phil Huxley, Tao Group
Jani Vaarala, Nokia	Remi Arnaud, Sony
Jerry Evans, Sun	Robert Simpson, Bitboys
John Metcalfe, Imagination Technologies	Tero Sarkkinen, Futuremark
Jon Leech, Silicon Graphics	Timo Suoranta, Futuremark
Kari Pulli, Nokia	Thomas Tannert, Silicon Graphics
Lane Roberts, Symbian	Tomi Aarnio, Nokia
Madhukar Budagavi, Texas Instruments	Tom McReynolds, Nvidia
Mathias Agopian, PalmSource	Tom Olson, Texas Instruments
Mark Callow, HI	Ville Miettinen, Hybrid Graphics

Appendix C

Version 1.2

EGL version 1.2, approved on July 8, 2005, is the third release of EGL. It adds support for the OpenVG 2D client API, in addition to support for OpenGL ES, and generalizes EGL concepts to enable supporting other client APIs in the future.

C.1 Acknowledgements

EGL 1.2 is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a partial list of contributors, including the company that they represented at the time of their contribution:

Aaftab Munshi, ATI	ing Group
Anu Ramanathan, TI	Members of the Khronos OpenVG Working
Daniel Rice, Sun Microsystems	Group
Espen Aamodt, Falanx	Michael.Nonweiler, ARM
Jani Vaarala, Nokia	Neil Trevett, 3Dlabs / NVIDIA
Jon Leech, SGI	Petri Kero, Hybrid Graphics
Jussi Räsänen, Hybrid Graphics	Robert Simpson, Bitboys
Koichi Mori, Nokia	Simon Fenney, PowerVR
Mark Callow, HI Corporation	Tom Olson, TI
Members of the Khronos OpenGL ES Work-	

Appendix D

Version 1.3

EGL version 1.3 was voted out of the OpenKODE Working Group on December 4, 2006, and formally approval by the Khronos Board of Promoters on February 8, 2007. EGL 1.3 is the fourth release of EGL. It adds support for separate OpenGL ES 1.x and 2.x contexts with the `EGL_CONTEXT_CLIENT_VERSION` attribute to **eglCreateContext** and the `EGL_OPENGL_ES2_BIT` in the `EGL_RENDERABLE_TYPE` attribute, and adds the `EGL_MATCH_NATIVE_PIXMAP` pseudo-attribute to **eglChooseConfig**, to allow selecting configs matching specific native pixmaps. The `EGL_CONFORMANT` attribute was added to indicate if client API contexts will pass the required conformance tests, and the `EGL_SURFACE_TYPE` attribute was extended with the `EGL_VG_COLORSPACE_LINEAR_BIT` and `EGL_VG_ALPHA_FORMAT_PRE_BIT` bitfields to define whether or not linear colorspace and premultiplied alpha format are supported by the OpenVG implementation. For naming consistency, some tokens from EGL 1.2 have been renamed as shown in table D.1. The old names are also retained for backwards compatibility. The specification adds a number of clarifications (but not behavior changes) regarding config sorting, surface resource ownership, multiple client API context versions, and SDK issues.

Finally, the `eglplatform.h` header is defined to accompany the reference `egl.h` header provided by Khronos.

D.1 Acknowledgements

EGL 1.3 is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a list of contributors, including the company that they represented at the time of their contribution:

EGL 1.2 Token Name	EGL 1.3 Token Name
EGL_COLORSPACE	EGL_VG_COLORSPACE
EGL_COLORSPACE_LINEAR	EGL_VG_COLORSPACE_LINEAR
EGL_COLORSPACE_sRGB	EGL_VG_COLORSPACE_sRGB
EGL_ALPHA_FORMAT	EGL_VG_ALPHA_FORMAT
EGL_ALPHA_FORMAT_PRE	EGL_VG_ALPHA_FORMAT_PRE
EGL_ALPHA_FORMAT_NONPRE	EGL_VG_ALPHA_FORMAT_NONPRE
NativeDisplayType	EGLNativeDisplayType
NativePixmapType	EGLNativePixmapType
NativeWindowType	EGLNativeWindowType

Table D.1: Renamed tokens

Aaftab Munshi, ATI	ing Group
Daniel Rice, Sun Microsystems	Members of the Khronos OpenKODE Working Group
Espen Aamodt, Falanx	Members of the Khronos OpenVG Working Group
Gary King, NVIDIA	Neil Trevett, NVIDIA
Jani Vaarala, Nokia	Petri Kero, Hybrid Graphics
Jasin Bushnaief, Hybrid Graphics	Remi Arnaud, Sony Computer Entertainment
Jay Abbott, TAO	Robert J. Simpson, Bitboys
Jon Kennedy, 3Dlabs	Robert Palmer, Symbian
Jon Leech	Sampo Lappalainen, Hybrid Graphics
Jussi Räsänen, Hybrid Graphics	Simon Fenney, Imagination Technologies
Kalle Raita, Hybrid Graphics	Sven Gothel, ATI
Kari Pulli, Nokia	Teemu Rantalaiho, Hybrid Graphics
Koichi Mori, Nokia	Tom Olson, TI
Leonardo Estevez, TI	
Mark Callow, HI Corporation	
Members of the Khronos OpenGL ES Work-	

Appendix E

Version 1.4

EGL version 1.4 was voted out of the Khronos Technical Working Group on March 25, 2008, and formally approved by the Khronos Board of Promoters on May 29, 2008.

EGL 1.4 is the fifth release of EGL. It introduces the following new features:

- Allow multisampled configurations for OpenVG, by relaxing OpenGL ES-specific language and documenting that multisample buffer resolution may be performed when switching which client API is rendering to a surface.
- Allow control of multisample resolution behavior (use of a box filter) using the `EGL_MULTISAMPLE_RESOLVE` `EGLSurface` attribute.
- Allow control of swap behavior (preserving back buffer contents) using the `EGL_SWAP_BEHAVIOR` bit in the `EGL_SURFACE_TYPE` `EGLSurface` attribute.
- Enable support for OpenGL (in addition to, or instead of OpenGL ES) as a client API.
- Relax definition of `EGLNativeDisplayType` to allow a variety of mappings to X and Microsoft Windows data structures.
- Document the meaning of the `EGL_LEVEL` `EGLConfig` attribute.
- Document that `eglMakeCurrent` can raise an `EGL_BAD_ACCESS` error when binding more contexts in the current thread group than are supported by the implementation.
- Add a specific example of how `eglCreatePbufferFromClientBuffer` can fail due to implementation constraints.

- Fix prototypes of functions with empty argument lists.

E.1 Updates to EGL 1.4

After the initial version of EGL 1.4 was released, minor changes and corrections were made in later revisions as described below.

Changes in the revision approved on January 20, 2009:

- Change object destruction behavior such that object handles become invalid immediately after an object is deleted, although the underlying object may remain valid if it's current to a context. This affects **eglTerminate** (section 3.2), **eglDestroySurface** (section 3.5.5), **eglDestroyContext** (section 3.7.2), and **eglGetCurrentContext** and **eglGetCurrentSurface** (section 3.7.4).
- Clarify initialization and termination behavior of `EGLDisplay`, and behavior of EGL functions when passed an uninitialized display, in sections 3.2 and 3.7.3.

Changes in the revision approved on April 15, 2009:

- Specified in section 2.1.2 that all objects exist in the namespace of an `EGLDisplay` (bug 4303).
- Clarified meaning of `EGL_PIXEL_ASPECT_RATIO` and the purpose of `EGL_DISPLAY_SCALING` in section 3.5.6 (bug 3594).

Changes in the revision approved on June 23, 2009:

- Expanded description of “generic” errors applying to multiple commands in section 3.1 (bug 4993).
- Noted in sections 3.7.4 and 3.7.3 that `EGL_NO_DISPLAY` is not a valid `EGLDisplay`, and passing it as a display parameter should generate errors (bug 4993).
- Added clarification of meaning of config masks in section 3.4.1 (bug 5276).

Changes in the revision approved on September 25, 2009:

- Updated language in section 3.5.1 to make clear that the window system (as well as EGL and client APIs other than OpenVG) is not necessarily affected by the value of the `EGL_VG_ALPHA_FORMAT` attribute, and that preferred window system behavior is to ignore `EGL_VG_ALPHA_FORMAT` (bug 5526).
- Clarified error conditions for **`eglCreatePbufferFromClientBuffer`** in section 3.5.3 (bug 5473).

Changes in the revision approved on March 3, 2010:

- Change descriptions of `EGL_SWAP_BEHAVIOR_PRESERVED_BIT` in table 3.2 and `EGL_SWAP_BEHAVIOR` in section 3.4 to specify that they apply only to the color buffer. Relax language in section 3.10.1 to allow ancillary buffer contents to be undefined after swap, regardless of the value of `EGL_SWAP_BEHAVIOR`; clarify how `EGL_SWAP_BEHAVIOR` controls color buffer preservation; and add a footnote describing this subtle behavior change relative to older versions of EGL 1.4 (bug 5970).

Changes in the revision approved on April 7, 2010:

- Update table 3.1 and the description of `EGL_BUFFER_SIZE` in section 3.4 to clarify that this attribute is simply the sum of the RGBA or LA component sizes, and does not include any padding or alignment bits that may be present in the underlying pixel format (bug 6143).

Changes in the revision approved on May 21, 2010:

- Note that `EGL_MATCH_NATIVE_PIXMAP` is not a valid *attribute* to **`eglGetConfigAttrib`** in section 3.4.3 (bug 6285).

Changes in the revision approved on July 21, 2010:

- Clarify lifetime of shared objects when contexts on the share list are destroyed in section 3.7.2 (Bug 6582).

Changes in the revision approved on October 6, 2010:

- Fix typo in section 2.4 (public Bug 340).
- Refine **`eglTerminate`** language in section 3.2 to specify that handles to all types of EGL resources owned by the terminated display are invalidated, although the display handle itself remains valid (Bug 6776).

- Fix error condition for **eglCreateWindowSurface** in section 3.5.1 to be generated if there is already an **EGLSurface** associated with the native window, rather than an **EGLConfig** (Bug 6667).
- Expand footnote describing counterintuitive behavior of **EGLConfig** sort rule 3 in section 3.4.1 (public Bug 327).
- Add Tero Pihlajakoski to the Acknowledgements.

Changes in the revision approved on April 20, 2011:

- Note that **EGL_DONT_CARE** is not a valid attribute value for **EGL_MATCH_NATIVE_PIXMAP** in section 3.4.1 (Bug 7456).
- Correct sort order of **EGL_COLOR_BUFFER_TYPE** in table 3.4 (Bug 7431).

Changes in the revision approved on February 13, 2013:

- Clarify support for OpenGL as well as OpenGL ES in sections 1, 2.2, 2.2, 2.2.2, 2.3, 2.4, 2.6, and 5 (Bug 9864).
- Added new section 2.2.2.1, clarifying that the *y* coordinate used when rendering to native window or pixmap surfaces is inverted relative to the client API coordinate system, so that images appear as expected. N.b. this is not a behavior change (Bug 9701).
- Note in section 3.1 that since **eglGetError** always returns error information about the most recently called EGL function, calling **eglGetError** twice in a row will return **EGL_SUCCESS** on the second call.
- Add language to the description of **eglBindAPI** in section 3.7 making **EGL_OPENGL_API** and **EGL_OPENGL_ES_API** equivalent for all purposes other than **eglCreateContext**, and added **eglCopyBuffers** and **eglSwapBuffers** to the list of commands affected by the current rendering API (Bug 9118).
- Minor language fixes to description of **eglGetProcAddress** in section 3.11 (Bug 9865).
- Clarify support for OpenGL as well as OpenGL ES in chapter 6 (Bug 9864).

Changes in the revision approved on December 4, 2013:

- Modified the definition of **EGLint** in section 2.1.1 so that it may not be large enough to hold a native pointer, and described why the regression is being adopted (Bug 11027).

- Updated section 2.2.2.1 to not mandate that all window systems invert the coordinate system relative to client APIs (Bug 9701).
- Change selection type of `EGL_CONFIG_ID` from *Exact* to *Special* in table 3.4 (Bug 10567).
- Added new section 3.7.3.2 specifying that EGL does not provide ordering guarantees across `eglMakeCurrent` (Bug 10664).
- Change description of `eglQueryContext` query in section 3.7.4 so `EGL_CONTEXT_CLIENT_VERSION` returns the version of the context actually created, not the version requested (Bug 10906).
- Clarify that querying `EGL_RENDER_BUFFER` returns values depending on the draw surface in section 3.7.4; that `eglWaitClient` and `eglWaitNative` guarantee synchronization to both read and draw surfaces in section 3.8; and that `eglSwapInterval` affects, and `eglSwapBuffers` and `eglCopyBuffers` are restricted to the currently bound draw surface in sections 3.10.3 and 3.10.4 (Bug 10200).
- Add a footnote to the description of `eglGetProcAddress` in section 3.11 clarifying that calling through an extension function pointer to an extension not implemented by a client API results in undefined behavior (Bug 10147).

E.2 Acknowledgements

EGL 1.4 is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a list of contributors, including the company that they represented at the time of their contribution:

Acorn Pooley, NVIDIA	Ian Romanick, Intel
Andrzej Mamona, AMD	Jim Van Welzen, NVIDIA
Barthold Lichtenbelt, NVIDIA	Jon Leech
Benj Lipchak, AMD	Kari Pulli, Nokia
Benji Bowman, Imagination Technologies	Leonardo Estevez, TI
Bill Licea-Kane, AMD	Mark Callow, HI Corporation
Dongkyun Jeong, Samsung	Marko Lukat, Antix Labs
Ed Plowman, ARM	Matti Paavola, Nokia
Gabriele Svelto, ST Microelectronics	Maurice Ribble, AMD
Gary King, NVIDIA	Members of the Khronos OpenGL ES,
Georg Kolling, Imagination Technologies	OpenKODE, OpenMAX, OpenVG, and
Graham Connor, Imagination Technologies	OpenWF Working Groups

Michael Giovinco, Seaweed Systems
Neil Trevett, NVIDIA
Pasi Keranen, Nokia
Pierre Boudier, AMD
Richard Sahlin, Ericsson
Robert Palmer, Symbian
Robert Simpson, AMD
Roger Nixon, Broadcom

Sami Kyostila, Nokia
Steven Fischer, Motorola
Tero Pihlajakoski, Symbio
Tim Renouf, Antix Labs
Tom Olson, TI
Yeshwant Muthusamy, Nokia
Zhifang Long, Marvell

Appendix F

Version 1.5

EGL version 1.5 was voted out of the Khronos Technical Working Group on January 31, 2014, and formally approved by the Khronos Board of Promoters on March 14, 2014.

EGL 1.5 is the sixth release of EGL. It introduces the following new features (the EGL extension(s) each feature is based on are also shown parenthetically):

- Platform support:
 - Distinguishing client and display extensions, and defining a method to query, without initializing a display, the set of supported client extensions (EGL_EXT_client_extensions).
 - Providing a mechanism for support of multiple *platforms* (such as window systems or offscreen rendering frameworks) in a single EGL implementation at runtime (EGL_EXT_platform_base).
- Client API interoperability:
 - Sync objects representing events whose completion can be tested or waited on. Such events include fences placed in client API command streams (EGL_KHR_fence_sync) and events triggered by OpenCL event objects (EGL_KHR_cl_event2), and the ability to wait for sync objects in the server for a client API context, allowing application code to continue to execute in parallel (EGL_KHR_wait_sync).
- Image sharing:
 - Definition of image objects suitable for sharing 2D arrays of image data between client APIs (EGL_KHR_image_base)

- Methods to create image objects from OpenGL and OpenGL ES API resources including two- and three-dimensional textures, cube maps and render buffers (EGL_KHR_gl_texture_2D_image, EGL_KHR_gl_texture_3D_image, EGL_KHR_gl_texture_cubemap_image, and EGL_KHR_gl_renderbuffer_image).
- General API cleanup:
 - A new context creation command with attributes specifying the requested OpenGL and OpenGL ES version, context properties, profile, and the ability to be made current without providing a default framebuffer (EGL_KHR_create_context), as well as robust buffer access behavior and graphics reset notification behavior (EGL_EXT_create_context_robustness).
 - Defining **eglGetProcAddress** to support querying of all EGL and client API functions, not just extensions (EGL_KHR_get_all_proc_addresses and EGL_KHR_client_get_all_proc_addresses).
 - Enabling creation of EGLSurfaces which will be rendered to in sRGB by OpenGL and OpenGL ES contexts supporting that capability (EGL_KHR_gl_colorspace).
 - Extending **eglMakeCurrent** to make a context current without either a read or draw surface (EGL_KHR_surfaceless_context).

F.1 Change Log for Released Specifications

Changes in the revision approved on August 27, 2014:

- Remove language in section 3.9 stating that inapplicable attributes to **eglCreateImage** are ignored, since this is inconsistent with the explicit error defined for this case (Bug 12585).

Changes in the revision approved on May 21, 2014:

- Allow querying the EGL client version string by passing EGL_NO_DISPLAY to **eglQueryString** in section 3.3 (Bug 12204), and define the meaning of the client version (Bug 12204).
- Change error code for invalid *type* arguments to **eglCreateSync** to EGL_BAD_PARAMETER in section 3.8.1 (Bug 11963).

- Document in section 3.9.1 that respecification of an `EGLImage` sibling in an OpenGL or OpenGL ES context results in orphaning of the `EGLImage` (Bug 11851).

Changes in the initial release of March 12, 2014, relative to the EGL 1.4 Specification:

- Add new features as described in section F.
- Minor typos and fixes - add OpenCL to section 1, add missing EGL types to section 2.1.1 and display-destruction discussion in section 3.2, retile section 3.3 more generically, clarify applicability of `EGL_LEVEL` in section 3.4, fix parameter name for `native_window` in section 3.5.1, clarify allowed types of OpenCL events in section 3.8.1.2, typos in sections 3.9 and 3.11 (Bug 11577).
- Add footnote to description of `EGLAttrib` in section 2.1.1 explaining why not all EGL features using attribute lists have been updated to support `EGLAttrib` interface variants (Bug 11850).
- Added **`eglSwapInterval`** to the list of commands affected by the current rendering API set with **`eglBindAPI`** in section 3.7 (Bug 11384).
- Modify description of context reset notification strategy in section 3.7.1.6 to describe as relevant, but not require EXT extensions (Bug 9313).
- Change **`eglCreateContext`** error in section 3.7.1.6 when `config` does not support the requested client API from `EGL_BAD_CONFIG` to `EGL_BAD_MATCH`, and clarify that the final `EGL_BAD_MATCH` error is intended as the error to be generated if context creation failed for reasons not enumerated previously in the Errors section (Bug 11562).
- Remove redundant error for **`eglCreateContext`** in section 3.7.1.6, and remove error when specifying an OpenGL profile mask for a context version that doesn't support profiles (Bug 11562).
- Clarify that the GL viewport/scissor context state initialization described in section 3.7.3 only applies when a context is made current for the first time **and** it is without a default framebuffer.
- Clarify completeness requirements on GL textures passed to **`eglCreateImage`** in section 3.9 (Bug 11081).

F.2 Acknowledgements

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