The X Keyboard Extension: Library Specification

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X Consortium Standard

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Matt Landau
Manager, X Window System
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5 February 1996
The following table shows the font conventions used in this document:

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1 Overview

The X Keyboard Extension provides capabilities that are lacking or are cumbersome in the core X protocol.

1.1 Core X Protocol Support for Keyboards

The core X protocol specifies the ways that the Shift, Control, and Lock modifiers and the modifiers bound to the Mode_switch or Num_Lock keysyms interact to generate keysyms and characters. The core protocol also allows users to specify that a key affects one or more modifiers. This behavior is simple and fairly flexible, but it has a number of limitations that make it difficult or impossible to properly support many common varieties of keyboard behavior. The limitations of core protocol support for keyboards include:

- Use of a single, uniform, four-symbol mapping for all keyboard keys makes it difficult to properly support keyboard overlays, PC-style break keys, or keyboards that comply with ISO9995, or a host of other national and international standards.
- A second keyboard group may be specified using a modifier, but this has side effects that wreak havoc with client grabs and X toolkit translations. Furthermore, this approach limits the number of keyboard groups to two.
- Poorly specified locking key behavior requires X servers to look for a few “magic” keysyms to determine that keys should lock when pressed. This leads to incompatibilities between X servers with no way for clients to detect implementation differences.
- Poorly specified capitalization and control behavior requires modifications to X library source code to support new character sets or locales and can lead to incompatibilities between system wide and X library capitalization behavior.
- Limited interactions between modifiers specified by the core protocol make many common keyboard behaviors difficult or impossible to implement. For example, there is no reliable way to indicate whether or not the shift modifier should “cancel” the lock modifier.
- The lack of any explicit descriptions for indicators, most modifiers, and other aspects of the keyboard appearance requires clients that wish to clearly describe the keyboard to a user to resort to a mish-mash of prior knowledge and heuristics.

1.2 Xkb Keyboard Extension Support for Keyboards

The X Keyboard Extension makes it possible to clearly and explicitly specify most aspects of keyboard behavior on a per-key basis. It adds the notion of a keyboard group to the global keyboard state and provides mechanisms to more closely track the logical and physical state of the keyboard. For keyboard-control clients, Xkb provides descriptions and symbolic names for many aspects of keyboard appearance and behavior.

In addition, the X Keyboard Extension includes additional keyboard controls designed to make keyboards more accessible to people with movement impairments.

1.3 Xkb Extension Components

The Xkb extension is composed of two parts: a server extension, and a client-side X library extension. These consist of a loadable module that may be activated when an X server is started and a modified version of Xlib. Both server and Xlib versions must be at least X11 R6.
Figure 1.1 shows the overall structure of the Xkb extension:

**Xkb Extension**

![Diagram of Xkb Extension](image)

**Figure 1.1 Overall Xkb Structure**

The server portion of the Xkb extension encompasses a database of named keyboard components, in unspecified format, that may be used to configure a keyboard. Internally, the server maintains a *keyboard description* that includes the keyboard state and configuration (mapping). By “keyboard” we mean the logical keyboard device, which includes not only the physical keys, but also potentially a set of up to 32 indicators (usually LEDs) and bells.

The keyboard description is a composite of several different data structures, each of which may be manipulated separately. When manipulating the server components, the design allows partial components to be transmitted between the server and a client. The individual components are shown in Figure 1.1.

**Client Map**

The key mapping information needed to convert arbitrary keycodes to symbols.

**Server Map**

The key mapping information categorizing keys by functionality (which keys are modifiers, how keys behave, and so on).

**Controls**

Client configurable quantities effecting how the keyboard behaves, such as repeat behavior and modifications for people with movement impairments.
Indicators

The mapping of behavior to indicators.

Geometry

A complete description of the physical keyboard layout, sufficient to draw a representation of the keyboard.

Names

A mapping of names to various aspects of the keyboard such as individual virtual modifiers, indicators, and bells.

Compatibility Map

The definition of how to map core protocol keyboard state to Xkb keyboard state.

A client application interrogates and manipulates the keyboard by reading and writing portions of the server description for the keyboard. In a typical sequence a client would fetch the current information it is interested in, modify it, and write it back. If a client wishes to track some portion of the keyboard state, it typically maintains a local copy of the portion of the server keyboard description dealing with the items of interest and updates this local copy from events describing state transitions that are sent by the server.

A client may request the server to reconfigure the keyboard either by sending explicit reconfiguration instructions to it, or by telling it to load a new configuration from its database of named components. Partial reconfiguration and incremental reconfiguration are both supported.

1.3.1 Groups and Shift Levels

The graphic characters or control functions that may be accessed by one key are logically arranged in groups and levels. See section 14.1 for a complete description of groups and levels.

1.3.2 Radio Groups

A radio group is a set of keys whose behavior simulates a set of radio buttons. Once a key in a radio group is pressed, it stays logically depressed until another key in the group is pressed, at which point the previously depressed key is logically released. Consequently, at most one key in a radio group can be logically depressed at one time. A radio group is defined by a radio group index, an optional name, and by assigning each key in the radio group XkbKB_RadioGroup behavior and the radio group index.

1.4 Client Types

This specification differentiates between three different classes of client applications:

- Xkb-aware applications
  These applications make specific use of Xkb functionality and APIs not present in the core protocol.
- Xkb-capable applications
  These applications make no use of Xkb extended functionality and Application Programming Interfaces (APIs) directly. However, they are linked with a version of Xlib that includes Xkb and indirectly benefit from some of Xkb’s features.
• Xkb-unaware applications
  These applications make no use of Xkb extended functionality or APIs and require
  Xkb’s functionality to be mapped to core Xlib functionality to operate properly.

1.5 Compatibility With the Core Protocol

Because the Xkb extension allows a keyboard to be configured in ways not foreseen by
the core protocol, and because Xkb-unaware clients are allowed to connect to a server
using the Xkb extension, there must be a means of converting between the Xkb domain
and the core protocol. The Xkb server extension maintains a compatibility map as part of
its keyboard description; this map controls the conversion of Xkb generated events to core
protocol events and the results of core protocol requests to appropriate Xkb state and con-
figuration.

1.6 Additional Protocol Errors

The Xkb extension adds a single protocol error, BadKeyboard, to the core protocol error
set. See section 2.6 for a discussion of the BadKeyboard protocol error.

1.7 Extension Library Functions

The X Keyboard Extension replaces the core protocol definition of a keyboard with a
more comprehensive one. The X Keyboard Extension library interfaces are included in
Xlib.1

Xlib detects the presence of the X Keyboard server extension and uses Xkb protocol to
replace some standard X library functions related to the keyboard. If an application uses
only standard X library functions to examine the keyboard or process key events, it should
not need to be modified when linked with an X library containing the X keyboard exten-
sion. All of the keyboard-related X library functions have been modified to automatically
use Xkb protocol when the server extension is present.

The Xkb extension adds library interfaces to allow a client application to directly manipu-
late the new capabilities.

1.7.1 Error Indications

Xkb functions that communicate with the X server check to be sure the Xkb extension has
been properly initialized prior to doing any other operations. If the extension has not been
properly initialized or the application, library, and server versions are incompatible, these
functions return an error indication as shown in Table 1.1. Because of this test, BadAc-
cess and BadMatch (due to incompatible versions) protocol errors should normally not
be generated.

Table 1.1 Function Error Returns Due to Extension Problems

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<td>Bool</td>
<td>False</td>
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<tr>
<td>Status</td>
<td>BadAccess</td>
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1. X11R6.1 is the first release by the X Consortium, Inc., that includes the X Keyboard Extension in Xlib. X11R6
 included work in progress on this extension as nonstandard additions to the library.
Many Xkb functions do not actually communicate with the X server; they only require processing in the client-side portion of the library. Furthermore, some applications may never actually need to communicate with the server; they simply use the Xkb library capabilities. The functions that do not communicate with the server return either a pointer to a structure, a Bool, or a Status. These functions check that the application has queried the Xkb library version and return the values shown in Table 1.1 if it has not.
The X Keyboard Extension 2   Initialization and General Programming

2 Initialization and General Programming Information

2.1 Extension Header Files

The following include files are part of the Xkb standard:

- `<X11/XKBlib.h>`
  XKBlib.h is the main header file for Xkb; it declares constants, types, and functions.
- `<X11/extensions/XKBstr.h>`
  XKBstr.h declares types and constants for Xkb. It is included automatically from `<X11/XKBlib.h>`; you should never need to reference it directly in your application code.
- `<X11/extensions/XKB.h>`
  XKB.h defines constants for Xkb. It is included automatically from `<X11/XKBstr.h>`; you should never need to reference it directly in your application code.
- `<X11/extensions/XKBgeom.h>`
  XKBgeom.h declares types, symbolic constants, and functions for manipulating keyboard geometry descriptions.

2.2 Extension Name

The name of the Xkb extension is given in `<X11/extensions/Xkb.h>`:

```
#define XkbName "XKEYBOARD"
```

Most extensions to the X protocol are initialized by calling `XInitExtension` and passing the extension name. However, as explained in section 2.4, Xkb requires a more complex initialization sequence, and a client program should not call `XInitExtension` directly.

2.3 Determining Library Compatibility

If an application is dynamically linked, both the X server and the client-side X library must contain the Xkb extension in order for the client to use the Xkb extension capabilities. Therefore a dynamically linked application must check both the library and the server for compatibility before using Xkb function calls. A properly written program must check for compatibility between the version of the Xkb library that is dynamically loaded and the one used when the application was built. It must then check the server version for compatibility with the version of Xkb in the library.

If your application is statically linked, you must still check for server compatibility and may check library compatibility. (It is possible to compile against one set of header files and link against a different, incompatible, version of the library, although this should not normally occur.)

To determine the compatibility of a library at runtime, call `XkbLibraryVersion`.

```c
Bool XkbLibraryVersion(int * lib_major_in_out, int * lib_minor_in_out)
{
  /* specifies and returns the major Xkb library version. */
  int * lib_major_in_out,
  /* specifies and returns the minor Xkb library version. */
  int * lib_minor_in_out;
}
```

Pass the symbolic value `XkbMajorVersion` in `lib_major_in_out` and `XkbMinorVersion` in `lib_minor_in_out`. These arguments represent the version of the library used at compile time. The `XkbLibraryVersion` function backfills the major and minor version numbers of the library used at run time in `lib_major_in_out` and `lib_minor_in_out`. If the
versions of the compile time and run time libraries are compatible, *XkbLibraryVersion* returns *True*, otherwise, it returns *False*.

In addition, in order to use the Xkb extension, you must ensure that the extension is present in the server and that the server supports the version of the extension expected by the client. Use *XkbQueryExtension* to do this, as described in the next section.

### 2.4 Initializing the Keyboard Extension

Call *XkbQueryExtension* to check for the presence and compatibility of the extension in the server and to initialize the extension. Because of potential version mismatches, you cannot use the generic extension mechanism functions (*XQueryExtension* and *XInitExtension*) for checking for the presence of, and initializing the Xkb extension.

You must call *XkbQueryExtension* or *XkbOpenDisplay* before using any other Xkb library interfaces, unless such usage is explicitly allowed in the interface description in this document. The exceptions are: *XkbIgnoreExtension*, *XkbLibraryVersion*, and a handful of audible-bell functions. You should not use any other Xkb functions if the extension is not present or is uninitialized. In general, calls to Xkb library functions made prior to initializing the Xkb extension cause *BadAccess* protocol errors.

*XkbQueryExtension* both determines whether a compatible Xkb extension is present in the X server and initializes the extension when it is present.

```c
bool XkbQueryExtension(Display *dpy, int *opcode_rtrn, int *event_rtrn, int *error_rtrn, int *major_in_out, int *minor_in_out)
```

The *XkbQueryExtension* function determines whether a compatible version of the X Keyboard Extension is present in the server. If a compatible extension is present, *XkbQueryExtension* returns *True*; otherwise, it returns *False*.

If a compatible version of Xkb is present, *XkbQueryExtension* initializes the extension. It backfills the major opcode for the keyboard extension in *opcode_rtrn*, the base event code in *event_rtrn*, the base error code in *error_rtrn*, and the major and minor version numbers of the extension in *major_in_out* and *minor_in_out*. The major opcode is reported in the *req_major* fields of some Xkb events. For a discussion of the base event code, see section 4.1.
As a convenience, you can use the function \texttt{XkbOpenDisplay} to perform these three tasks at once: open a connection to an X server, check for a compatible version of the Xkb extension in both the library and the server, and initialize the extension for use.

\texttt{Display *XkbOpenDisplay(display_name, event_rtrn, error_rtrn, major_in_out, minor_in_out, reason_rtrn)}

- \texttt{char *display_name}; /* hardware display name, which determines the display and communications domain to be used */
- \texttt{int * event_rtrn}; /* backfilled with the extension base event code */
- \texttt{int * error_rtrn}; /* backfilled with the extension base error code */
- \texttt{int * major_in_out}; /* compile time lib major version in, server major version out */
- \texttt{int * minor_in_out}; /* compile time lib minor version in, server minor version out */
- \texttt{int * reason_rtrn}; /* backfilled with a status code */

\texttt{XkbOpenDisplay} is a convenience function that opens an X display connection and initializes the X keyboard extension. In all cases, upon return \texttt{reason_rtrn} contains a status value indicating success or the type of failure. If \texttt{major_in_out} and \texttt{minor_in_out} are not NULL, \texttt{XkbOpenDisplay} first calls \texttt{XkbLibraryVersion} to determine whether the client library is compatible, passing it the values pointed to by \texttt{major_in_out} and \texttt{minor_in_out}. If the library is incompatible, \texttt{XkbOpenDisplay} backfills \texttt{major_in_out} and \texttt{minor_in_out} with the major and minor extension versions of the library being used and returns NULL. If the library is compatible, \texttt{XkbOpenDisplay} next calls \texttt{XOpenDisplay} with the \texttt{display_name}. If this fails, the function returns NULL. If successful, \texttt{XkbOpenDisplay} calls \texttt{XkbQueryExtension} and backfills the major and minor Xkb server extension version numbers in \texttt{major_in_out} and \texttt{minor_in_out}. If the server extension version is not compatible with the library extension version or if the server extension is not present, \texttt{XkbOpenDisplay} closes the display and returns NULL. When successful, the function returns the display connection.

The possible values for \texttt{reason_rtrn} are:

- \texttt{XkbOD_BadLibraryVersion} indicates \texttt{XkbLibraryVersion} returned False.
- \texttt{XkbOD_ConnectionRefused} indicates the display could not be opened.
- \texttt{XkbOD_BadServerVersion} indicates the library and the server have incompatible extension versions.
- \texttt{XkbOD_NonXkbServer} indicates the extension is not present in the X server.
- \texttt{XkbOD_Success} indicates that the function succeeded.

### 2.5 Disabling the Keyboard Extension

If a server supports the Xkb extension, the X library normally implements preXkb keyboard functions using the Xkb keyboard description and state. The server Xkb keyboard state may differ from the preXkb keyboard state. This difference does not affect most clients, but there are exceptions. To allow these clients to work properly, you may instruct the extension not to use Xkb functionality.

Call \texttt{XkbIgnoreExtension} to prevent core X library keyboard functions from using the X Keyboard Extension. You must call \texttt{XkbIgnoreExtension} before you open a server connection; Xkb does not provide a way to enable or disable use of the extension once a connection is established.

\texttt{Bool XkbIgnoreExtension(ignore)}

\texttt{Bool ignore; /* True means ignore the extension */}
The X Keyboard Extension tells the X library whether to use the X Keyboard Extension on any subsequently opened X display connections. If ignore is True, the library does not initialize the Xkb extension when it opens a new display. This forces the X server to use compatibility mode and communicate with the client using only core protocol requests and events. If ignore is False, the library treats subsequent calls to XOpenDisplay normally and uses Xkb extension requests, events, and state. Do not explicitly use Xkb on a connection for which it is disabled. XkbIgnoreExtension returns False if it was unable to apply the ignore request.

2.6 Protocol Errors

Many of the Xkb extension library functions described in this document can cause the X server to report an error, referred to in this document as a BadXxx protocol error, where Xxx is some name. These errors are handled in the normal manner, by the default Xlib error handler or one replacing it. Note that X protocol errors are not necessarily reported immediately because of the buffering of X protocol requests in Xlib and the server.

Table 2.1 lists the protocol errors that can be generated, and their causes.

<table>
<thead>
<tr>
<th>Error</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>BadAccess</td>
<td>The Xkb extension has not been properly initialized</td>
</tr>
<tr>
<td>BadKeyboard</td>
<td>The device specified was not a valid core or input extension device</td>
</tr>
<tr>
<td>BadImplementation</td>
<td>Invalid reply from server</td>
</tr>
<tr>
<td>BadAlloc</td>
<td>Unable to allocate storage</td>
</tr>
<tr>
<td>BadMatch</td>
<td>A compatible version of Xkb was not available in the server or an argument has correct type and range, but is otherwise invalid</td>
</tr>
<tr>
<td>BadValue</td>
<td>An argument is out of range</td>
</tr>
<tr>
<td>BadAtom</td>
<td>A name is neither a valid Atom or None</td>
</tr>
<tr>
<td>BadDevice</td>
<td>Device, Feedback Class, or Feedback ID invalid</td>
</tr>
</tbody>
</table>

The Xkb extension adds a single protocol error, BadKeyboard, to the core protocol error set. This error code will be reported as the error_rtn when XkbQueryExtension is called. When a BadKeyboard error is reported in an XErrorEvent, additional information is reported in the resource_id field. The most significant byte of the resource_id is a further refinement of the error cause, as defined in Table 2.2. The least significant byte will contain the device, class, or feedback ID as indicated in the table.

<table>
<thead>
<tr>
<th>high-order byte</th>
<th>value</th>
<th>meaning</th>
<th>low-order byte</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbErr_BadDevice</td>
<td>0xff</td>
<td>device not found</td>
<td>device ID</td>
<td></td>
</tr>
<tr>
<td>XkbErr_BadClass</td>
<td>0xfe</td>
<td>device found, but it is of the wrong class</td>
<td>class ID</td>
<td></td>
</tr>
<tr>
<td>XkbErr_BadId</td>
<td>0xfd</td>
<td>device found, class ok, but device does not contain a feedback with the indicated ID</td>
<td>feedback ID</td>
<td></td>
</tr>
</tbody>
</table>

2.7 Display and Device Specifications in Function Calls

Where a connection to the server is passed as an argument (Display*) and an XkbDescPtr is also passed as an argument, the Display* argument must match the dpy field of the XkbDescRec pointed to by the XkbDescPtr argument, or else the dpy field of the XkbDescRec must be NULL. If they don’t match or the dpy field is not NULL, a
BadMatch error is returned (either in the return value or a backfilled Status variable). Upon successful return, the dpy field of the XkbDescRec always contains the Display* value passed in.

The Xkb extension can communicate with the X input extension if it is present. Consequently, there can potentially be more than one input device connected to the server. Most Xkb library calls that require communicating with the server involve both a server connection (Display * dpy) and a device identifier (unsigned int device_spec). In some cases, the device identifier is implicit and is taken as the device_spec field of an XkbDescRec structure passed as an argument.

The device identifier can specify any X input extension device with a KeyClass component, or it can specify the constant, XkbUseCoreKbd. The use of XkbUseCoreKbd allows applications to indicate the core keyboard without having to determine its device identifier.

Where an Xkb device identifier is passed as an argument and an XkbDescPtr is also passed as an argument, if either the argument or the XkbDescRec device_spec field is XkbUseCoreKbd, and if the function returns successfully, the XkbDescPtr device_spec field will have been converted from XkbUseCoreKbd to a real Xkb device ID. If the function does not complete successfully, the device_spec field remains unchanged. Subsequently, the device id argument must match the device_spec field of the XkbDescPtr argument. If they don’t match, a BadMatch error is returned (either in the return value or a backfilled Status variable).

When the Xkb extension in the server hands an application a device identifier to use for the keyboard, that ID is the input extension identifier for the device if the server supports the X Input Extension. If the server does not support the input extension, the meaning of the identifier is undefined — the only guarantee is that when you use XkbUseCoreKbd, XkbUseCoreKbd will work and the identifier returned by the server will refer to the core keyboard device.
3 Data Structures

An Xkb keyboard description consists of a variety of data structures, each of which describes some aspect of the keyboard. Although each data structure has its own peculiarities, there are a number of features common to nearly all Xkb structures. This chapter describes these common features and techniques for manipulating them.

Many Xkb data structures are interdependent; changing a field in one might require changes to others. As an additional complication, some Xkb library functions allocate related components as a group to reduce fragmentation and allocator overhead. In these cases, simply allocating and freeing fields of Xkb structures might corrupt program memory. Creating and destroying such structures or keeping them properly synchronized during editing is complicated and error prone.

Xkb provides functions and macros to allocate and free all major data structures. You should use them instead of allocating and freeing the structures yourself.

3.1 Allocating Xkb Data Structures

Xkb provides functions, known as allocators, to create and initialize Xkb data structures. In most situations, the Xkb functions that read a keyboard description from the server call these allocators automatically. As a result, you will seldom have to directly allocate or initialize Xkb data structures.

However, if you need to enlarge an existing structure or construct a keyboard definition from scratch, you may need to allocate and initialize Xkb data structures directly. Each major Xkb data structure has its own unique allocator. The allocator functions share common features: allocator functions for structures with optional components take as an input argument a mask of subcomponents to be allocated. Allocators for data structures containing variable-length data take an argument specifying the initial length of the data.

You may call an allocator to change the size of the space allocated for variable-length data. When you call an allocator with an existing data structure as a parameter, the allocator does not change the data in any of the fields, with one exception: variable-length data might be moved. The allocator resizes the allocated memory if the current size is too small. This normally involves allocating new memory, copying existing data to the newly allocated memory, and freeing the original memory. This possible reallocation is important to note because local variables pointing into Xkb data structures might be invalidated by calls to allocator functions.

3.2 Adding Data and Editing Data Structures

You should edit most data structures via the Xkb-supplied helper functions and macros, although a few data structures can be edited directly. The helper functions and macros make sure everything is initialized and interdependent values are properly updated for those Xkb structures that have interdependencies. As a general rule, if there is a helper function or macro to edit the data structure, use it. For example, increasing the width of a type requires you to resize every key that uses that type. This is complicated and ugly, which is why there’s an XkbResizeKeyType function.

Many Xkb data structures have arrays whose size is reported by two fields. The first field, whose name is usually prefixed by sz_, represents the total number of elements that can be stored in the array. The second field, whose name is usually prefixed by num_, specifies
the number of elements currently stored there. These arrays typically represent data whose
total size cannot always be determined when the array is created. In these instances, the
usual way to allocate space and add data is as follows:

- Call the allocator function with some arbitrary size, as a hint.
- For those arrays that have an Xkb...Add... function, call it each time you want to add
  new data to the array. The function expands the array if necessary.

For example, call:

XkbAllocGeomShapes(geom,4)

to say “I’ll need space for four new shapes in this geometry.” This makes sure that
sz_shapes - num_shapes >= 4, and resizes the shapes array if it isn’t. If this function suc-
ceeds, you are guaranteed to have space for the number of shapes you need.

When you call an editing function for a structure, you do not need to check for space,
because the function automatically checks the sz_ and num_ fields of the array, resizes the
array if necessary, adds the entry to the array, and then updates the num_ field.

3.3 Making Changes to the Server's Keyboard Description

In Xkb, as in the core protocol, the client and server have independent copies of the data
structures that describe the keyboard. The recommended way to change some aspect of the
keyboard mapping in the X server is to edit a local copy of the Xkb keyboard description
and then send only the changes to the X server. This method helps eliminate the need to
transfer the entire keyboard description or even an entire data structure for only minor
changes.

To help you keep track of the changes you make to a local copy of the keyboard descrip-
tion, Xkb provides separate special changes data structures for each major Xkb data struc-
ture. These data structures do not contain the actual changed values: they only indicate the
changes that have been made to the structures that actually describe the keyboard.

When you wish to change the keyboard description in the server, you first modify a local
copy of the keyboard description and then flag the modifications in an appropriate
changes data structure. When you finish editing the local copy of the keyboard descrip-
tion, you pass your modified version of the keyboard description and the modified
changes data structure to an Xkb function. This function uses the modified keyboard
description and changes structure to pass only the changed information to the server. Note
that modifying the keyboard description but not setting the appropriate flags in the
changes data structure causes indeterminate behavior.

3.4 Tracking Keyboard Changes in the Server

The server reports all changes in its keyboard description to any interested clients via spe-
cial Xkb events. Just as clients use special changes data structures to change the keyboard
description in the server, the server uses special changes data structures to tell a client
what changed in the server’s keyboard description.

Unlike clients, however, the server does not always pass the new values when it reports
changes to its copy of the keyboard description. Instead, the server only passes a changes
data structure when it reports changes to its keyboard description. This is done for effi-
ciency reasons — some clients do not always need to update their copy of the keyboard
description with every report from the server.
When your client application receives a report from the server indicating the keyboard description has changed, you can determine the set of changes by passing the event to an Xkb function that “notes” event information in the corresponding changes data structure. These “note changes” functions are defined for all major Xkb components, and their names have the form XkbNote{Component}Changes, where Component is the name of a major Xkb component such as Map or Names. When you want to copy these changes from the server into a local copy of the keyboard description, use the corresponding Xkb-{Component}GetChanges function, passing it the changes structure. The function then retrieves only the changed structures from the server and copies the modified pieces into the local keyboard description.

### 3.5 Freeing Data Structures

For the same reasons you should not directly use malloc to allocate Xkb data structures, you should not free Xkb data structures or components directly using free or Xfree. Xkb provides functions to free the various data structures and their components. Always use the free functions supplied by Xkb. There is no guarantee that any particular field can be safely freed by free or Xfree.
4 Xkb Events

The primary way the X server communicates with clients is by sending X events to them. Some events are sent to all clients, while others are sent only to clients that have requested them. Some of the events that can be requested are associated with a particular window and are only sent to those clients who have both requested the event and specified the window in which the event occurred.

The Xkb extension uses events to communicate the keyboard status to interested clients. These events are not associated with a particular window. Instead, all Xkb keyboard status events are reported to all interested clients, regardless of which window currently has the keyboard focus and regardless of the grab state of the keyboard.1

The X server reports the events defined by the Xkb extension to your client application only if you have requested them. You may request Xkb events by calling either \texttt{XkbSelectEvents} or \texttt{XkbSelectEventDetails}. \texttt{XkbSelectEvents} requests Xkb events by their event type and causes them to be reported to your client application under all circumstances. You can specify a finer granularity for event reporting by using \texttt{XkbSelectEventDetails}; in this case events are reported only when the specific detail conditions you specify have been met.

4.1 Xkb Event Types

The Xkb Extension adds new event types to the X protocol definition. An Xkb event type is defined by two fields in the X event data structure. One is the \texttt{type} field, containing the \texttt{base event code}. This base event code is a value the X server assigns to each X extension at runtime that identifies the extension that generated the event; thus, the event code in the \texttt{type} field identifies the event as an Xkb extension event, rather than an event from another extension or a core X protocol event. You can obtain the base event code via a call to \texttt{XkbQueryExtension} or \texttt{XkbOpenDisplay}. The second field is the Xkb event type, which contains a value uniquely identifying each different Xkb event type. Possible values are defined by constants declared in the header file `<X11/extensions/Xkb.h>`.

Table 4.1 lists the categories of events defined by Xkb and their associated event types, as defined in \texttt{Xkb.h}. Each event is described in more detail in the section referenced for that event.

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Conditions Generating Event</th>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbNewKeyboardNotify</td>
<td>Keyboard geometry; keycode range change</td>
<td>19</td>
<td>187</td>
</tr>
<tr>
<td>XkbMapNotify</td>
<td>Keyboard mapping change</td>
<td>14.4</td>
<td>122</td>
</tr>
<tr>
<td>XkbStateNotify</td>
<td>Keyboard state change</td>
<td>5.4</td>
<td>25</td>
</tr>
<tr>
<td>XkbControlsNotify</td>
<td>Keyboard controls state change</td>
<td>10.11</td>
<td>79</td>
</tr>
<tr>
<td>XkbIndicatorStateNotify</td>
<td>Keyboard indicators state change</td>
<td>8.5</td>
<td>45</td>
</tr>
<tr>
<td>XkbIndicatorMapNotify</td>
<td>Keyboard indicators map change</td>
<td>8.5</td>
<td>45</td>
</tr>
<tr>
<td>XkbNamesNotify</td>
<td>Keyboard name change</td>
<td>18.5</td>
<td>185</td>
</tr>
<tr>
<td>XkbCompatMapNotify</td>
<td>Keyboard compatibility map change</td>
<td>17.5</td>
<td>178</td>
</tr>
<tr>
<td>XkbBellNotify</td>
<td>Keyboard bell generated</td>
<td>9.4</td>
<td>52</td>
</tr>
</tbody>
</table>

1. The one exception to this rule is the \texttt{XkbExtensionDeviceNotify} event report that is sent when a client attempts to use an unsupported feature of an X Input Extension device (see section 21.4).
4.2 Xkb Event Data Structures

Xkb reports each event it generates in a unique structure holding the data values needed to describe the conditions the event is reporting. However, all Xkb events have certain things in common. These common features are contained in the same fields at the beginning of all Xkb event structures and are described in the **XkbAnyEvent** structure:

```
typedef struct {
    int type; /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time time; /* server time when event generated */
    int xkb_type; /* Xkb minor event code */
    unsigned int device; /* Xkb device ID, will not be XkbUseCoreKbd */
} XkbAnyEvent;
```

For any Xkb event, the type field is set to the base event code for the Xkb extension, assigned by the server to all Xkb extension events. The serial, send_event, and display fields are as described for all X11 events. The time field is set to the time when the event was generated and is expressed in milliseconds. The xkb_type field contains the minor extension event code, which is the extension event type, and is one of the values listed in Table 4.1. The device field contains the keyboard device identifier associated with the event. This is never XkbUseCoreKbd, even if the request that generated the event specified a device of XkbUseCoreKbd. If the request that generated the event specified XkbUseCoreKbd, device contains a value assigned by the server to specify the core keyboard. If the request that generated the event specified an X input extension device, device contains that same identifier.

Other data fields specific to individual Xkb events are described in subsequent chapters where the events are described.

4.3 Selecting Xkb Events

Xkb events are selected using an event mask, much the same as normal core X events are selected. However, unlike selecting core X events, where you must specify the selection status (on or off) for all possible event types whenever you wish to change the selection criteria for any one event, Xkb allows you to restrict the specification to only the event types you wish to change. This means that you do not need to remember the event selection values for all possible types each time you want to change one of them.

Many Xkb event types are generated under several different circumstances. When selecting to receive an Xkb event, you may specify either that you want it delivered under all circumstances, or that you want it delivered only for a subset of the possible circumstances.
You can also deselect an event type that was previously selected for, using the same granularity.

Xkb provides two functions to select and deselect delivery of Xkb events. XkbSelectEvents allows you to select or deselect delivery of more than one Xkb event type at once. Events selected using XkbSelectEvents are delivered to your program under all circumstances that generate the events. To restrict delivery of an event to a subset of the conditions under which it occurs, use XkbSelectEventDetails. XkbSelectEventDetails only allows you to change the selection conditions for a single event at a time, but it provides a means of fine-tuning the conditions under which the event is delivered.

To select and/or deselect for delivery of one or more Xkb events and have them delivered under all conditions, use XkbSelectEvents.

Bool XkbSelectEvents(display, device_spec, bits_to_change, values_for_bits)
  Display * display; /* connection to the X server */
  unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
  unsigned long int bits_to_change; /* determines events to be selected/deselected */
  unsigned long int values_for_bits; /* 1 => select, 0 => deselect; for events in bits_to_change */

This request changes the Xkb event selection mask for the keyboard specified by device_spec.

Each Xkb event that can be selected is represented by a bit in the bits_to_change and values_for_bits masks. Only the event selection bits specified by the bits_to_change parameter are affected; any unspecified bits are left unchanged. To turn on event selection for an event, set the bit for the event in the bits_to_change parameter and set the corresponding bit in the values_for_bits parameter. To turn off event selection for an event, set the bit for the event in the bits_to_change parameter and do not set the corresponding bit in the values_for_bits parameter. The valid values for both of these parameters are an inclusive bitwise OR of the masks shown in Table 4.2. There is no interface to return your client’s current event selection mask. Clients cannot set other clients’ event selection masks.

If a bit is not set in the bits_to_change parameter, but the corresponding bit is set in the values_for_bits parameter, a BadMatch protocol error results. If an undefined bit is set in either the bits_to_change or the values_for_bits parameter, a BadValue protocol error results.

All event selection bits are initially zero for clients using the Xkb extension. Once you set some bits, they remain set for your client until you clear them via another call to XkbSelectEvents.

XkbSelectEvents returns False if the Xkb extension has not been initialized and True otherwise.

To select or deselect for a specific Xkb event and optionally place conditions on when events of that type are reported to your client, use XkbSelectEventDetails. This allows you
to exercise a finer granularity of control over delivery of Xkb events with \textit{XkbSelectEvents}.

\textbf{Bool} \texttt{XkbSelectEventDetails}(\texttt{display, device\_spec, event\_type, bits\_to\_change, values\_for\_bits})

\begin{verbatim}
Display * display; /* connection to the X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int event_type; /* Xkb event type of interest */
unsigned long int bits_to_change; /* event selection details */
unsigned long int values_for_bits; /* values for bits selected by bits_to_change */
\end{verbatim}

While \textit{XkbSelectEvents} allows multiple events to be selected, \textit{XkbSelectEventDetails} changes the selection criteria for a single type of Xkb event. The interpretation of the \textit{bits\_to\_change} and \textit{values\_for\_bits} masks depends on the event type in question.

\textit{XkbSelectEventDetails} changes the Xkb event selection mask for the keyboard specified by \textit{device\_spec} and the Xkb event specified by \textit{event\_type}. To turn on event selection for an event detail, set the bit for the detail in the \textit{bits\_to\_change} parameter and set the corresponding bit in the \textit{values\_for\_bits} parameter. To turn off event detail selection for a detail, set the bit for the detail in the \textit{bits\_to\_change} parameter and do not set the corresponding bit in the \textit{values\_for\_bits} parameter.

If an invalid event type is specified, a \texttt{BadValue} protocol error results. If a bit is not set in the \textit{bits\_to\_change} parameter, but the corresponding bit is set in the \textit{values\_for\_bits} parameter, a \texttt{BadMatch} protocol error results. If an undefined bit is set in either the \textit{bits\_to\_change} or the \textit{values\_for\_bits} parameter, a \texttt{BadValue} protocol error results.

For each type of Xkb event, the legal event details that you can specify in the \textit{XkbSelectEventDetails} request are listed in the chapters that describe each event in detail.

\subsection*{4.3.1 Event Masks}

The X server reports the events defined by Xkb to your client application only if you have requested them via a call to \textit{XkbSelectEvents} or \textit{XkbSelectEventDetails}. Specify the event types in which you are interested in a mask, as described in section 4.3.

Table 4.2 lists the event mask constants that can be specified with the \textit{XkbSelectEvents} request and the circumstances in which the mask should be specified.

\begin{table}[h]
\centering
\caption{XkbSelectEvents Mask Constants}
\begin{tabular}{l|c|l}
\hline
\textit{Event Mask} & \textit{Value} & \textit{Notification Wanted} \\
\hline
XkbNewKeyboardNotifyMask & (1L<<0) & Keyboard geometry change \\
XkbMapNotifyMask & (1L<<1) & Keyboard mapping change \\
XkbStateNotifyMask & (1L<<2) & Keyboard state change \\
XkbControlsNotifyMask & (1L<<3) & Keyboard control change \\
XkbIndicatorStateNotifyMask & (1L<<4) & Keyboard indicator state change \\
XkbIndicatorMapNotifyMask & (1L<<5) & Keyboard indicator map change \\
XkbNamesNotifyMask & (1L<<6) & Keyboard name change \\
XkbCompatMapNotifyMask & (1L<<7) & Keyboard compat map change \\
XkbBellNotifyMask & (1L<<8) & Bell \\
XkbActionMessageMask & (1L<<9) & Action message \\
XkbAccessXNotifyMask & (1L<<10) & AccessX features \\
XkbExtensionDeviceNotifyMask & (1L<<11) & Extension device \\
\hline
\end{tabular}
\end{table}
4.4  **Unified Xkb Event Type**

The XkbEvent structure is a union of the individual structures declared for each Xkb event type and for the core protocol XEvent type. Given an XkbEvent structure, you may use the type field to determine if the event is an Xkb event (type equals the Xkb base event code; see section 2.4). If the event is an Xkb event, you may then use the any.xkb_type field to determine the type of Xkb event and thereafter access the event-dependent components using the union member corresponding to the particular Xkb event type.

```c
typedef union _XkbEvent {
    int type;
    XkbAnyEvent any;
    XkbStateNotifyEvent state;
    XkbMapNotifyEvent map;
    XkbControlsNotifyEvent ctrls;
    XkbIndicatorNotifyEvent indicators;
    XkbBellNotifyEvent bell;
    XkbAccessXNotifyEvent accessx;
    XkbNamesNotifyEvent names;
    XkbCompatMapNotifyEvent compat;
    XkbActionMessageEvent message;
    XkbExtensionDeviceNotifyEvent device;
    XkbNewKeyboardNotifyEvent new_kbd;
    XEvent core;
} XkbEvent;
```

This unified Xkb event type includes a normal XEvent as used by the core protocol, so it is straightforward for applications that use Xkb events to call the X library event functions without having to cast every reference. For example, to get the next event, you can simply declare a variable of type XkbEvent and call:

```c
XNextEvent(dpy,&xkbev.core);
```
5 Keyboard State

Keyboard state encompasses all of the transitory information necessary to map a physical key press or release to an appropriate event. The Xkb keyboard state consists of primitive components and additional derived components that are maintained for efficiency reasons. Figure 5.1 shows the components of Xkb keyboard state and their relationships.

5.1 Keyboard State Description

The Xkb keyboard state is comprised of the state of all keyboard modifiers, the keyboard group, and the state of the pointer buttons. These are grouped into the following components:

- The locked group and locked modifiers
- The latched group and latched modifiers
- The base group and base modifiers
- The effective group and effective modifiers
- The state of the core pointer buttons

Figure 5.1 Xkb State
The modifiers are Shift, Lock, Control, and Mod1-Mod5, as defined by the core protocol. A modifier can be thought of as a toggle that is either set or unset. All modifiers are initially unset. When a modifier is locked, it is set and remains set for all future key events, until it is explicitly unset. A latched modifier is set, but automatically unsets after the next key event that does not change the keyboard state. Locked and latched modifier state can be changed by keyboard activity or via Xkb extension library functions.

The Xkb extension provides support for keysym groups, as defined by ISO9995:

| Group | A logical state of a keyboard providing access to a collection of characters. A group usually contains a set of characters that logically belong together and that may be arranged on several shift levels within that group. |

The Xkb extension supports up to four keysym groups. Groups are named beginning with one and indexed beginning with zero. All group states are indicated using the group index. At any point in time, there is zero or one locked group, zero or one latched group, and one base group. When a group is locked, it supersedes any previous locked group and remains the locked group for all future key events, until a new group is locked. A latched group applies only to the next key event that does not change the keyboard state. The locked and latched group can be changed by keyboard activity or via Xkb extension library functions.

Changing to a different group changes the keyboard state to produce characters from a different group. Groups are typically used to switch between keysyms of different languages and locales.

The pointer buttons are Button1 - Button5, as defined by the core protocol.

The base group and base modifiers represent keys that are physically or logically down. These and the pointer buttons can be changed by keyboard activity and not by Xkb requests. It is possible for a key to be logically down, but not physically down, and neither latched nor locked.

The effective modifiers are the bitwise union of the locked, latched, and the base modifiers.

The effective group is the arithmetic sum of the group indices of the latched group, locked group, and base group, which is then normalized by some function. The result is a meaningful group index.

\[
\text{effective group} = f(\text{locked group} + \text{latched group} + \text{base group})
\]

The function \( f \) ensures that the effective group is within range. The precise function is specified for the keyboard and can be retrieved through the keyboard description. It may wrap around, clamp down, or default. Few applications will actually examine the effective group, and far fewer still will examine the locked, latched, and base groups.

There are two circumstances under which groups are normalized:

---

1. Keys may be logically down when they are physically up because of their electrical properties or because of the keyboard extension in the X server having filtered the key release, for esoteric reasons.
1. The global locked or effective group changes. In this case, the changed group is normalized into range according to the settings of the groups_wrap field of the XkbControlsRec structure for the keyboard (see section 10.7.1).

2. The Xkb library is interpreting an event with an effective group that is legal for the keyboard as a whole, but not for the key in question. In this case, the group to use for this event only is determined using the group_info field of the key symbol mapping (XkbSymMapRec) for the event key.

Each nonmodifier key on a keyboard has zero or more symbols, or keysyms, associated with it. These are the logical symbols that the key can generate when it is pressed. The set of all possible keysyms for a keyboard is divided into groups. Each key is associated with zero or more groups; each group contains one or more symbols. When a key is pressed, the determination of which symbol for the key is selected is based on the effective group and the shift level, which is determined by which modifiers are set.

A client that does not explicitly call Xkb functions, but that otherwise makes use of an X library containing the Xkb extension, will have keyboard state represented in bits 0 - 14 of the state field of events that report modifier and button state. Such a client is said to be Xkb-capable. A client that does explicitly call Xkb functions is an Xkb-aware client. The Xkb keyboard state includes information derived from the effective state and from two server parameters that can be set through the keyboard extension. The following components of keyboard state pertain to Xkb-capable and Xkb-aware clients:

- lookup state: lookup group and lookup modifiers
- grab state: grab group and grab modifiers

The lookup modifiers and lookup group are represented in the state field of core X events. The modifier state and keycode of a key event are used to determine the symbols associated with the event. For KeyPress and KeyRelease events, the lookup modifiers are computed as:

\[
((\text{base} \mid \text{latched} \mid \text{locked}) \& \neg \text{server\_internal\_modifiers})
\]

Otherwise the lookup modifiers are computed as:

\[
(((\text{base} \mid \text{latched} \mid (\text{locked} \& \neg \text{ignore\_locks})) \& \neg \text{server\_internal\_modifiers})
\]

The lookup group is the same as the effective group.

When an Xkb-capable or Xkb-aware client wishes to map a keycode to a keysym, it should use the lookup state — the lookup group and the lookup modifiers.

The grab state is the state used when matching events to passive grabs. If the event activates a grab, the grab modifiers and grab group are represented in the state field of core X events; otherwise, the lookup state is used. The grab modifiers are computed as:

\[
(((\text{base} \mid \text{latched} \mid (\text{locked} \& \neg \text{ignore\_locks})) \& \neg \text{server\_internal\_modifiers})
\]

If the server’s IgnoreGroupLock control (see section 10.7.3) is not set, the grab group is the same as the effective group. Otherwise, the grab group is computed from the base group and latched group, ignoring the locked group.

The final three components of Xkb state are applicable to clients that are not linked with an Xlib containing the X keyboard extension library and therefore are not aware of the keyboard extension (Xkb-unaware clients):
• The compatibility modifier state
• The compatibility lookup modifier state
• The compatibility grab modifier state

The X11 protocol interpretation of modifiers does not include direct support for multiple groups. When an Xkb-extended X server connects to an Xkb-unaware client, the compatibility states remap the keyboard group into a core modifier whenever possible. The compatibility state corresponds to the effective modifier and effective group state, with the group remapped to a modifier. The compatibility lookup and grab states correspond to the lookup and grab states, respectively, with the group remapped to a modifier. The compatibility lookup state is reported in events that do not trigger passive grabs; otherwise, the compatibility grab state is reported.

5.2 Changing the Keyboard State

5.2.1 Changing Modifiers

The functions in this section that change the use of modifiers use a mask in the parameter `affect`. It is a bitwise inclusive OR of the legal modifier masks:

```
<table>
<thead>
<tr>
<th>Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShiftMask</td>
</tr>
<tr>
<td>LockMask</td>
</tr>
<tr>
<td>ControlMask</td>
</tr>
<tr>
<td>Mod1Mask</td>
</tr>
<tr>
<td>Mod2Mask</td>
</tr>
<tr>
<td>Mod3Mask</td>
</tr>
<tr>
<td>Mod4Mask</td>
</tr>
<tr>
<td>Mod5Mask</td>
</tr>
</tbody>
</table>
```

Table 5.1 Real Modifier Masks

To lock and unlock any of the eight real keyboard modifiers, use `XkbLockModifiers`:

```
Bool XkbLockModifiers(display, device_spec, affect, values)

Display * display; /* connection to the X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int affect; /* mask of real modifiers whose lock state is to change */
unsigned int values; /* 1 => lock, 0 => unlock; only for modifiers selected by affect */
```

`XkbLockModifiers` sends a request to the server to lock the real modifiers selected by both `affect` and `values` and to unlock the real modifiers selected by `affect` but not selected by `values`. `XkbLockModifiers` does not wait for a reply from the server. It returns `True` if the request was sent, and `False` otherwise.

To latch and unlatch any of the eight real keyboard modifiers, use `XkbLatchModifiers`:

```
Bool XkbLatchModifiers(display, device_spec, affect, values)

Display * display; /* connection to the X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int affect; /* mask of modifiers whose latch state is to change */
unsigned int values; /* 1 => latch, 0 => unlatch; only for mods selected by affect */
```
XkbLatchModifiers sends a request to the server to latch the real modifiers selected by both affect and values and to unlatch the real modifiers selected by affect but not selected by values. XkbLatchModifiers does not wait for a reply from the server. It returns True if the request was sent, and False otherwise.

5.2.2 Changing Groups

Reference the keysym group indices with these symbolic constants:

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbGroup1Index</td>
<td>0</td>
</tr>
<tr>
<td>XkbGroup2Index</td>
<td>1</td>
</tr>
<tr>
<td>XkbGroup3Index</td>
<td>2</td>
</tr>
<tr>
<td>XkbGroup4Index</td>
<td>3</td>
</tr>
</tbody>
</table>

To lock the keysym group, use XkbLockGroup.

Bool XkbLockGroup(display, device_spec, group)

To latch the keysym group, use XkbLatchGroup.

Bool XkbLatchGroup(display, device_spec, group)

5.3 Determining Keyboard State

Xkb keyboard state may be represented in an XkbStateRec structure:

```c
typedef struct {
    unsigned char group; /* effective group index */
    unsigned char base_group; /* base group index */
    unsigned char latched_group; /* latched group index */
    unsigned char locked_group; /* locked group index */
    unsigned char mods; /* effective modifiers */
    unsigned char base_mods; /* base modifiers */
    unsigned char latched.mods; /* latched modifiers */
    unsigned char locked.mods; /* locked modifiers */
    unsigned char compat_state; /* effective group => modifiers */
    unsigned char grab.mods; /* modifiers used for grabs */
    unsigned char compat_grab.mods; /* mods used for compatibility mode grabs */
    unsigned char lookup.mods; /* modifiers used to lookup symbols */
    unsigned char compat_lookup.mods; /* mods used for compatibility lookup */
} XkbStateRec;
```
unsigned short ptr_buttons; /* 1 bit => corresponding pointer btn is down */
}

To obtain the keyboard state, use \texttt{XkbGetState}.

\textbf{Status \texttt{XkbGetState}(display, device\_spec, state\_return)}

\begin{verbatim}
Display * display; /* connection to the X server */
unsigned int device\_spec; /* device ID, or \texttt{XkbUseCoreKbd} */
XkbStatePtr state\_return; /* backfilled with Xkb state */
\end{verbatim}

The \texttt{XkbGetState} function queries the server for the current keyboard state, waits for a reply, and then backfills \texttt{state\_return} with the results.

All group values are expressed as group indices in the range [0..3]. Modifiers and the compatibility modifier state values are expressed as the bitwise union of the core X11 modifier masks. The pointer button state is reported as in the core X11 protocol.

### 5.4 Tracking Keyboard State

The Xkb extension reports \texttt{XkbStateNotify} events to clients wanting notification whenever the Xkb state changes. The changes reported include changes to any aspect of the keyboard state: when a modifier is set or unset, when the current group changes, or when a pointer button is pressed or released. As with all Xkb events, \texttt{XkbStateNotify} events are reported to all interested clients without regard to the current keyboard input focus or grab state.

There are many different types of Xkb state changes. Xkb defines an event detail mask corresponding to each type of change. The event detail masks are listed in Table 5.3.

\begin{table}[h]
\centering
\caption{XkbStateNotify Event Detail Masks}
\begin{tabular}{ll}
\toprule
\textit{Mask} & \textit{Value} \\
\midrule
\texttt{XkbModifierStateMask} & (1L \textless\textgreater 0) \\
\texttt{XkbModifierBaseMask} & (1L \textless\textgreater 1) \\
\texttt{XkbModifierLatchMask} & (1L \textless\textgreater 2) \\
\texttt{XkbModifierLockMask} & (1L \textless\textgreater 3) \\
\texttt{XkbGroupStateMask} & (1L \textless\textgreater 4) \\
\texttt{XkbGroupBaseMask} & (1L \textless\textgreater 5) \\
\texttt{XkbGroupLatchMask} & (1L \textless\textgreater 6) \\
\texttt{XkbGroupLockMask} & (1L \textless\textgreater 7) \\
\texttt{XkbCompatStateMask} & (1L \textless\textgreater 8) \\
\texttt{XkbGrabModsMask} & (1L \textless\textgreater 9) \\
\texttt{XkbCompatGrabModsMask} & (1L \textless\textgreater 10) \\
\texttt{XkbLookupModsMask} & (1L \textless\textgreater 11) \\
\texttt{XkbCompatLookupModsMask} & (1L \textless\textgreater 12) \\
\texttt{XkbPointerButtonMask} & (1L \textless\textgreater 13) \\
\texttt{XkbAllStateComponentsMask} & (0x3fff) \\
\bottomrule
\end{tabular}
\end{table}

To track changes in the keyboard state for a particular device, select to receive \texttt{XkbStateNotify} events by calling either \texttt{XkbSelectEvents} or \texttt{XkbSelectEventDetails} (see section 4.3).
To receive `XkbStateNotify` events under all possible conditions, use `XkbSelectEvents` and pass `XkbStateNotifyMask` in both `bits_to_change` and `values_for_bits`.

To receive `XkbStateNotify` events only under certain conditions, use `XkbSelectEventDetails` using `XkbStateNotify` as the `event_type` and specifying the desired state changes in `bits_to_change` and `values_for_bits` using mask bits from Table 5.3.

The structure for `XkbStateNotify` events is:

```c
typedef struct {
    int type;       /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time time;      /* server time when event generated */
    int xkb_type;   /* XkbStateNotify */
    int device;     /* Xkb device ID, will not be XkbUseCoreKbd */
    unsigned int changed; /* bits indicating what has changed */
    int group;      /* group index of effective group */
    int base_group; /* group index of base group */
    int latched_group; /* group index of latched group */
    int locked_group; /* group index of locked group */
    unsigned int mods; /* effective modifiers */
    unsigned int base.mods; /* base modifiers */
    unsigned int latched.mods; /* latched modifiers */
    unsigned int locked.mods; /* locked modifiers */
    int compat_state; /* computed compatibility state */
    unsigned char grab.mods; /* modifiers used for grabs */
    unsigned char compat_grab.mods; /* modifiers used for compatibility grabs */
    unsigned char lookup.mods; /* modifiers used to lookup symbols */
    unsigned char compat_lookup.mods; /* mods used for compatibility look up */
    int ptr_buttons; /* core pointer buttons */
    KeyCode keycode; /* keycode causing event, 0 if programmatic */
    char event_type; /* core event if req_major or req_minor non zero */
    char req_major; /* major request code if program trigger, else 0 */
    char req.minor; /* minor request code if program trigger, else 0 */
} XkbStateNotifyEvent;
```

When you receive an `XkbStateNotify` event, the `changed` field indicates which elements of keyboard state have changed. This will be the bitwise inclusive OR of one or more of the `XkbStateNotify` event detail masks shown in Table 5.3. All fields reported in the event are valid, but only those indicated in `changed` have changed values.

The `group` field is the group index of the effective keysym group. The `base_group`, `latched_group`, and `locked_group` fields are set to a group index value representing the base group, the latched group, and the locked group, respectively. The X server can set the modifier and compatibility state fields to a union of the core modifier mask bits; this union represents the corresponding modifier states. The `ptr_button` field gives the state of the core pointer buttons as a mask composed of an inclusive OR of zero or more of the core pointer button masks.

Xkb state changes can occur either in response to keyboard activity or under application control. If a key event caused the state change, the `keycode` field gives the keycode of the
key event, and the \textit{event\_type} field is set to either \texttt{KeyPress} or \texttt{KeyRelease}. If a pointer button event caused the state change, the \textit{keycode} field is zero, and the \textit{event\_type} field is set to either \texttt{ButtonPress} or \texttt{ButtonRelease}. Otherwise, the major and minor codes of the request that caused the state change are given in the \textit{req\_major} and \textit{req\_minor} fields, and the \textit{keycode} field is zero. The \textit{req\_major} value is the same as the major extension opcode.
6 Complete Keyboard Description

The complete Xkb description for a keyboard device is accessed using a single structure containing pointers to major Xkb components. This chapter describes this single structure and provides references to other sections of this document that discuss the major Xkb components in detail.

6.1 The XkbDescRec Structure

The complete description of an Xkb keyboard is given by an XkbDescRec. The component structures in the XkbDescRec represent the major Xkb components outlined in Figure 1.1.

typedef struct {
    struct _XDisplay * display; /* connection to X server */
    unsigned short flags; /* private to Xkb, do not modify */
    unsigned short device_spec; /* device of interest */
    KeyCode min_key_code; /* minimum keycode for device */
    KeyCode max_key_code; /* maximum keycode for device */
    XkbControlsPtr ctrls; /* controls */
    XkbServerMapPtr server; /* server keymap */
    XkbClientMapPtr map; /* client keymap */
    XkbIndicatorPtr indicators; /* indicator map */
    XkbNamesPtr names; /* names for all components */
    XkbCompatMapPtr compat; /* compatibility map */
    XkbGeometryPtr geom; /* physical geometry of keyboard */
} XkbDescRec, *XkbDescPtr;

The display field points to an X display structure. The flags field is private to the library: modifying flags may yield unpredictable results. The device_spec field specifies the device identifier of the keyboard input device, or XkbUseCoreKeyboard, which specifies the core keyboard device. The min_key_code and max_key_code fields specify the least and greatest keycode that can be returned by the keyboard.

The other fields specify structure components of the keyboard description and are described in detail in other sections of this document. Table 6.1 identifies the subsequent sections of this document that discuss the individual components of the XkbDescRec.

<table>
<thead>
<tr>
<th>XkbDescRec Field</th>
<th>For more info</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctrls</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>server</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>map</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>indicators</td>
<td>Chapter 8</td>
</tr>
<tr>
<td>names</td>
<td>Chapter 18</td>
</tr>
<tr>
<td>compat</td>
<td>Chapter 17</td>
</tr>
<tr>
<td>geom</td>
<td>Chapter 13</td>
</tr>
</tbody>
</table>

Each structure component has a corresponding mask bit that is used in function calls to indicate that the structure should be manipulated in some manner, such as allocating it or...
freeing it. These masks and their relationships to the fields in the XkbDescRec are shown in Table 6.2.

<table>
<thead>
<tr>
<th>Mask Bit</th>
<th>XkbDescRec Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbControlsMask</td>
<td>ctrls</td>
<td>(1L&lt;&lt;0)</td>
</tr>
<tr>
<td>XkbServerMapMask</td>
<td>server</td>
<td>(1L&lt;&lt;1)</td>
</tr>
<tr>
<td>XkbClientMapMask</td>
<td>map</td>
<td>(1L&lt;&lt;2)</td>
</tr>
<tr>
<td>XkbIndicatorMapMask</td>
<td>indicators</td>
<td>(1L&lt;&lt;3)</td>
</tr>
<tr>
<td>XkbNamesMask</td>
<td>names</td>
<td>(1L&lt;&lt;4)</td>
</tr>
<tr>
<td>XkbCompatMapMask</td>
<td>compat</td>
<td>(1L&lt;&lt;5)</td>
</tr>
<tr>
<td>XkbGeometryMask</td>
<td>geom</td>
<td>(1L&lt;&lt;6)</td>
</tr>
<tr>
<td>XkbAllComponentsMask</td>
<td>All Fields</td>
<td>(0x7f)</td>
</tr>
</tbody>
</table>

### 6.2 Obtaining a Keyboard Description from the Server

To retrieve one or more components of a keyboard device description, use XkbGetKeyboard (see also XkbGetKeyboardbyName).

```c
XkbDescPtr XkbGetKeyboard(display, which, device_spec)
```

Display * display; /* connection to X server */
unsigned int which; /* mask indicating components to return */
unsigned int device_spec; /* device for which to fetch description, or XkbUseCoreKbd */

`XkbGetKeyboard` allocates and returns a pointer to a keyboard description. It queries the server for those components specified in the `which` parameter for device `device_spec` and copies the results to the `XkbDescRec` it allocated. The remaining fields in the keyboard description are set to NULL. The valid masks for `which` are those listed in Table 6.2.

`XkbGetKeyboard` can generate BadAlloc protocol errors.

To free the returned keyboard description, use XkbFreeKeyboard (see section 6.4).

### 6.3 Tracking Changes to the Keyboard Description in the Server

The server can generate events whenever its copy of the keyboard description for a device changes. Refer to section 14.4 for detailed information on tracking changes to the keyboard description.

### 6.4 Allocating and Freeing a Keyboard Description

Applications seldom need to directly allocate a keyboard description; calling XkbGetKeyboard usually suffices. In the event you need to create a keyboard description from scratch, however, use XkbAllocKeyboard rather than directly calling malloc or Xmalloc.

```c
XkbDescRec * XkbAllocKeyboard(void)
```

If `XkbAllocKeyboard` fails to allocate the keyboard description, it returns NULL. Otherwise, it returns a pointer to an empty keyboard description structure. The `device_spec` field will have been initialized to XkbUseCoreKbd. You may then either fill in the structure components or use Xkb functions to obtain values for the structure components from a keyboard device.
To destroy either an entire an XkbDescRec or just some of its members, use XkbFreeKeyboard.

```c
void XkbFreeKeyboard(xkb, which, free_all)
    XkbDescPtr xkb;            /* keyboard description with components to free */
    unsigned int which;        /* mask selecting components to free */
    Bool free_all;             /* True => free all components and xkb */

XkbFreeKeyboard frees the components of xkb specified by which and sets the corresponding values to NULL. If free_all is True, XkbFreeKeyboard frees every non-NULL component of xkb and then frees the xkb structure itself.
```
7 Virtual Modifiers

The core protocol specifies that certain keystyms, when bound to modifiers, affect the rules of keycode to keysym interpretation for all keys; for example, when the Num_Lock keysym is bound to some modifier, that modifier is used to select between shifted and unshifted state for the numeric keypad keys. The core protocol does not provide a convenient way to determine the mapping of modifier bits (in particular Mod1 through Mod5) to keystyms such as Num_Lock and Mode_switch. Using the core protocol only, a client application must retrieve and search the modifier map to determine the keycodes bound to each modifier, and then retrieve and search the keyboard mapping to determine the keystyms bound to the keycodes. It must repeat this process for all modifiers whenever any part of the modifier mapping is changed.

Xkb alleviates these problems by defining virtual modifiers. In addition to the eight core modifiers, referred to as the real modifiers, Xkb provides a set of sixteen named virtual modifiers. Each virtual modifier can be bound to any set of the real modifiers (Shift, Lock, Control, and Mod1-Mod5).

The separation of function from physical modifier bindings makes it easier to specify more clearly the intent of a binding. X servers do not all assign modifiers the same way — for example, Num_Lock might be bound to Mod2 for one vendor and to Mod4 for another. This makes it cumbersome to automatically remap the keyboard to a desired configuration without some kind of prior knowledge about the keyboard layout and bindings. With XKB, applications can use virtual modifiers to specify the desired behavior, without regard for the actual physical bindings in effect.

7.1 Virtual Modifier Names and Masks

Virtual modifiers are named by converting their string name to an XAtom and storing the Atom in the names.vmods array in an XkbDescRec structure (see section 6.1). The position of a name Atom in the names.vmods array defines the bit position used to represent the virtual modifier and also the index used when accessing virtual modifier information in arrays: the name in the i-th (0 relative) entry of names.vmods is the i-th virtual modifier, represented by the mask (1<<i). Throughout Xkb, various functions have a parameter that is a mask representing virtual modifier choices. In each case, the i-th bit (0 relative) of the mask represents the i-th virtual modifier.

To set the name of a virtual modifier, use XkbSetNames, using XkbVirtualModNames- Mask in which and the name in the xkb argument; to retrieve indicator names, use XkbGet-Names. These functions are discussed in Chapter 18.

7.2 Modifier Definitions

An Xkb modifier definition enumerates a collection of real and virtual modifiers but does not in itself bind those modifiers to any particular key or to each other. Modifier definitions are included in a number of structures in the keyboard description to define the collection of modifiers that affect or are affected by some other entity. A modifier definition is relevant only in the context of some other entity such as an indicator map, a control, or a key type. (See sections 8.2.2, 10.8, and 15.2.)

```c
typedef struct _XkbMods {
    unsigned char mask;    /* real_mods | vmods mapped to real modifiers */
    unsigned char real_mods;  /* real modifier bits */
} XkbMods;
```
An Xkb modifier definition consists of a set of bit masks corresponding to the eight real modifiers (realMods); a similar set of bitmasks corresponding to the 16 named virtual modifiers (vmods); and an effective mask (mask). The effective mask represents the set of all real modifiers that can logically be set either by setting any of the real modifiers or by setting any of the virtual modifiers in the definition. mask is derived from the real and virtual modifiers and should never be explicitly changed — it contains all of the real modifiers specified in the definition (realMods) plus any real modifiers that are bound to the virtual modifiers specified in the definition (vmods). The binding of the virtual modifiers to real modifiers is exterior to the modifier definition. Xkb automatically recomputes the mask field of modifier definitions as necessary. Whenever you access a modifier definition that has been retrieved using an Xkb library function, the mask field will be correct for the keyboard mapping of interest.

7.3 Binding Virtual Modifiers to Real Modifiers

The binding of virtual modifiers to real modifiers is defined by the server.vmods array in an XkbDescRec structure. Each entry contains the real modifier bits that are bound to the virtual modifier corresponding to the entry. The overall relationship of fields dealing with virtual modifiers in the server keyboard description are shown in Figure 16.2.

7.4 Virtual Modifier Key Mapping

Xkb maintains a virtual modifier mapping, which lists the virtual modifiers associated with, or bound to, each key. The real modifiers bound to a virtual modifier always include all of the modifiers bound to any of the keys that specify that virtual modifier in their virtual modifier mapping. The server.vmodmap array indicates which virtual modifiers are bound to each key; each entry is a bitmask for the virtual modifier bits. The server.vmodmap array is indexed by keycode.

The vmodmap and vmods members of the server map are the “master” virtual modifier definitions. Xkb automatically propagates any changes to these fields to all other fields that use virtual modifier mappings (see section 16.4).

For example, if Mod3 is bound to the Num_Lock key by the core protocol modifier mapping, and the NumLock virtual modifier is bound to they Num_Lock key by the virtual modifier mapping, Mod3 is added to the set of modifiers associated with NumLock.

The virtual modifier mapping is normally updated whenever actions are automatically applied to symbols (see section 16.4 for details), and few applications should need to change the virtual modifier mapping explicitly.

Use XkbGetMap (see section 14.2) to get the virtual modifiers from the server or use XkbGetVirtualMods (see section 16.4.1) to update a local copy of the virtual modifiers bindings from the server. To set the binding of a virtual modifier to a real modifier, use XkbSetMap (see section 14.3).
To determine the mapping of virtual modifiers to core X protocol modifiers, use \texttt{XkbVirtualModsToReal}.

\begin{verbatim}
Bool XkbVirtualModsToReal(xkb, virtual_mask, mask_rtrn)
    XkbDescPtr xkb; /* keyboard description for input device */
    unsigned int virtual_mask; /* virtual modifier mask to translate */
    unsigned int * mask_rtrn; /* backfilled with real modifiers */
\end{verbatim}

If the keyboard description defined by \texttt{xkb} includes bindings for virtual modifiers, \texttt{XkbVirtualModsToReal} uses those bindings to determine the set of real modifiers that correspond to the set of virtual modifiers specified in \texttt{virtual_mask}. The \texttt{virtual_mask} parameter is a mask specifying the virtual modifiers to translate; the i-th bit (0 relative) of the mask represents the i-th virtual modifier. If \texttt{mask_rtrn} is non-\texttt{NULL}, \texttt{XkbVirtual ModsToReal} backfills it with the resulting real modifier mask. If the keyboard description in \texttt{xkb} does not include virtual modifier bindings, \texttt{XkbVirtualModsToReal} returns \texttt{False}; otherwise, it returns \texttt{True}.

\textbf{Note} It is possible for a local (client-side) keyboard description (the \texttt{xkb} parameter) to not contain any virtual modifier information (simply because the client has not requested it) while the server's corresponding definition may contain virtual modifier information.

\subsection*{7.4.1 Inactive Modifier Sets}
An unbound virtual modifier is one that is not bound to any real modifier (server->vmods[virtual_modifier_index] is zero).

Some Xkb operations ignore modifier definitions in which the virtual modifiers are unbound. Consider this example:

\begin{verbatim}
if (state matches \{Shift\}) Do OneThing;
if (state matches \{Shift+NumLock\}) Do Another;
\end{verbatim}

If the NumLock virtual modifier is not bound to any real modifiers, the effective masks for these two cases are identical (that is, contain only \texttt{Shift}). When it is essential to distinguish between OneThing and Another, Xkb considers only those modifier definitions for which all virtual modifiers are bound.

\subsection*{7.5 Conventions}
The Xkb extension does not require any specific virtual modifier names. However, everyone benefits if the same names are used for common modifiers. The following names are suggested:

\begin{verbatim}
NumLock
ScrollLock
Alt
Meta
AltGr
LevelThree
\end{verbatim}

\subsection*{7.6 Example}
If the second (0-relative) entry in \texttt{names.vmods} contains the Atom for "NumLock", then 0x4 (1<<2) is the virtual modifier bit for the \texttt{NumLock} virtual modifier. If server.vmods[2]
contains Mod3Mask, then the NumLock virtual modifier is bound to the Mod3 real modifier.

A virtual modifier definition for this example would have:

```
real_mods = 0
vmods = 0x4 (NumLock named virtual modifier)
mask = 0x20 (Mod3Mask)
```

Continuing the example, if the keyboard has a Num_Lock keysym bound to the key with keycode 14, and the NumLock virtual modifier is bound to this key, server.vmodmap[14] contains 0x4.

Finally, if the keyboard also used the real Mod1 modifier for numeric lock operations, the modifier definition below would represent the situation where either the key bound to Mod1 or the NumLock virtual modifier could be used for this purpose:

```
real_mods = 0x8 (Mod1Mask)
vmods = 0x4 (NumLock named virtual modifier)
mask = 0x28 (Mod1Mask | Mod3Mask)
```
8 Indicators

Although the core X implementation supports up to 32 LEDs on an input device, it does not provide any linkage between the state of the LEDs and the logical state of the input device. For example, most keyboards have a CapsLock LED, but X does not provide a mechanism to make the LED automatically follow the logical state of the CapsLock key.

Furthermore, the core X implementation does not provide clients with the ability to determine what bits in the led_mask field of the XKeyboardState map to the particular LEDs on the keyboard. For example, X does not provide a method for a client to determine what bit to set in the led_mask field to turn on the Scroll Lock LED or whether the keyboard even has a Scroll Lock LED.

Xkb provides indicator names and programmable indicators to help solve these problems. Using Xkb, clients can determine the names of the various indicators, determine and control the way that the individual indicators should be updated to reflect keyboard changes, and determine which of the 32 keyboard indicators reported by the protocol are actually present on the keyboard. Clients may also request immediate notification of changes to the state of any subset of the keyboard indicators, which makes it straightforward to provide an on-screen “virtual” LED panel. This chapter describes Xkb indicators and the functions used for manipulating them.

8.1 Indicator Names

Xkb provides the capability of symbolically naming indicators. Xkb itself doesn’t use these symbolic names for anything; they are there only to help make the keyboard description comprehensible to humans. To set the names of specific indicators, use XkbSetNames as discussed in Chapter 18. Then set the map using XkbSetMap (see section 14.3) or XkbSetNamedIndicator (below). To retrieve indicator names, use XkbGetNames (Chapter 18).

8.2 Indicator Data Structures

Use the indicator description record, XkbIndicatorRec, and its indicator map, XkbIndicatorMapRec, to inquire about and control most indicator properties and behaviors.

8.2.1 XkbIndicatorRec

The description for all the Xkb indicators is held in the indicators field of the complete keyboard description (see Chapter 6), which is defined as follows:

```
#define XkbNumIndicators 32

typedef struct {
    unsigned long phys_indicators; /* LEDs existence */
    XkbIndicatorMapRec maps[XkbNumIndicators]; /* indicator maps */
} XkbIndicatorRec,*XkbIndicatorPtr;
```

This structure contains the phys_indicators field, which relates some information about the correspondence between indicators and physical LEDs on the keyboard, and an array of indicator maps, one map per indicator.

The phys_indicators field indicates which indicators are bound to physical LEDs on the keyboard; if a bit is set in phys_indicators, then the associated indicator has a physical
LED associated with it. This field is necessary because some indicators may not have cor-
responding physical LEDs on the keyboard. For example, most keyboards have an LED 
for indicating the state ofCapsLock, but most keyboards do not have an LED that indi-
cates the current group. Becausephys_indicatorsdescribes a physical characteristic of the 
keyboard, you cannot directly change it under program control. However, if a client pro-
gram loads a completely new keyboard description viaXkbGetKeyboardByName, or if a 
new keyboard is attached and the X implementation notices, phys_indicators changes if 
the indicators for the new keyboard are different.

### 8.2.2 XkbIndicatorMapRec

Each indicator has its own set of attributes that specify whether clients can explicitly set 
its state and whether it tracks the keyboard state. The attributes of each indicator are held 
in themapsarray, which is an array ofXkbIndicatorRecstructures:

```c
typedef struct {
    unsigned char flags; /* how the indicator can be changed */
    unsigned char which_groups; /* match criteria for groups */
    unsigned char groups; /* which keyboard groups the indicator watches */
    unsigned char which_mods; /* match criteria for modifiers */
    XkbModsRec mods; /* which modifiers the indicator watches */
    unsigned int ctrls; /* which controls the indicator watches */
} XkbIndicatorMapRec, *XkbIndicatorMapPtr;
```

This indicator map specifies for each indicator:

- The conditions under which the keyboard modifier state affects the indicator
- The conditions under which the keyboard group state affects the indicator
- The conditions under which the state of the boolean controls affects the indicator
- The effect (if any) of attempts to explicitly change the state of the indicator using the 
  functionsXkbSetControlsorXChangeKeyboardControl

For more information on the effects of explicit changes to indicators and the relationship 
to the indicator map, see section 8.4.1.

**XkbIndicatorMapRec flags field**

Theflagsfield specifies the conditions under which the indicator can be changed and the 
effects of changing the indicator. The valid values forflagsand their effects are shown in 
Table 8.1.

<table>
<thead>
<tr>
<th>Value</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbIM_NoExplicit</td>
<td>(1L&lt;&lt;7) Client applications cannot change the state of the indicator.</td>
</tr>
<tr>
<td>XkbIM_NoAutomatic</td>
<td>(1L&lt;&lt;6) Xkb does not automatically change the value of the indicator based upon a change in the keyboard state, regardless of the values for the other fields of the indicator map.</td>
</tr>
<tr>
<td>XkbIM_LEDDrivesKB</td>
<td>(1L&lt;&lt;5) A client application changing the state of the indicator causes the state of the keyboard to change.</td>
</tr>
</tbody>
</table>

Note that ifXkbIM_NoAutomaticis not set, by default the indicator follows the key-
board state.
If `XkbIM_LEDDrivesKB` is set and `XkbIM_NoExplicit` is not, and if you call a function which updates the server’s image of the indicator map (such as `XkbSetIndicatorMap` or `XkbSetNamedIndicator`), Xkb changes the keyboard state and controls to reflect the other fields of the indicator map, as described in the remainder of this section. If you attempt to explicitly change the value of an indicator for which `XkbIM_LEDDrivesKB` is absent or for which `XkbIM_NoExplicit` is present, keyboard state or controls are unaffected.

For example, a keyboard designer may want to make the CapsLock LED controllable only by the server, but allow the Scroll Lock LED to be controlled by client applications. To do so, the keyboard designer could set the `XkbIM_NoExplicit` flag for the CapsLock LED, but not set it for the Scroll Lock LED. Or the keyboard designer may wish to allow the CapsLock LED to be controlled by both the server and client applications and also have the server to automatically change the CapsLock modifier state whenever a client application changes the CapsLock LED. To do so, the keyboard designer would not set the `XkbIM_NoExplicit` flag, but would instead set the `XkbIM_LEDDrivesKB` flag.

The remaining fields in the indicator map specify the conditions under which Xkb automatically turns on or off (only if `XkbIM_NoAutomatic` is not set). If these conditions match the keyboard state, Xkb turns the indicator on. If the conditions do not match, Xkb turns the indicator off.

### XkbIndicatorMapRec which_groups and groups fields

The `which_groups` and the `groups` fields of an indicator map determine how the keyboard group state affects the corresponding indicator. The `which_groups` field controls the interpretation of `groups` and may contain any one of the following values:

```c
#define XkbIM_UseNone 0
#define XkbIM_UseBase (1L << 0)
#define XkbIM_UseLatched (1L << 1)
#define XkbIM_UseLocked (1L << 2)
#define XkbIM_UseEffective (1L << 3)
#define XkbIM_UseAnyGroup XkbIM_UseLatched | XkbIM_UseLocked | XkbIM_UseEffective
```

The `groups` field specifies what keyboard groups an indicator watches and is the bitwise inclusive OR of the following valid values:

```c
#define XkbGroup1Mask (1<<0)
#define XkbGroup2Mask (1<<1)
#define XkbGroup3Mask (1<<2)
#define XkbGroup4Mask (1<<3)
#define XkbAnyGroupMask (1<<7)
#define XkbAllGroupsMask (0xf)
```
If XkbIM_NoAutomatic is not set (the keyboard drives the indicator), the effect of which_groups and groups is shown in Table 8.2.

**Table 8.2 XkbIndicatorMapRec which_groups and groups, Keyboard Drives Indicator**

<table>
<thead>
<tr>
<th>which_groups</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbIM_UseNone</td>
<td>The groups field and the current keyboard group state are ignored.</td>
</tr>
<tr>
<td>XkbIM_UseBase</td>
<td>If groups is nonzero, the indicator is lit whenever the base keyboard group is nonzero. If groups is zero, the indicator is lit whenever the base keyboard group is zero.</td>
</tr>
<tr>
<td>XkbIM_UseLatched</td>
<td>If groups is nonzero, the indicator is lit whenever the latched keyboard group is nonzero. If groups is zero, the indicator is lit whenever the latched keyboard group is zero.</td>
</tr>
<tr>
<td>XkbIM_UseLocked</td>
<td>The groups field is interpreted as a mask. The indicator is lit when the current locked keyboard group matches one of the bits that are set in groups.</td>
</tr>
<tr>
<td>XkbIM_UseEffective</td>
<td>The groups field is interpreted as a mask. The indicator is lit when the current effective keyboard group matches one of the bits that are set in groups.</td>
</tr>
</tbody>
</table>

The effect of which_groups and groups when you change an indicator for which XkbIM_LEDDrivesKB is set (the indicator drives the keyboard) is shown in Table 8.3. The “New State” column refers to the new state to which you set the indicator.

**Table 8.3 XkbIndicatorMapRec which_groups and groups, Indicator Drives Keyboard**

<table>
<thead>
<tr>
<th>which_groups</th>
<th>New State</th>
<th>Effect on Keyboard Group State</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbIM_UseNone</td>
<td>On or Off</td>
<td>No effect</td>
</tr>
<tr>
<td>XkbIM_UseBase</td>
<td>On or Off</td>
<td>No effect</td>
</tr>
<tr>
<td>XkbIM_UseLatched</td>
<td>Off</td>
<td>The groups field is treated as a group mask. The keyboard group latch is changed to the lowest numbered group specified in groups; if groups is empty, the keyboard group latch is changed to zero.</td>
</tr>
<tr>
<td>XkbIM_UseLatched</td>
<td>On</td>
<td>The groups field is treated as a group mask. If the indicator is explicitly extinguished, keyboard group latch is changed to the lowest numbered group not specified in groups; if groups is zero, the keyboard group latch is set to the index of the highest legal keyboard group.</td>
</tr>
<tr>
<td>XkbIM_UseLocked</td>
<td>On</td>
<td>If the groups mask is empty, group is not changed; otherwise, the locked keyboard group is changed to the lowest numbered group specified in groups.</td>
</tr>
<tr>
<td>XkbIM_UseEffective</td>
<td>Off</td>
<td>Locked keyboard group is changed to the lowest numbered group that is not specified in the groups mask, or to Group1 if the groups mask contains all keyboard groups.</td>
</tr>
</tbody>
</table>

**XkbIndicatorMapRec which_mods and mods fields**

The mods field specifies what modifiers an indicator watches. The mods field is an Xkb modifier definition, XkbModifierRec, as described in section 7.2, which can specify both real and virtual modifiers. The mods field takes effect even if some or all of the virtual indicators specified in mods are unbound. To specify the mods field, in general, assign the modifiers of interest to mods.real_mods and the virtual modifiers of interest to mods.vmods. You can disregard the mods.mask field unless your application needs to interpret the indicator map directly (that is, to simulate automatic indicator behavior on its own). Relatively
few applications need to do so, but if you find it necessary, you can either read the indicator map back from the server after you update it (the server automatically updates the mask field whenever any of the real or virtual modifiers are changed in the modifier definition) or you can use \texttt{XkbVirtualModsToReal} to determine the proper contents for the mask field, assuming that the \texttt{XkbDescRec} contains the virtual modifier definitions.

\texttt{which_mods} specifies what criteria Xkb uses to determine a match with the corresponding \texttt{mods} field by specifying one or more components of the Xkb keyboard state. If \texttt{XkbIM_NoAutomatic} is not set (the keyboard drives the indicator), the indicator is lit whenever any of the modifiers specified in the \texttt{mask} field of the \texttt{mods} modifier definition are also set in any of the current keyboard state components specified by \texttt{which_mods}. Remember that the \texttt{mask} field is comprised of all of the real modifiers specified in the definition plus any real modifiers that are bound to the virtual modifiers specified in the definition. (See Chapter 5 for more information on the keyboard state and Chapter 7 for more information on virtual modifiers.) Use a bitwise inclusive OR of the following values to compose a value for \texttt{which_mods}:

\begin{verbatim}
#define XkbIM_UseNone 0
#define XkbIM_UseBase  (1L << 0)
#define XkbIM_UseLatched (1L << 1)
#define XkbIM_UseLocked  (1L << 2)
#define XkbIM_UseEffective (1L << 3)
#define XkbIM_UseCompat  (1L << 4)
#define XkbIM_UseAnyMods XkbIM_UseBase | XkbIM_UseLatched | XkbIM_UseLocked | XkbIM_UseEffective | XkbIM_UseCompat
\end{verbatim}

If \texttt{XkbIM_NoAutomatic} is not set (the keyboard drives the indicator), the effect of \texttt{which_mods} and \texttt{mods} is shown in Table 8.4

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{\textit{which_mods}} & \textbf{Effect on Keyboard Modifiers} \\
\hline
XkbIM\_UseNone & The mods field and the current keyboard modifier state are ignored. \\
XkbIM\_UseBase & The indicator is lit when any of the modifiers specified in the mask field of mods are on in the keyboard base state. If both \texttt{mods.real\_mods} and \texttt{mods.vmods} are zero, the indicator is lit when the base keyboard state contains no modifiers. \\
XkbIM\_UseLatched & The indicator is lit when any of the modifiers specified in the \texttt{mask} field of \texttt{mods} are latched. If both \texttt{mods.real\_mods} and \texttt{mods.vmods} are zero, the indicator is lit when none of the modifier keys are latched. \\
XkbIM\_UseLocked & The indicator is lit when any of the modifiers specified in the \texttt{mask} field of \texttt{mods} are locked. If both \texttt{mods.real\_mods} and \texttt{mods.vmods} are zero, the indicator is lit when none of the modifier keys are locked. \\
XkbIM\_UseEffective & The indicator is lit when any of the modifiers specified in the \texttt{mask} field of \texttt{mods} are in the effective keyboard state. If both \texttt{mods.real\_mods} and \texttt{mods.vmods} are zero, the indicator is lit when the effective keyboard state contains no modifiers. \\
XkbIM\_UseCompat & The indicator is lit when any of the modifiers specified in the \texttt{mask} field of \texttt{mods} are in the keyboard compatibility state. If both \texttt{mods.real\_mods} and \texttt{mods.vmods} are zero, the indicator is lit when the keyboard compatibility state contains no modifiers. \\
\hline
\end{tabular}
\caption{XkbIndicatorMapRec \texttt{which\_mods} and \texttt{mods}, Keyboard Drives Indicator}
\end{table}
The effect on the keyboard modifiers of \textit{which\_mods} and \textit{mods} when you change an indicator for which \texttt{XkbIM\_LEDDrivesKB} is set (the indicator drives the keyboard) is shown in Table 8.5. The “New State” column refers to the new state to which you set the indicator.

\textbf{Table 8.5 XkbIndicatorMapRec which\_mods and mods, Indicator Drives Keyboard}

<table>
<thead>
<tr>
<th>\textit{which_mods}</th>
<th>New State</th>
<th>Effect on Keyboard Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{XkbIM_UseNone} or \texttt{XkbIM_UseBase}</td>
<td>On or Off</td>
<td>No Effect</td>
</tr>
<tr>
<td>\texttt{XkbIM_UseLatched}</td>
<td>On</td>
<td>Any modifiers specified in the \textit{mask} field of \textit{mods} are added to the latched modifiers.</td>
</tr>
<tr>
<td>\texttt{XkbIM_UseLatched}</td>
<td>Off</td>
<td>Any modifiers specified in the \textit{mask} field of \textit{mods} are removed from the latched modifiers.</td>
</tr>
<tr>
<td>\texttt{XkbIM_UseLocked, XkbIM_UseCompat, or XkbIM_UseEffective}</td>
<td>On</td>
<td>Any modifiers specified in the \textit{mask} field of \textit{mods} are added to the locked modifiers.</td>
</tr>
<tr>
<td>\texttt{XkbIM_UseLocked}</td>
<td>Off</td>
<td>Any modifiers specified in the \textit{mask} field of \textit{mods} are removed from the locked modifiers.</td>
</tr>
<tr>
<td>\texttt{XkbIM_UseCompat} or \texttt{XkbIM_UseEffective}</td>
<td>Off</td>
<td>Any modifiers specified in the \textit{mask} field of \textit{mods} are removed from both the locked and latched modifiers.</td>
</tr>
</tbody>
</table>

\textbf{XkbIndicatorMapRec \texttt{ctrls} field}

The \textit{ctrls} field specifies what controls (see Chapter 10) the indicator watches and is composed using the bitwise inclusive OR of the following values:

\begin{verbatim}
#define XkbRepeatKeysMask (1L << 0)
#define XkbSlowKeysMask (1L << 1)
#define XkbBounceKeysMask (1L << 2)
#define XkbStickyKeysMask (1L << 3)
#define XkbMouseKeysMask (1L << 4)
#define XkbMouseKeysAccelMask (1L << 5)
#define XkbAccessXKeysMask (1L << 6)
#define XkbAccessXTimerMask (1L << 7)
#define XkbAccessXFeedbackMask (1L << 8)
#define XkbAudibleBellMask (1L << 9)
#define XkbOverlay1Mask (1L << 10)
#define XkbOverlay2Mask (1L << 11)
#define XkbAllBooleanCtrlsMask (0x00001FFF)
\end{verbatim}

\texttt{Xkb} lights the indicator whenever any of the boolean controls specified in \textit{ctrls} is enabled.

\textbf{8.3 Getting Information About Indicators}

\texttt{Xkb} allows applications to obtain information about indicators using two different methods. The first method, which is similar to the core X implementation, uses a mask to specify the indicators. The second method, which is more suitable for applications concerned with interoperability, uses indicator names. The correspondence between the indicator name and the bit position in masks is as follows: one of the parameters returned from \texttt{XkbGetNamedIndicators} is an index that is the bit position to use in any function call that
requires a mask of indicator bits, as well as the indicator’s index into the XkbIndica-


torRec array of indicator maps.

### 8.3.1 Getting Indicator State

Because the state of the indicators is relatively volatile, the keyboard description does not

hold the current state of the indicators. To obtain the current state of the keyboard indicators, use XkbGetIndicatorState.

Status XkbGetIndicatorState(display, device_spec, state_return)

Display * display; /* connection to the X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int * state_return; /* backfilled with a mask of the indicator state */

XkbGetIndicatorState queries the display for the state of the indicators on the device specified by the device_spec. For each indicator that is “turned on” on the device, the associated bit is set in state_return. If a compatible version of the Xkb extension is not available in the server, XkbGetIndicatorState returns a BadMatch error. Otherwise, it sends the request to the X server, places the state of the indicators into state_return, and returns Success. Thus the value reported by XkbGetIndicatorState is identical to the value reported by the core protocol.

### 8.3.2 Getting Indicator Information by Index

To get the map for one or more indicators, using a mask to specify the indicators, use XkbGetIndicatorMap.

Status XkbGetIndicatorMap(dpy, which, desc)

Display * dpy; /* connection to the X server */
unsigned int which; /* mask of indicators for which maps should be returned */
XkbDescPtr desc; /* keyboard description to be updated */

XkbGetIndicatorMap obtains the maps from the server for only those indicators specified by the which mask and copies the values into the keyboard description specified by desc. If the indicators field of the desc parameter is NULL, XkbGetIndicatorMap allocates and initializes it.

XkbGetIndicatorMap can generate BadAlloc, BadLength, BadMatch, and BadImple-

mentation errors.

To free the indicator maps, use XkbFreeIndicatorMaps (see section 8.6).

### 8.3.3 Getting Indicator Information by Name

Xkb also allows applications to refer to indicators by name. Use XkbGetNames to get the indicator names (see Chapter 18). Using names eliminates the need for hard-coding bit-mask values for particular keyboards. For example, instead of using vendor-specific constants such as WSKBLed_ScrollLock mask on Digital workstations or XLED_SCROLL_LOCK on Sun workstations, you can instead use XkbGetNamedIndicator to look up information on the indicator named “Scroll Lock.”
Use XkbGetNamedIndicator to look up the indicator map and other information for an indicator by name.

**Bool XkbGetNamedIndicator**

```c
Bool XkbGetNamedIndicator(Display * dpy, unsigned int device_spec, Atom name, int * ndx_rtn, Bool * state_rtn, XkbIndicatorMapPtr * map_rtn, Bool * real_rtn);
```

- **dpy**: connection to the X server.
- **device_spec**: keyboard device ID, or XkbUseCoreKbd.
- **name**: name of the indicator to be retrieved.
- **ndx_rtn**: backfilled with the index of the retrieved indicator.
- **state_rtn**: backfilled with the current state of the retrieved indicator.
- **map_rtn**: backfilled with the mapping for the retrieved indicator.
- **real_rtn**: True if the named indicator is real (physical).

If the device specified by `device_spec` has an indicator named `name`, XkbGetNamedIndicator returns True and populates the rest of the parameters with information about the indicator. Otherwise, XkbGetNamedIndicator returns False.

The `ndx_rtn` field returns the zero-based index of the named indicator. This index is the bit position to use in any function call that requires a mask of indicator bits, as well as the indicator's index into the XkbIndicatorRec array of indicator maps. `state_rtn` returns the current state of the named indicator (True = on, False = off). `map_rtn` returns the indicator map for the named indicator. In addition, if the indicator is mapped to a physical LED, the `real_rtn` parameter is set to True.

Each of the “_rtn” arguments is optional; you can pass NULL for any unneeded “_rtn” arguments.

XkbGetNamedIndicator can generate BadAtom and BadImplementation errors.

### 8.4 Changing Indicator Maps and State

Just as you can get the indicator map using a mask or using an indicator name, so you can change it using a mask or a name.

**Note** You cannot change the `phys_indicators` field of the indicators structure. The only way to change the `phys_indicators` field is to change the keyboard map.

There are two ways to make changes to indicator maps and state: either change a local copy of the indicator maps and use XkbSetIndicatorMap or XkbSetNamedIndicator, or, to reduce network traffic, use an XkbIndicatorChangesRec structure and use XkbChangeIndicators.

### 8.4.1 Effects of Explicit Changes on Indicators

This section discusses the effects of explicitly changing indicators depending upon different settings in the indicator map. See Tables 8.3 and Table 8.5 for information on the effects of the indicator map fields when explicit changes are made.

If XkbIM_LEDDrivesKB is set and XkbIM_NoExplicit is not, and if you call a function that updates the server's image of the indicator map (such as XkbSetIndicatorMap or XkbSetNamedIndicator), Xkb changes the keyboard state and controls to reflect the other fields of the indicator map. If you attempt to explicitly change the value of an indicator for which XkbIM_LEDDrivesKB is absent or for which XkbIM_NoExplicit is present, keyboard state or controls are unaffected.
If neither \texttt{XkbIM\_NoAutomatic} nor \texttt{XkbIM\_NoExplicit} is set in an indicator map, Xkb honors any request to change the state of the indicator, but the new state might be immediately superseded by automatic changes to the indicator state if the keyboard state or controls change.

The effects of changing an indicator that drives the keyboard are cumulative; it is possible for a single change to affect keyboard group, modifiers, and controls simultaneously.

If you change an indicator for which both the \texttt{XkbIM\_LEDDrivesKB} and \texttt{XkbIM\_NoAutomatic} flags are specified, Xkb applies the keyboard changes specified in the other indicator map fields and changes the indicator to reflect the state that was explicitly requested. The indicator remains in the new state until it is explicitly changed again.

If the \texttt{XkbIM\_NoAutomatic} flag is not set and \texttt{XkbIM\_LEDDrivesKB} is set, Xkb applies the changes specified in the other indicator map fields and sets the state of the indicator to the values specified by the indicator map. Note that it is possible in this case for the indicator to end up in a different state than the one that was explicitly requested. For example, Xkb does not extinguish an indicator with \texttt{which\_mods} of \texttt{XkbIM\_UseBase} and \texttt{mods} of \texttt{Shift} if, at the time Xkb processes the request to extinguish the indicator, one of the Shift keys is physically depressed.

If you explicitly light an indicator for which \texttt{XkbIM\_LEDDrivesKB} is set, Xkb enables all of the boolean controls specified in the \texttt{ctrls} field of its indicator map. Explicitly extinguishing such an indicator causes Xkb to disable all of the boolean controls specified in \texttt{ctrls}.

\texttt{8.4.2 Changing Indicator Maps by Index}

To update the maps for one or more indicators, first modify a local copy of the keyboard description, then use \texttt{XkbSetIndicatorMap} to download the changes to the server:

\begin{verbatim}
Bool XkbSetIndicatorMap(dpy, which, desc)
    Display * dpy;    /* connection to the X server */
    unsigned int which; /* mask of indicators to change */
    XkbDescPtr desc;   /* keyboard description from which the maps are taken */
\end{verbatim}

For each bit set in the \texttt{which} parameter, \texttt{XkbSetIndicatorMap} sends the corresponding indicator map from the \texttt{desc} parameter to the server.
8.4.3 Changing Indicator Maps by Name

`XkbSetNamedIndicator` can do several related things:

- Name an indicator if it is not already named
- Toggle the state of the indicator
- Set the indicator to a specified state
- Set the indicator map for the indicator

```c
Bool XkbSetNamedIndicator(dpy, device_spec, name, change_state, state, create_new, map)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dpy</code></td>
<td>Display * connection to the X server</td>
</tr>
<tr>
<td><code>device_spec</code></td>
<td>unsigned int device ID, or <code>XkbUseCoreKbd</code></td>
</tr>
<tr>
<td><code>name</code></td>
<td>Atom name of the indicator to change</td>
</tr>
<tr>
<td><code>change_state</code></td>
<td>Bool * whether to change the indicator state or not *</td>
</tr>
<tr>
<td><code>state</code></td>
<td>Bool * desired new state for the indicator *</td>
</tr>
<tr>
<td><code>create_new</code></td>
<td>Bool * whether a new indicator with the specified name should be created when necessary *</td>
</tr>
<tr>
<td><code>map</code></td>
<td>XkbIndicatorMapPtr * new map for the indicator *</td>
</tr>
</tbody>
</table>

If a compatible version of the Xkb extension is not available in the server, `XkbSetNamedIndicator` returns `False`. Otherwise, it sends a request to the X server to change the indicator specified by `name` and returns `True`.

If `change_state` is `True`, and the optional parameter, `state`, is not `NULL`, `XkbSetNamedIndicator` tells the server to change the state of the named indicator to the value specified by `state`.

If an indicator with the name specified by `name` does not already exist, the `create_new` parameter tells the server whether it should create a new named indicator. If `create_new` is `True`, the server finds the first indicator that doesn’t have a name and gives it the name specified by `name`.

If the optional parameter, `map`, is not `NULL`, `XkbSetNamedIndicator` tells the server to change the indicator’s map to the values specified in `map`.

`XkbSetNamedIndicator` can generate `BadAtom` and `BadImplementation` errors. In addition, it can also generate `XkbIndicatorStateNotify` (see section 8.5), `XkbIndicatorMapNotify`, and `XkbNamesNotify` events (see section 18.5).

8.4.4 The XkbIndicatorChangesRec Structure

The `XkbIndicatorChangesRec` identifies small modifications to the indicator map. Use it with the function `XkbChangeIndicators` to reduce the amount of traffic sent to the server.

```c
typedef struct _XkbIndicatorChanges {
    unsigned int state_changes;
    unsigned int map_changes;
} XkbIndicatorChangesRec,*XkbIndicatorChangesPtr;
```

The `state_changes` field is a mask that specifies the indicators that have changed state, and `map_changes` is a mask that specifies the indicators whose maps have changed.
To change indicator maps or state without passing the entire keyboard description, use `XkbChangeIndicators`.

```c
Bool XkbChangeIndicators(dpy, xkb, changes, state)
    Display * dpy; /* connection to the X server */
    XkbDescPtr xkb; /* keyboard description from which names are to be taken. */
    XkbIndicatorChangesPtr changes; /* indicators to be updated on the server */
    unsigned int state; /* new state of indicators listed in changes->state_changes */
```

`XkbChangeIndicators` copies any maps specified by `changes` from the keyboard description, `xkb`, to the server specified by `dpy`. If any bits are set in the `state_changes` field of `changes`, `XkbChangeIndicators` also sets the state of those indicators to the values specified in the `state` mask. A 1 bit in `state` turns the corresponding indicator on, a 0 bit turns it off.

`XkbChangeIndicators` can generate `BadAtom` and `BadImplementation` errors. In addition, it can also generate `XkbIndicatorStateNotify` and `XkbIndicatorMapNotify` events (see section 8.5).

### 8.5 Tracking Changes to Indicator State or Map

Whenever an indicator changes state, the server sends `XkbIndicatorStateNotify` events to all interested clients. Similarly, whenever an indicator’s map changes, the server sends `XkbIndicatorMapNotify` events to all interested clients.

To receive `XkbIndicatorStateNotify` events, use `XkbSelectEvents` (see section 4.3) with both the `bits_to_change` and `values_for_bits` parameters containing `XkbIndicatorStateNotifyMask`. To receive `XkbIndicatorMapNotify` events, use `XkbSelectEvents` with `XkbIndicatorMapNotifyMask`.

To receive events for only specific indicators, use `XkbSelectEventDetails`. Set the `event_type` parameter to `XkbIndicatorStateNotify` or `XkbIndicatorMapNotify`, and set both the `bits_to_change` and `values_for_bits` detail parameters to a mask where each bit specifies one indicator, turning on those bits that specify the indicators for which you want to receive events.

Both types of indicator events use the same structure:

```c
typedef struct _XkbIndicatorNotify {
    int     type;   /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool    send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time    time;    /* server time when event generated */
    int     xkb_type; /* specifies state or map notify */
    int     device;  /* Xkb device ID, will not be XkbUseCoreKbd*/
    unsigned int changed; /* mask of indicators with new state or map */
    unsigned int state; /* current state of all indicators */
} XkbIndicatorNotifyEvent;
```
The \textit{xkb\_type} is either \texttt{XkbIndicatorStateNotify} or \texttt{XkbIndicatorMapNotify}, depending on whether the event is a \texttt{kb\_Indicator\_State\_Notify} event or \texttt{kb\_Indicator\_Map\_Notify} event.

The \textit{changed} parameter is a mask that is the bitwise inclusive OR of the indicators that have changed. If the event is of type \texttt{XkbIndicatorMapNotify}, \textit{changed} reports the maps that changed. If the event is of type \texttt{XkbIndicatorStateNotify}, \textit{changed} reports the indicators that have changed state. \textit{state} is a mask that specifies the current state of all indicators, whether they have changed or not, for both \texttt{XkbIndicatorStateNotify} and \texttt{IndicatorMapNotify} events.

When your client application receives either a \texttt{XkbIndicatorStateNotify} event or \texttt{XkbIndicatorMapNotify} event, you can note the changes in a changes structure by calling \texttt{XkbNoteIndicatorChanges}.

\begin{verbatim}
void XkbNoteIndicatorChanges( old, new, wanted )
    XkbIndicatorChangesPtr old;  /* XkbIndicatorChanges structure to be updated */
    XkbIndicatorNotifyEvent * new; /* event from which changes are to be copied */
    unsigned int wanted; /* which changes are to be noted */
\end{verbatim}

The \textit{wanted} parameter is the bitwise inclusive OR of \texttt{XkbIndicatorMapMask} and \texttt{XkbIndicatorStateMask}. \texttt{XkbNoteIndicatorChanges} copies any changes reported in \texttt{new} and specified in \textit{wanted} into the changes record specified by \texttt{old}.

To update a local copy of the keyboard description with the actual values, pass the results of one or more calls to \texttt{XkbNoteIndicatorChanges} to \texttt{XkbGetIndicatorChanges}:

\begin{verbatim}
Status XkbGetIndicatorChanges(display, xkb, changes, state)
    Display * display;  /* connection to the X server */
    XkbDescPtr xkb;    /* keyboard description to hold the new values */
    XkbIndicatorChangesPtr changes; /* indicator maps/state to be obtained from the server */
    unsigned int * state;  /* backfilled with the state of the indicators */
\end{verbatim}

\texttt{XkbGetIndicatorChanges} examines the \textit{changes} parameter, pulls over the necessary information from the server, and copies the results into the \texttt{xkb} keyboard description. If any bits are set in the \textit{state\_changes} field of \texttt{changes}, \texttt{XkbGetIndicatorChanges} also places the state of those indicators in \textit{state}. If the \textit{indicators} field of \texttt{xkb} is NULL, \texttt{XkbGetIndicatorChanges} allocates and initializes it. To free the \textit{indicators} field, use \texttt{XkbFreeIndicators} (see section 8.6).

\texttt{XkbGetIndicatorChanges} can generate \texttt{BadAlloc}, \texttt{BadImplementation}, and \texttt{BadMatch} errors.

### 8.6 Allocating and Freeing Indicator Maps

Most applications do not need to directly allocate the \textit{indicators} member of the keyboard description record (the keyboard description record is described in Chapter 6). If the need arises, however, use \texttt{XkbAllocIndicatorMaps}.

\begin{verbatim}
Status XkbAllocIndicatorMaps(xkb)
    XkbDescPtr xkb;  /* keyboard description structure */
\end{verbatim}

The \texttt{xkb} parameter must point to a valid keyboard description. If it doesn’t, \texttt{XkbAllocIndicatorMaps} returns a \texttt{BadMatch} error. Otherwise, \texttt{XkbAllocIndicatorMaps} allocates and initializes the \textit{indicators} member of the keyboard description record and returns \texttt{Success}.
cess. If `XkbAllocIndicatorMaps` was unable to allocate the indicators record, it reports a `BadAlloc` error.

To free memory used by the `indicators` member of an `XkbDescRec` structure, use `XkbFreeIndicatorMaps`.

```c
void XkbFreeIndicatorMaps(xkb)
    XkbDescPtr xkb;    /* keyboard description structure */
```

If the `indicators` member of the keyboard description record pointed to by `xkb` is not `NULL`, `XkbFreeIndicatorMaps` frees the memory associated with the `indicators` member of `xkb`.
The X Keyboard Extension

9 Bells

The core X protocol allows only applications to explicitly sound the system bell with a given duration, pitch, and volume. Xkb extends this capability by allowing clients to attach symbolic names to bells, disable audible bells, and receive an event whenever the keyboard bell is rung. For the purposes of this document, the audible bell is defined to be the system bell, or the default keyboard bell, as opposed to any other audible sound generated elsewhere in the system.

You can ask to receive XkbBellNotify events (see section 9.4) when any client rings any one of the following:

- The default bell
- Any bell on an input device that can be specified by a bell_class and bell_id pair
- Any bell specified only by an arbitrary name. (This is, from the server’s point of view, merely a name, and not connected with any physical sound-generating device. Some client application must generate the sound, or visual feedback, if any, that is associated with the name.)

You can also ask to receive XkbBellNotify events when the server rings the default bell or if any client has requested events only (without the bell sounding) for any of the bell types previously listed.

You can disable audible bells on a global basis (to set the AudibleBell control, see Chapter 10). For example, a client that replaces the keyboard bell with some other audible cue might want to turn off the AudibleBell control to prevent the server from also generating a sound and avoid cacophony. If you disable audible bells and request to receive XkbBellNotify events, you can generate feedback different from the default bell.

You can, however, override the AudibleBell control by calling one of the functions that force the ringing of a bell in spite of the setting of the AudibleBell control — XkbForceDeviceBell or XkbForceBell (see section 9.3.3). In this case the server does not generate a bell event.

Just as some keyboards can produce keyclicks to indicate when a key is pressed or repeating, Xkb can provide feedback for the controls by using special beep codes. The AccessXFeedback control is used to configure the specific types of operations that generate feedback. See section 10.6.3 for a discussion on AccessXFeedback control.

This chapter describes bell names, the functions used to generate named bells, and the events the server generates for bells.

9.1 Bell Names

You can associate a name to an act of ringing a bell by converting the name to an Atom and then using this name when you call the functions listed in this chapter. If an event is generated as a result, the name is then passed to all other clients interested in receiving XkbBellNotify events. Note that these are arbitrary names and that there is no binding to any sounds. Any sounds or other effects (such as visual bells on the screen) must be generated by a client application upon receipt of the bell event containing the name. There is no default name for the default keyboard bell. The server does generate some predefined bells for the AccessX controls (see section 10.6.3). These named bells are shown in Table 9.1; the name is included in any bell event sent to clients that have requested to receive XkbBellNotify events.
Using Xkb you can generate bell events that do not necessarily ring the system bell. This is useful if you need to use an audio server instead of the system beep. For example, when an audio client starts, it could disable the audible bell (the system bell) and then listen for XkbBellNotify events (see section 9.4). When it receives a XkbBellNotify event, the audio client could then send a request to an audio server to play a sound.

You can control the audible bells feature by passing the XkbAudibleBellMask to XkbChangeEnabledControls (see section 10.1.1). If you set XkbAudibleBellMask on, the server rings the system bell when a bell event occurs. This is the default. If you set XkbAudibleBellMask off and a bell event occurs, the server does not ring the system bell unless you call XkbForceDeviceBell or XkbForceBell (see section 9.3.3).

Audible bells are also part of the per-client auto-reset controls. For more information on auto-reset controls, see section 10.1.2.

### Table 9.1 Predefined Bells

<table>
<thead>
<tr>
<th>Action</th>
<th>Named Bell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator turned on</td>
<td>AX_IndicatorOn</td>
</tr>
<tr>
<td>Indicator turned off</td>
<td>AX_IndicatorOff</td>
</tr>
<tr>
<td>More than one indicator changed state</td>
<td>AX_IndicatorChange</td>
</tr>
<tr>
<td>Control turned on</td>
<td>AX_FeatureOn</td>
</tr>
<tr>
<td>Control turned off</td>
<td>AX_FeatureOff</td>
</tr>
<tr>
<td>More than one control changed state</td>
<td>AX_FeatureChange</td>
</tr>
<tr>
<td>SlowKeys and BounceKeys about to be turned on or off</td>
<td>AX_SlowKeysWarning</td>
</tr>
<tr>
<td>SlowKeys key pressed</td>
<td>AX_SlowKeyPress</td>
</tr>
<tr>
<td>SlowKeys key accepted</td>
<td>AX_SlowKeyAccept</td>
</tr>
<tr>
<td>SlowKeys key rejected</td>
<td>AX_SlowKeyReject</td>
</tr>
<tr>
<td>Accepted SlowKeys key released</td>
<td>AX_SlowKeyRelease</td>
</tr>
<tr>
<td>BounceKeys key rejected</td>
<td>AX_BounceKeyReject</td>
</tr>
<tr>
<td>StickyKeys key latched</td>
<td>AX_StickyLatch</td>
</tr>
<tr>
<td>StickyKeys key locked</td>
<td>AX_StickyLock</td>
</tr>
<tr>
<td>StickyKeys key unlocked</td>
<td>AX_StickyUnlock</td>
</tr>
</tbody>
</table>

### 9.2 Audible Bells

Using Xkb you can generate bell events that do not necessarily ring the system bell. This is useful if you need to use an audio server instead of the system beep. For example, when an audio client starts, it could disable the audible bell (the system bell) and then listen for XkbBellNotify events (see section 9.4). When it receives a XkbBellNotify event, the audio client could then send a request to an audio server to play a sound.

You can control the audible bells feature by passing the XkbAudibleBellMask to XkbChangeEnabledControls (see section 10.1.1). If you set XkbAudibleBellMask on, the server rings the system bell when a bell event occurs. This is the default. If you set XkbAudibleBellMask off and a bell event occurs, the server does not ring the system bell unless you call XkbForceDeviceBell or XkbForceBell (see section 9.3.3).

Audible bells are also part of the per-client auto-reset controls. For more information on auto-reset controls, see section 10.1.2.

### 9.3 Bell Functions

Use the functions described in this section to ring bells and to generate bell events.

The input extension has two types of feedbacks that can generate bells — bell feedback and keyboard feedback. Some of the functions in this section have bell_class and bell_id parameters; set them as follows: Set bell_class to BellFeedbackClass or KbdFeedbackClass. A device can have more than one feedback of each type; set bell_id to the particular bell feedback of bell_class type.
Table 9.2 shows the conditions that cause a bell to sound or an XkbBellNotifyEvent to be generated when a bell function is called.

<table>
<thead>
<tr>
<th>Function called</th>
<th>AudibleBell</th>
<th>Server sounds a bell</th>
<th>Server sends an XkbBellNotifyEvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbDeviceBell</td>
<td>On</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbDeviceBell</td>
<td>Off</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbBell</td>
<td>On</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbBell</td>
<td>Off</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbDeviceBellEvent</td>
<td>On or Off</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbBellEvent</td>
<td>On or Off</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>XkbDeviceForceBell</td>
<td>On or Off</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>XkbForceBell</td>
<td>On or Off</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### 9.3.1 Generating Named Bells

To ring the bell on an X input extension device or the default keyboard, use XkbDeviceBell.

```
Bool XkbDeviceBell(display, window, device_id, bell_class, bell_id, percent, name)
```

Display * display; /* connection to the X server */
Window window; /* window for which the bell is generated, or None */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int bell_class; /* X input extension bell class of the bell to be rung */
unsigned int bell_id; /* X input extension bell ID of the bell to be rung */
int percent; /* bell volume, from -100 to 100 inclusive */
Atom name; /* a name for the bell, or NULL */

Set percent to be the volume relative to the base volume for the keyboard as described for XBell.

Note that bell_class and bell_id indicate the bell to physically ring. name is simply an arbitrary moniker for the client application’s use.

To determine the current feedback settings of an extension input device, use XGetFeedbackControl. See the X input extension documentation for more information on XGetFeedbackControl and related data structures.

If a compatible keyboard extension is not present in the X server, XkbDeviceBell immediately returns False. Otherwise, XkbDeviceBell rings the bell as specified for the display and keyboard device and returns True. If you have disabled the audible bell, the server does not ring the system bell, although it does generate a XkbBellNotify event.

You can call XkbDeviceBell without first initializing the keyboard extension.

As a convenience function, Xkb provides a function to ring the bell on the default keyboard: XkbBell.

```
Bool XkbBell(display, window, percent, name)
```

Display * display; /* connection to the X server */
Window window; /* event window, or None */
int percent; /* relative volume, which can range from -100 to 100 inclusive */
Atom name; /* a bell name, or NULL */
If a compatible keyboard extension isn’t present in the X server, XkbBell calls XBell with the specified display and percent, and returns False. Otherwise, XkbBell calls XkbDeviceBell with the specified display, window, percent, and name, a device_spec of XkbUseCoreKbd, a bell_class of XkbDfltXIClass, and a bell_id of XkbDfltXIId, and returns True.

If you have disabled the audible bell, the server does not ring the system bell, although it does generate a XkbBellNotify event.

You can call XkbBell without first initializing the keyboard extension.

9.3.2 Generating Named Bell Events

Using Xkb, you can also generate a named bell event that does not ring any bell. This allows you to do things such as generate events when your application starts.

For example, if an audio client listens for these types of bells, it can produce a “whoosh” sound when it receives a named bell event to indicate a client just started. In this manner, applications can generate start-up feedback and not worry about producing annoying beeps if an audio server is not running.

To cause a bell event for an X input extension device or for the keyboard, without ringing the corresponding bell, use XkbDeviceBellEvent.

Boolean XkbDeviceBellEvent(display, window, device_spec, bell_class, bell_id, percent, name)

Display * display; /* connection to the X server */
Window * window; /* event window, or None */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int bell_class; /* input extension bell class for the event */
unsigned int bell_id; /* input extension bell ID for the event */
int percent; /* volume for the bell, which can range from -100 to 100 inclusive */
Atom name; /* a bell name, or NULL */

If a compatible keyboard extension isn’t present in the X server, XkbDeviceBellEvent immediately returns False. Otherwise, XkbDeviceBellEvent causes an XkbBellNotify event to be sent to all interested clients and returns True. Set percent to be the volume relative to the base volume for the keyboard as described for XBell.

In addition, XkbDeviceBellEvent may generate Atom protocol errors as well as XkbBellNotify events. You can call XkbBell without first initializing the keyboard extension.

As a convenience function, Xkb provides a function to cause a bell event for the keyboard without ringing the corresponding bell: XkbBellEvent.

Boolean XkbBellEvent(display, window, percent, name)

Display * display; /* connection to the X server */
Window * window; /* the event window, or None */
int percent; /* relative volume, which can range from -100 to 100 inclusive */
Atom name; /* a bell name, or NULL */

If a compatible keyboard extension isn’t present in the X server, XkbBellEvent immediately returns False. Otherwise, XkbBellEvent calls XkbDeviceBellEvent with the specified display, window, percent, and name, a device_spec of XkbUseCoreKbd, a bell_class
of XkbDfltXIClass, and a bell_id of XkbDfltXIId, and returns what XkbDevice-
BellEvent returns.

XkbBellEvent generates a XkbBellNotify event.

You can call XkbBellEvent without first initializing the keyboard extension.

### 9.3.3 Forcing a Server-Generated Bell

To ring the bell on any keyboard, overriding user preference settings for audible bells, use XkbForceDeviceBell.

```c
Bool XkbForceDeviceBell (display, window, device_spec, bell_class, bell_id, percent)
    Display * display; /* connection to the X server */
    Window window; /* event window, or None */
    unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
    unsigned int bell_class; /* input extension class of the bell to be rung */
    unsigned int bell_id; /* input extension ID of the bell to be rung */
    int percent; /* relative volume, which can range from -100 to 100 inclusive */
```

If a compatible keyboard extension isn’t present in the X server, XkbForceDeviceBell immediately returns False. Otherwise, XkbForceDeviceBell rings the bell as specified for the display and keyboard device and returns True. Set percent to be the volume relative to the base volume for the keyboard as described for XBell. There is no name parameter because XkbForceDeviceBell does not cause an XkbBellNotify event.

You can call XkbBell without first initializing the keyboard extension.

To ring the bell on the default keyboard, overriding user preference settings for audible bells, use XkbForceBell.

```c
Bool XkbForceBell (display, percent)
    Display * display; /* connection to the X server */
    int percent; /* volume for the bell, which can range from -100 to 100 inclusive */
```

If a compatible keyboard extension isn’t present in the X server, XkbForceBell calls XBell with the specified display and percent and returns False. Otherwise, XkbForceBell calls XkbForceDeviceBell with the specified display and percent, device_spec = XkbUseCoreKbd, bell_class = XkbDfltXIClass, bell_id = XkbDfltXIId, window = None, and name = NULL, and returns what XkbForceDeviceBell returns.

XkbForceBell does not cause an XkbBellNotify event.

You can call XkbBell without first initializing the keyboard extension.

### 9.4 Detecting Bells

Xkb generates XkbBellNotify events for all bells except for those resulting from calls to XkbForceDeviceBell and XkbForceBell. To receive XkbBellNotify events under all possible conditions, pass XkbBellNotifyMask in both the bits_to_change and values_for_bits parameters to XkbSelectEvents (see section 4.3).

The XkbBellNotify event has no event details. It is either selected or it is not. However, you can call XkbSelectEventDetails using XkbNotify as the event_type and specifying XkbAllBellNotifyMask in bits_to_change and values_for_bits. This has the same effect as a call to XkbSelectEvents.
The structure for the XkbBellNotify event type contains:

typedef struct _XkbBellNotify {
    int type;      /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time time;      /* server time when event generated */
    int xkb_type;   /* XkbBellNotify */
    unsigned int device; /* Xkb device ID, will not be XkbUseCoreKbd */
    int percent;   /* requested volume as % of max */
    int pitch;     /* requested pitch in Hz */
    int duration;  /* requested duration in microseconds */
    unsigned int bell_class; /* X input extension feedback class */
    unsigned int bell_id; /* X input extension feedback ID */
    Atom name;     /* "name" of requested bell */
    Window window; /* window associated with event */
    Bool event_only; /* False => the server did not produce a beep */
} XkbBellNotifyEvent;

If your application needs to generate visual bell feedback on the screen when it receives a bell event, use the window ID in the XkbBellNotifyEvent, if present.
10 Keyboard Controls

The Xkb extension is composed of two parts: a server extension, and a client-side X library extension. This chapter discusses functions used to modify controls effecting the behavior of the server portion of the Xkb extension. Chapter 11 discusses functions used to modify controls that affect only the behavior of the client portion of the extension; those controls are known as Library Controls.

Xkb contains control features that affect the entire keyboard, known as global keyboard controls. Some of the controls may be selectively enabled and disabled; these controls are known as the Boolean Controls. Boolean Controls can be turned on or off under program control and can also be automatically set to an on or off condition when a client program exits. The remaining controls, known as the Non-Boolean Controls, are always active. The XkbControlsRec structure describes the current state of most of the global controls and the attributes effecting the behavior of each of these Xkb features. This chapter describes the Xkb controls and how to manipulate them.

There are two possible components for each of the Boolean Controls: attributes describing how the control should work, and a state describing whether the behavior as a whole is enabled or disabled. The attributes and state for most of these controls are held in the XkbControlsRec structure (see section 10.8).

You can manipulate the Xkb controls individually, via convenience functions, or as a whole. To treat them as a group, modify an XkbControlsRec structure to describe all of the changes to be made, and then pass that structure and appropriate flags to an Xkb library function, or use a XkbControlsChangesRec (see section 10.10.1) to reduce network traffic. When using a convenience function to manipulate one control individually, you do not use an XkbControlsRec structure directly.

The Xkb controls are grouped as shown in Table 10.1.

<table>
<thead>
<tr>
<th>Type of Control</th>
<th>Control Name</th>
<th>Boolean Control?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls for enabling and disabling other controls</td>
<td>EnabledControls</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>AutoReset</td>
<td>No</td>
</tr>
<tr>
<td>Control for bell behavior</td>
<td>AudibleBell</td>
<td>Boolean</td>
</tr>
<tr>
<td>Controls for repeat key behavior</td>
<td>PerKeyRepeat</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>RepeatKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>DetectableAutorepeat</td>
<td>Boolean</td>
</tr>
<tr>
<td>Controls for keyboard overlays</td>
<td>Overlay1</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>Overlay2</td>
<td>Boolean</td>
</tr>
<tr>
<td>Controls for using the mouse from the keyboard</td>
<td>MouseKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>MouseKeysAccel</td>
<td>Boolean</td>
</tr>
<tr>
<td>Controls for better keyboard access by physically impaired persons</td>
<td>AccessXFeedback</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>AccessXKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>AccessXTimeout</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>BounceKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>SlowKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>StickyKeys</td>
<td>Boolean</td>
</tr>
<tr>
<td>Controls for general keyboard mapping</td>
<td>GroupsWrap</td>
<td>No</td>
</tr>
</tbody>
</table>
The X Keyboard Extension 10   Keyboard Controls

The individual categories and controls are described first, together with functions for manipulating them. A description of the XkbControlsRec structure and the general functions for dealing with all of the controls at once follow at the end of the chapter.

10.1 Controls that Enable and Disable Other Controls

Enable and disable the boolean controls under program control by using the Enabled-Controls control; enable and disable them upon program exit by configuring the AutoReset control.

10.1.1 The EnabledControls Control

The EnabledControls control is a bit mask where each bit that is turned on means the corresponding control is enabled, and when turned off, disabled. It corresponds to the enabledCtrls field of an XkbControlsRec structure (see section 10.8). The bits describing which controls are turned on or off are defined in Table 10.7.

Use XkbChangeEnabledControls to manipulate the EnabledControls control.

Bool XkbChangeEnabledControls(dpy, device_spec, mask, values)

The mask parameter specifies the boolean controls to be enabled or disabled, and the values mask specifies the new state for those controls. Valid values for both of these masks are composed of a bitwise inclusive OR of bits taken from the set of mask bits in Table 10.7, using only those masks with “ok” in the enabledCtrls column.

If the X server does not support a compatible version of Xkb or the Xkb extension has not been properly initialized, XkbChangeEnabledControls returns False; otherwise, it sends the request to the X server and returns True.

Note that the EnabledControls control only enables and disables controls; it does not configure them. Some controls, such as the AudibleBell control, have no configuration attributes and are therefore manipulated solely by enabling and disabling them. Others, however, have additional attributes to configure their behavior. For example, the RepeatControl control uses repeat_delay and repeat_interval fields to describe the timing behavior of keys that repeat. The RepeatControl behavior is turned on or off

---

### Table 10.1 Xkb Keyboard Controls

<table>
<thead>
<tr>
<th>Type of Control</th>
<th>Control Name</th>
<th>Boolean Control?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous per-client controls</td>
<td>IgnoreGroupLock</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>IgnoreLockMods</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>InternalMods</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>GrabsUseXKBState</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>LookupStateWhenGrab bed</td>
<td>Boolean</td>
</tr>
<tr>
<td></td>
<td>SendEventUsesXKBState</td>
<td>Boolean</td>
</tr>
</tbody>
</table>

The mask parameter specifies the boolean controls to be enabled or disabled, and the values mask specifies the new state for those controls. Valid values for both of these masks are composed of a bitwise inclusive OR of bits taken from the set of mask bits in Table 10.7, using only those masks with “ok” in the enabledCtrls column.

If the X server does not support a compatible version of Xkb or the Xkb extension has not been properly initialized, XkbChangeEnabledControls returns False; otherwise, it sends the request to the X server and returns True.

Note that the EnabledControls control only enables and disables controls; it does not configure them. Some controls, such as the AudibleBell control, have no configuration attributes and are therefore manipulated solely by enabling and disabling them. Others, however, have additional attributes to configure their behavior. For example, the RepeatControl control uses repeat_delay and repeat_interval fields to describe the timing behavior of keys that repeat. The RepeatControl behavior is turned on or off
depending on the value of the XkbRepeatKeysMask bit, but you must use other means, as described in this chapter, to configure its behavior in detail.

### 10.1.2 The AutoReset Control

You can configure the boolean controls to automatically be enabled or disabled when a program exits. This capability is controlled via two masks maintained in the X server on a per-client basis. There is no client-side Xkb data structure corresponding to these masks. Whenever the client exits for any reason, any boolean controls specified in the auto-reset mask are set to the corresponding value from the auto-reset values mask. This makes it possible for clients to “clean up after themselves” automatically, even if abnormally terminated. The bits used in the masks correspond to the EnabledControls control bits.

For example, a client that replaces the keyboard bell with some other audible cue might want to turn off the AudibleBell control to prevent the server from also generating a sound and avoid cacophony. If the client were to exit without resetting the AudibleBell control, the user would be left without any feedback at all. Setting AudibleBell in both the auto-reset mask and auto-reset values guarantees that the audible bell will be turned back on when the client exits.

To get the current values of the auto-reset controls, use XkbGetAutoResetControls.

```
Bool XkbGetAutoResetControls(dpy, auto_ctrls, auto_values)
    Display * dpy; /* connection to X server */
    unsigned int * auto_ctrls; /* specifies which bits in auto_values are relevant */
    unsigned int * auto_values; /* 1 bit => corresponding control has auto-reset on */

XkbGetAutoResetControls backfills auto_ctrls and auto_values with the AutoReset control attributes for this particular client. It returns True if successful, and False otherwise.

To change the current values of the AutoReset control attributes, use XkbSetAutoResetControls.

```

```
Bool XkbSetAutoResetControls(dpy, changes, auto_ctrls, auto_values)
    Display * dpy; /* connection to X server */
    unsigned int changes; /* controls for which to change auto-reset values */
    unsigned int * auto_ctrls; /* controls from changes that should auto reset */
    unsigned int * auto_values; /* 1 bit => auto-reset on */

XkbSetAutoResetControls changes the auto-reset status and associated auto-reset values for the controls selected by changes. For any control selected by changes, if the corresponding bit is set in auto_ctrls, the control is configured to auto-reset when the client exits. If the corresponding bit in auto_values is on, the control is turned on when the client exits; if zero, the control is turned off when the client exits. For any control selected by changes, if the corresponding bit is not set in auto_ctrls, the control is configured to not reset when the client exits. For example:

To leave the auto-reset controls for StickyKeys the way they are:

    ok = XkbSetAutoResetControls(dpy, 0, 0, 0);

To change the auto-reset controls so that StickyKeys are unaffected when the client exits:

    ok = XkbSetAutoResetControls(dpy, XkbStickyKeysMask, 0, 0);
```
To change the auto-reset controls so that StickyKeys are turned off when the client exits:

```c
ok = XkbSetAutoResetControls(dpy, XkbStickyKeysMask, XkbStickyKeysMask, 0);
```

To change the auto-reset controls so that StickyKeys are turned on when the client exits:

```c
ok = XkbSetAutoResetControls(dpy, XkbStickyKeysMask, XkbStickyKeysMask, XkbStickyKeysMask);
```

`XkbSetAutoResetControls` backfills `autoCtrls` and `autoValues` with the auto-reset controls for this particular client. Note that all of the bits are valid in the returned values, not just the ones selected in the `changes` mask.

### 10.2 Control for Bell Behavior

The X server’s generation of sounds is controlled by the AudibleBell control. Configuration of different bell sounds is discussed in Chapter 9.

#### 10.2.1 The AudibleBell Control

The AudibleBell control is a boolean control that has no attributes. As such, you may enable and disable it using either the `EnabledControls` control or the `AutoReset` control discussed in section 10.1.1. When enabled, protocol requests to generate a sound result in the X server actually producing a real sound; when disabled, requests to the server to generate a sound are ignored unless the sound is forced. See section 9.2.

### 10.3 Controls for Repeat Key Behavior

The repeating behavior of keyboard keys is governed by three controls, the PerKeyRepeat control, which is always active, and the RepeatKeys and DetectableAutorepeat controls, which are boolean controls that may be enabled and disabled. PerKeyRepeat determines which keys are allowed to repeat. RepeatKeys governs the behavior of an individual key when it is repeating. DetectableAutorepeat allows a client to detect when a key is repeating as a result of being held down.

#### 10.3.1 The PerKeyRepeat Control

The PerKeyRepeat control is a bitmask long enough to contain a bit for each key on the device; it determines which individual keys are allowed to repeat. The Xkb PerKeyRepeat control provides no functionality different from that available via the core X protocol. There are no convenience functions in Xkb for manipulating this control. The PerKeyRepeat control settings are carried in the `per_key_repeat` field of an `XkbControlsRec` structure, discussed in section 10.8.

#### 10.3.2 The RepeatKeys Control

The core protocol allows only control over whether or not the entire keyboard or individual keys should auto-repeat when held down. RepeatKeys is a boolean control that extends this capability by adding control over the delay until a key begins to repeat and the rate at which it repeats. RepeatKeys is coupled with the core auto-repeat control: when RepeatKeys is enabled or disabled, the core auto-repeat is enabled or disabled and vice versa.
Auto-repeating keys are controlled by two attributes. The first, *timeout*, is the delay after the initial press of an auto-repeating key and the first generated repeat event. The second, *interval*, is the delay between all subsequent generated repeat events. As with all boolean controls, configuring the attributes that determine how the control operates does not automatically enable the control as a whole; see section 10.1.

To get the current attributes of the RepeatKeys control for a keyboard device, use **XkbGetAutoRepeatRate**.

```c
Bool XkbGetAutoRepeatRate(display, device_spec, timeout_rtrn, interval_rtrn)
    Display * display; /* connection to X server */
    unsigned int device_spec; /* desired device ID, or XkbUseCoreKbd */
    unsigned int * timeout_rtrn; /* backfilled with initial repeat delay, ms */
    unsigned int * interval_rtrn; /* backfilled with subsequent repeat delay, ms */
```

*XkbGetAutoRepeatRate* queries the server for the current values of the RepeatControls control attributes, backfills *timeout_rtrn* and *interval_rtrn* with them, and returns True. If a compatible version of the Xkb extension is not available in the server *XkbGetAutoRepeatRate* returns False.

To set the attributes of the RepeatKeys control for a keyboard device, use **XkbSetAutoRepeatRate**.

```c
Bool XkbSetAutoRepeatRate(display, device_spec, timeout, interval)
    Display * display; /* connection to X server */
    unsigned int device_spec; /* device to configure, or XkbUseCoreKbd */
    unsigned int timeout; /* initial delay, ms */
    unsigned int interval; /* delay between repeats, ms */
```

*XkbSetAutoRepeatRate* sends a request to the X server to configure the AutoRepeat control attributes to the values specified in *timeout* and *interval*.

*XkbSetAutoRepeatRate* does not wait for a reply; it normally returns True. Specifying a zero value for either *timeout* or *interval* causes the server to generate a BadValue protocol error. If a compatible version of the Xkb extension is not available in the server, *XkbSetAutoRepeatRate* returns False.

**10.3.3 The DetectableAutorepeat Control**

Auto-repeat is the generation of multiple key events by a keyboard when the user presses a key and holds it down. Keyboard hardware and device-dependent X server software often implement auto-repeat by generating multiple KeyPress events with no intervening KeyRelease event. The standard behavior of the X server is to generate a KeyRelease event for every KeyPress event. If the keyboard hardware and device-dependent software of the X server implement auto-repeat by generating multiple KeyPress events, the device-independent part of the X server by default synthetically generates a KeyRelease event after each KeyPress event. This provides predictable behavior for X clients, but does not allow those clients to detect the fact that a key is auto-repeating.

Xkb allows clients to request detectable auto-repeat. If a client requests and the server supports DetectableAutorepeat, Xkb generates KeyRelease events only when the key is physically released. If DetectableAutorepeat is not supported or has not been requested, the server synthesizes a KeyRelease event for each repeating KeyPress event it generates.
DetectableAutorepeat, unlike the other controls in this chapter, is not contained in the XkbControlsRec structure, nor can it be enabled or disabled via the EnabledControls control. Instead, query and set DetectableAutorepeat using XkbGetDetectableAutorepeat and XkbSetDetectableAutorepeat.

DetectableAutorepeat is a condition that applies to all keyboard devices for a client’s connection to a given X server; it cannot be selectively set for some devices and not for others. For this reason, none of the Xkb library functions involving DetectableAutorepeat involve a device specifier.

To determine whether or not the server supports DetectableAutorepeat, use XkbGetDetectableAutorepeat.

```
Bool XkbGetDetectableAutorepeat(display, supported_rtrn)
    Display * display; /* connection to X server */
    Bool * supported_rtrn; /* backfilled True if DetectableAutorepeat supported */
```

XkbGetDetectableAutorepeat queries the server for the current state of DetectableAutorepeat and waits for a reply. If supported_rtrn is not NULL, it backfills supported_rtrn with True if the server supports DetectableAutorepeat, and False otherwise. XkbGetDetectableAutorepeat returns the current state of DetectableAutorepeat for the requesting client: True if DetectableAutorepeat is set, and False otherwise.

To set DetectableAutorepeat, use XkbSetDetectableAutorepeat. This request affects all keyboard activity for the requesting client only; other clients still see the expected nondetectable auto-repeat behavior, unless they have requested otherwise.

```
Bool XkbSetDetectableAutorepeat(display, detectable, supported_rtrn)
    Display * display; /* connection to X server */
    Bool detectable; /* True => set DetectableAutorepeat */
    Bool * supported_rtrn; /* backfilled True if DetectableAutorepeat supported */
```

XkbSetDetectableAutorepeat sends a request to the server to set DetectableAutorepeat on for the current client if detectable is True, and off it detectable is False; it then waits for a reply. If supported_rtrn is not NULL, XkbSetDetectableAutorepeat backfills supported_rtrn with True if the server supports DetectableAutorepeat, and False if it does not. XkbSetDetectableAutorepeat returns the current state of DetectableAutorepeat for the requesting client: True if DetectableAutorepeat is set, and False otherwise.

10.4 Controls for Keyboard Overlays (Overlay1 and Overlay2 Controls)

A keyboard overlay allows some subset of the keyboard to report alternate keycodes when the overlay is enabled. For example, a keyboard overlay can be used to simulate a numeric or editing keypad on a keyboard that does not actually have one by reusing some portion of the keyboard as an overlay. This technique is very common on portable computers and embedded systems with small keyboards.

Xkb includes direct support for two keyboard overlays, using the Overlay1 and Overlay2 controls. When Overlay1 is enabled, all of the keys that are members of the first keyboard overlay generate an alternate keycode. When Overlay2 is enabled, all of the keys that are members of the second keyboard overlay generate an alternate keycode. The two overlays are mutually exclusive; any particular key may be in at most one overlay. Overlay1 and Overlay2 are boolean controls. As such, you may enable and disable
them using either the EnabledControls control or the AutoReset control discussed in section 10.1.1.

To specify the overlay to which a key belongs and the alternate keycode it should generate when that overlay is enabled, assign it either the XkbKB_Overlay1 or XkbKB_Overlay2 key behaviors, as described in section 16.2.

10.5 Controls for Using the Mouse from the Keyboard

Using Xkb, it is possible to configure the keyboard to allow simulation of the X pointer device. This simulation includes both movement of the pointer itself and press and release events associated with the buttons on the pointer. Two controls affect this behavior: the MouseKeys control determines whether or not simulation of the pointer device is active, as well as configuring the default button; the MouseKeysAccel control determines the movement characteristics of the pointer when simulated via the keyboard. Both of them are boolean controls; as such, you may enable and disable them using either the EnabledControls control or the AutoReset control discussed in section 10.1.1. The individual keys that simulate different aspects of the pointer device are determined by the keyboard mapping, discussed in Chapter 16.

10.5.1 The MouseKeys Control

The MouseKeys control allows a user to control all the mouse functions from the keyboard. When MouseKeys are enabled, all keys with MouseKeys actions bound to them generate core pointer events instead of normal KeyPress and KeyRelease events.

The MouseKeys control has a single attribute, mk_dflt_btn that specifies the core button number to be used by mouse keys actions that do not explicitly specify a button. There is no convenience function for getting or setting the attribute; instead use XkbGetControls and XkbSetControls (see sections 10.9 and 10.10).

Note MouseKeys can also be turned on and off by pressing the key combination necessary to produce an XK_Po�er_EnableKeys keysym. The de facto default standard for this is Shift+Alt+NumLock, but this may vary depending on the keymap.

10.5.2 The MouseKeysAccel Control

When the MouseKeysAccel control is enabled, the effect of a key-activated pointer motion action changes as a key is held down. If the control is disabled, pressing a mouse-pointer key yields one mouse event. When MouseKeysAccel is enabled, mouse movement is defined by an initial distance specified in the XkbSA_MovePtr action and the following fields in the XkbControlsRec structure (see section 10.8).

<table>
<thead>
<tr>
<th>Field</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>mk_delay</td>
<td>Time (ms) between the initial key press and the first repeated motion event</td>
</tr>
<tr>
<td>mk_interval</td>
<td>Time (ms) between repeated motion events</td>
</tr>
<tr>
<td>mk_time_to_max</td>
<td>Number of events (count) before the pointer reaches maximum speed</td>
</tr>
<tr>
<td>mk_max_speed</td>
<td>The maximum speed (in pixels per event) the pointer reaches</td>
</tr>
<tr>
<td>mk_curve</td>
<td>The ramp used to reach maximum pointer speed</td>
</tr>
</tbody>
</table>

Table 10.2 MouseKeysAccel Fields
There are no convenience functions to query or change the attributes of the MouseKeysAccel control; instead use XkbGetControls and XkbSetControls (see sections 10.9 and 10.10).

The effects of the attributes of the MouseKeysAccel control depend on whether the XkbSA_MovePtr action (see section 16.1) specifies relative or absolute pointer motion.

**Absolute Pointer Motion**

If an XkbSA_MovePtr action specifies an absolute position for one of the coordinates but still allows acceleration, all repeated events contain any absolute coordinates specified in the action. For example, if the XkbSA_MovePtr action specifies an absolute position for the X direction, but a relative motion for the Y direction, the pointer accelerates in the Y direction, but stays at the same X position.

**Relative Pointer Motion**

If the XkbSA_MovePtr action specifies relative motion, the initial event always moves the cursor the distance specified in the action. After mk_delay milliseconds, a second motion event is generated, and another occurs every mk_interval milliseconds until the user releases the key.

Between the time of the second motion event and mk_time_to_max intervals, the change in pointer distance per interval increases with each interval. After mk_time_to_max intervals have elapsed, the change in pointer distance per interval remains the same and is calculated by multiplying the original distance specified in the action by mk_max_speed.

For example, if the XkbSA_MovePtr action specifies a relative motion in the X direction of 5, mk_delay=160, mk_interval=40, mk_time_to_max=30, and mk_max_speed=30, the following happens when the user presses the key:

- The pointer immediately moves 5 pixels in the X direction when the key is pressed.
- After 160 milliseconds (mk_delay), and every 40 milliseconds thereafter (mk_interval), the pointer moves in the X direction.
- The distance in the X direction increases with each interval until 30 intervals (mk_time_to_max) have elapsed.
- After 30 intervals, the pointer stops accelerating, and moves 150 pixels (mk_max_speed * the original distance) every interval thereafter, until the key is released.

The increase in pointer difference for each interval is a function of mk_curve. Events after the first but before maximum acceleration has been achieved are accelerated according to the formula:

\[
d(\text{step}) = \text{action\_delta} \times \left( \frac{\text{max\_accel}}{\text{steps\_to\_max}\cdot\text{curveFactor}} \right) \times \text{steps\_to\_max}\cdot\text{curveFactor}
\]

Where action_delta is the relative motion specified by the XkbSA_MovePtr action, mk_max_speed and mk_time_to_max are parameters to the MouseKeysAccel control, and the curveFactor is computed using the MouseKeysAccel mk_curve parameter as follows:

\[
\text{curveFactor}(\text{curve}) = 1 + \frac{\text{curve}}{1000}
\]
With the result that a \textit{mk\_curve} of zero causes the distance moved to increase linearly from \textit{action\_delta} to \((\text{mk\_max\_speed} \times \text{action\_delta})\). A negative \textit{mk\_curve} causes an initial sharp increase in acceleration that tapers off, and a positive curve yields a slower initial increase in acceleration followed by a sharp increase as the number of pointer events generated by the action approaches \textit{mk\_time\_to\_max}. The legal values for \textit{mk\_curve} are between -1000 and 1000.

A distance vs. time graph of the pointer motion is shown in Figure 10.1.

![Figure 10.1 MouseKeys Acceleration](image)

**Figure 10.1 MouseKeys Acceleration**

### 10.6 Controls for Better Keyboard Access by Physically Impaired Persons

The Xkb extension includes several controls specifically aimed at making keyboard use more effective for physically impaired people. All of these controls are boolean controls and may be individually enabled and disabled, as well as configured to tune their specific behavior. The behavior of these controls is based on the AccessDOS package\(^1\).

---

\(^1\) AccessDOS provides access to the DOS operating system for people with physical impairments and was developed by the Trace R&D Center at the University of Wisconsin. For more information on AccessDOS, contact the Trace R&D Center, Waisman Center and Department of Industrial Engineering, University of Wisconsin-Madison WI 53705-2280. Phone: 608-262-6966, e-mail: info@trace.wisc.edu.
10.6.1 The AccessXKeys Control

Enabling or disabling the keyboard controls through a graphical user interface may be impossible for people who need to use the controls. For example, a user who needs SlowKeys (see section 10.6.6) may not even be able to start the graphical application, let alone use it, if SlowKeys is not enabled. To allow easier access to some of the controls, the AccessXKeys control provides a set of special key sequences similar to those available in AccessDOS.

When the AccessXKeys control is enabled, the user can turn controls on or off from the keyboard by entering the following standard key sequences:

- Holding down a shift key by itself for eight seconds toggles the SlowKeys control.
- Pressing and releasing the left or right Shift key five times in a row, without any intervening key events and with less than 30 seconds delay between consecutive presses, toggles the state of the StickyKeys control.
- Simultaneously operating two or more modifier keys deactivates the StickyKeys control.

When the AccessXKeys control is disabled, Xkb does not look for the above special key sequences.

Some of these key sequences optionally generate audible feedback of the change in state, as described in section 10.6.3, or XkbControlsNotify events, described in section 10.11.

10.6.2 The AccessXTimeout Control

In environments where computers are shared, features such as SlowKeys present a problem: if SlowKeys is on, the keyboard can appear to be unresponsive because keys are not accepted until they are held for a certain period of time. To help solve this problem, Xkb provides an AccessXTimeout control to automatically change the enabled/disabled state of any boolean controls and to change the value of the AccessXKeys and AccessXFeedback control attributes if the keyboard is idle for a specified period of time.

When a timeout as specified by AccessXTimeout occurs and a control is consequently modified, Xkb generates an XkbControlsNotify event. For more information on XkbControlsNotify events, refer to section 10.11.

Use XkbGetAccessXTimeout to query the current AccessXTimeout options for a keyboard device.

Bool XkbGetAccessXTimeout(display, device_spec, timeout_rtrn, ctrls_mask_rtrn, ctrls_values_rtrn, opts_mask_rtrn, opts_values_rtrn)

XkbGetAccessXTimeout sends a request to the X server to obtain the current values for the AccessXTimeout attributes, waits for a reply, and backfills the values into the appropriate arguments. The parameters opts_mask_rtrn and opts_values_rtrn are backfilled with...
the options to modify and the values for `ax_options`, which is a field in the `XkbControlsRec` structure (see section 10.8). `XkbGetAccessXTimeout` returns `True` if successful; if a compatible version of the Xkb extension is not available in the server, `XkbGetAccessXTimeout` returns `False`.

To configure the `AccessXTimeout` options for a keyboard device, use `XkbSetAccessXTimeout`.

```c
Bool XkbSetAccessXTimeout(display, device_spec, timeout, ctrls_mask, ctrls_values, 
                          opts_mask, opts_values)
```

- `Display * display; /* connection to X server */`
- `unsigned int device_spec; /* device to configure, or XkbUseCoreKbd */`
- `unsigned short timeout; /* seconds idle until AccessXTimeout occurs */`
- `unsigned int ctrls_mask; /* boolean controls to modify */`
- `unsigned int ctrls_values; /* new bits for controls selected by ctrls_mask */`
- `unsigned short opts_mask; /* ax_options to change */`
- `unsigned short opts_values; /* new bits for ax_options selected by opts_mask */`

`timeout` specifies the number of seconds the keyboard must be idle before the controls are modified. `ctrls_mask` specifies what controls are to be enabled or disabled, and `ctrls_values` specifies whether those controls are to be enabled or disabled. The bit values correspond to those for enabling and disabling boolean controls (see section 10.1.1). The `opts_mask` field specifies which attributes of the `AccessXKeys` and `AccessXFeedback` controls are to be changed, and `opts_values` specifies the new values for those options. The bit values correspond to those for the `ax_options` field of an `XkbDescRec` (see section 10.8).

`XkbSetAccessXTimeout` sends a request to configure the `AccessXTimeout` control to the server. It does not wait for a reply, and normally returns `True`. If a compatible version of the Xkb extension is not available in the server, `XkbSetAccessXTimeout` returns `False`.

### 10.6.3 The AccessXFeedback Control

Just as some keyboards can produce keyclicks to indicate when a key is pressed or repeating, Xkb can provide feedback for the controls by using special beep codes. Use the `AccessXFeedback` control to configure the specific types of operations that generate feedback.

There is no convenience function for modifying the `AccessXFeedback` control, although the feedback as a whole can be enabled or disabled just as other boolean controls are (see section 10.1). Individual beep codes are turned on or off by modifying the following bits in the `ax_options` field of an `XkbControlsRec` structure and using `XkbSetControls` (see section 10.10):

<table>
<thead>
<tr>
<th>Action</th>
<th>Beep Code</th>
<th>ax_options bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED turned on</td>
<td>High-pitched beep</td>
<td><code>XkbAX_IndicatorFBMask</code></td>
</tr>
<tr>
<td>LED turned off</td>
<td>Low-pitched beep</td>
<td><code>XkbAX_IndicatorFBMask</code></td>
</tr>
<tr>
<td>More than one LED changed state</td>
<td>Two high-pitched beeps</td>
<td><code>XkbAX_IndicatorFBMask</code></td>
</tr>
<tr>
<td>Control turned on</td>
<td>Rising tone</td>
<td><code>XkbAX_FeatureFBMask</code></td>
</tr>
<tr>
<td>Control turned off</td>
<td>Falling tone</td>
<td><code>XkbAX_FeatureFBMask</code></td>
</tr>
<tr>
<td>More than one control changed state</td>
<td>Two high-pitched beeps</td>
<td><code>XkbAX_FeatureFBMask</code></td>
</tr>
</tbody>
</table>
Implementations that cannot generate continuous tones may generate multiple beeps instead of falling and rising tones; for example, they can generate a high-pitched beep followed by a low-pitched beep instead of a continuous falling tone. Other implementations can only ring the bell with one fixed pitch. In these cases, use the \texttt{XkbAX\_DumbBellFBMask} bit of \texttt{ax\_options} to indicate that the bell can only ring with a fixed pitch.

When any of the above feedbacks occur, Xkb may generate a \texttt{Xkb\_Bell\_Notify} event (see section 9.4).

### 10.6.4 AccessXNotify Events

The server can generate \texttt{XkbAccessX\_Notify} events for some of the global keyboard controls. The structure for the \texttt{XkbAccessX\_Notify} event type is as follows:

\begin{verbatim}
typedef struct {
  int type; /* Xkb extension base event code */
  unsigned long serial; /* X server serial number for event */
  Bool send_event; /* True => synthetically generated */
  Display * display; /* server connection where event generated */
  Time time; /* server time when event generated */
  int xkb_type; /* XkbAccessX\_Notify */
  int device; /* Xkb device ID, will not be XkbUseCoreKbd */
  int detail; /* XkbAXN\_* */
  KeyCode keycode; /* key of event */
  int slowKeysDelay; /* current SlowKeys delay */
  int debounceDelay; /* current debounce delay */
} XkbAccessXNotifyEvent;
\end{verbatim}

The \texttt{detail} field describes what AccessX event just occurred and can be any of the values in Table 10.4.

\begin{table}[h]
\centering
\begin{tabular}{ll}
\hline
\textbf{detail} & \textbf{Reason} \\
\hline
\texttt{XkbAXN\_SKPress} & A key was pressed when SlowKeys was enabled. \\
\texttt{XkbAXN\_SKAccept} & A key was accepted (held longer than the SlowKeys delay). \\
\texttt{XkbAXN\_SKReject} & An accepted SlowKeys key was released. \\
\texttt{XkbAXN\_SKRelease} & A key was rejected (released before the SlowKeys delay expired). \\
\end{tabular}
\caption{AccessX\_Notify Events}
\end{table}
The keycode field reports the keycode of the key for which the event occurred. If the action is related to SlowKeys, the slowKeysDelay field contains the current SlowKeys acceptance delay. If the action is related to BounceKeys, the debounceDelay field contains the current BounceKeys debounce delay.

Selecting for AccessX Events

To receive XkbAccessXNotify events under all possible conditions, use XkbSelectEvents (see section 4.3) and pass XkbAccessXNotifyMask in both bits_to_change and values_for_bits.

To receive XkbStateNotify events only under certain conditions, use XkbSelectEventDetails using XkbAccessXNotify as the event_type and specifying the desired state changes in bits_to_change and values_for_bits using mask bits from Table 10.5.

<table>
<thead>
<tr>
<th>Table 10.5 AccessXNotify Event Details</th>
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</thead>
<tbody>
<tr>
<td>XkbAccessXNotify Event Details Value</td>
</tr>
<tr>
<td>XkbAXN_SKPressMask (1&lt;&lt;0)</td>
</tr>
<tr>
<td>XkbAXN_SKAceptMask (1&lt;&lt;1)</td>
</tr>
<tr>
<td>XkbAXN_SKRejectMask (1&lt;&lt;2)</td>
</tr>
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<td>XkbAXN_SKReleaseMask (1&lt;&lt;3)</td>
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<td>XkbAXN_BKAcceptMask (1&lt;&lt;4)</td>
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<tr>
<td>XkbAXN_BKRejectMask (1&lt;&lt;5)</td>
</tr>
<tr>
<td>XkbAXN_AXKWarningMask (1&lt;&lt;6)</td>
</tr>
<tr>
<td>XkbAXN_AllEventsMask (0x7f)</td>
</tr>
</tbody>
</table>

10.6.5 StickyKeys, RepeatKeys, and MouseKeys Events

The StickyKeys, RepeatKeys, and MouseKeys controls do not generate specific events. Instead, the latching, unlatching, locking, or unlocking of modifiers using StickyKeys generates XkbStateNotify events as described in section 5.4. Repeating keys generate normal KeyPress and KeyRelease events, though the auto-repeat can be detected using DetectableAutorepeat (see section 10.3.3). Finally, MouseKeys generates pointer events identical to those of the core pointer device.

10.6.6 The SlowKeys Control

Some users may accidentally bump keys while moving a hand or typing stick toward the key they want. Usually, the keys that are accidentally bumped are just hit for a very short period of time. The SlowKeys control helps filter these accidental bumps by telling the server to wait a specified period, called the SlowKeys acceptance delay, before delivering key events. If the key is released before this period elapses, no key events are generated. Users can then bump any number of keys on their way to the one they want without accidentally getting those characters. Once they have reached the key they want, they can then
hold the desired key long enough for the computer to accept it. SlowKeys is a boolean control with one configurable attribute.

When the SlowKeys control is active, the server reports the initial key press, subsequent acceptance or rejection, and release of any key to interested clients by sending an appropriate AccessXNotify event (see section 10.6.4).

To get the SlowKeys acceptance delay for a keyboard device, use XkbGetSlowKeysDelay.

**Bool XkbGetSlowKeysDelay(display, device_spec, delay_rtrn)**

Display * display; /* connection to X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int * delay_rtrn; /* backfilled with SlowKeys delay, ms */

XkbGetSlowKeysDelay requests the attributes of the SlowKeys control from the server, waits for a reply and backfills delay_rtrn with the SlowKeys delay attribute. XkbGetSlowKeysDelay returns True if successful; if a compatible version of the Xkb extension is not available in the server, XkbGetSlowKeysDelay returns False.

To set the SlowKeys acceptance delay for a keyboard device, use XkbSetSlowKeysDelay.

**Bool XkbSetSlowKeysDelay(display, device_spec, delay)**

Display * display; /* connection to X server */
unsigned int device_spec; /* device to configure, or XkbUseCoreKbd */
unsigned int delay; /* SlowKeys delay, ms */

XkbSetSlowKeysDelay sends a request to configure the SlowKeys control to the server. It does not wait for a reply, and normally returns True. Specifying a value of 0 for the delay parameter causes XkbSetSlowKeys to generate a BadValue protocol error. If a compatible version of the Xkb extension is not available in the server XkbSetSlowKeysDelay returns False.

### 10.6.7 The BounceKeys Control

Some users may accidentally “bounce” on a key when they release it. They press it once, then accidentally press it again after they release it. The BounceKeys control temporarily disables a key after it has been pressed, effectively “debouncing” the keyboard. The period of time the key is disabled after it is released is known as the BounceKeys delay. BounceKeys is a boolean control.

When the BounceKeys control is active, the server reports acceptance or rejection of any key to interested clients by sending an appropriate AccessXNotify event (see section 10.6.4).

Use XkbGetBounceKeysDelay to query the current BounceKeys delay for a keyboard device.

**Bool XkbGetBounceKeysDelay(display, device_spec, delay_rtrn)**

Display * display; /* connection to X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int * delay_rtrn; /* backfilled with bounce keys delay, ms */

XkbGetBounceKeysDelay requests the attributes of the BounceKeys control from the server, waits for a reply, and backfills delay_rtrn with the BounceKeys delay attribute.
The X Keyboard Extension returns True if successful; if a compatible version of the Xkb
extension is not available in the server, XkbGetSlowKeysDelay returns False.

To set the Bounce Keys delay for a keyboard device, use XkbSetBounceKeysDelay.

Bool XkbSetBounceKeysDelay(display, device_spec, delay)
    Display * display; /* connection to X server */
    unsigned int device_spec; /* device to configure, or XkbUseCoreKbd */
    unsigned int delay; /* bounce keys delay, ms */

XkbSetBounceKeysDelay sends a request to configure the BounceKeys control to the
server. It does not wait for a reply and normally returns True. Specifying a value of zero
for the delay parameter causes XkbSetBounceKeysDelay to generate a BadValue protocol
error. If a compatible version of the Xkb extension is not available in the server, XkbSetBounceKeysDelay returns False.

10.6.8 The StickyKeys Control

Some people find it difficult or even impossible to press two keys at once. For example, a
one-fingered typist or someone using a mouth stick cannot press the Shift and 1 keys at the
same time. The StickyKeys control solves this problem by changing the behavior of the
modifier keys. With StickyKeys, the user can first press a modifier, release it, then press
another key. For example, to get an exclamation point on a PC-style keyboard, the user
can press the Shift key, release it, and then press the 1 key.

StickyKeys also allows users to lock modifier keys without requiring special locking
keys. When StickyKeys is enabled, a modifier is latched when the user presses it just
once. The user can press a modifier twice in a row to lock it, and then unlock it by pressing
it one more time.

When a modifier is latched, it becomes unlatched when the user presses a nonmodifier key
or a pointer button. For instance, to enter the sequence Shift+Control+Z the user could
press and release the Shift key to latch it, then press and release the Control key to latch it,
and finally press and release the Z key. Because the Control key is a modifier key, pressing
it does not unlatch the Shift key. Thus, after the user presses the Control key, both the
Shift and Control modifiers are latched. When the user presses the Z key, the effect is
as though the user had pressed Shift+Control+Z. In addition, because the Z key is not
a modifier key, the Shift and Control modifiers are unlatched.

Locking a modifier key means that the modifier affects any key or pointer button the user
presses until the user unlocks it or it is unlocked programmatically. For example, to enter
the sequence ("XKB") on a keyboard where '(' is a shifted '9', ')' is a shifted '0', and '¨'
is a shifted single quote, the user could press and release the Shift key twice to lock the
Shift modifier. Then, when the user presses the 9, ' ', x, k, b, ' ', and 0 keys in sequence, it
generates ("XKB"). To unlock the Shift modifier, the user can press and release the Shift
key.

StickyKeys is a boolean control with two separate attributes that may be individually
configured: one to automatically disable it, and one to control the latching behavior of
modifier keys.
StickyKeys Options

The StickyKeys control has two options that can be accessed via the `ax_options` of an `XkbControlsRec` structure (see section 10.8). The first option, TwoKeys, specifies whether StickyKeys should automatically turn off when two keys are pressed at the same time. This feature is useful for shared computers so people who do not want them do not need to turn StickyKeys off if a previous user left StickyKeys on. The second option, LatchToLock, specifies whether or not StickyKeys locks a modifier when pressed twice in a row.

Use `XkbGetStickyKeysOptions` to query the current StickyKeys attributes for a keyboard device.

```c
Bool XkbGetStickyKeysOptions(display, device_spec, options_rtrn)
    Display * display; /* connection to X server */
    unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
    unsigned int * options_rtrn; /* backfilled with StickyKeys option mask */
```

`XkbGetStickyKeysOptions` requests the attributes of the StickyKeys control from the server, waits for a reply, and backfills `options_rtrn` with a mask indicating whether the individual StickyKeys options are on or off. Valid bits in `options_rtrn` are:

- `XkbAX_TwoKeysMask`
- `XkbAX_LatchToLockMask`

`XkbGetStickyKeysOptions` returns True if successful; if a compatible version of the Xkb extension is not available in the server, `XkbGetStickyKeysOptions` returns False.

To set the StickyKeys attributes for a keyboard device, use `XkbSetStickyKeysOptions`.

```c
Bool XkbSetStickyKeysOptions(display, device_spec, mask, values)
    Display * display; /* connection to X server */
    unsigned int device_spec; /* device to configure, or XkbUseCoreKbd */
    unsigned int mask; /* selects StickyKeys attributes to modify */
    unsigned int values; /* values for selected attributes */
```

`XkbSetStickyKeysOptions` sends a request to configure the StickyKeys control to the server. It does not wait for a reply and normally returns True. The valid bits to use for both the `mask` and `values` parameters are:

- `XkbAX_TwoKeysMask`
- `XkbAX_LatchToLockMask`

If a compatible version of the Xkb extension is not available in the server, `XkbSetStickyKeysOptions` returns False.

10.7 Controls for General Keyboard Mapping

There are several controls that apply to the keyboard mapping in general. They control handling of out-of-range group indices and how modifiers are processed and consumed in the server. These are:

- `GroupsWrap`
- `IgnoreGroupLock`
- `IgnoreLockMods`
- `InternalMods`
IgnoreGroupLock is a boolean control; the rest are always active.

Without the modifier processing options provided by Xkb, passive grabs set via translations in a client (for example, Alt<KeyPress>space) do not trigger if any modifiers other than those specified by the translation are set. This results in problems in the user interface when either NumLock or a secondary keyboard group is active. The IgnoreLockMods and IgnoreGroupLock controls make it possible to avoid this behavior without exhaustively specifying a grab for every possible modifier combination.

10.7.1 The GroupsWrap Control

The GroupsWrap control determines how illegal groups are handled on a global basis. There are a number of valid keyboard sequences that can cause the effective group number to go out of range. When this happens, the group must be normalized back to a valid number. The GroupsWrap control specifies how this is done.

When dealing with group numbers, all computations are done using the group index, which is the group number minus one. There are three different algorithms; the GroupsWrap control specifies which one is used:

- **XkbRedirectIntoRange**
  All invalid group numbers are converted to a valid group number by taking the last four bits of the GroupsWrap control and using them as the group index. If the result is still out of range, Group one is used.

- **XkbClampIntoRange**
  All invalid group numbers are converted to the nearest valid group number. Group numbers larger than the highest supported group number are mapped to the highest supported group; those less than one are mapped to group one.

- **XkbWrapIntoRange**
  All invalid group numbers are converted to a valid group number using integer modulus applied to the group index.

There are no convenience functions for manipulating the GroupsWrap control. Manipulate the GroupsWrap control via the groups_wrap field in the XkbControlsRec structure, then use XkbSetControls and XkbGetControls (see section 10.9 and section 10.10) to query and change this control.

**Note** See also section 15.3.2 or a discussion of the related field, group_info, which also normalizes a group under certain circumstances.

10.7.2 The IgnoreLockMods Control

The core protocol does not provide a way to exclude specific modifiers from grab calculations, with the result that locking modifiers sometimes have unanticipated side effects.

The IgnoreLockMods control specifies modifiers that should be excluded from grab calculations. These modifiers are also not reported in any core events except KeyPress and KeyRelease events that do not activate a passive grab and that do not occur while a grab is active.
Manipulate the $\text{IgnoreLockMods}$ control via the $\text{ignore\_lock}$ field in the $\text{XkbControlsRec}$ structure, then use $\text{XkbSetControls}$ and $\text{XkbGetControls}$ (see sections 10.9 and 10.10) to query and change this control. Alternatively, use $\text{XkbSetIgnoreLockMods}$.

To set the modifiers that, if locked, are not to be reported in matching events to passive grabs, use $\text{XkbSetIgnoreLockMods}$.

### 10.7.3 The $\text{IgnoreGroupLock}$ Control

The $\text{IgnoreGroupLock}$ control is a boolean control with no attributes. If enabled, it specifies that the locked state of the keyboard group should not be considered when activating passive grabs.

Because $\text{IgnoreGroupLock}$ is a boolean control with no attributes, use the general boolean controls functions (see section 10.1) to change its state.

### 10.7.4 The $\text{InternalMods}$ Control

The core protocol does not provide any means to prevent a modifier from being reported in events sent to clients; $\text{Xkb}$, however makes this possible via the $\text{InternalMods}$ control. It specifies modifiers that should be consumed by the server and not reported to clients. When a key is pressed and a modifier that has its bit set in the $\text{InternalMods}$ control is reported to the server, the server uses the modifier when determining the actions to apply for the key. The server then clears the bit, so it is not actually reported to the client. In addition, modifiers specified in the $\text{InternalMods}$ control are not used to determine grabs and are not used to calculate core protocol compatibility state.
Manipulate the `InternalMods` control via the `internal` field in the `XkbControlsRec` structure, using `XkbSetControls` and `XkbGetControls` (see sections 10.9 and 10.10). Alternatively, use `XkbSetServerInternalMods`.

To set the modifiers that are consumed by the server before events are delivered to the client, use `XkbSetServerInternalMods`.

```
Bool XkbSetServerInternalMods(display, device_spec, affect_real, real_values, affect_virtual, virtual_values)
Display * display; /* connection to the X server */
unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
unsigned int affect_real; /* mask of real modifiers affected by this call */
unsigned int real_values; /* values for affected real modifiers (1=>set, 0=>unset) */
unsigned int affect_virtual; /* mask of virtual modifiers affected by this call */
unsigned int virtual_values; /* values for affected virtual modifiers (1=>set, 0=>unset) */
```

`XkbSetServerInternalMods` sends a request to the server to change the internal modifiers consumed by the server. `affect_real` and `real_values` are masks of real modifier bits indicating which real modifiers are to be added and removed from the server’s internal modifiers control. Modifiers selected by both `affect_real` and `real_values` are added to the server’s internal modifiers control; those selected by `affect_real` but not by `real_values` are removed from the server’s internal modifiers mask. Valid values for `affect_real` and `real_values` consist of any combination of the eight core modifier bits: ShiftMask, LockMask, ControlMask, Mod1Mask - Mod5Mask. `affect_virtual` and `virtual_values` are masks of virtual modifier bits indicating which virtual modifiers are to be added and removed from the server’s internal modifiers control. Modifiers selected by both `affect_virtual` and `virtual_values` are added to the server’s internal modifiers control; those selected by `affect_virtual` but not by `virtual_values` are removed from the server’s internal modifiers control. See section 7.1 for a discussion of virtual modifier masks to use in `affect_virtual` and `virtual_values`. `XkbSetServerInternalMods` does not wait for a reply from the server. It returns `True` if the request was sent and `False` otherwise.

### 10.8 The `XkbControlsRec` Structure

Many of the individual controls described in sections 10.1 through 10.7 may be manipulated via convenience functions discussed in those sections. Some of them, however, have no convenience functions. The `XkbControlsRec` structure allows the manipulation of one or more of the controls in a single operation and to track changes to any of them in conjunction with the `XkbGetControls` and `XkbSetControls` functions. This is the only way to manipulate those controls that have no convenience functions.

The `XkbControlsRec` structure is defined as follows:

```c
#define XkbMaxLegalKeyCode 255
#define XkbPerKeyBitArraySize ((XkbMaxLegalKeyCode+1)/8)
typedef struct {
    unsigned char mk_dflt_btn; /* default button for keyboard driven mouse */
    unsigned char num_groups; /* number of keyboard groups */
    unsigned char groups_wrap; /* how to wrap out-of-bounds groups */
    XkbModsRec internal; /* defines server internal modifiers */
    XkbModsRec ignore_lock; /* modifiers to ignore when checking for grab */
    unsigned int enabledCtrls; /* 1 bit => corresponding boolean control enabled */
} XkbControlsRec;
```
The general-purpose functions that work with the `XkbControlsRec` structure use a mask to specify which controls are to be manipulated. Table 10.6 lists these controls, the masks used to select them in the general function calls (which parameter), and the data fields in the `XkbControlsRec` structure that comprise each of the individual controls. Also listed are the bit used to turn boolean controls on and off and the section where each control is described in more detail.

### Table 10.6 Xkb Controls

<table>
<thead>
<tr>
<th>Control</th>
<th>Control Selection Mask (which parameter)</th>
<th>Relevant XkbControlsRec Data Fields</th>
<th>Boolean Control enabled_ctrls bit</th>
<th>Section</th>
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</thead>
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<td>ax_options:</td>
<td>XkbAccessXFeedbackMask</td>
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<tr>
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<td></td>
<td>XkbAX_*FBMask</td>
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<tr>
<td>AccessXKeys</td>
<td>XkbAccessXKeysMask</td>
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<td>XkbAccessXKeysMask</td>
<td>10.6.1</td>
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<tr>
<td>AccessXTimeout</td>
<td>XkbAccessXTimeoutMask</td>
<td>ax_timeout</td>
<td>XkbAccessXTimeoutMask</td>
<td>10.6.2</td>
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<td>ax_time</td>
<td>XkbAccessXTimeoutMask</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>axt_ctrls_values</td>
<td>XkbAccessXTimeoutMask</td>
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<td>AudibleBell</td>
<td></td>
<td></td>
<td>XkbAudibleBellMask</td>
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<tr>
<td>AutoReset</td>
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<tr>
<td>BounceKeys</td>
<td>XkbBounceKeysMask</td>
<td>debounce_delay</td>
<td>XkbBounceKeysMask</td>
<td>10.6.7</td>
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<tr>
<td>Detectable-Autorepeat</td>
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<td>EnabledControls</td>
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<td>GroupsWrap</td>
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<td>IgnoreLockMods</td>
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<td>MouseKeys</td>
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<td></td>
<td></td>
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<td>10.5.1</td>
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</tbody>
</table>
Table 10.7 shows the actual values for the individual mask bits used to select controls for modification and to enable and disable the control. Note that the same mask bit is used to specify general modifications to the parameters used to configure the control (which), and to enable and disable the control (enabled_ctrls). The anomalies in the table (no “ok” in column) are for controls that have no configurable attributes; and for controls that are not boolean controls and therefore cannot be enabled or disabled.

### Table 10.6 Xkb Controls

<table>
<thead>
<tr>
<th>Control</th>
<th>Control Selection Mask</th>
<th>Relevant XkbControlsRec Data Fields</th>
<th>Boolean Control enabled_ctrls bit</th>
<th>Section</th>
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<tr>
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<td>XkbAX_LatchToLockMask</td>
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</tbody>
</table>

Table 10.7 shows the actual values for the individual mask bits used to select controls for modification and to enable and disable the control. Note that the same mask bit is used to specify general modifications to the parameters used to configure the control (which), and to enable and disable the control (enabled_ctrls). The anomalies in the table (no “ok” in column) are for controls that have no configurable attributes; and for controls that are not boolean controls and therefore cannot be enabled or disabled.

### Table 10.7 Controls Mask Bits

<table>
<thead>
<tr>
<th>Mask Bit</th>
<th>which or changed_ctrls</th>
<th>enabled_ctrls</th>
<th>Value</th>
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</thead>
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<tr>
<td>XkbRepeatKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;0)</td>
</tr>
<tr>
<td>XkbSlowKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;1)</td>
</tr>
<tr>
<td>XkbBounceKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;2)</td>
</tr>
<tr>
<td>XkbStickyKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;3)</td>
</tr>
<tr>
<td>XkbMouseKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;4)</td>
</tr>
<tr>
<td>XkbMouseKeysAccelMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;5)</td>
</tr>
<tr>
<td>XkbAccessXKeysMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;6)</td>
</tr>
<tr>
<td>XkbAccessXTtimeoutMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;7)</td>
</tr>
<tr>
<td>XkbAccessXFeedbackMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;8)</td>
</tr>
<tr>
<td>XkbAudibleBellMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;9)</td>
</tr>
<tr>
<td>XkbOverlay1Mask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;10)</td>
</tr>
<tr>
<td>XkbOverlay2Mask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;11)</td>
</tr>
<tr>
<td>XkbIgnoreGroupLockMask</td>
<td>ok</td>
<td>ok</td>
<td>(1L&lt;&lt;12)</td>
</tr>
<tr>
<td>XkbGroupsWrapMask</td>
<td>ok</td>
<td></td>
<td>(1L&lt;&lt;27)</td>
</tr>
<tr>
<td>XkbInternalModsMask</td>
<td>ok</td>
<td></td>
<td>(1L&lt;&lt;28)</td>
</tr>
<tr>
<td>XkbIgnoreLockModsMask</td>
<td>ok</td>
<td></td>
<td>(1L&lt;&lt;29)</td>
</tr>
<tr>
<td>XkbPerKeyRepeatMask</td>
<td>ok</td>
<td></td>
<td>(1L&lt;&lt;30)</td>
</tr>
<tr>
<td>XkbControlsEnabledMask</td>
<td>ok</td>
<td></td>
<td>(1L&lt;&lt;31)</td>
</tr>
<tr>
<td>XkbAccessXOptionsMask</td>
<td>ok</td>
<td>ok</td>
<td>(XkbStickyKeysMask</td>
</tr>
</tbody>
</table>
The individual fields of the `XkbControlsRec` structure are defined as follows.

**mk_dflt_btn**

`mk_dflt_btn` is an attribute of the `MouseKeys` control (see section 10.5). It specifies the mouse button number to use for keyboard simulated mouse button operations. Its value should be one of the core symbols `Button1` - `Button5`.

**num_groups**

`num_groups` is not a part of any control, but is reported in the `XkbControlsRec` structure whenever any of its components are fetched from the server. It reports the number of groups the particular keyboard configuration uses and is computed automatically by the server whenever the keyboard mapping changes.

**groups_wrap**

`groups_wrap` is an attribute of the `GroupsWrap` control (see section 10.7.1). It specifies the handling of illegal groups on a global basis. Valid values for `groups_wrap` are shown in Table 10.8.

<table>
<thead>
<tr>
<th><code>groups_wrap</code> symbolic name</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>XkbWrapIntoRange</code></td>
<td>(0x00)</td>
</tr>
<tr>
<td><code>XkbClampIntoRange</code></td>
<td>(0x40)</td>
</tr>
<tr>
<td><code>XkbRedirectIntoRange</code></td>
<td>(0x80)</td>
</tr>
</tbody>
</table>

When `groups_wrap` is set to `XkbRedirectIntoRange`, its four low-order bits specify the index of the group to use.

**internal**

`internal` is an attribute of the `InternalMods` control (see section 10.7.4). It specifies modifiers to be consumed in the server and not passed on to clients when events are reported. Valid values consist of any combination of the eight core modifier bits: `ShiftMask`, `LockMask`, `ControlMask`, `Mod1Mask` - `Mod5Mask`.

**ignore_lock**

`ignore_lock` is an attribute of the `IgnoreLockMods` control (see section 10.7.2). It specifies modifiers to be ignored in grab calculations. Valid values consist of any combination of the eight core modifier bits: `ShiftMask`, `LockMask`, `ControlMask`, `Mod1Mask` - `Mod5Mask`.

**enabled_ctrls**

`enabled_ctrls` is an attribute of the `EnabledControls` control (see section 10.1.1). It contains one bit per boolean control. Each bit determines whether the corresponding con-
control is enabled or disabled; a one bit means the control is enabled. The mask bits used to enable these controls are listed in Table 10.7, using only those masks with “ok” in the enabled_ctrls column.

**repeat_delay and repeat_interval**

*repeat_delay* and *repeat_interval* are attributes of the RepeatKeys control (see section 10.3.2). *repeat_delay* is the initial delay before a key begins repeating, in milliseconds; *repeat_interval* is the delay between subsequent key events, in milliseconds.

**slow_keys_delay**

*slow_keys_delay* is an attribute of the SlowKeys control (see section 10.6.6). Its value specifies the SlowKeys acceptance delay period in milliseconds before a key press is accepted by the server.

**debounce_delay**

*debounce_delay* is an attribute of the BounceKeys control (see section 10.6.7). Its value specifies the BounceKeys delay period in milliseconds for which the key is disabled after having been pressed before another press of the same key is accepted by the server.

**mk_delay, mk_interval, mk_time_to_max, mk_max_speed, and mk_curve**

*mk_delay, mk_interval, mk_time_to_max, mk_max_speed, and mk_curve* are attributes of the MouseKeysAccel control. Refer to section 10.5.2 for a description of these fields and the units involved.

**ax_options**

The *ax_options* field contains attributes used to configure two different controls, the StickyKeys control (see section 10.6.8) and the AccessXFeedback control (see section 10.6.3). The *ax_options* field is a bitmask and may include any combination of the bits defined in Table 10.9.

**Table 10.9 Access X Enable/Disable Bits (ax_options field)**

<table>
<thead>
<tr>
<th>Access X Control</th>
<th>ax_options bit</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AccessXFeedback</td>
<td>XkbAX_SKPressFBMask</td>
<td>(1L &lt;&lt; 0)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_SKAcceptFBMask</td>
<td>(1L &lt;&lt; 1)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_FeatureFBMask</td>
<td>(1L &lt;&lt; 2)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_SlowWarnFBMask</td>
<td>(1L &lt;&lt; 3)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_IndicatorFBMask</td>
<td>(1L &lt;&lt; 4)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_StickyKeysFBMask</td>
<td>(1L &lt;&lt; 5)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_SKReleaseFBMask</td>
<td>(1L &lt;&lt; 8)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_SKRejectFBMask</td>
<td>(1L &lt;&lt; 9)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_BKRejectFBMask</td>
<td>(1L &lt;&lt; 10)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_DumbBellFBMask</td>
<td>(1L &lt;&lt; 11)</td>
</tr>
<tr>
<td>StickyKeys</td>
<td>XkbAX_TwoKeysMask</td>
<td>(1L &lt;&lt; 6)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_LatchToLockMask</td>
<td>(1L &lt;&lt; 7)</td>
</tr>
<tr>
<td></td>
<td>XkbAX_AllOptionsMask</td>
<td>(0xFFF)</td>
</tr>
</tbody>
</table>
The fields pertaining to each control are relevant only when the control is enabled (XkbAccessXFeedbackMask or XkbStickyKeysMask bit is turned on in the enabled_cntrls field).

Xkb provides a set of convenience macros for working with the ax_options field of an XkbControlsRec structure:

```c
#define XkbAX_NeedOption(c,w) ((c)->ax_options&(w))
```

The XkbAX_NeedOption macro is useful for determining whether a particular AccessX option is enabled or not. It accepts a pointer to an XkbControlsRec structure and a valid mask bit from Table 10.9. If the specified mask bit in the ax_options field of the controls structure is set, the macro returns the mask bit. Otherwise, it returns zero. Thus,

XkbAX_NeedOption(ctlrec, XkbAX_LatchToLockMask)

is nonzero if the latch to lock transition for latching keys is enabled, and zero if it is disabled. Note that XkbAX_NeedOption only determines whether or not the particular capability is configured to operate; the XkbAccessXFeedbackMask bit must also be turned on in enabled_cntrls for the capability to actually be functioning.

```c
#define XkbAX_AnyFeedback(c) ((c)->enabled_ctrls&XkbAccessXFeedbackMask)
```

The XkbAX_AnyFeedback macro accepts a pointer to an XkbControlsRec structure and tells whether the AccessXFeedback control is enabled or not. If the AccessXFeedback control is enabled, the macro returns XkbAccessXFeedbackMask. Otherwise, it returns zero.

```c
#define XkbAX_NeedFeedback(c,w) (XkbAX_AnyFeedback(c)&&XkbAX_NeedOption(c,w))
```

The XkbAX_NeedFeedback macro is useful for determining if both the AccessXFeedback control and a particular AccessX feedback option are enabled. The macro accepts a pointer to an XkbControlsRec structure and a feedback option from the table above. If both the AccessXFeedback control and the specified feedback option are enabled, the macro returns True. Otherwise it returns False.

ax_timeout, axt_optms_mask, axt_optms_values, axt_ctrls_mask, and axt_ctrls_values

ax_timeout, act_optms_mask, axt_optms_values, axt_ctrls_mask, and axt_ctrls_values are attributes of the AccessXTimeout control. Refer to section 10.6.2 for a description of these fields and the units involved.

per_key_repeat

The per_key_repeat field mirrors the auto_repeats field of the core protocol XKeyboard-State structure: changing the auto_repeats field automatically changes per_key_repeat and vice versa. It is provided for convenience and to reduce protocol traffic. For example, to obtain the individual repeat key behavior as well as the repeat delay and rate, use XkbGetControls. If the per_key_repeat were not in this structure, you would have to call both XGetKeyboardControl and XkbGetControls to get this information. The bits correspond to keycodes. The first seven keys (keycodes 1-7) are indicated in per_key_repeat[0], with bit
position 0 (low order) corresponding to the fictitious keycode 0. Following array elements correspond to 8 keycodes per element. A 1 bit indicates that the key is a repeating key.

10.9 Querying Controls

Use `XkbGetControls` to find the current state of Xkb server controls.

Status `XkbGetControls(display, which, xkb)`

Display * `display`; /* connection to X server */
unsigned long `which`; /* mask of controls requested */
XkbDescPtr `xkb`; /* keyboard description for controls information*/

`XkbGetControls` queries the server for the requested control information, waits for a reply, and then copies the server’s values for the requested information into the `ctrls` structure of the `xkb` argument. Only those components specified by the `which` parameter are copied. Valid values for `which` are any combination of the masks listed in Table 10.7 that have “ok” in the `which` column.

If `xkb->ctrls` is `NULL`, `XkbGetControls` allocates and initializes it before obtaining the values specified by `which`. If `xkb->ctrls` is not `NULL`, `XkbGetControls` modifies only those portions of `xkb->ctrls` corresponding to the values specified by `which`.

`XkbGetControls` returns `Success` if successful; otherwise, it returns `BadAlloc` if it cannot obtain sufficient storage, `BadMatch` if `xkb` is `NULL` or `which` is empty, or `BadImplementation`.

To free the `ctrls` member of a keyboard description, use `XkbFreeControls` (see section 10.12).

The `num_groups` field in the `ctrls` structure is always filled in by `XkbGetControls`, regardless of which bits are selected by `which`.

10.10 Changing Controls

There are two ways to make changes to controls: either change a local copy keyboard description and call `XkbSetControls`, or, to reduce network traffic, use an `XkbControlsChangesRec` structure and call `XkbChangeControls`.

To change the state of one or more controls, first modify the `ctrls` structure in a local copy of the keyboard description and then use `XkbSetControls` to copy those changes to the X server.

Bool `XkbSetControls(display, which, xkb)`

Display * `display`; /* connection to X server */
unsigned long `which`; /* mask of controls to change */
XkbDescPtr `xkb`; /* `ctrls` field contains new values to be set */

For each bit that is set in the `which` parameter, `XkbSetControls` sends the corresponding values from the `xkb->ctrls` field to the server. Valid values for `which` are any combination of the masks listed in Table 10.7 that have “ok” in the `which` column.

If `xkb->ctrls` is `NULL`, the server does not support a compatible version of Xkb, or the Xkb extension has not been properly initialized, `XkbSetControls` returns `False`. Otherwise, it sends the request to the X server and returns `True`. 
Note that changes to attributes of controls in the XkbControlsRec structure are apparent only when the associated control is enabled, although the corresponding values are still updated in the X server. For example, the repeat_delay and repeat_interval fields are ignored unless the RepeatKeys control is enabled (that is, the X server's equivalent of xkb->ctrls has XkbRepeatKeyMask set in enabled_ctrls). It is permissible to modify the attributes of a control in one call to XkbSetControls and enable the control in a subsequent call. See section 10.1.1 for more information on enabling and disabling controls.

Note that the enabled_ctrls field is itself a control — the EnabledControls control. As such, to set a specific configuration of enabled and disabled boolean controls, you must set enabled_ctrls to the appropriate bits to enable only the controls you want and disable all others, then specify the XkbControlsEnabledMask in a call to XkbSetControls. Because this is somewhat awkward if all you want to do is enable and disable controls, and not modify any of their attributes, a convenience function is also provided for this purpose (XkbChangeEnabledControls, section 10.1.1).

10.10.1 The XkbControlsChangesRec Structure

The XkbControlsChangesRec structure allows applications to track modifications to an XkbControlsRec structure and thereby reduce the amount of traffic sent to the server. The same XkbControlsChangesRec structure may be used in several successive modifications to the same XkbControlsRec structure, then subsequently used to cause all of the changes, and only the changes, to be propagated to the server. The XkbControlsChangesRec structure is defined as follows:

```c
typedef struct _XkbControlsChanges {
    unsigned int changed_ctrls; /* bits indicating changed control data */
    unsigned int enabled_ctrls_changes; /* bits indicating enabled/disabled controls */
    Bool num_groups_changed; /* True if number of keyboard groups changed */
} XkbControlsChangesRec,*XkbControlsChangesPtr;
```

The changed_ctrls field is a mask specifying which logical sets of data in the controls structure have been modified. In this context, modified means set, that is, if a value is set to the same value it previously contained, it has still been modified, and is noted as changed. Valid values for changed_ctrls are any combination of the masks listed in Table 10.7 that have “ok” in the changed_ctrls column. Setting a bit implies the corresponding data fields from the “Relevant XkbControlsRec Data Fields” column in Table 10.6 have been modified. The enabled_ctrls_changes field specifies which bits in the enabled_ctrls field have changed. If the number of keyboard groups has changed, the num_groups_changed field is set to True.

If you have an Xkb description with controls that have been modified and an XkbControlsChangesRec that describes the changes that have been made, the XkbChangeControls function provides a flexible method for updating the controls in a server to match those in the changed keyboard description.

```c
Bool XkbChangeControls(dpy, xkb, changes)
    Display * dpy; /* connection to X server */
    XkbDescPtr xkb; /* keyboard description with changed xkb->ctrls */
    XkbControlsChangesPtr changes; /* which parts of xkb->ctrls have changed */
```

XkbChangeControls copies any controls fields specified by changes from the keyboard description controls structure, xkb->ctrls, to the server specified by dpy.
10.11 Tracking Changes to Keyboard Controls

Whenever a field in the controls structure changes in the server’s keyboard description, the server sends an XkbControlsNotify event to all interested clients. To receive XkbControlsNotify events under all possible conditions, use XkbSelectEvents (see section 4.3) and pass XkbControlsNotifyMask in both bits_to_change and values_for_bits.

To receive XkbControlsNotify events only under certain conditions, use XkbSelectEventDetails using XkbControlsNotify as the event_type and specifying the desired state changes in bits_to_change and values_for_bits using mask bits from Table 10.7.

The structure for the XkbControlsNotify event is defined as follows:

```
typedef struct {
  int    type;  /* Xkb extension base event code */
  unsigned long serial;  /* X server serial number for event */
  Bool   send_event;  /* True => synthetically generated */
  Display * display;  /* server connection where event generated */
  Time   time;  /* server time when event generated */
  int    xkb_type;  /* XkbCompatMapNotify */
  int    device;  /* Xkb device ID, will not be XkbUseCoreKbd */
  unsigned int changedCtrls;  /* bits indicating which controls data have changed*/
  unsigned int enabledCtrls;  /* controls currently enabled in server */
  unsigned int enabledCtrlChanges;  /* bits indicating enabled/disabled controls */
  int    num_groups;  /* current number of keyboard groups */
  KeyCode keycode;  /* != 0 => keycode of key causing change */
  char   event_type;  /* Type of event causing change */
  char   req_major;  /* major event code of event causing change */
  char   req_minor;  /* minor event code of event causing change */
} XkbControlsNotifyEvent;
```

The changedCtrls field specifies the controls components that have changed and consists of bits taken from the masks defined in Table 10.7 with “ok” in the changedCtrls column.

The controls currently enabled in the server are reported in the enabledCtrls field. If any controls were just enabled or disabled (that is, the contents of the enabledCtrls field changed), they are flagged in the enabledCtrlChanges field. The valid bits for these fields are the masks listed in Table 10.7 with “ok” in the enabledCtrls column. The num_groups field reports the number of groups bound to the key belonging to the most number of groups and is automatically updated when the keyboard mapping changes.

If the change was caused by a request from a client, the keycode and event_type fields are set to zero and the req_major and req_minor fields identify the request. The req_major value is the same as the major extension opcode. Otherwise, event_type is set to the type of event that caused the change (one of_KeyPress, _KeyRelease, _DeviceKeyPress, _DeviceKeyRelease, _ButtonPress or _ButtonRelease), and req_major and req_minor are undefined. If event_type is _KeyPress or _KeyRelease, _DeviceKeyPress or _DeviceKeyRelease, the keycode field is set to the key that caused the change. If event_type is _ButtonPress or _ButtonRelease, keycode contains the button number.
When a client receives an `XkbControlsNotify` event, it can note the changes in a changes structure using `XkbNoteControlsChanges`.

```c
void XkbNoteControlsChanges(changes, new, wanted)
    XkbControlsChangesPtr changes; /* records changes indicated by new */
    XkbControlsNotifyEvent * new; /* tells which things have changed */
    unsigned int wanted; /* tells which parts of new to record in changes */
```

The `wanted` parameter is a bitwise inclusive OR of bits taken from the set of masks specified in Table 10.7 with “ok” in the `changed_ctrls` column. `XkbNoteControlsChanges` copies any changes reported in `new` and specified in `wanted` into the changes record specified by `old`.

Use `XkbGetControlsChanges` to update a local copy of a keyboard description with the changes previously noted by one or more calls to `XkbNoteControlsChanges`.

```c
Status XkbGetControlsChanges(dpy, xkb, changes)
    Display * dpy; /* connection to X server */
    XkbDescPtr xkb; /* xkb->ctrls will be updated */
    XkbNameChangesPtr changes; /* indicates which parts of xkb->ctrls to update */
```

`XkbGetControlsChanges` examines the `changes` parameter, queries the server for the necessary information, and copies the results into the `xkb->ctrls` keyboard description. If the `ctrls` field of `xkb` is `NULL`, `XkbGetControlsChanges` allocates and initializes it. To free the `ctrls` field, use `XkbFreeControls` (see section 10.12).

`XkbGetControlsChanges` returns `Success` if successful and can generate `BadAlloc`, `BadImplementation`, and `BadMatch` errors.

### 10.12 Allocating and Freeing an XkbControlsRec

The need to allocate an `XkbControlsRec` structure seldom arises; Xkb creates one when an application calls `XkbGetControls` or a related function. For those situations where there is not an `XkbControlsRec` structure allocated in the `XkbDescRec`, allocate one by calling `XkbAllocControls`.

```c
Status XkbAllocControls(xkb, which)
    XkbDescPtr xkb; /* Xkb description in which to allocate ctrls rec */
    unsigned int which; /* mask of components of ctrls to allocate */
```

`XkbAllocControls` allocates the `ctrls` field of the `xkb` parameter, initializes all fields to zero, and returns `Success`. If the `ctrls` field is not `NULL`, `XkbAllocControls` simply returns `Success`. If `xkb` is `NULL`, `XkbAllocControls` reports a `BadMatch` error. If the `ctrls` field could not be allocated, it reports a `BadAlloc` error.

The `which` mask specifies the individual fields of the `ctrls` structure to be allocated and can contain any of the valid masks defined in Table 10.7. Because none of the currently existing controls have any structures associated with them, which is currently of little practical value in this call.
To free memory used by the `ctrls` member of an `XkbDescRec` structure, use `XkbFreeControls`:

```c
void XkbFreeControls(xkb, which, free_all)
    XkbDescPtr xkb; /* Xkb description in which to free controls components */
    unsigned int which; /* mask of components of `ctrls` to free */
    Bool free_all; /* True => free everything + `ctrls` itself */
```

`XkbFreeControls` frees the specified components of the `ctrls` field in the `xkb` keyboard description and sets the corresponding structure component values to `NULL` or `zero`. The `which` mask specifies the fields of `ctrls` to be freed and can contain any of the controls components specified in Table 10.7.

If `free_all` is `True`, `XkbFreeControls` frees every non-`NULL` structure component in the controls, frees the `XkbControlsRec` structure referenced by the `ctrls` member of `xkb`, and sets `ctrls` to `NULL`.

### 10.13 The Miscellaneous Per-client Controls

You can configure the boolean per-client controls which affect the `state` reported in button and key events. See section 12.1.1, 12.3, 12.5, and 16.3.11 of the XKB Protocol specification for more details.

To get the current values of the per-client controls, use `XkbGetPerClientControls`.

```c
Bool XkbGetPerClientControls(dpy, ctrls)
    Display * dpy; /* connection to X server */
    unsigned int * ctrls; /* 1 bit => corresponding control is on */
```

`XkbGetPerClientControls` backfills `ctrls` with the per-client control attributes for this particular client. It returns `True` if successful, and `False` otherwise.

To change the current values of the per-client control attributes, use `XkbSetPerClientControls`.

```c
Bool XkbSetPerClientControls(dpy, ctrls)
    Display * dpy; /* connection to X server */
    unsigned int change; /* 1 bit => change control */
    unsigned int * value; /* 1 bit => change control on */
```

`XkbSetPerClientControls` changes the per-client values for the controls selected by `change` to the corresponding value in `value`. Legal values for `change` and `value` are: `XkbPCF_GrabsUseXKBStateMask`, `XkbPCF.LookupStateWhenGrabbed`, and `XkbPCF_SendEventUsesXKBState`. More than one control may be changed at one time by OR-ing the values together. `XkbSetPerClientControls` backfills `value` with the per-client control attributes for this particular client. It returns `True` if successful, and `False` otherwise.
11 X Library Controls

The Xkb extension is composed of two parts: a server extension, and a client-side X library extension. Chapter 10 discusses functions used to modify controls affecting the behavior of the server portion of the Xkb extension. This chapter discusses functions used to modify controls that affect only the behavior of the client portion of the extension; these controls are known as Library Controls.

All of the Library Controls are boolean flags that may be enabled and disabled. The controls can be divided into several categories:

- Controls affecting general string lookups
- Controls affecting compose processing
- Controls affecting event delivery

There are two types of string lookups performed by $XLookupString$. The first type involves translating a single keycode into a string; the controls in the first category affect this type of lookup. The second type involves translating a series of keysyms into a string; the controls in the second category affect this type of lookup.

An Xkb implementation is required to support the programming interface for all of the controls. However, an implementation may choose not to support the semantics associated with the controls that deal with compose processing. In this case, a program that accesses these controls should still function normally; however, the feedback that would normally occur with the controls enabled may be missing.

11.1 Controls Affecting Keycode-to-String Translation

The first type of string lookups, which are here called *simple string lookups*, involves translating a single keycode into a string. Because these simple lookups involve only a single keycode, all of the information needed to do the translation is contained in the keyboard state in a single event. The controls affecting simple string lookups are:

- ForceLatin1Lookup
- ConsumeLookupMods
- LevelOneUsesShiftAndLock

11.1.1 ForceLatin1Lookup

If the ForceLatin1Lookup control is enabled, $XLookupString$ only returns strings using the Latin1 character set. If ForceLatin1Lookup is not enabled, $XLookupString$ can return characters that are not in the Latin1 set. By default, this control is disabled, allowing characters outside of the Latin1 set to be returned.

11.1.2 ConsumeLookupMods

Simple string lookups in $XLookupString$ involve two different translation phases. The first phase translates raw device keycodes to individual keysyms. The second phase attempts to map the resulting keysym into a string of one or more characters. In the first phase, some of the modifiers are normally used to determine the appropriate shift level for a key.

The ConsumeLookupMods control determines whether or not $XLookupString$ *consumes* the modifiers it uses during the first phase of processing (mapping a keycode to a keysym). When a modifier is consumed, it is effectively removed from the working copy of...
the keyboard state information \texttt{XLookupString} is using and appears to be unset for the remainder of the processing.

If the \texttt{ConsumeLookupMods} control is enabled, \texttt{XLookupString} does not use the modifiers used to translate the keycode of the event to a keysym when it is determining the string associated with a keysym. For example, assume the keymap for the ‘A’ key only contains the shift modifier and the \texttt{ConsumeLookupMods} control is enabled. If a user presses the Shift key and the A key while the Num_Lock key is locked, \texttt{XLookupString} uses the Shift modifier when mapping the keycode for the ‘a’ key to the keysym for ‘A’; subsequently, it only uses the NumLock modifier when determining the string associated with the keysym ‘A’.

If the \texttt{ConsumeLookupMods} control is not enabled, \texttt{XLookupString} uses all of the event modifiers to determine the string associated with a keysym. This behavior mirrors the behavior of \texttt{XLookupString} in the core implementation.

The \texttt{ConsumeLookupMods} control is unset by default. For more information on modifier consumption, refer to Chapter 12.

11.1.3 AlwaysConsumeShiftAndLock

The \texttt{AlwaysConsumeShiftAndLock} control, if enabled, forces \texttt{XLookupString} to consume the Shift and Lock modifiers when processing all keys, even if the definition for the key type does not specify these modifiers. The \texttt{AlwaysConsumeShiftAndLock} control is unset by default. See section 15.2 for a discussion of key types.

11.2 Controls Affecting Compose Processing

The second type of string lookup performed by \texttt{XLookupString} involves translating a series of keysyms into a string. Because these lookups can involve more than one key event, they require \texttt{XLookupString} to retain some state information between successive calls. The process of mapping a series of keysyms to a string is known as compose processing. The controls affecting compose processing are:

\begin{verbatim}
ConsumeKeysOnComposeFail
ComposeLED
BeepOnComposeFail
\end{verbatim}

Because different vendors have historically used different algorithms to implement compose processing, and these algorithms may be incompatible with the semantics required by the Xkb compose processing controls, implementation of the compose processing controls is optional in an Xkb implementation.

11.2.1 ConsumeKeysOnComposeFail

Some compose processing algorithms signal the start of a compose sequence by a key event meaning “start compose”.\footnote{Another possibility is to have the compose processing simply be the result of a finite state acceptor; a compose sequence would never fail for a properly written finite state acceptor.} The subsequent key events should normally result in a valid composition yielding a valid translation to a string. If the subsequent key events do not have a valid translation, some decision must be made about what to do with the key events that were processed while attempting the compose. The \texttt{ConsumeKeysOnCom-
The X Keyboard Extension

11 X Library Controls

11.2 The X Library Controls

11.2.1 ConsumeKeysOnComposeFail

The ConsumeKeysOnComposeFail control allows a client to specify what happens with the key events XLookupString has been considering when it reaches a dead end in a compose sequence.

If the ConsumeKeysOnComposeFail control is set, all keys associated with a failed compose sequence should be consumed (discarded). If the ConsumeKeysOnComposeFail control is not set, the key events associated with a failed compose sequence should be processed as a normal sequence of key events.

The ConsumeKeysOnComposeFail control is disabled by default.

11.2.2 ComposeLED

The ComposeLED control allows a client to specify whether or not an indicator should be set and cleared to provide feedback when compose processing is in progress. The control does not specify which indicator should be used; the mapping for this is up to the individual implementation. If the ComposeLED control is enabled, it specifies that an indicator should be set when a compose sequence is in progress and cleared when one is not in progress. The ComposeLED control is disabled by default.

While the Xkb extension does not specify the type of type of indicator to be used when the ComposeLED control is implemented, a consistent convention between implementations is to everyone’s benefit. If a named indicator is used for this purpose, the recommended name is “Compose”. Note that some implementations may use an unnamed, custom hardware LED for this purpose.

11.2.3 BeepOnComposeFail

The BeepOnComposeFail control allows a client to specify whether or not a bell should be activated to provide feedback when a compose sequence fails. The control does not specify the type of bell that should be used; the mapping for this is up to the individual implementation. If the BeepOnComposeFail control is enabled, it specifies that a bell should be activated when a compose sequence fails. The BeepOnComposeFail control is disabled by default. If implemented, the bell should be activated using XkbBell or XkbDeviceBell.

While the Xkb extension does not specify the type of bell to be used when the BeepOnComposeFail control is implemented, a consistent convention between implementations is to everyone’s benefit. If a named bell is used for this purpose, the recommended name is “ComposeFail”.

11.3 Controls Effecting Event Delivery

11.3.1 IgnoreNewKeyboards

When Xkb is initialized, it implicitly forces requests for NewKeyboardNotify events. These events may be used by the Xkb library extension internally; they are normally translated into core protocol MappingNotify events before being passed to the client. While delivering the event to the client is appropriate in most cases, it is not appropriate for some clients that maintain per-key data structures. This is because once the server has sent a NewKeyboardNotify event, it is free to send the client events for all keys in the new range and that range may be outside of the per-key data structures the client is maintaining.
The `IgnoreNewKeyboards` control, if enabled, prevents Xkb from mapping `NewKeyboardNotify` events to core `MappingNotify` events and passing them to the client. The control is initially disabled.

11.4 Manipulating the Library Controls

The Library Controls are manipulated using functions that deal with bitmasks to indicate which controls to manipulate. The controls are identified by the masks defined in Table 11.1.

### Table 11.1 Library Control Masks

<table>
<thead>
<tr>
<th>Library Control Mask</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbLC_ForceLatin1Lookup</td>
<td>(1 &lt;&lt; 0)</td>
</tr>
<tr>
<td>XkbLC_ConsumeLookupMods</td>
<td>(1 &lt;&lt; 1)</td>
</tr>
<tr>
<td>XkbLC_AlwaysConsumeShiftAndLock</td>
<td>(1 &lt;&lt; 2)</td>
</tr>
<tr>
<td>XkbLC_IgnoreNewKeyboards</td>
<td>(1 &lt;&lt; 3)</td>
</tr>
<tr>
<td>XkbLC_ConsumeKeysOnComposeFail</td>
<td>(1 &lt;&lt; 29)</td>
</tr>
<tr>
<td>XkbLC_ComposeLED</td>
<td>(1 &lt;&lt; 30)</td>
</tr>
<tr>
<td>XkbLC_BeepOnComposeFail</td>
<td>(1 &lt;&lt; 31)</td>
</tr>
<tr>
<td>XkbLC_AllControls</td>
<td>(0xc0000007)</td>
</tr>
</tbody>
</table>

11.4.1 Determining Which Library Controls are Implemented

To determine which Library Controls are actually implemented, use `XkbXlibControlsImplemented`.

```c
unsigned int XkbXlibControlsImplemented(display)

Display * display; /* connection to X server */
```

`XkbXlibControlsImplemented` returns a bitmask indicating the controls actually implemented in the Xkb library and is composed of an inclusive OR of bits from Table 11.1.

11.4.2 Determining the State of the Library Controls

To determine the current state of the Library Controls, use `XkbGetXlibControls`.

```c
unsigned int XkbGetXlibControls(display)

Display * display; /* connection to X server */
```

`XkbGetXlibControls` returns the current state of the Library Controls as a bit mask that is an inclusive OR of the control masks from Table 11.1 for the controls that are enabled. For the optional compose processing controls, the fact that a control is enabled does not imply that it is actually implemented.

11.4.3 Changing the State of the Library Controls

To change the state of the Library Controls, use `XkbSetXlibControls`.

```c
Bool XkbSetXlibControls(display, bits_to_change, values_for_bits)

Display * display; /* connection to X server */
unsigned long bits_to_change; /* selects controls to be modified */
unsigned long values_for_bits; /* turns selected controls on (1) or off (0) */
```
XkbSetXlibControls modifies the state of the controls selected by bits_to_change; only the controls selected by bits_to_change are modified. If the bit corresponding to a control is on in bits_to_change and also on in values_for_bits, the control is enabled. If the bit corresponding to a control is on in bits_to_change but off in values_for_bits, the control is disabled. bits_to_change should be an inclusive OR of bits from Table 11.1.
12 Interpreting Key Events

Xkb provides functions to help developers interpret key events without having to directly interpret Xkb data structures. Xkb also modifies the behavior of several core X library functions.

12.1 Effects of Xkb on the Core X Library

When support for Xkb is built into the X library, the XOpenDisplay function looks for a compatible version of Xkb on the server. If it finds a compatible version, it initializes the extension and enables implicit support for Xkb in a number of X library functions. This makes it possible for clients to take advantage of nearly all Xkb features without having to be rewritten or even recompiled, if they are built with shared libraries. This implicit support is invisible to most clients, but it can have side effects, so the extension includes ways to control or disable it.

12.1.1 Effects of Xkb on Event State

Because XOpenDisplay initializes Xkb, some events contain an Xkb description of the keyboard state instead of that normally used by the core protocol. See section 17.1.1 for more information about the differences between Xkb keyboard state and that reported by the core protocol.

12.1.2 Effects of Xkb on MappingNotify Events

When Xkb is missing or disabled, the X library tracks changes to the keyboard mapping using MappingNotify events. Whenever the keyboard mapping is changed, the server sends all clients a MappingNotify event to report the change. When a client receives a MappingNotify event, it is supposed to call XRefreshKeyboardMapping to update the keyboard description used internally by the X library.

The X Keyboard Extension uses XkbMapNotify and XkbNewKeyboardNotify events to track changes to the keyboard mapping. When an Xkb-aware client receives either event, it should call XkbRefreshKeyboardMapping to update the keyboard description used internally by the X library. To avoid duplicate events, the X server does not send core protocol MappingNotify events to a client that has selected for XkbMapNotify events.

The implicit support for Xkb selects for XkbMapNotify events. This means that clients that do not explicitly use Xkb but that are using a version of the X library that has implicit support for Xkb do not receive MappingNotify events over the wire. Clients that were not written with Xkb in mind do not recognize or properly handle the new Xkb events, so the implicit support converts them to MappingNotify events that report approximately the same information, unless the client has explicitly selected for the Xkb version of the event.

An Xkb-capable X server does not send events from keys that fall outside the legal range of keycodes expected by that client. Once the server sends a client an XkbNewKeyboard-Notify event, it reports events from all keys because it assumes that any client that has received an XkbNewKeyboardNotify event expects key events from the new range of keycodes. The implicit support for Xkb asks for XkbNewKeyboardNotify events, so the range of keycodes reported to the client might vary without the client’s knowledge. Most clients don’t really care about the range of legal keycodes, but some clients maintain information about each key and might have problems with events that come from unex-
pected keys. Such clients can set the XkbLC_IgnoreNewKeyboards library control (see section 11.3.1) to prevent the implicit support from requesting notification of changes to the legal range of keycodes.

12.1.3 X Library Functions Affected by Xkb

The following X library functions are modified by Xkb:

- XKeycodeToKeysym
- XKeysymToKeycode
- XLookupKeysym
- XLookupString
- XRefreshKeyboardMapping
- XRebindKeysym

The implicit support for Xkb replaces a number of X library functions with versions that understand and use the X Keyboard Extension. In most cases, the semantics of the new versions are identical to those of the old, but there are occasional visible differences. This section lists all of the functions that are affected and the differences in behavior, if any, that are visible to clients.

The XKeycodeToKeysym function reports the keysym associated with a particular index for a single key. The index specifies a column of symbols in the core keyboard mapping (that is, as reported by the core protocol GetKeyboardMapping request). The order of the symbols in the core mapping does not necessarily correspond to the order of the symbols used by Xkb; section 17.1.3 describes the differences.

The XKeysymToKeycode function reports a keycode to which a particular keysym is bound. When Xkb is missing or disabled, this function looks in each column of the core keyboard mapping in turn and returns the lowest numbered key that matches in the lowest numbered group. When Xkb is present, this function uses the Xkb ordering for symbols instead.

The XLookupKeysym function reports the symbol in a specific column of the key associated with an event. Whether or not Xkb is present, the column specifies an index into the core symbol mapping.

The XLookupString function reports the symbol and string associated with a key event, taking into account the keycode and keyboard state as reported in the event. When Xkb is disabled or missing, XLookupString uses the rules specified by the core protocol and reports only ISO Latin-1 characters. When Xkb is present, XLookupString uses the explicit keyboard group, key types, and rules specified by Xkb. When Xkb is present, XLookupString is allowed, but not required, to return strings in character sets other than ISO Latin-1, depending on the current locale. If any key bindings are defined, XLookupString does not use any consumed modifiers (see sections 11.1.2 and 15.2) to determine matching bindings.

The XRefreshKeyboardMapping function updates the X library’s internal representation of the keyboard to reflect changes reported via MappingNotify events. When Xkb is missing or disabled, this function reloads the entire modifier map or keyboard mapping. When Xkb is present, the implicit Xkb support keeps track of the changed components reported by each XkbMapNotify event and updates only those pieces of the keyboard description that have changed. If the implicit support has not noted any keyboard mapping changes, XRefreshKeyboardMapping updates the entire keyboard description.
The \texttt{XRebindKeysym} function associates a string with a keysym and a set of modifiers. Xkb does not directly change this function, but it does affect the way that the state reported in the event is compared to the state specified to \texttt{XRebindKeysym}. When Xkb is missing or disabled, \texttt{XLookupString} returns the specified string if the modifiers in the event exactly match the modifiers from this call. When Xkb is present, any modifiers used to determine the keysym are consumed and are not used to look up the string.

### 12.2 Xkb Event and Keymap Functions

To find the keysym bound to a particular key at a specified group and shift level, use \texttt{XkbKeycodeToKeysym}.

\textbf{KeySym \texttt{XkbKeycodeToKeysym}(dpy, kc, group, level)}

- \texttt{Display * dpy;} /* connection to X server */
- \texttt{KeyCode kc;} /* key of interest */
- \texttt{unsigned int group;} /* group of interest */
- \texttt{unsigned int level;} /* shift level of interest */

\(\texttt{XkbKeycodeToKeysym}\) returns the keysym bound to a particular group and shift level for a particular key on the core keyboard. If \(\texttt{kc}\) is not a legal keycode for the core keyboard, or if \(\texttt{group}\) or \(\texttt{level}\) are out of range for the specified key, \(\texttt{XkbKeycodeToKeysym}\) returns \texttt{NoSymbol}.

To find the set of modifiers bound to a particular keysym on the core keyboard, use \texttt{XkbKeysymToModifiers}.

\textbf{unsigned int \texttt{XkbKeysymToModifiers}(dpy, ks) }

- \texttt{Display * dpy;} /* connection to X server */
- \texttt{KeySym ks;} /* keysym of interest */

\(\texttt{XkbKeysymToModifiers}\) finds the set of modifiers currently bound to the keysym \(\texttt{ks}\) on the core keyboard. The value returned is the mask of modifiers bound to the keysym \(\texttt{ks}\). If no modifiers are bound to the keysym, \(\texttt{XkbKeysymToModifiers}\) returns zero; otherwise, it returns the inclusive OR of zero or more of the following: \texttt{ShiftMask}, \texttt{ControlMask}, \texttt{LockMask}, \texttt{Mod1Mask}, \texttt{Mod2Mask}, \texttt{Mod3Mask}, \texttt{Mod4Mask}, and \texttt{Mod5Mask}.

Use \texttt{XkbLookupKeySym} to find the symbol associated with a key for a particular state.

\textbf{Bool \texttt{XkbLookupKeySym}(dpy, key, state, mods_rtrn, sym_rtrn)}

- \texttt{Display * dpy;} /* connection to X server */
- \texttt{KeyCode key;} /* key for which symbols are to be found */
- \texttt{unsigned int state;} /* state for which symbol should be found */
- \texttt{unsigned int * mods_rtrn;} /* backfilled with unconsumed modifiers */
- \texttt{KeySym * sym_rtrn;} /* backfilled with symbol associated with key + state */

\(\texttt{XkbLookupKeySym}\) is the equivalent of the core \texttt{XLookupKeySym} function. For the core keyboard, given a keycode \(\texttt{key}\) and an Xkb state \(\texttt{state}\), \(\texttt{XkbLookupKeySym}\) returns the symbol associated with the key in \(\texttt{sym_rtrn}\) and the list of modifiers that should still be applied in \(\texttt{mods_rtrn}\). The \texttt{state} parameter is the state from a \texttt{KeyPress} or \texttt{KeyRelease} event. \(\texttt{XkbLookupKeySym}\) returns \texttt{True} if it succeeds.
Use \texttt{XkbLookupKeyBinding} to find the string bound to a key by \texttt{XRebindKeySym}. \texttt{XkbLookupKeyBinding} is the equivalent of the core \texttt{XLookupString} function.

\begin{verbatim}
int XkbLookupKeyBinding(dpy, sym, state, buf, nbytes, extra_rtrn)
    Display * dpy; /* connection to server */
    KeySym sym; /* symbol to be looked up */
    unsigned int state; /* state for which string is to be looked up */
    char * buf; /* buffer into which returned string is written */
    int nbytes; /* size of buffer in bytes */
    int * extra_rtrn; /* backfilled with number bytes overflow */
\end{verbatim}

\texttt{XRebindKeySym} binds an ASCII string to a specified keysym, so that the string and key-sym are returned when the key is pressed and a specified list of modifiers are also being held down. \texttt{XkbLookupKeyBinding} returns in \texttt{buf} the string associated with the keysym \texttt{sym} and modifier state \texttt{state}. \texttt{buf} is NULL terminated unless there’s an overflow. If the string returned is larger than \texttt{nbytes}, a count of bytes that does not fit into the buffer is returned in \texttt{extra_rtrn}. \texttt{XkbTranslateKeySym} returns the number of bytes that it placed into \texttt{buf}.

To find the string and symbol associated with a keysym for a given keyboard state, use \texttt{XkbTranslateKeySym}.

\begin{verbatim}
int XkbTranslateKeySym(dpy, sym_inout, mods, buf, nbytes, extra_rtrn)
    Display * dpy; /* connection to X server */
    KeySym * sym_inout; /* symbol to be translated; result of translation */
    unsigned int mods; /* modifiers to apply to sym_inout */
    char * buf; /* buffer into which returned string is written */
    int nbytes; /* size of buffer in bytes */
    int * extra_rtrn; /* number of bytes overflow */
\end{verbatim}

\texttt{XkbTranslateKeySym} applies the transformations specified in \texttt{mods} to the symbol specified by \texttt{sym_inout}. It returns in \texttt{buf} the string, if any, associated with the keysym for the current locale. If the transformations in \texttt{mods} changes the keysym, \texttt{sym_inout} is updated accordingly. If the string returned is larger than \texttt{nbytes}, a count of bytes that does not fit into the buffer is returned in \texttt{extra_rtrn}. \texttt{XkbTranslateKeySym} returns the number of bytes it placed into \texttt{buf}.

To update the keyboard description that is internal to the X library, use \texttt{XkbRefreshKeyboardMapping}.

\begin{verbatim}
Status XkbRefreshKeyboardMapping(event)
    XkbMapNotifyEvent * event; /* event initiating remapping */
\end{verbatim}

\texttt{XkbRefreshKeyboardMapping} is the Xkb equivalent of the core \texttt{XRefreshKeyboardMapping} function. It requests that the X server send the current key mapping information to this client. A client usually invokes \texttt{XkbRefreshKeyboardMapping} after receiving a \texttt{XkbMapNotify} event. \texttt{XkbRefreshKeyboardMapping} returns \texttt{Success} if it succeeds and \texttt{BadMatch} if the event is not an Xkb event.

The \texttt{XkbMapNotify} event can be generated when some client calls \texttt{XkbSetMap}, \texttt{XkbChangeMap}, \texttt{XkbGetKeyboardByName}, or any of the standard X library functions that change the keyboard mapping or modifier mapping.
To translate a keycode to a key symbol and modifiers, use \texttt{XkbTranslateKeyCode}.

\begin{verbatim}
bool XkbTranslateKeyCode(xkb, key, mods, mods_rtrn, keysym_rtrn)
  XkbDescPtr xkb; /* keyboard description to use for translation */
  KeyCode key; /* keycode to translate */
  unsigned int mods; /* modifiers to apply when translating key */
  unsigned int *mods_rtrn; /* backfilled with unconsumed modifiers */
  KeySym *keysym_rtrn; /* keysym resulting from translation */
\end{verbatim}

\texttt{mods_rtrn} is backfilled with the modifiers consumed by the translation process. \texttt{mods} is a bitwise inclusive OR of the legal modifier masks: \texttt{ShiftMask}, \texttt{LockMask}, \texttt{ControlMask}, \texttt{Mod1Mask}, \texttt{Mod2Mask}, \texttt{Mod3Mask}, \texttt{Mod4Mask}, \texttt{Mod5Mask}. The \texttt{AlwaysConsume-ShiftAndLock} library control (see section 11.1.3), if enabled, causes \texttt{XkbTranslateKeyCode} to consume shift and lock. \texttt{XkbTranslateKeyCode} returns \texttt{True} if the translation resulted in a keysym, and \texttt{False} if it resulted in \texttt{NoSymbol}. 
13 Keyboard Geometry

The Xkb description of a keyboard includes an optional keyboard geometry that describes the physical appearance of the keyboard. Keyboard geometry describes the shape, location, and color of all keyboard keys or other visible keyboard components such as indicators. The information contained in a keyboard geometry is sufficient to allow a client program to draw an accurate two-dimensional image of the keyboard.

You can retrieve a keyboard geometry from an X server that supports Xkb, or you can allocate it from scratch and initialize it in a client program. The keyboard geometry need not have any correspondence with the physical keyboard that is connected to the X server.

Geometry measurements are specified in \( \text{mm}/10 \) units. The origin (0,0) is in the top left corner of the keyboard image. A component’s own origin is also its upper left corner. In some cases a component needs to be drawn rotated. For example, a special keyboard may have a section of keys arranged in rows in a rectangular area, but the entire rectangle may not be in alignment with the rest of the keyboard, and instead, it is rotated from horizontal by 30°. Rotation for a geometry object is specified in \( 1/10^0 \) increments about its origin. An example of a keyboard with rotated sections is shown in Figure 13.1.

![Rotated Sections](image)

Figure 131 Rotated Keyboard Sections

Some geometry components include a priority, which indicates the order in which overlapping objects should be drawn. Objects should be drawn in order from highest priority (0) to lowest (255).

The keyboard geometry’s top-level description is stored in a XkbGeometryRec structure. This structure contains three types of information:

1. Lists of items, not used to draw the basic keyboard, but indexed by the geometry descriptions that comprise the entire keyboard geometry (colors, geometry properties, key aliases, shapes)
2. A number of singleton items that describe the keyboard as a whole (keyboard name, width and height, a color for the keyboard as a whole, and a color for keyboard key labels)
3. A list of the keyboard’s sections and nonkey doodads

The top-level geometry is described in more detail in the following.

The lists of items used by components of the keyboard geometry description is as follows:
• The top-level keyboard geometry description includes a list of up to \(\text{MaxColors}(32)\) color names. A color name is a string whose interpretation is not specified by Xkb. The \text{XkbColorRec} structure provides a field for this name as well as a pixel field. The pixel field is a convenient place for an application to store a pixel value or color definition, if it needs to. All other geometry data structures refer to colors using their indices in this global list.

• The top-level keyboard geometry description includes a list of geometry properties. A geometry property associates an arbitrary string with an equally arbitrary name. Geometry properties can be used to provide hints to programs that display images of keyboards, but they are not interpreted by Xkb. No other geometry structures refer to geometry properties. As an example of a possible use of properties, consider the pause/break key on most PC keyboards: the “break” symbol is usually on the front of the key and is often a different color. A program might set a property to:

\[
\text{LBL\_PAUS} = \{\text{Pause/top/black,Break/front/red}\}
\]

and use the property information to draw the key with a front label as well as a top label.

• The top-level keyboard geometry description includes a list of key aliases (see Chapter 18). Key aliases allow the keyboard layout designer to assign multiple key names to a single key.

\textbf{Note} Key aliases defined in the geometry component of a keyboard mapping override those defined in the keycodes component of the server database, which are stored in the \text{XkbNamesRec} (\text{xkb->names}). Therefore, consider the key aliases defined by the geometry before considering key aliases supplied by the keycodes.

• The top-level keyboard geometry description includes a list of shapes; other keyboard components refer to shapes by their index in this list. A shape consists of an arbitrary name of type Atom and one or more closed-polygon outlines. All points in an outline are specified relative to the origin of its enclosing shape, that is, whichever shape that contains this outline in its list of outlines. One outline is the primary outline. The primary outline is by default the first outline, or it can be optionally specified by the primary field in the \text{XkbShapeRec} structure. A keyboard display application can generate a simpler but still accurate keyboard image by displaying only the primary outlines for each shape. Nonrectangular keys must include a rectangular approximation as one of the outlines associated with the shape. The approximation is not normally displayed but can be used by very simple keyboard display applications to generate a recognizable but degraded image of the keyboard.

The \text{XkbGeometryRec} top-level geometry description contains the following information that pertains to the keyboard as a whole:

• A keyboard symbolic name of type Atom to help users identify the keyboard.

• The width and height of the keyboard, in \(\text{mm}/10\). For nonrectangular keyboards, the width and height describe the smallest bounding box that encloses the outline of the keyboard.

• The base color of the keyboard is the predominant color on the keyboard and is used as the default color for any components whose color is not explicitly specified.

• The label color is the color used to draw the labels on most of the keyboard keys.

• The label font is a string that describes the font used to draw labels on most keys; label fonts are arbitrary strings, because Xkb does not specify the format or name space for font names.

The keyboard is subdivided into named \textit{sections} of related keys and \textit{doodads}. The sections and doodads on the keyboard are listed in the \text{XkbGeometryRec} top-level keyboard geometry description. A \textit{section} is composed of keys that are physically together and logi-
Figure 13.2  Keyboard with Four Sections

13.1 Shapes and Outlines

A *shape*, used to draw keyboard components and stored in a XkbShapeRec structure, has:

- An arbitrary name of type Atom.
- Bounds (two x and y coordinates) that describe the corners of a rectangle containing the shape’s top surface outline.
- A list of one or more outlines (described below).
- Optional pointers to a primary and an approximation outline (described below). If either of these pointers is NULL, the default primary/approximation outline is the first one in the list of outlines for the shape.

An *outline*, stored in a XkbOutlineRec structure, is a list of one or more points that describes a single closed-polygon, as follows:

- A list with a single point describes a rectangle with one corner at the origin of the shape (0,0) and the opposite corner at the specified point.
- A list of two points describes a rectangle with one corner at the position specified by the first point and the opposite corner at the position specified by the second point.
- A list of three or more points describes an arbitrary polygon. If necessary, the polygon is automatically closed by connecting the last point in the list with the first.
- A nonzero value for the *corner_radius* field specifies that the corners of the polygon should be drawn as circles with the specified radius.

All points in an outline are specified relative to the origin of the enclosing shape. Points in an outline may have negative values for the X and Y coordinate.

One outline is the primary outline; a keyboard display application can generate a simple but still accurate keyboard image by displaying only the primary outlines for each shape. The default primary outline is the first in a shape’s list of outlines. If the *primary* field of the XkbShapeRec structure is not NULL, it points to the primary outline. A rectangular approximation must be included for nonrectangular keys as one of the outlines associated with the shape; the approximation is not normally displayed but can be used by very simple keyboard display applications to generate a recognizable but degraded image of the keyboard.
13.2 Sections

As previously noted, a keyboard is subdivided into sections of related keys. Each section has its own coordinate system — if a section is rotated, the coordinates of any components within the section are interpreted relative to the edges that were on the top and left before rotation. The components that make up a section, stored in a XkbSectionRec, include:

- An arbitrary name of type Atom.
- A priority, to indicate drawing order. 0 is the highest priority, 255 the lowest.
- Origin of the section, relative to the origin of the keyboard.
- The width and height and the angle of rotation.
- A list of rows. A row is a list of horizontally or vertically adjacent keys. Horizontal rows parallel the (prerotation) top of the section, and vertical rows parallel the (prerotation) left of the section. All keys in a horizontal row share a common top coordinate; all keys in a vertical row share a left coordinate. Figure 13.3 shows the alpha section from the keyboard shown in Figure 13.2, divided into rows. Rows and keys are defined below.

13.3 Rows and Keys

A row description (XkbRowRec) consists of the coordinates of its origin relative to its enclosing section, a flag indicating whether the row is horizontal or vertical, and a list of keys in the row.

A key description (XkbKeyRec) consists of a key name, a shape, a key color, and a gap. The key name should correspond to one of the keys named in the keyboard names description, the shape specifies the appearance of the key, and the key color specifies the color of the key (not the label on the key; the label color is stored in the XkbGeometryRec). Keys are normally drawn immediately adjacent to one another from left to right (or top to bottom) within a row. The gap field specifies the distance between a key and its predecessor.
13.4 Doodads

Doodads can be global to the keyboard or part of a section. Doodads have symbolic names of arbitrary length. The only doodad name whose interpretation is specified by Xkb is “Edges”, which, if present, describes the outline of the entire keyboard.

Each doodad’s origin is stored in fields named left and top, which are the coordinates of the doodad’s origin relative to its enclosing object, whether it be a section or the top-level keyboard. The priority for doodads that are listed in the top-level geometry is relative to the other doodads listed in the top-level geometry and the sections listed in the top-level geometry. The priority for doodads listed in a section are relative to the other components of the section. Each doodad is stored in a structure with a type field, which specifies the type of doodad.

Xkb supports five types of doodads:

- An indicator doodad describes one of the physical keyboard indicators. Indicator doodads specify the shape of the indicator, the indicator color when it is lit (on_color) and the indicator color when it is dark (off_color).
- An outline doodad describes some aspect of the keyboard to be drawn as one or more hollow, closed polygons. Outline doodads specify the shape, color, and angle of rotation about the doodad origin at which they should be drawn.
- A solid doodad describes some aspect of the keyboard to be drawn as one or more filled polygons. Solid doodads specify the shape, color, and angle of rotation about the doodad origin at which they should be drawn.
- A text doodad describes a text label somewhere on the keyboard. Text doodads specify the label string, the font and color to use when drawing the label, and the angle of rotation of the doodad about its origin.
- A logo doodad is a catch-all, which describes some other visible element of the keyboard. A logo doodad is essentially an outline doodad with an additional symbolic name that describes the element to be drawn. If a keyboard display program recognizes the symbolic name, it can draw something appropriate within the bounding region of the shape specified in the doodad. If the symbolic name does not describe a recognizable image, it should draw an outline using the specified shape, outline, and angle of rotation. The Xkb extension does not specify the interpretation of logo names.

The structures these doodads are stored in and the values of the type fields are shown in Table 13.1.

<table>
<thead>
<tr>
<th>Doodad</th>
<th>Structure</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>indicator doodad</td>
<td>XkbIndicatorDoodadRec</td>
<td>XkbIndicatorDoodad</td>
</tr>
<tr>
<td>outline doodad</td>
<td>XkbShapeDoodadRec</td>
<td>XkbOutlineDoodad</td>
</tr>
<tr>
<td>solid doodad</td>
<td>XkbShapeDoodadRec</td>
<td>XkbSolidDoodad</td>
</tr>
<tr>
<td>text doodad</td>
<td>XkbTextDoodadRec</td>
<td>XkbTextDoodad</td>
</tr>
<tr>
<td>logo doodad</td>
<td>XkbLogoDoodadRec</td>
<td>XkbLogoDoodad</td>
</tr>
</tbody>
</table>

13.5 Overlay Rows and Overlay Keys

An overlay row (XkbOverlayRowRec) contains a pointer to the row it overlays and a list of overlay keys.

Each overlay key definition (XkbOverlayKeyRec) indicates a key that can yield multiple keycodes and consists of a field named under, which specifies the primary name of the
key and a field named \textit{over}, which specifies the name for the key when the overlay key-code is selected. The key specified in \textit{under} must be a member of the section that contains the overlay key definition, while the key specified in \textit{over} must not be.

\section*{13.6 Drawing a Keyboard Representation}

To draw a representation of the keyboard, draw in the following order:

\begin{itemize}
  \item Draw the top-level keyboard as a rectangle, using its width and height.
  \item For each component (section or doodad) of the top-level geometry, in priority order:
    \begin{itemize}
      \item If component is a section
        \begin{itemize}
          \item For each row, in the order it appears in the section
            \begin{itemize}
              \item Draw keys in the order they appear in the row
            \end{itemize}
          \end{itemize}
        \end{itemize}
    \end{itemize}
  \end{itemize}
Else draw doodad
13.7 Geometry Data Structures

In the following figures, a solid arrow denotes a pointer to an array of structures or a singleton structure. A dotted arrow denotes an index or a pointer into the array.

![Diagram of X Keyboard Extension 13: Geometry Data Structures]

**Figure 13.4 Xkb Geometry Data Structures**
Figure 13.5 Xkb Geometry Data Structures (Doodads)
typedef struct _XkbGeometry { /* top-level keyboard geometry structure */
    Atom name; /* keyboard name */
    unsigned short width_mm; /* keyboard width in mm/10 */
    unsigned short height_mm; /* keyboard height in mm/10 */
    char * label_font; /* font for key labels */ /* font for key labels */
    XkbColorPtr label_color; /* color for key labels - pointer into colors array */
    XkbColorPtr base_color; /* color for basic keyboard - pointer into colors array */
    unsigned short sz_properties; /* size of properties array */
    unsigned short sz_colors; /* size of colors array */
    unsigned short sz_shapes; /* size of shapes array */
    unsigned short sz_sections; /* size of sections array */
    unsigned short sz_doodads; /* size of doodads array */
    unsigned short sz_key_aliases; /* size of key aliases array */
    unsigned short num_properties; /* number of properties in the properties array */
    unsigned short num_colors; /* number of colors in the colors array */
    unsigned short num_shapes; /* number of shapes in the shapes array */
    unsigned short num_sections; /* number of sections in the sections array */
    unsigned short num_doodads; /* number of doodads in the doodads array */
};

Figure 13.6 Xkb Geometry Data Structures (Overlays)
unsigned short num_key_aliases; /* number of key aliases in the key */
XkbPropertyPtr properties; /* properties array */
XkbColorPtr colors; /* colors array */
XkbShapePtr shapes; /* shapes array */
XkbSectionPtr sections; /* sections array */
XkbDoodadPtr doodads; /* doodads array */
XkbKeyAliasPtr key_aliases; /* key aliases array */
}

The doodads array is only for doodads not contained in any of the sections that has its own doodads. The key aliases contained in the key_aliases array take precedence over any defined in the keycodes component of the keyboard description.

typedef struct _XkbProperty {
    char * name; /* property name */
    char * value; /* property value */
} XkbPropertyRec, *XkbPropertyPtr;

typedef struct _XkbColor {
    unsigned int pixel; /* color */
    char * spec; /* color name */
} XkbColorRec, *XkbColorPtr;

typedef struct _XkbKeyAliasRec {
    char real[XkbKeyNameLength]; /* real name of the key */
    char alias[XkbKeyNameLength]; /* alias for the key */
} XkbKeyAliasRec, *XkbKeyAliasPtr;

typedef struct _XkbPoint { /* x,y coordinates */
    short x; /* x */
    short y; /* y */
} XkbPointRec, *XkbPointPtr;

typedef struct _XkbOutline {
    unsigned short num_points; /* number of points in the outline */
    unsigned short sz_points; /* size of the points array */
    unsigned short corner_radius; /* draw corners as circles with this radius */
    XkbPointPtr points; /* array of points defining the outline */
} XkbOutlineRec, *XkbOutlinePtr;

typedef struct _XkbBounds { /* upper left corner of the bounds, in \text{mm}/10 */
    short x1,y1; /* upper left corner of the bounds, in \text{mm}/10 */
    short x2,y2; /* lower right corner of the bounds, in \text{mm}/10 */
} XkbBoundsRec, *XkbBoundsPtr;

typedef struct _XkbShape { /* shape’s name */
    Atom name; /* shape’s name */
    unsigned short num_outlines; /* number of outlines for the shape */
    unsigned short sz_outlines; /* size of the outlines array */
    XkbOutlinePtr outlines; /* array of outlines for the shape */
    XkbOutlinePtr approx; /* pointer into the array to the approximating outline */
    XkbOutlinePtr primary; /* pointer into the array to the primary outline */
    XkbBoundsRec bounds; /* bounding box for the shape; encompasses all outlines */
} XkbShapeRec, *XkbShapePtr;
If `approx` and/or `primary` is `NULL`, the default value is used. The default primary outline is the first element in the outlines array, as is the default approximating outline.

```c
typedef struct _XkbKey {
    XkbKeyNameRec name; /* key name */
    short gap; /* gap in mm/10 from previous key in row */
    unsigned char shape_ndx; /* index of shape for key */
    unsigned char color_ndx; /* index of color for key body */
} XkbKeyRec, *XkbKeyPtr;
```

```c
typedef struct _XkbRow {
    short top; /* top coordinate of row origin, relative to section’s origin */
    short left; /* left coordinate of row origin, relative to section’s origin */
    unsigned short num_keys; /* number of keys in the keys array */
    unsigned short sz_keys; /* size of the keys array */
    int vertical; /* True => vertical row, False => horizontal row */
    XkbKeyPtr keys; /* array of keys in the row */
    XkbBoundsRec bounds; /* bounding box for the row */
} XkbRowRec, *XkbRowPtr;
```

`top` and `left` are in `mm/10`.

```c
typedef struct _XkbOverlayRec {
    Atom name; /* overlay name */
    XkbSectionPtr section_under; /* the section under this overlay */
    unsigned short num_rows; /* number of rows in the rows array */
    unsigned short sz_rows; /* size of the rows array */
    XkbOverlayRowPtr rows; /* array of rows in the overlay */
    XkbBoundsPtr bounds; /* bounding box for the overlay */
} XkbOverlayRec, *XkbOverlayPtr;
```

```c
row_under is an index into the array of `rows` in the section under this overlay. The section under this overlay row is the one pointed to by `section_under` in this overlay row’s `XkbOverlayRec`.
```

```c
typedef struct _XkbOverlayRow {
    unsigned short row_under; /* index into the row under this overlay row */
    unsigned short num_keys; /* number of keys in the keys array */
    unsigned short sz_keys; /* size of the keys array */
    XkbOverlayKeyPtr keys; /* array of keys in the overlay row */
} XkbOverlayRowRec, *XkbOverlayRowPtr;
```

```c
row_under is an index into the array of `rows` in the section under this overlay. The section under this overlay row is the one pointed to by `section_under` in this overlay row’s `XkbOverlayRec`.
```

```c
typedef struct _XkbOverlayKey {
    XkbKeyNameRec over; /* name of this overlay key */
    XkbKeyNameRec under; /* name of the key under this overlay key */
} XkbOverlayKeyRec, *XkbOverlayKeyPtr;
```

```c
typedef struct _XkbSection {
    Atom name; /* section name */
    unsigned char priority; /* drawing priority, 0=>highest, 255=>lowest */
    short top; /* top coordinate of section origin */
    short left; /* left coordinate of row origin */
    unsigned short width; /* section width, in mm/10 */
    unsigned short height; /* section height, in mm/10 */
} XkbSectionRec, *XkbSectionPtr;
```
short angle; /* angle of section rotation, counterclockwise */
unsigned short num_rows; /* number of rows in the rows array */
unsigned short num_doodads; /* number of doodads in the doodads array */
unsigned short num_overlays; /* number of overlays in the overlays array */
unsigned short sz_rows; /* size of the rows array */
unsigned short sz_doodads; /* size of the doodads array */
unsigned short sz_overlays; /* size of the overlays array */
XkbRowPtr rows; /* section rows array */
XkbDoodadPtr doodads; /* section doodads array */
XkbBoundsRec bounds; /* bounding box for the section, before rotation */
XkbOverlayPtr overlays; /* section overlays array */

} XkbSectionRec, *XkbSectionPtr;

top and left are the origin of the section, relative to the origin of the keyboard, in \( \text{mm/10} \). angle is in \( \frac{1}{10} \) degrees.

**DoodadRec Structures**

The doodad arrays in the XkbGeometryRec and the XkbSectionRec may contain any of the doodad structures and types shown in Table 13.1.

The doodad structures form a union:

```c
typedef union _XkbDoodad {
    XkbAnyDoodadRec any;
    XkbShapeDoodadRec shape;
    XkbTextDoodadRec text;
    XkbIndicatorDoodadRec indicator;
    XkbLogoDoodadRec logo;
} XkbDoodadRec, *XkbDoodadPtr;
```

The top and left coordinates of each doodad are the coordinates of the origin of the doodad relative to the keyboard’s origin if the doodad is in the XkbGeometryRec doodad array, and with respect to the section’s origin if the doodad is in a XkbSectionRec doodad array. The color_ndx or on_color_ndx and off_color_ndx fields are color indices into the XkbGeometryRec’s color array and are the colors to draw the doodads with. Similarly, the shape_ndx fields are indices into the XkbGeometryRec’s shape array.

```c
typedef struct _XkbShapeDoodad {
    Atom name; /* doodad name */
    unsigned char type; /* XkbOutlineDoodad or XkbSolidDoodad */
    unsigned char priority; /* drawing priority, 0 => highest, 255 => lowest */
    short top; /* top coordinate, in \( \text{mm/10} \) */
    short left; /* left coordinate, in \( \text{mm/10} \) */
    short angle; /* angle of rotation, clockwise, in \( \frac{1}{10} \) degrees */
    unsigned short color_ndx; /* doodad color */
    unsigned short shape_ndx; /* doodad shape */
} XkbShapeDoodadRec, *XkbShapeDoodadPtr;
```

```c
typedef struct _XkbTextDoodad {
    Atom name; /* doodad name */
    unsigned char type; /* XkbTextDoodad */
    unsigned char priority; /* drawing priority, 0 => highest, 255 => lowest */
    short top; /* top coordinate, in \( \text{mm/10} \) */
} XkbTextDoodadRec, *XkbTextDoodadPtr;
```
The X Keyboard Extension 13  Keyboard Geometry

short left; /* left coordinate, in \text{mm/10} */
short angle; /* angle of rotation, clockwise, in \text{1/10 degrees} */
short width; /* width in \text{mm/10} */
short height; /* height in \text{mm/10} */
unsigned short color_ndx; /* doodad color */
char * text; /* doodad text */
char * font; /* arbitrary font name for doodad text */
}

XkbTextDoodadRec, *XkbTextDoodadPtr;

typedef struct _XkbIndicatorDoodad {
Atom name; /* doodad name */
unsigned char type; /* XkbIndicatorDoodad */
unsigned char priority; /* drawing priority, 0=>highest, 255=>lowest */
short top; /* top coordinate, in \text{mm/10} */
short left; /* left coordinate, in \text{mm/10} */
short angle; /* angle of rotation, clockwise, in \text{1/10 degrees} */
unsigned short shape_ndx; /* doodad shape */
unsigned short on_color_ndx; /* color for doodad if indicator is on */
unsigned short off_color_ndx; /* color for doodad if indicator is off */
} XkbIndicatorDoodadRec, *XkbIndicatorDoodadPtr;

typedef struct _XkbLogoDoodad {
Atom name; /* doodad name */
unsigned char type; /* XkbLogoDoodad */
unsigned char priority; /* drawing priority, 0=>highest, 255=>lowest */
short top; /* top coordinate, in \text{mm/10} */
short left; /* left coordinate, in \text{mm/10} */
short angle; /* angle of rotation, clockwise, in \text{1/10 degrees} */
unsigned short color_ndx; /* doodad color */
unsigned short shape_ndx; /* doodad shape */
char * logo_name; /* text for logo */
} XkbLogoDoodadRec, *XkbLogoDoodadPtr;

13.8 Getting Keyboard Geometry From the Server

You can load a keyboard geometry as part of the keyboard description returned by \textit{XkbGetKeyboard}. However, if a keyboard description has been previously loaded, you can instead obtain the geometry by calling the \textit{XkbGetGeometry}. In this case, the geometry returned is the one associated with the keyboard whose device ID is contained in the keyboard description.

To load a keyboard geometry if you already have the keyboard description, use \textit{XkbGetGeometry}.

\textbf{Status} \textbf{XkbGetGeometry}(dpy, xkb)

\begin{verbatim}
Display * dpy; /* connection to the X server */
XkbDescPtr xkb; /* keyboard description that contains the ID for the keyboard and into which the geometry should be loaded */
\end{verbatim}

\textit{XkbGetGeometry} can return BadValue, BadImplementation, BadName, BadAlloc, or BadLength errors or Success if it succeeds.
It is also possible to load a keyboard geometry by name. The X server maintains a data-
base of keyboard components (see Chapter 20). To load a keyboard geometry description
from this database by name, use XkbGetNamedGeometry.

Status XkbGetNamedGeometry(dpy, xkb, name)

  Display * dpy;    /* connection to the X server */
  XkbDescPtr xkb;    /* keyboard description into which the geometry should be loaded */
  Atom name;         /* name of the geometry to be loaded */

XkbGetNamedGeometry can return BadName if the name cannot be found.

13.9 Using Keyboard Geometry

Xkb provides a number of convenience functions to help use a keyboard geometry. These
include functions to return the bounding box of a shape’s top surface and to update the
bounding box of a shape row or section.

A shape is made up of a number of outlines. Each outline is a polygon made up of a num-
ber of points. The bounding box of a shape is a rectangle that contains all the outlines of
that shape.

Figure 13.7  Key Surface, Shape Outlines, and Bounding Box

To determine the bounding box of the top surface of a shape, use XkbComputeShapeTop.

Bool XkbComputeShapeTop(shape, bounds_rtrn)

  XkbShapePtr shape;    /* shape to be examined */
  XkbBoundsPtr bounds_rtrn /* backfilled with the bounding box for the shape */

XkbComputeShapeTop returns a BoundsRec that contains two x and y coordinates. These
coordinates describe the corners of a rectangle that contains the outline that describes the
top surface of the shape. The top surface is defined to be the approximating outline if the
approx field of shape is not NULL. If approx is NULL, the top surface is defined as the last
outline in the shape’s array of outlines. XkbComputeShapeTop returns False if shape is
NULL or if there are no outlines for the shape; otherwise, it returns True.

A ShapeRec contains a BoundsRec that describes the bounds of the shape. If you add or
delete an outline to or from a shape, the bounding box must be updated. To update the
bounding box of a shape, use XkbComputeShapeBounds.

Bool XkbComputeShapeBounds(shape)

  XkbShapePtr shape;    /* shape to be examined */

XkbComputeShapeBounds updates the BoundsRec contained in the shape by examining
all the outlines of the shape and setting the BoundsRec to the minimum x and minimum
y, and maximum x and maximum y values found in those outlines. \texttt{XkbComputeShapeBounds} returns \texttt{False} if \texttt{shape} is \texttt{NULL} or if there are no outlines for the shape; otherwise, it returns \texttt{True}.

If you add or delete a key to or from a row, or if you update the shape of one of the keys in that row, you may need to update the bounding box of that row. To update the bounding box of a row, use \texttt{XkbComputeRowBounds}.

\begin{verbatim}
Bool XkbComputeRowBounds(geom, section, row)
    XkbGeometryPtr geom; /* geometry that contains the section */
    XkbSectionPtr section; /* section that contains the row */
    XkbRowPtr row; /* row to be examined and updated */

XkbComputeRowBounds checks the bounds of all keys in the row and updates the bounding box of the row if necessary. \texttt{XkbComputeRowBounds} returns \texttt{False} if any of the arguments is \texttt{NULL}; otherwise, it returns \texttt{True}.

If you add or delete a row to or from a section, or if you change the geometry of any of the rows in that section, you may need to update the bounding box for that section. To update the bounding box of a section, use \texttt{XkbComputeSectionBounds}.

\begin{verbatim}
Bool XkbComputeSectionBounds(geom, section)
    XkbGeometryPtr geom; /* geometry that contains the section */
    XkbSectionPtr section; /* section to be examined and updated */

XkbComputeSectionBounds examines all the rows of the section and updates the bounding box of that section so that it contains all rows. \texttt{XkbComputeSectionBounds} returns \texttt{False} if any of the arguments is \texttt{NULL}; otherwise, it returns \texttt{True}.

Keys that can generate multiple keycodes may be associated with multiple names. Such keys have a primary name and an alternate name. To find the alternate name by using the primary name for a key that is part of an overlay, use \texttt{XkbFindOverlayForKey}.

\begin{verbatim}
char * XkbFindOverlayForKey(geom, section, under)
    XkbGeometryPtr geom; /* geometry that contains the section */
    XkbSectionPtr section; /* section to be searched for matching keys */
    char * under. /* primary name of the key to be considered */

XkbFindOverlayForKey uses the primary name of the key, \texttt{under}, to look up the alternate name, which it returns.
\end{verbatim}

\subsection{13.10 Adding Elements to a Keyboard Geometry}

Xkb provides functions to add a single new element to the top-level keyboard geometry. In each case the \texttt{num_*} fields of the corresponding structure is incremented by 1. These functions do not change \texttt{sz_*} unless there is no more room in the array. Some of these functions fill in the values of the element’s structure from the arguments. For other functions, you must explicitly write code to fill the structure’s elements.

The top-level geometry description includes a list of \textit{geometry properties}. A geometry property associates an arbitrary string with an equally arbitrary name. Programs that display images of keyboards can use geometry properties as hints, but they are not interpreted by Xkb. No other geometry structures refer to geometry properties.
To add one property to an existing keyboard geometry description, use `XkbAddGeomProperty`.

```c
XkbPropertyPtr XkbAddGeomProperty(XkbGeometryPtr geom, const char *name, const char *value)
```

To add one key alias to an existing keyboard geometry description, use `XkbAddGeomKeyAlias`.

```c
XkbKeyAliasPtr XkbAddGeomKeyAlias(XkbGeometryPtr geom, const char *alias, const char *real)
```

To add one color name to an existing keyboard geometry description, use `XkbAddGeomColor`.

```c
XkbColorPtr XkbAddGeomColor(XkbGeometryPtr geom, const char *spec, unsigned int pixel)
```

To add one outline to an existing shape, use `XkbAddGeomOutline`.

```c
XkbOutlinePtr XkbAddGeomOutline(XkbShapePtr shape, int sz_points)
```

`XkbAddGeomProperty` adds one property with the specified `name` and `value` to the keyboard geometry specified by `geom`. `XkbAddGeomProperty` returns `NULL` if any of the parameters is empty or if it was not able to allocate space for the property. To allocate space for an arbitrary number of properties, use the `XkbAllocGeomProps` function.

`XkbAddGeomKeyAlias` adds one key alias with the value `alias` to the geometry `geom`, and associates it with the key whose real name is `real`. `XkbAddGeomKeyAlias` returns `NULL` if any of the parameters is empty or if it was not able to allocate space for the alias. To allocate space for an arbitrary number of aliases, use the `XkbAllocGeomKeyAliases` function.

`XkbAddGeomColor` adds the specified color `name` and `pixel` to the specified geometry `geom`. The top-level geometry description includes a list of up to `MaxColors` (32) color names. A color name is a string whose interpretation is not specified by Xkb and neither is the `pixel` value’s interpretation. All other geometry data structures refer to colors using their indices in this global list or pointers to colors in this list. `XkbAddGeomColor` returns `NULL` if any of the parameters is empty or if it was not able to allocate space for the color. To allocate space for an arbitrary number of colors to a geometry, use the `XkbAllocGeomColors` function.

To add one outline to an existing shape, use `XkbAddGeomOutline`. An outline consists of an arbitrary number of points. `XkbAddGeomOutline` adds an outline to the specified `shape` by reserving `sz_points` points for it. The new outline is allocated and zeroed. `XkbAddGeomOutline` returns `NULL` if any of the parameters is empty or if it was not able to allocate space. To allocate space for an arbitrary number of outlines to a shape, use `XkbAllocGeomOutlines`. 
To add a shape to a keyboard geometry, use \texttt{XkbAddGeomShape}.

\begin{verbatim}
XkbShapePtr XkbAddGeomShape(geom, name, sz_outlines)
    XkbGeometryPtr geom; /* geometry to be updated */
    Atom name; /* name of the new shape */
    int sz_outlines; /* number of outlines to be reserved */
\end{verbatim}

A geometry contains an arbitrary number of shapes, each of which is made up of an arbitrary number of outlines. \texttt{XkbAddGeomShape} adds a shape to a geometry \texttt{geom} by allocating space for \texttt{sz_outlines} outlines for it and giving it the name specified by \texttt{name}. If a shape with name \texttt{name} already exists in the geometry, a pointer to the existing shape is returned. \texttt{XkbAddGeomShape} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space. To allocate space for an arbitrary number of geometry shapes, use \texttt{XkbAllocGeomShapes}.

To add one key at the end of an existing row of keys, use \texttt{XkbAddGeomKey}.

\begin{verbatim}
XkbKeyPtr XkbAddGeomKey(row)
    XkbRowPtr row; /* row to be updated */
\end{verbatim}

Keys are grouped into rows. \texttt{XkbAddGeomKey} adds one key to the end of the specified \texttt{row}. The key is allocated and zeroed. \texttt{XkbAddGeomKey} returns \texttt{NULL} if \texttt{row} is empty or if it was not able to allocate space for the key. To allocate space for an arbitrary number of keys to a row, use \texttt{XkbAllocGeomKeys}.

To add one section to an existing keyboard geometry, use \texttt{XkbAddGeomSection}.

\begin{verbatim}
XkbSectionPtr XkbAddGeomSection(geom, name, sz_rows, sz_doodads, sz_overlays)
    XkbGeometryPtr geom; /* geometry to be updated */
    Atom name; /* name of the new section */
    int sz_rows; /* number of rows to reserve in the section */
    int sz_doodads; /* number of doodads to reserve in the section */
    int sz_overlays; /* number of overlays to reserve in the section */
\end{verbatim}

A keyboard geometry contains an arbitrary number of sections. \texttt{XkbAddGeomSection} adds one section to an existing keyboard geometry \texttt{geom}. The new section contains space for the number of rows, doodads, and overlays specified by \texttt{sz_rows}, \texttt{sz_doodads}, and \texttt{sz_overlays}. The new section is allocated and zeroed and given the name specified by \texttt{name}. If a section with name \texttt{name} already exists in the geometry, a pointer to the existing section is returned. \texttt{XkbAddGeomSection} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space for the section. To allocate space for an arbitrary number of sections to a geometry, use \texttt{XkbAllocGeomSections}.

To add a row to a section, use \texttt{XkbAddGeomRow}.

\begin{verbatim}
XkbRowPtr XkbAddGeomRow(section, sz_keys)
    XkbSectionPtr section; /* section to be updated */
    int sz_keys; /* number of keys to be reserved */
\end{verbatim}

One of the components of a keyboard geometry section is one or more rows of keys. \texttt{XkbAddGeomRow} adds one row to the specified \texttt{section}. The newly created row contains space for the number of keys specified in \texttt{sz_keys}. They are allocated and zeroed, but otherwise uninitialized. \texttt{XkbAddGeomRow} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space for the row. To allocate space for an arbitrary number of rows to a section, use the \texttt{XkbAllocGeomRows} function.
To add one doodad to a section of a keyboard geometry or to the top-level geometry, use \textit{XkbAddGeomDoodad}.

\begin{verbatim}
XkbDoodadPtr XkbAddGeomDoodad(geom, section, name)
  XkbGeometryPtr geom;    /* geometry to which the doodad is added */
  XkbSectionPtr section;  /* section, if any, to which the doodad is added */
  Atom name;              /* name of the new doodad */

A doodad describes some visible aspect of the keyboard that is not a key and is not a section. \textit{XkbAddGeomDoodad} adds a doodad with name specified by \textit{name} to the geometry \textit{geom} if \textit{section} is \texttt{NULL} or to the section of the geometry specified by \textit{section} if \textit{section} is not \texttt{NULL}. \textit{XkbAddGeomDoodad} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space for the doodad. If there is already a doodad with the name \textit{name} in the doodad array for the geometry (if \textit{section} is \texttt{NULL}) or the section (if \textit{section} is non-\texttt{NULL}), a pointer to that doodad is returned. To allocate space for an arbitrary number of doodads to a section, use the \textit{XkbAllocGeomSectionDoodads} function. To allocate space for an arbitrary number of doodads to a keyboard geometry, use the \textit{XkbAllocGeomDoodads} function.

To add one overlay to a section, use \textit{XkbAddGeomOverlay}.

\begin{verbatim}
XkbOverlayPtr XkbAddGeomOverlay(section, name, sz_rows)
  XkbSectionPtr section;  /* section to which an overlay will be added */
  Atom name;              /* name of the overlay */
  int sz_rows;            /* number of rows to reserve in the overlay */

\textit{XkbAddGeomOverlay} adds an overlay with the specified name to the specified \textit{section}. The new overlay is created with space allocated for \textit{sz_rows} rows. If an overlay with name \textit{name} already exists in the section, a pointer to the existing overlay is returned. \textit{XkbAddGeomOverlay} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space for the overlay. To allocate space for an arbitrary number of overlays to a section, use the \textit{XkbAllocGeomOverlay} function.

To add a row to an existing overlay, use \textit{XkbAddGeomOverlayRow}.

\begin{verbatim}
XkbOverlayRowPtr XkbAddGeomOverlayRow(overlay, row_under, sz_keys)
  XkbOverlayPtr overlay;   /* overlay to be updated */
  XkbRowPtr row_under;     /* row to be overlayed in the section overlay overlays */
  int sz_keys;             /* number of keys to reserve in the row */

\textit{XkbAddGeomOverlayRow} adds one row to the \textit{overlay}. The new row contains space for \textit{sz_keys} keys. If \textit{row_under} specifies a row that doesn’t exist on the underlying section, \textit{XkbAddGeomOverlayRow} returns \texttt{NULL} and doesn’t change the overlay. \textit{XkbAddGeomOverlayRow} returns \texttt{NULL} if any of the parameters is empty or if it was not able to allocate space for the overlay.

To add a key to an existing overlay row, use \textit{XkbAddGeomOverlayKey}.

\begin{verbatim}
XkbOverlayKeyPtr XkbAddGeomOverlayKey(overlay, row, under)
  XkbOverlayPtr overlay;   /* overlay to be updated */
  XkbRowPtr row;          /* row in overlay to be updated */
  char * under;           /* primary name of the key to be considered */

\textit{XkbAddGeomOverlayKey} adds one key to the \textit{row} in the \textit{overlay}. If there is no key named \textit{under} in the row of the underlying section, \textit{XkbAddGeomOverlayKey} returns \texttt{NULL}.
\end{verbatim}
\end{verbatim}
13.11 Allocating and Freeing Geometry Components

Xkb provides a number of functions to allocate and free subcomponents of a keyboard geometry. Use these functions to create or modify keyboard geometries. Note that these functions merely allocate space for the new element(s), and it is up to you to fill in the values explicitly in your code. These allocation functions increase sz_* but never touch num_* (unless there is an allocation failure, in which case they reset both sz_* and num_* to zero). These functions return Success if they succeed, BadAlloc if they are not able to allocate space, or BadValue if a parameter is not as expected.

To allocate space for an arbitrary number of outlines to a shape, use XkbAllocGeomOutlines.

Status XkbAllocGeomOutlines(shape, num_needed)
   XkbShapePtr shape; /* shape for which outlines should be allocated */
   int num_needed; /* number of new outlines required */

XkbAllocGeomOutlines allocates space for num_needed outlines in the specified shape. The outlines are not initialized.

To free geometry outlines, use XkbFreeGeomOutlines.

void XkbFreeGeomOutlines(shape, first, count, free_all)
   XkbShapePtr shape; /* shape in which outlines should be freed */
   int first; /* first outline to be freed */
   int count; /* number of outlines to be freed */
   Bool free_all; /* True => all outlines are freed */

If free_all is True, all outlines are freed regardless of the value of first or count. Otherwise, count outlines are freed beginning with the one specified by first.

To allocate space for an arbitrary number of keys to a row, use XkbAllocGeomKeys.

Status XkbAllocGeomKeys(row, num_needed)
   XkbRowPtr row; /* row to which keys should be allocated */
   int num_needed; /* number of new keys required */

XkbAllocGeomKeys allocates num_needed keys and adds them to the row. No initialization of the keys is done.

To free geometry keys, use XkbFreeGeomKeys.

void XkbFreeGeomKeys(row, first, count, free_all)
   XkbRowPtr row; /* row in which keys should be freed */
   int first; /* first key to be freed */
   int count; /* number of keys to be freed */
   Bool free_all; /* True => all keys are freed */

If free_all is True, all keys are freed regardless of the value of first or count. Otherwise, count keys are freed beginning with the one specified by first.

To allocate geometry properties, use XkbAllocGeomProps.

Status XkbAllocGeomProps(geom, num_needed)
   XkbGeometryPtr geom; /* geometry for which properties should be allocated */
   int num_needed; /* number of new properties required */
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**XkbAllocGeomProps** allocates space for `num_needed` properties and adds them to the specified geometry `geom`. No initialization of the properties is done. A geometry property associates an arbitrary string with an equally arbitrary name. Geometry properties can be used to provide hints to programs that display images of keyboards, but they are not interpreted by Xkb. No other geometry structures refer to geometry properties.

To free geometry properties, use **XkbFreeGeomProperties**.

```c
void XkbFreeGeomProperties(geom, first, count, free_all)

XkbGeometryPtr geom; /* geometry in which properties should be freed */
int first; /* first property to be freed */
int count; /* number of properties to be freed */
Bool free_all; /* True => all properties are freed */
```

If `free_all` is `True`, all properties are freed regardless of the value of `first` or `count`. Otherwise, `count` properties are freed beginning with the one specified by `first`.

To allocate geometry key aliases, use **XkbAllocGeomKeyAliases**.

```c
Status XkbAllocGeomKeyAliases(geom, num_needed)

XkbGeometryPtr geom; /* geometry for which key aliases should be allocated */
int num_needed; /* number of new key aliases required */
```

**XkbAllocGeomKeyAliases** allocates space for `num_needed` key aliases and adds them to the specified geometry `geom`. A key alias is a pair of strings that associates an alternate name for a key with the real name for that key.

To free geometry key aliases, use **XkbFreeGeomKeyAliases**.

```c
void XkbFreeGeomKeyAliases(geom, first, count, free_all)

XkbGeometryPtr geom; /* geometry in which key aliases should be freed */
int first; /* first key alias to be freed */
int count; /* number of key aliases to be freed */
Bool free_all; /* True => all key aliases are freed */
```

If `free_all` is `True`, all aliases in the top level of the specified geometry `geom` are freed regardless of the value of `first` or `count`. Otherwise, `count` aliases in `geom` are freed beginning with the one specified by `first`.

To allocate geometry colors, use **XkbAllocGeomColors**.

```c
Status XkbAllocGeomColors(geom, num_needed)

XkbGeometryPtr geom; /* geometry for which colors should be allocated */
int num_needed; /* number of new colors required. */
```

**XkbAllocGeomColors** allocates space for `num_needed` colors and adds them to the specified geometry `geom`. A color name is a string whose interpretation is not specified by Xkb. All other geometry data structures refer to colors using their indices in this global list or pointers to colors in this list.
To free geometry colors, use `XkbFreeGeomColors`.

```c
void XkbFreeGeomColors(geom, first, count, free_all)

    XkbGeometryPtr geom; /* geometry in which colors should be freed */
    int first; /* first color to be freed */
    int count; /* number of colors to be freed */
    Bool free_all; /* True => all colors are freed */
```

If `free_all` is `True`, all colors are freed regardless of the value of `first` or `count`. Otherwise, `count` colors are freed beginning with the one specified by `first`.

To allocate points in an outline, use `XkbAllocGeomPoints`.

```c
Status XkbAllocGeomPoints(outline, num_needed)

    XkbOutlinePtr outline; /* outline for which points should be allocated */
    int num_needed; /* number of new points required */
```

`XkbAllocGeomPoints` allocates space for `num_needed` points in the specified `outline`. The points are not initialized.

To free points in an outline, use `XkbFreeGeomPoints`.

```c
void XkbFreeGeomPoints(outline, first, count, free_all)

    XkbOutlinePtr outline; /* outline in which points should be freed */
    int first; /* first point to be freed. */
    int count; /* number of points to be freed */
    Bool free_all; /* True => all points are freed */
```

If `free_all` is `True`, all points are freed regardless of the value of `first` and `count`. Otherwise, the number of points specified by `count` are freed, beginning with the point specified by `first` in the specified outline.

To allocate space for an arbitrary number of geometry shapes, use `XkbAllocGeomShapes`.

```c
Status XkbAllocGeomShapes(geom, num_needed)

    XkbGeometryPtr geom; /* geometry for which shapes should be allocated */
    int num_needed; /* number of new shapes required */
```

`XkbAllocGeomShapes` allocates space for `num_needed` shapes in the specified geometry `geom`. The shapes are not initialized.

To free geometry shapes, use `XkbFreeGeomShapes`.

```c
void XkbFreeGeomShapes(geom, first, count, free_all)

    XkbGeometryPtr geom; /* geometry in which shapes should be freed */
    int first; /* first shape to be freed */
    int count; /* number of shapes to be freed */
    Bool free_all; /* True => all shapes are freed */
```

If `free_all` is `True`, all shapes in the geometry are freed regardless of the values of `first` and `count`. Otherwise, `count` shapes are freed, beginning with the shape specified by `first`.

To allocate geometry sections, use `XkbAllocGeomSections`.

```c
Status XkbAllocGeomSections(geom, num_needed)

    XkbGeometryPtr geom; /* geometry for which sections should be allocated */
    int num_needed; /* number of new sections required */
```
**XkbAllocGeomSections** allocates *num_needed* sections and adds them to the geometry *geom*. No initialization of the sections is done.

To free geometry sections, use **XkbFreeGeomSections**.

```c
void XkbFreeGeomSections(geom, first, count, free_all)
    XkbGeometryPtr geom; /* geometry in which sections should be freed */
    int first; /* first section to be freed */
    int count; /* number of sections to be freed */
    Bool free_all; /* True => all sections are freed */
```

If *free_all* is True, all sections are freed regardless of the value of *first* and *count*. Otherwise, the number of sections specified by *count* are freed, beginning with the section specified by *first* in the specified geometry.

To allocate rows in a section, use **XkbAllocGeomRows**.

```c
Status XkbAllocGeomRows(section, num_needed)
    XkbSectionPtr section; /* section for which rows should be allocated */
    int num_needed; /* number of new rows required */
```

**XkbAllocGeomRows** allocates *num_needed* rows and adds them to the *section*. No initialization of the rows is done.

To free rows in a section, use **XkbFreeGeomRows**.

```c
void XkbFreeGeomRows(section, first, count, free_all)
    XkbSectionPtr section; /* section in which rows should be freed */
    int first; /* first row to be freed */
    int count; /* number of rows to be freed */
    Bool free_all; /* True => all rows are freed */
```

If *free_all* is True, all rows are freed regardless of the value of *first* and *count*. Otherwise, the number of rows specified by *count* are freed, beginning with the row specified by *first* in the specified section.

To allocate overlays in a section, use **XkbAllocGeomOverlays**.

```c
Status XkbAllocGeomOverlays(section, num_needed)
    XkbSectionPtr section; /* section for which overlays should be allocated */
    int num_needed; /* number of new overlays required */
```

**XkbAllocGeomOverlays** allocates *num_needed* overlays and adds them to the *section*. No initialization of the overlays is done.

To free rows in an section, use **XkbFreeGeomOverlays**.

```c
void XkbFreeGeomOverlays(section, first, count, free_all)
    XkbSectionPtr section; /* section in which overlays should be freed */
    int first; /* first overlay to be freed */
    int count; /* number of overlays to be freed */
    Bool free_all; /* True => all overlays are freed */
```

If *free_all* is True, all overlays are freed regardless of the value of *first* and *count*. Otherwise, the number of overlays specified by *count* are freed, beginning with the overlay specified by *first* in the specified section.
To allocate rows in a overlay, use \texttt{XkbAllocGeomOverlayRows}.

\textbf{Status} \texttt{XkbAllocGeomOverlayRows}(overlay, num\textunderscore needed)

\begin{verbatim}
XkbSectionPtr overlay; /* section for which rows should be allocated */
int num\textunderscore needed; /* number of new rows required */
\end{verbatim}

\texttt{XkbAllocGeomOverlayRows} allocates \texttt{num\textunderscore needed} rows and adds them to the \texttt{overlay}. No initialization of the rows is done.

To free rows in an overlay, use \texttt{XkbFreeGeomOverlayRows}.

\begin{verbatim}
void XkbFreeGeomOverlayRows(overlay, first, count, free\textunderscore all)
XkbSectionPtr overlay; /* section in which rows should be freed */
int first; /* first row to be freed. */
int count; /* number of rows to be freed */
Bool free\textunderscore all; /* True => all rows are freed */
\end{verbatim}

If \texttt{free\textunderscore all} is \texttt{True}, all rows are freed regardless of the value of \texttt{first} and \texttt{count}. Otherwise, the number of rows specified by \texttt{count} are freed, beginning with the row specified by \texttt{first} in the specified overlay.

To allocate keys in an overlay row, use \texttt{XkbAllocGeomOverlayKeys}.

\textbf{Status} \texttt{XkbAllocGeomOverlayKeys}(row, num\textunderscore needed)

\begin{verbatim}
XkbRowPtr row; /* section for which rows should be allocated */
int num\textunderscore needed; /* number of new rows required */
\end{verbatim}

\texttt{XkbAllocGeomOverlayKeys} allocates \texttt{num\textunderscore needed} keys and adds them to the \texttt{row}. No initialization of the keys is done.

To free keys in an overlay row, use \texttt{XkbFreeGeomOverlayKeys}.

\begin{verbatim}
void XkbFreeGeomOverlayKeys(row, first, count, free\textunderscore all)
XkbRowPtr row; /* row in which keys should be freed */
int first; /* first key to be freed. */
int count; /* number of keys to be freed */
Bool free\textunderscore all; /* True => all keys are freed */
\end{verbatim}

If \texttt{free\textunderscore all} is \texttt{True}, all keys are freed regardless of the value of \texttt{first} and \texttt{count}. Otherwise, the number of keys specified by \texttt{count} are freed, beginning with the key specified by \texttt{first} in the specified row.

To allocate doodads that are global to a keyboard geometry, use \texttt{XkbAllocGeomDoodads}.

\textbf{Status} \texttt{XkbAllocGeomDoodads}(geom, num\textunderscore needed)

\begin{verbatim}
XkbGeometryPtr geom; /* geometry for which doodads should be allocated */
int num\textunderscore needed; /* number of new doodads required */
\end{verbatim}

\texttt{XkbAllocGeomDoodads} allocates \texttt{num\textunderscore needed} doodads and adds them to the specified geometry \texttt{geom}. No initialization of the doodads is done.

To allocate doodads that are specific to a section, use \texttt{XkbAllocGeomSectionDoodads}.

\textbf{Status} \texttt{XkbAllocGeomSectionDoodads}(section, num\textunderscore needed)

\begin{verbatim}
XkbSectionPtr section; /* section for which doodads should be allocated */
int num\textunderscore needed; /* number of new doodads required */
\end{verbatim}
XkbAllocGeomSectionDoodads allocates num_needed doodads and adds them to the specified section. No initialization of the doodads is done.

To free geometry doodads, use XkbFreeGeomDoodads.

void XkbFreeGeomDoodads(doodads, count, free_all)
    XkbDoodadPtr doodads;  /* doodads to be freed */
    int count;            /* number of doodads to be freed */
    Bool free_all;       /* True => all doodads are freed */

If free_all is True, all doodads in the array are freed, regardless of the value of count. Otherwise, count doodads are freed.

To allocate an entire geometry, use XkbAllocGeometry.

Status XkbAllocGeometry(xkb, sizes)
    XkbDescPtr xkb;  /* keyboard description for which geometry is to be allocated */
    XkbGeometrySizesPtr sizes; /* initial sizes for all geometry components */

XkbAllocGeometry allocates a keyboard geometry and adds it to the keyboard description specified by xkb. The keyboard description should be obtained via the XkbGetKeyboard or XkbAllocKeyboard functions. The sizes parameter specifies the number of elements to be reserved for the subcomponents of the keyboard geometry and can be zero or more. These subcomponents include the properties, colors, shapes, sections, and doodads.

To free an entire geometry, use XkbFreeGeometry.

void XkbFreeGeometry(geom, which, free_all)
    XkbGeometryPtr geom; /* geometry to be freed */
    unsigned int which;  /* mask of geometry components to be freed */
    Bool free_all;       /* True => the entire geometry is freed. */

The values of which and free_all determine how much of the specified geometry is freed. The valid values for which are:

#define XkbGeomPropertiesMask (1<<0)
#define XkbGeomColorsMask (1<<1)
#define XkbGeomShapesMask (1<<2)
#define XkbGeomSectionsMask (1<<3)
#define XkbGeomDoodadsMask (1<<4)
#define XkbGeomAllMask (0x1f)

If free_all is True, the entire geometry is freed regardless of the value of which. Otherwise, the portions of the geometry specified by which are freed.
14 **Xkb Keyboard Mapping**

The Xkb keyboard mapping contains all the information the server and clients need to interpret key events. This chapter provides an overview of the terminology used to describe an Xkb keyboard mapping and introduces common utilities for manipulating the keyboard mapping.

The mapping consists of two components, a server map and a client map. The *client* map is the collection of information a client needs to interpret key events from the keyboard. It contains a global list of key types and an array of key symbol maps, each of which describes the symbols bound to a key and the rules to be used to interpret those symbols. The *server* map contains the information the server needs to interpret key events. This includes actions and behaviors for each key, explicit components for a key, and the virtual modifiers and the per-key virtual modifier mapping.

For detailed information on particular components of the keyboard map, refer to Chapter 15, “Xkb Client Keyboard Mapping” and Chapter 16, “Xkb Server Keyboard Mapping.”

14.1 **Notation and Terminology**

The graphic characters or control functions that may be accessed by one key are logically arranged in groups and levels, where *group* and *level* are defined as in the ISO9995 standard:

- **Group**: A logical state of a keyboard providing access to a collection of graphic characters. Usually these graphic characters logically belong together and may be arranged on several levels within a group.

- **Level**: One of several states (normally 2 or 3) governing which graphic character is produced when a graphic key is actuated. In certain cases the level may also affect function keys.

These definitions, taken from the ISO standard, refer to graphic keys and characters. In the context of Xkb, Group and Level are not constrained to graphic keys and characters; they may be used with any key to access any character the key is capable of generating.

Level is often referred to as “Shift Level”. Levels are numbered sequentially starting at one.

**Note**  
Shift level is derived from the modifier state, but not necessarily in the same way for all keys. For example, the **Shift** modifier selects shift level 2 on most keys, but for keypad keys the modifier bound to **Num_Lock** (that is, the **NumLock** virtual modifier) also selects shift level 2.
For example, consider the following key (the gray characters indicate symbols that are implied or expected but are not actually engraved on the key):

```
    Shift Level
      G1L1 = a
      G1L2 = A
      G2L1 = æ
      G2L2 = Æ

  L1  L2  L1  L2
  a   A   æ   Æ
  G1  G2
```

Figure 14.1 Shift Levels and Groups

This key has two groups, indicated by the columns, and each group has two shift levels. For the first group (Group1), the symbol shift level one is a, and the symbol for shift level two is A. For the second group, the symbol for shift level one is æ, and the symbol for shift level two is Æ.

14.1.1 Core Implementation

The standard interpretation rules for the core X keymap only allow clients to access keys such as the one shown in Figure 14.1. That is, clients using the standard interpretation rules can only access one of four keyyms for any given KeyPress event — two different symbols in two different groups.

In general, the Shift modifier, the Lock modifier, and the modifier bound to the Num_Lock key are used to change between shift level 1 and shift level 2. To switch between groups, the core implementation uses the modifier bound to the Mode_switch key. When the Mode_switch modifier is set, the keyboard is logically in Group 2. When the Mode_switch modifier is not set, the keyboard is logically in Group 1.

The core implementation does not clearly specify the behavior of keys. For example, the locking behavior of the CapsLock and Num_Lock keys depends on the vendor.

14.1.2 Xkb Implementation

Xkb extends the core implementation by providing access to up to four keyboard groups with up to 63 shift levels per key. In addition, Xkb provides precise specifications regarding the behavior of keys. In Xkb, modifier state and the current group are independent (with the exception of compatibility mapping, discussed in Chapter 17).

Xkb handles switching between groups via key actions, independent of any modifier state information. Key actions are in the server map component and are described in detail in section 16.1.4.

Xkb handles shift levels by associating a key type with each group on each key. Each key type defines the shift levels available for the groups on keys of its type and specifies the modifier combinations necessary to access each level.

---

1. The core implementation restricts the number of symbols per key to 255. With four groups, this allows for up to 63 symbols (or shift levels) per group. Most keys will only have a few shift levels.
For example, Xkb allows key types where the Control modifier can be used to access the shift level two of a key. Key types are in the client map component and are described in detail in section 15.2.

Xkb provides precise specification of the behavior of a key using key behaviors. Key behaviors are in the server map component and are described in detail in section 16.2.

### 14.2 Getting Map Components from the Server

Xkb provides two functions to obtain the keyboard mapping components from the server. The first function, `XkbGetMap`, allocates an `XkbDescRec` structure, retrieves mapping components from the server, and stores them in the `XkbDescRec` structure it just allocated. The second function, `XkbGetUpdatedMap`, retrieves mapping components from the server and stores them in an `XkbDescRec` structure that has previously been allocated.

To allocate an `XkbDescRec` structure and populate it with the server’s keyboard client map and server map, use `XkbGetMap`. `XkbGetMap` is similar to `XkbGetKeyboard` (see section 6.2), but is used only for obtaining the address of an `XkbDescRec` structure that is populated with keyboard mapping components. It allows finer control over which substructures of the keyboard mapping components are to be populated. `XkbGetKeyboard` always returns fully populated components, while `XkbGetMap` can be instructed to return a partially populated component.

```c
XkbDescPtr XkbGetMap(display, which, device_spec)
    Display * display; /* connection to X server */
    unsigned int which; /* mask selecting subcomponents to populate */
    unsigned int device_spec; /* device_id, or XkbUseCoreKbd */
```

The `which` mask is a bitwise inclusive OR of the masks defined in Table 14.1. Only those portions of the keyboard server map and the keyboard client maps that are specified in `which` are allocated and populated.

In addition to allocating and obtaining the server map and the client map, `XkbGetMap` also sets the `device_spec`, the `min_key_code`, and `max_key_code` fields of the keyboard description.

`XkbGetMap` is synchronous; it queries the server for the desired information, waits for a reply, and then returns. If successful, `XkbGetMap` returns a pointer to the `XkbDescRec` structure it allocated. If unsuccessful, `XkbGetMap` returns `NULL`. When unsuccessful, one of the following protocol errors is also generated: `BadAlloc` (unable to allocate the `XkbDescRec` structure), `BadValue` (some mask bits in `which` are undefined), or `BadImplementation` (a compatible version of the Xkb extension is not available in the server). To free the returned data, use `XkbFreeClientMap`.

Xkb also provides convenience functions to get partial component definitions from the server. These functions are specified in the “convenience functions” column in Table 14.1. Refer to the sections listed in the table for more information on these functions.

### Table 14.1 Xkb Mapping Component Masks and Convenience Functions

<table>
<thead>
<tr>
<th>Mask</th>
<th>Value</th>
<th>Map Fields</th>
<th>Convenience Functions</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKeyTypesMask</td>
<td>(1&lt;&lt;0)</td>
<td>client</td>
<td>XkbGetKeyTypes</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>types</td>
<td>XkbResizeKeyType</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>size_types</td>
<td>XkbCopyKeyType</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>num_types</td>
<td>XkbCopyKeyTypes</td>
<td></td>
</tr>
</tbody>
</table>
Xkb defines combinations of these masks for convenience:

```
#define XkbResizableInfoMask (XkbKeyTypesMask)
#define XkbAllClientInfoMask (XkbKeyTypesMask | XkbKeySymsMask | XkbModifierMapMask)
#define XkbAllServerInfoMask (XkbExplicitComponentsMask | XkbKeyActionsMask | XkbKeyBehaviorsMask | XkbVirtualModsMask | XkbVirtualModMapMask)
#define XkbAllMapComponentsMask (XkbAllClientInfoMask | XkbAllServerInfoMask)
```

Key types, symbol maps, and actions are all interrelated: changes in one require changes in the others. The convenience functions make it easier to edit these components and handle the interdependencies.

To update the client or server map information in an existing keyboard description, use `XkbGetUpdatedMap`.

**Status** `XkbGetUpdatedMap(display, which, xkb)`

- `Display * display; /* connection to X server */`
- `unsigned int which; /* mask selecting subcomponents to populate */`
- `XkbDescPtr xkb; /* keyboard description to be updated */`

The `which` parameter is a bitwise inclusive OR of the masks in Table 14.1. If the needed components of the `xkb` structure are not already allocated, `XkbGetUpdatedMap` allocates them. `XkbGetUpdatedMap` fetches the requested information for the device specified in the `XkbDescRec` passed in the `xkb` parameter.

`XkbGetUpdatedMap` is synchronous; it queries the server for the desired information, waits for a reply, and then returns. If successful, `XkbGetUpdatedMap` returns `Success`. If unsuccessful, `XkbGetUpdatedMap` returns one of the following: `BadAlloc` (unable to allocate a component in the `XkbDescRec` structure), `BadValue` (some mask bits in `which` are undefined), `BadImplementation` (a compatible version of the Xkb extension is not available in the server or the reply from the server was invalid).
14.3 Changing Map Components in the Server

There are two ways to make changes to map components: either change a local copy of the keyboard map and call \texttt{XkbSetMap} to send the modified map to the server, or, to reduce network traffic, use an \texttt{XMapChangesRec} structure and call \texttt{XkbChangeMap}.

\begin{verbatim}
Bool XkbSetMap(dpy, which, xkb)
    Display * dpy; /* connection to X server */
    unsigned int which; /* mask selecting subcomponents to update */
    XkbDescPtr xkb; /* description from which new values are taken */
\end{verbatim}

Use \texttt{XkbSetMap} to send a complete new set of values for entire components (for example, all symbols, all actions, and so on) to the server. The \texttt{which} parameter specifies the components to be sent to the server, and is a bitwise inclusive OR of the masks listed in Table 14.1. The \texttt{xkb} parameter is a pointer to an \texttt{XkbDescRec} structure and contains the information to be copied to the server. For each bit set in the \texttt{which} parameter, \texttt{XkbSetMap} takes the corresponding structure values from the \texttt{xkb} parameter and sends it to the server specified by \texttt{dpy}.

If any components specified by \texttt{which} are not present in the \texttt{xkb} parameter, \texttt{XkbSetMap} returns \texttt{False}. Otherwise, it sends the update request to the server and returns \texttt{True}. \texttt{XkbSetMap} can generate \texttt{BadAlloc}, \texttt{BadLength}, and \texttt{BadValue} protocol errors.

Key types, symbol maps, and actions are all interrelated; changes in one require changes in the others. Xkb provides functions to make it easier to edit these components and handle the interdependencies. Table 14.1 lists these helper functions and provides a pointer to where they are defined.

14.3.1 The \texttt{XMapChangesRec} Structure

Use the \texttt{XMapChangesRec} structure to identify and track partial modifications to the mapping components and to reduce the amount of traffic between the server and clients.

\begin{verbatim}
typedef struct _XMapChanges {
    unsigned short changed; /* identifies valid components in structure */
    KeyCode min_key_code; /* lowest numbered keycode for device */
    KeyCode max_key_code; /* highest numbered keycode for device */
    unsigned char first_type; /* index of first key \texttt{type} modified */
    unsigned char num_types; /* # \texttt{types} modified */
    KeyCode first_key_sym; /* first key whose \texttt{key_sym_map} changed */
    unsigned char num_key_syms; /* # \texttt{key_sym_map} entries changed */
    KeyCode first_key_act; /* first key whose \texttt{key_acts} entry changed */
    unsigned char num_key_acts; /* # \texttt{key_acts} entries changed */
    KeyCode first_key_behavior; /* first key whose \texttt{behaviors} changed */
    unsigned char num_key_behaviors; /* # \texttt{behaviors} entries changed */
    KeyCode first_key_explicit; /* first key whose \texttt{explicit} entry changed */
    unsigned char num_key_explicit; /* # \texttt{explicit} entries changed */
    KeyCode first_modmap_key; /* first key whose \texttt{modmap} entry changed */
    unsigned char num_modmap_keys; /* # \texttt{modmap} entries changed */
    KeyCode first_vmodmap_key; /* first key whose \texttt{vmodmap} changed */
    unsigned char num_vmodmap_keys; /* # \texttt{vmodmap} entries changed */
    unsigned char pad1; /* reserved */
} XMapChangesRec;\
\end{verbatim}
The changed field identifies the map components that have changed in an XkbDescRec structure and may contain any of the bits in Table 14.1, which are also shown in Table 14.2. Every 1 bit in changed also identifies which other fields in the XkbMapChangesRec structure contain valid values, as indicated in Table 14.2. The min_key_code and max_key_code fields are for reference only; they are ignored on any requests sent to the server and are always updated by the server whenever it returns the data for an XkbMapChangesRec.

<table>
<thead>
<tr>
<th>Mask</th>
<th>Valid XkbMapChangesRec Fields</th>
<th>XkbDescRec Field Containing Changed Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKeyTypesMask</td>
<td>first_type, num_types</td>
<td>map-&gt;type[first_type] .. map-&gt;type[first_type + num_types - 1]</td>
</tr>
<tr>
<td>XkbKeySymsMask</td>
<td>first_key_sym, num_key_syms</td>
<td>map-&gt;key_sym_map[first_key_sym] .. map-&gt;key_sym_map[first_key_sym + num_key_syms - 1]</td>
</tr>
<tr>
<td>XkbModifierMapMask</td>
<td>first_modmap_key, num_modmap_keys</td>
<td>map-&gt;modmap[first_modmap_key] .. map-&gt;modmap[first_modmap_key + num_modmap_keys-1]</td>
</tr>
<tr>
<td>XkbExplicitComponentsMask</td>
<td>first_key_explicit, num_key_explicit</td>
<td>server-&gt;explicit[first_key_explicit] .. server-&gt;explicit[first_key_explicit + num_key_explicit - 1]</td>
</tr>
<tr>
<td>XkbKeyActionsMask</td>
<td>first_key_act, num_key_acts</td>
<td>server-&gt;key_acts[first_key_act] .. server-&gt;key_acts[first_key_act + num_key_acts - 1]</td>
</tr>
<tr>
<td>XkbKeyBehaviorsMask</td>
<td>first_key_behavior, num_key_behaviors</td>
<td>server-&gt;behaviors[first_key_behavior] .. server-&gt;behaviors[first_key_behavior + num_key_behaviors - 1]</td>
</tr>
<tr>
<td>XkbVirtualModsMask</td>
<td>vmods</td>
<td>server-&gt;vmods[*]</td>
</tr>
<tr>
<td>XkbVirtualModMapMask</td>
<td>first_vmodmap_key, num_vmodmap_keys</td>
<td>server-&gt;vmodmap[first_vmodmap_key] .. server-&gt;vmodmap[first_vmodmap_key + num_vmodmap_keys-1]</td>
</tr>
</tbody>
</table>

To update only partial components of a keyboard description, modify the appropriate fields in the server and map components of a local copy of the keyboard description, then call XkbChangeMap with an XkbMapChangesRec structure indicating which components have changed.

```
Bool XkbChangeMap(dpy, xkb, changes)
    Display * dpy;            /* connection to X server */
    XkbDescPtr xkb;            /* description from which new values are taken */
    XkbMapChangesPtr changes;  /* identifies component parts to update */
```

XkbChangeMap copies any components specified by the changes structure from the keyboard description, xkb, to the X server specified by dpy.
If any components specified by changes are not present in the xkb parameter, XkbChangeMap returns False. Otherwise, it sends a request to the server and returns True.

XkbChangeMap can generate BadAlloc, BadLength, and BadValue protocol errors.

### 14.4 Tracking Changes to Map Components

The Xkb extension reports XkbMapNotify events to clients wanting notification whenever a map component of the Xkb description for a device changes. There are many different types of Xkb keyboard map changes. Xkb uses an event detail mask to identify each type of change. The event detail masks are identical to the masks listed in Table 14.1.

To receive XkbMapNotify events under all possible conditions, use XkbSelectEvents (see section 4.3) and pass XkbMapNotifyMask in both bits_to_change and values_for_bits.

To receive XkbMapNotify events only under certain conditions, use XkbSelectEventDetails using XkbMapNotify as the event_type and specifying the desired map changes in bits_to_change and values_for_bits using mask bits from Table 14.1.

The structure for XkbMapNotify events is:

```c
typedef struct {
    int type;    /* Xkb extension base event code */
    unsigned long serial;    /* X server serial number for event */
    Bool send_event;    /* True => synthetically generated */
    Display * display;    /* server connection where event generated */
    Time time;    /* server time when event generated */
    int xkb_type;    /* XkbMapNotify */
    int device;    /* Xkb device ID, will not be XkbUseCoreKbd */
    unsigned int changed;    /* identifies valid fields in rest of event */
    unsigned int resized;    /* reserved */
    int first_type;    /* index of first key type modified */
    int num_types    /* # types modified */
    KeyCode min_key_code;    /* minimum keycode for device */
    KeyCode max_key_code;    /* maximum keycode for device */
    KeyCode first_key_sym;    /* first key whose key_sym_map changed */
    KeyCode first_key_act;    /* first key whose key_acts entry changed */
    KeyCode first_key_behavior;    /* first key whose behaviors changed */
    KeyCode first_key_explicit;    /* first key whose explicit entry changed */
    KeyCode first_modmap_key;    /* first key whose modmap entry changed */
    KeyCode first_vmodmap_key;    /* # modmap entries changed */
    int num_key_syms;    /* # key_sym_map entries changed */
    int num_key_acts;    /* # key_acts entries changed */
    int num_key_behaviors;    /* # behaviors entries changed */
    int num_key_explicit;    /* # explicit entries changed */
    int num_modmap_keys;    /* # modmap entries changed */
    int num_vmodmap_keys;    /* # vmodmap entries changed */
    unsigned int vmods;    /* mask indicating which vmods changed */
} XkbMapNotifyEvent;
```

The changed field specifies the map components that have changed and is the bitwise inclusive OR of the mask bits defined in Table 14.1. The other fields in this event are
interpreted as the like-named fields in an XkbMapChangesRec (see section 14.3.1). The XkbMapNotifyEvent structure also has an additional resized field that is reserved for future use.

14.5 Allocating and Freeing Client and Server Maps

Calling XkbGetMap (see section 14.2) should be sufficient for most applications to get client and server maps. As a result, most applications do not need to directly allocate client and server maps.

If you change the number of key types or construct map components without loading the necessary components from the X server, do not allocate any map components directly using malloc or Xmalloc. Instead, use the Xkb allocators, XkbAllocClientMap, and XkbAllocServerMap.

Similarly, use the Xkb destructors, XkbFreeClientMap, and XkbFreeServerMap instead of free or Xfree.

14.5.1 Allocating an Empty Client Map

To allocate and initialize an empty client map description record, use XkbAllocClientMap.

Status XkbAllocClientMap(xkb, which, type_count)

XkbDescPtr xkb; /* keyboard description in which to allocate client map */
unsigned int which; /* mask selecting map components to allocate */
unsigned int type_count; /* value of num_types field in map to be allocated */

XkbAllocClientMap allocates and initializes an empty client map in the map field of the keyboard description specified by xkb. The which parameter specifies the particular components of the client map structure to allocate and is a mask composed by a bitwise inclusive OR of one or more of the masks shown in Table 14.3.

### Table 14.3 XkbAllocClientMap Masks

<table>
<thead>
<tr>
<th>Mask</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKeyTypesMask</td>
<td>The type_count field specifies the number of entries to pre-allocate for the types field of the client map. If the type_count field is less than XkbNumRequiredTypes (see section 15.2.1), returns BadValue.</td>
</tr>
<tr>
<td>XkbKeySymMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the sym and key_sym_map fields of the client map. The fields are allocated to contain the maximum number of entries necessary for max_key_code - min_key_code + 1 keys.</td>
</tr>
<tr>
<td>XkbModifierMapMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the modmap field of the client map. The field is allocated to contain the maximum number of entries necessary for max_key_code - min_key_code + 1 keys.</td>
</tr>
</tbody>
</table>

**Note** The min_key_code and max_key_code fields of the xkb parameter must be legal values if the XkbKeySymMask or XkbModifierMapMask masks are set in the which parameter. If they are not valid, XkbAllocClientMap returns BadValue.

If the client map of the keyboard description is not NULL, and any fields are already allocated in the client map, XkbAllocClientMap does not overwrite the existing values; it sim-
ply ignores that part of the request. The only exception is the types array. If type_count is greater than the current num_types field of the client map, XkbAllocClientMap resizes the types array and resets the num_types field accordingly.

If XkbAllocClientMap is successful, it returns Success. Otherwise, it can return either BadMatch, BadAlloc, or BadValue errors.

14.5.2 Freeing a Client Map

To free memory used by the client map member of an XkbDescRec structure, use XkbFreeClientMap.

```c
void XkbFreeClientMap(xkb, which, free_all)
    XkbDescPtr xkb;  /* keyboard description containing client map to free */
    unsigned int which;  /* mask identifying components of map to free */
    Bool free_all;         /* True => free all client components and map itself */
```

XkbFreeClientMap frees the components of client map specified by which in the XkbDescRec structure specified by the xkb parameter and sets the corresponding structure component values to NULL. The which parameter specifies a combination of the client map masks shown in Table 14.3.

If free_all is True, which is ignored; XkbFreeClientMap frees every non-NULL structure component in the client map, frees the XkbClientMapRec structure referenced by the map member of the xkb parameter, and sets the map member to NULL.

14.5.3 Allocating an Empty Server Map

To allocate and initialize an empty server map description record, use XkbAllocServerMap.

```c
Status XkbAllocServerMap(xkb, which, count_acts)
    XkbDescPtr xkb;  /* keyboard description in which to allocate server map */
    unsigned int which;  /* mask selecting map components to allocate */
    unsigned int count_acts;  /* value of numActs field in map to be allocated */
```

XkbAllocServerMap allocates and initializes an empty server map in the server field of the keyboard description specified by xkb. The which parameter specifies the particular components of the server map structure to allocate, as specified in Table 14.4.

<table>
<thead>
<tr>
<th>Mask</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbExplicitComponentsMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the explicit field of the server map.</td>
</tr>
<tr>
<td>XkbKeyActionsMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the key_acts field of the server map. The count_acts parameter is used to allocate the acts field of the server map.</td>
</tr>
<tr>
<td>XkbKeyBehaviorsMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the behaviors field of the server map.</td>
</tr>
<tr>
<td>XkbVirtualModMapMask</td>
<td>The min_key_code and max_key_code fields of the xkb parameter are used to allocate the vmodmap field of the server map.</td>
</tr>
</tbody>
</table>

**Note** The min_key_code and max_key_code fields of the xkb parameter must be legal values. If they are not valid, XkbAllocServerMap returns BadValue.
If the server map of the keyboard description is not NULL and any fields are already allocated in the server map, XkbAllocServerMap does not overwrite the existing values. The only exception is with the acts array. If the count_acts parameter is greater than the current num_acts field of the server map, XkbAllocServerMap resizes the acts array and resets the num_acts field accordingly.

If XkbAllocServerMap is successful, it returns Success. Otherwise, it can return either BadMatch or BadAlloc errors.

14.5.4 Freeing a Server Map

To free memory used by the server member of an XkbDescRec structure, use XkbFreeServerMap.

```c
void XkbFreeServerMap(xkb, which, free_all)
    XkbDescPtr xkb;      /* keyboard description containing server map to free */
    unsigned int which;  /* mask identifying components of map to free */
    Bool free_all;       /* True => free all server map components and server itself */
```

The XkbFreeServerMap function frees the specified components of server map in the XkbDescRec structure specified by the xkb parameter and sets the corresponding structure component values to NULL. The which parameter specifies a combination of the server map masks and is a bitwise inclusive OR of the masks listed in Table 14.4. If free_all is True, which is ignored and XkbFreeServerMap frees every non-NULL structure component in the server map, frees the XkbServerMapRec structure referenced by the server member of the xkb parameter, and sets the server member to NULL.
15 Xkb Client Keyboard Mapping

The Xkb client map for a keyboard is the collection of information a client needs to interpret key events from the keyboard. It contains a global list of key types and an array of key symbol maps, each of which describes the symbols bound to a key and the rules to be used to interpret those symbols.

Figure 15.1 shows the relationships between elements in the client map:

![Diagram of Xkb Client Map](image)

**Figure 15.1 Xkb Client Map**
15.1 The XkbClientMapRec Structure

The map field of the complete Xkb keyboard description (see section 6.1) is a pointer to the Xkb client map, which is of type XkbClientMapRec:

```c
typedef struct { /* Client Map */
    unsigned char size_types; /* # occupied entries in types */
    unsigned char num_types; /* # entries in types */
    XkbKeyTypePtr types; /* vector of key types used by this keymap */
    unsigned short size_syms; /* length of the syms array */
    unsigned short num_syms; /* # entries in syms */
    KeySym * syms; /* linear 2d tables of keysyms, 1 per key */
    XkbSymMapPtr key_sym_map; /* 1 per keycode, maps keycode to syms */
    unsigned char * modmap; /* 1 per keycode, real mods bound to key */
} XkbClientMapRec, *XkbClientMapPtr;
```

The following sections describe each of the elements of the XkbClientMapRec structure in more detail.

15.2 Key Types

Key types are used to determine the shift level of a key given the current state of the keyboard. The set of all possible key types for the Xkb keyboard description are held in the types field of the client map, whose total size is stored in size_types, and whose total number of valid entries is stored in num_types. Key types are defined using the following structures:

```c
typedef struct { /* Key Type */
    XkbModsRec mods; /* modifiers used to compute shift level */
    unsigned char num_levels; /* total # shift levels, do not modify directly */
    unsigned char map_count; /* # entries in map, preserve (if non-NULL) */
    XkbKTMapEntryPtr map; /* vector of modifiers for each shift level */
    XkbModsPtr preserve; /* mods to preserve for corresponding map entry */
    Atom name; /* name of key type */
    Atom * level_names; /* array of names of each shift level */
} XkbKeyTypeRec, *XkbKeyTypePtr;
```

```c
typedef struct { /* Modifiers for a key type */
    Bool active; /* True => entry active when determining shift level */
    unsigned char level; /* shift level if modifiers match mods */
    XkbModsRec mods; /* mods needed for this level to be selected */
} XkbKTMapEntryRec, *XkbKTMapEntryPtr;
```

The mods field of a key type is an XkbModsRec (see section 7.2) specifying the modifiers the key type uses when calculating the shift level, and can be composed of both the core modifiers and virtual modifiers. To set the modifiers associated with a key type, modify the real_mods and vmods fields of the mods XkbModsRec accordingly. The mask field of the XkbModsRec is reserved for use by Xkb and is calculated from the real_mods and vmods fields.

The num_levels field holds the total number of shift levels for the key type. Xkb uses num_levels to ensure the array of symbols bound to a key is large enough. Do not modify num_levels directly to change the number if shift levels for a key type. Instead, use XkbResizeKeyType (see section 15.2.3).
The map field is a vector of XkbKTMEntryRec structures, with map_count entries, that specify the modifier combinations for each possible shift level. Each map entry contains an active field, a mods field, and a level field. The active field determines whether the modifier combination listed in the mods field should be considered when determining shift level. If active is False, this map entry is ignored. If active is True, the level field of the map entry specifies the shift level to use when the current modifier combination matches the combination specified in the mods field of the map entry.

Any combination of modifiers not explicitly listed somewhere in the map yields shift level one. In addition, map entries specifying unbound virtual modifiers are not considered.

Any modifiers specified in mods are normally consumed by XkbTranslateKeyCode (see section 12.1.3). For those rare occasions a modifier should be considered despite having been used to look up a symbol, key types include an optional preserve field. If a preserve member of a key type is not NULL, it represents a list of modifiers where each entry corresponds directly to one of the key type’s map. Each entry lists the modifiers that should not be consumed if the matching map entry is used to determine shift level.

Each shift level has a name and these names are held in the level_names array, whose length is num_levels. The type itself also has a name, which is held in the name field.

For example, consider how the server handles the following possible symbolic description of a possible key type (note that the format used to specify keyboard mappings in the server database is not specified by the Xkb extension, although this format is one possible example):

<table>
<thead>
<tr>
<th>Table 15.1 Example Key Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symbolic Description</strong></td>
</tr>
<tr>
<td>type “ALPHATHREE” {</td>
</tr>
<tr>
<td>modifiers = Shift+Lock+LevelThree;</td>
</tr>
<tr>
<td>map[None]= Level1;</td>
</tr>
<tr>
<td>map[Lock]= Level1;</td>
</tr>
<tr>
<td>map[Shift]= Level2;</td>
</tr>
<tr>
<td>map[LevelThree]= Level3;</td>
</tr>
<tr>
<td>map[Shift+LevelThree]= Level3;</td>
</tr>
<tr>
<td>preserve[None]= None;</td>
</tr>
<tr>
<td>preserve[Lock]= Lock;</td>
</tr>
<tr>
<td>preserve[Shift]= None;</td>
</tr>
<tr>
<td>preserve[LevelThree]= None;</td>
</tr>
<tr>
<td>preserve[Shift+Level3]= None;</td>
</tr>
<tr>
<td>level_name[Level1]= “Base”;</td>
</tr>
<tr>
<td>level_name[Level2]= “Caps”;</td>
</tr>
</tbody>
</table>
| };

The name of the example key type is “ALPHATHREE,” and the modifiers it pays attention to are Shift, Lock, and the virtual modifier LevelThree. There are three shift levels. The name of shift level one is “Base,” the name of shift level two is “Caps,” and the name of shift level three is “Level3.”
Given the combination of the map and preserve specifications, there are five map entries. The first map entry specifies that shift level one is to be used if no modifiers are set. The second entry specifies the Lock modifier alone also yields shift level one. The third entry specifies the Shift modifier alone yields shift level two. The fourth and fifth entries specify that the virtual LevelThree modifier alone, or in combination with the Shift modifier, yields shift level three.

Note Shift level three can be reached only if the virtual modifier LevelThree is bound to a real modifier (see section 16.4). If LevelThree is not bound to a real modifier, the map entries associated with it are ignored.

Because the Lock modifier is to be preserved for further event processing, the preserve list is not NULL and parallels the map list. All preserve entries, except for the one corresponding to the map entry that specifies the Lock modifier, do not list any modifiers. For the map entry that specifies the Lock modifier, the corresponding preserve list entry lists the Lock modifier, meaning do not consume the Lock modifier. In this particular case, the preserved modifier is passed to Xlib translation functions and causes them to notice that the Lock modifier is set; consequently, the Xlib functions apply the appropriate capitalization rules to the symbol. Because this preserve entry is set only for a modifier that yields shift level one, the capitalization occurs only for level-one symbols.

15.2.1 The Canonical Key Types

Xkb allows up to XkbMaxKeyTypes (255) key types to be defined, but requires at least XkbNumRequiredTypes (4) predefined types to be in a key map. These predefined key types are referred to as the canonical key types and describe the types of keys available on most keyboards. The definitions for the canonical key types are held in the first XkbNumRequiredTypes entries of the types field of the client map and are indexed using the following constants:

- XkbOneLevelIndex
- XkbTwoLevelIndex
- XkbAlphabeticIndex
- XkbKeypadIndex

ONE_LEVEL

The ONE_LEVEL key type describes groups that have only one symbol. The default ONE_LEVEL key type has no map entries and does not pay attention to any modifiers. A symbolic representation of this key type could look like the following:

```plaintext
type "ONE_LEVEL" {
  modifiers = None;
  map[None]= Level1;
  level_name[Level1]= "Any";
};
```

The description of the ONE_LEVEL key type is stored in the types[XkbOneLevelIndex] entry of the client key map.

TWO_LEVEL

The TWO_LEVEL key type describes groups that consist of two symbols but are neither alphabetic nor numeric keypad keys. The default TWO_LEVEL type uses only the Shift
modifier. It returns shift level two if \texttt{Shift} is set, and level one if it is not. A symbolic representation of this key type could look like the following:

```
    type "TWO_LEVEL" {
        modifiers = Shift;
        map[Shift]= Level2;
        level_name[Level1]= "Base";
        level_name[Level2]= "Shift";
    };
```

The description of the \texttt{TWO_LEVEL} key type is stored in the \texttt{types[XkbTwoLevelIndex]} entry of the client key map.

**ALPHABETIC**

The \texttt{ALPHABETIC} key type describes groups consisting of two symbols: the lowercase form of a symbol followed by the uppercase form of the same symbol. The default \texttt{ALPHABETIC} type implements locale-sensitive “Shift cancels CapsLock” behavior using both the \texttt{Shift} and \texttt{Lock} modifiers as follows:

- If \texttt{Shift} and \texttt{Lock} are both set, the default \texttt{ALPHABETIC} type yields level one.
- If \texttt{Shift} alone is set, it yields level two.
- If \texttt{Lock} alone is set, it yields level one, but preserves the \texttt{Lock} modifier so Xlib notices and applies the appropriate capitalization rules. The Xlib functions are locale-sensitive and apply different capitalization rules for different locales.
- If neither \texttt{Shift} nor \texttt{Lock} is set, it yields level one.

A symbolic representation of this key type could look like the following:

```
    type "ALPHABETIC" {
        modifiers = Shift+Lock;
        map[Shift]= Level2;
        preserve[Lock]= Lock;
        level_name[Level1]= "Base";
        level_name[Level2]= "Caps";
    };
```

The description of the \texttt{ALPHABETIC} key type is stored in the \texttt{types[XkbAlphabeticIndex]} entry of the client key map.

**KEYPAD**

The \texttt{KEYPAD} key type describes groups that consist of two symbols, at least one of which is a numeric keypad symbol. The numeric keypad symbol is assumed to reside at level two. The default \texttt{KEYPAD} key type implements “Shift cancels NumLock” behavior using the \texttt{Shift} modifier and the real modifier bound to the virtual modifier named “NumLock,” known as the \texttt{NumLock} modifier, as follows:

- If \texttt{Shift} and \texttt{NumLock} are both set, the default \texttt{KEYPAD} type yields level one.
- If \texttt{Shift} alone is set, it yields level two.
- If \texttt{NumLock} alone is set, it yields level two.
- If neither \texttt{Shift} nor \texttt{NumLock} is set, it yields level one.
A symbolic representation of this key type could look like the following:

```plaintext
type "KEYPAD" {
    modifiers = Shift+NumLock;
    map[None]= Level1;
    map[Shift]= Level2;
    map[NumLock]= Level2;
    map[Shift+NumLock]= Level1;
    level_name[Level1]= "Base";
    level_name[Level2]= "Caps";
};
```

The description of the KEYPAD key type is stored in the `types[XkbKeypadIndex]` entry of the client key map.

**Initializing the Canonical Key Types in a New Client Map**

To set the definitions of the canonical key types in a client map to their default values, use `XkbInitCanonicalKeyTypes`.

**Status** `XkbInitCanonicalKeyTypes(xkb, which, keypadVMod)`

- `XkbDescPtr xkb;` /* keyboard description containing client map to initialize */
- `unsigned int which;` /* mask of types to initialize */
- `int keypadVMod;` /* index of NumLock virtual modifier */

`XkbInitCanonicalKeyTypes` initializes the first `XkbNumRequiredTypes` key types of the keyboard specified by the `xkb` parameter to their default values. The `which` parameter specifies what canonical key types to initialize and is a bitwise inclusive OR of the following masks: `XkbOneLevelMask`, `XkbTwoLevelMask`, `XkbAlphabeticMask`, and `XkbKeypadMask`. Only those canonical types specified by the `which` mask are initialized.

If `XkbKeypadMask` is set in the `which` parameter, `XkbInitCanonicalKeyTypes` looks up the `NumLock` named virtual modifier to determine which virtual modifier to use when initializing the KEYPAD key type. If the `NumLock` virtual modifier does not exist, `XkbInitCanonicalKeyTypes` creates it.

`XkbInitCanonicalKeyTypes` normally returns `Success`. It returns `BadAccess` if the Xkb extension has not been properly initialized, and `BadAccess` if the `xkb` parameter is not valid.

**15.2.2 Getting Key Types from the Server**

To obtain the list of available key types in the server’s keyboard mapping, use `XkbGetKeyTypes`.

**Status** `XkbGetKeyTypes(dpy, first, num, xkb)`

- `Display * dpy;` /* connection to X server */
- `unsigned int first;` /* index to first type to get, 0 => 1st type */
- `unsigned int num;` /* number of key types to be returned */
- `XkbDescPtr xkb;` /* keyboard description containing client map to update */

**Note** `XkbGetKeyTypes` is used to obtain descriptions of the key types themselves, not the key types bound to individual keys. To obtain the key types bound to an individual key, refer to the `key_sym_map` field of the client map (see section 15.3.1).
**XkbGetKeyTypes** queries the server for the desired types, waits for a reply, and returns the desired types in the *xkb->map->types*. If successful, it returns Success.

**XkbGetKeyTypes** returns BadAccess if the Xkb extension has not been properly initialized and BadValue if the combination of first and num results in numbers out of valid range.

### 15.2.3 Changing the Number of Levels in a Key Type

To change the number of levels in a key type, use **XkbResizeKeyType**.

**Status XkbResizeKeyType**(xkb, type_ndx, map_count, want_preserve, new_num_lvls)

- `XkbDescPtr xkb;` /* keyboard description containing client map to update */
- `int type_ndx;` /* index in xkb->map->types of type to change */
- `int map_count;` /* total # of map entries needed for the type */
- `Bool want_preserve;` /* True => list of preserved modifiers is necessary */
- `int new_num_lvls;` /* new max # of levels for type */

**XkbResizeKeyType** changes the type specified by xkb->map->types[type_ndx], and reallocates the symbols and actions bound to all keys that use the type, if necessary. **XkbResizeKeyType** updates only the local copy of the types in xkb; to update the server’s copy for the physical device, use **XkbSetMap** or **XkbChangeMap** after calling **XkbResizeKeyType**.

The map_count parameter specifies the total number of map entries needed for the type, and can be zero or greater. If map_count is zero, **XkbResizeKeyType** frees the existing map and preserve entries for the type if they exist and sets them to NULL.

The want_preserve parameter specifies whether a preserve list for the key should be created. If want_preserve is True, the preserve list with map_count entries is allocated or reallocated if it already exists. Otherwise, if want_preserve is False, the preserve field is freed if necessary and set to NULL.

The new_num_lvls parameter specifies the new maximum number of shift levels for the type and is used to calculate and resize the symbols and actions bound to all keys that use the type.

If type_ndx does not specify a legal type, new_num_lvls is less than 1, or the map_count is less than zero, **XkbResizeKeyType** returns BadValue. If **XkbResizeKeyType** encounters any problems with allocation, it returns BadAlloc. Otherwise, it returns Success.

### 15.2.4 Copying Key Types

Use **XkbCopyKeyType** and **XkbCopyKeyTypes** to copy one or more XkbKeyTypeRec structures.

**Status XkbCopyKeyType**(from, into)

- `XkbKeyTypePtr from;` /* pointer to XkbKeyTypeRec to be copied */
- `XkbKeyTypePtr into;` /* pointer to XkbKeyTypeRec to be changed */

**XkbCopyKeyType** copies the key type specified by from to the key type specified by into. Both must point to legal XkbKeyTypeRec structures. Xkb assumes from and into point to different places. As a result, overlaps can be fatal. **XkbCopyKeyType** frees any existing map, preserve, and level_names in into prior to copying. If any allocation errors occur while copying from to into, **XkbCopyKeyType** returns BadAlloc. Otherwise, **XkbCopyKeyType** copies from to into and returns Success.
Status `XkbCopyKeyTypes`\(\text{from, into, num\_types}\)

`XkbKeyTypePtr` from; /* pointer to array of `XkbKeyRecs` to copy */
`XkbKeyTypePtr` into; /* pointer to array of `XkbKeyRecs` to change */
`int` num\_types; /* number of types to copy */

`XkbCopyKeyTypes` copies `num\_types` `XkbKeyRecs` structures from the array specified by `from` into the array specified by `into`. It is intended for copying between, rather than within, keyboard descriptions, so it doesn’t check for overlaps. The same rules that apply to the `from` and `into` parameters in `XkbCopyKeyType` apply to each entry of the `from` and `into` arrays of `XkbCopyKeyTypes`. If any allocation errors occur while copying `from` to `into`, `XkbCopyKeyTypes` returns `BadAlloc`. Otherwise, `XkbCopyKeyTypes` copies `from` to `into` and returns `Success`.

### 15.3 Key Symbol Map

The entire list of key symbols for the keyboard mapping is held in the `sym` field of the client map. Whereas the core keyboard mapping is a two-dimensional array of `KeySymbs` whose rows are indexed by keycode, the `sym` field of `Xkb` is a linear list of `KeySymbs` that needs to be indexed uniquely for each key. This section describes the key symbol map and the methods for determining the symbols bound to a key.

The reason the `sym` field is a linear list of `KeySymbs` is to reduce the memory consumption associated with a keymap; because `Xkb` allows individual keys to have multiple shift levels and a different number of groups per key, a single two-dimensional array of `KeySymbs` would potentially be very large and sparse. Instead, `Xkb` provides a small two-dimensional array of `KeySymbs` for each key. To store all of these individual arrays, `Xkb` concatenates each array together in the `sym` field of the client map.

In order to determine which `KeySymbs` in the `sym` field are associated with each keycode, the client map contains an array of key symbol mappings, held in the `key\_sym\_map` field. The `key\_sym\_map` field is an array of `XkbSymMapRec` structures indexed by keycode. The `key\_sym\_map` array has `min\_key\_code` unused entries at the start to allow direct indexing using a keycode. All keycodes falling between the minimum and maximum legal keycodes, inclusive, have `key\_sym\_map` arrays, whether or not any key actually yields that code. The `XkbSymMapRec` structure is defined as follows:

```c
#define XkbNumKbdGroups 4
#define XkbMaxKbdGroup (XkbNumKbdGroups-1)

typedef struct { /* map to keysyms for a single keycode */
    unsigned char kt_index[XkbNumKbdGroups]; /* key type index for each group */
    unsigned char group_info; /* # of groups and out of range group handling */
    unsigned char width; /* max # of shift levels for key */
    unsigned short offset; /* index to keysym table in sym array */
} XkbSymMapRec, *XkbSymMapPtr;
```

These fields are described in detail in the following sections.

#### 15.3.1 Per-Key Key Type Indices

The `kt_index` array of the `XkbSymMapRec` structure contains the indices of the key types (see section 15.2) for each possible group of symbols associated with the key. To obtain the index of a key type or the pointer to a key type, `Xkb` provides the following macros, to access the key types:
Note The array of key types is of fixed width and is large enough to hold key types for the maximum legal number of groups (XkbNumKbdGroups, currently four); if a key has fewer than XkbNumKbdGroups groups, the extra key types are reported but ignored.

```c
int XkbKeyTypeIndex(xkb, keycode, group) /* macro*/
XkbDescPtr xkb; /* Xkb description of interest */
KeyCode keycode; /* keycode of interest */
int group; /* group index */
```

XkbKeyTypeIndex computes an index into the types vector of the client map in xkb from the given keycode and group index.

```c
XkbKeyTypePtr XkbKeyType(xkb, keycode, group) /* macro */
XkbDescPtr xkb; /* Xkb description of interest */
KeyCode keycode; /* keycode of interest */
int group; /* group index */
```

XkbKeyType returns a pointer to the key type in the types vector of the client map in xkb corresponding to the given keycode and group index.

### 15.3.2 Per-Key Group Information

The group_info field of an XkbSymMapRec is an encoded value containing the number of groups of symbols bound to the key as well as the specification of the treatment of out-of-range groups. It is legal for a key to have zero groups, in which case it also has zero symbols and all events from that key yield NoSymbol. To obtain the number of groups of symbols bound to the key, use XkbKeyNumGroups. To change the number of groups bound to a key, use XkbChangeTypesOfKey (see section 15.3.6). To obtain a mask that determines the treatment of out-of-range groups, use XkbKeyGroupInfo and XkbOutOfRangeGroupInfo.

The keyboard controls (see Chapter 10) contain a groups_wrap field specifying the handling of illegal groups on a global basis. That is, when the user performs an action causing the effective group to go out of the legal range, the groups_wrap field specifies how to normalize the effective keyboard group to a group that is legal for the keyboard as a whole, but there is no guarantee that the normalized group will be within the range of legal groups for any individual key. The per-key group_info field specifies how a key treats a legal effective group if the key does not have a type specified for the group of concern. For example, the Enter key usually has just one group defined. If the user performs an action causing the global keyboard group to change to Group2, the group_info field for the Enter key describes how to handle this situation.

Out-of-range groups for individual keys are mapped to a legal group using the same options as are used for the overall keyboard group. The particular type of mapping used is controlled by the bits set in the group_info flag, as shown in Table 15.2. See section 10.7.1 for more details on the normalization methods in this table.

<table>
<thead>
<tr>
<th>Bits set in group_info</th>
<th>Normalization method</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbRedirectIntoRange</td>
<td>XkbRedirectIntoRange</td>
</tr>
<tr>
<td>XkbClampIntoRange</td>
<td>XkbClampIntoRange</td>
</tr>
<tr>
<td>none of the above</td>
<td>XkbWrapIntoRange</td>
</tr>
</tbody>
</table>
Xkb provides the following macros to access group information:

```c
int XkbKeyNumGroups(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */

XkbKeyNumGroups returns the number of groups of symbols bound to the key corresponding to `keycode`.
```

```c
unsigned char XkbKeyGroupInfo(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */

XkbKeyGroupInfo returns the `group_info` field from the `XkbSymMapRec` structure associated with the key corresponding to `keycode`.
```

```c
unsigned char XkbOutOfRangeGroupInfo(grp_inf) /* macro */
    unsigned char grp_inf; /* group_info field of XkbSymMapRec */

XkbOutOfRangeGroupInfo returns only the out-of-range processing information from the `group_info` field of an `XkbSymMapRec` structure.
```

```c
unsigned char XkbOutOfRangeGroupNumber(grp_inf) /* macro */
    unsigned char grp_inf; /* group_info field of XkbSymMapRec */

XkbOutOfRangeGroupNumber returns the out-of-range group number, represented as a group index, from the `group_info` field of an `XkbSymMapRec` structure.
```

### 15.3.3 Key Width

The maximum number of shift levels for a type is also referred to as the width of a key type. The `width` field of the `key_sym_map` entry for a key contains the width of the widest type associated with the key. The `width` field cannot be explicitly changed; it is updated automatically whenever the symbols or set of types bound to a key are changed.

### 15.3.4 Offset in to the Symbol Map

The key width and number of groups associated with a key are used to form a small two-dimensional array of `KeySyms` for a key. This array may be different sizes for different keys. The array for a single key is stored as a linear list, in row-major order. The arrays for all of the keys are stored in the `syms` field of the client map. There is one row for each group associated with a key and one column for each level. The index corresponding to a given group and shift level is computed as:

```
idx = group_index * key_width + shift_level
```

The `offset` field of the `key_sym_map` entry for a key is used to access the beginning of the array.

Xkb provides the following macros for accessing the `width` and `offset` for individual keys, as well as macros for accessing the two-dimensional array of symbols bound to the key:

```c
int XkbKeyGroupsWidth(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */

XkbKeyGroupsWidth returns the number of groups of symbols bound to the key corresponding to `keycode`.
```
XkbKeyGroupsWidth computes the maximum width associated with the key corresponding to keycode.

```c
int XkbKeyGroupWidth(xkb, keycode, grp) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
    int grp; /* group of interest */
```

XkbKeyGroupWidth computes the width of the type associated with the group grp for the key corresponding to keycode.

```c
int XkbKeySymOffset(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
```

XkbKeySymOffset returns the offset of the two-dimensional array of keysyms for the key corresponding to keycode.

```c
int XkbKeyNumSyms(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
```

XkbKeyNumSyms returns the total number of keysyms for the key corresponding to keycode.

```c
KeySym * XkbKeySymPtr(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
```

XkbKeySymPtr returns the pointer to the two-dimensional array of keysyms for the key corresponding to keycode.

```c
KeySym XkbKeySymEntry(xkb, keycode, shift, grp)/* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
    int shift; /* shift level of interest */
    int grp; /* group of interest */
```

XkbKeySymEntry returns the keysym corresponding to shift level shift and group grp from the two-dimensional array of keysyms for the key corresponding to keycode.

### 15.3.5 Getting the Symbol Map for Keys from the Server

To obtain the symbols for a subset of the keys in a keyboard description, use XkbGetKeySyms:

```c
Status XkbGetKeySyms(dpy, first, num, xkb)
    Display * dpy; /* connection to X server */
    unsigned int first; /* keycode of first key to get */
    unsigned int num; /* number of keycodes for which syms desired */
    XkbDescPtr xkb; /* Xkb description to be updated */
```

XkbGetKeySyms sends a request to the server to obtain the set of keysyms bound to num keys starting with the key whose keycode is first. It waits for a reply and returns the keysyms in the map.syms field of xkb. If successful, XkbGetKeySyms returns Success. The xkb parameter must be a pointer to a valid Xkb keyboard description.
If the client map in the xkb parameter has not been allocated, XkbGetKeySyms allocates and initializes it before obtaining the symbols.

If a compatible version of Xkb is not available in the server or the Xkb extension has not been properly initialized, XkbGetKeySyms returns BadAccess. If num is less than 1 or greater than XkbMaxKeyCount, XkbGetKeySyms returns BadValue. If any allocation errors occur, XkbGetKeySyms returns BadAlloc.

### 15.3.6 Changing the Number of Groups and Types Bound to a Key

To change the number of groups and the types bound to a key, use XkbChangeTypesOfKey.

**Status** XkbChangeTypesOfKey(xkb, key, n_groups, groups, new_types_in, p_changes)

- XkbDescPtr xkb; /* keyboard description to be changed */
- int key; /* keycode for key of interest */
- int n_groups; /* new number of groups for key */
- unsigned int groups; /* mask indicating groups to change */
- int * new_types_in; /* indices for new groups specified in groups */
- XkbMapChangesPtr p_changes; /* notes changes made to xkb */

XkbChangeTypesOfKey reallocates the symbols and actions bound to the key, if necessary, and initializes any new symbols or actions to NoSymbol or NoAction, as appropriate. If the p_changes parameter is not NULL, XkbChangeTypesOfKey adds the XkbKeySyms_Mask to the changes field of p_changes and modifies the first_key_sym and num_key_syms fields of p_changes to include the key that was changed. See section 14.3.1 for more information on the XkbMapChangesPtr structure. If successful, XkbChangeTypesOfKey returns Success.

The n_groups parameter specifies the new number of groups for the key. The groups parameter is a mask specifying the groups for which new types are supplied and is a bitwise inclusive OR of the following masks: XkbGroup1Mask, XkbGroup2Mask, XkbGroup3Mask, and XkbGroup4Mask.

The new_types_in parameter is an integer array of length n_groups. Each entry represents the type to use for the associated group and is an index into xkb->map->types. The new_types_in array is indexed by group index; if n_groups is four and groups only has Group1Mask and Group3Mask set, new_types_in looks like this:

- new_types_in[0] = type for Group1
- new_types_in[1] = ignored
- new_types_in[2] = type for Group3
- new_types_in[3] = ignored

For convenience, Xkb provides the following constants to use as indices to the groups:

<table>
<thead>
<tr>
<th>Table 15.3 Group Index Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Name</td>
</tr>
<tr>
<td>XkbGroup1Index</td>
</tr>
<tr>
<td>XkbGroup2Index</td>
</tr>
<tr>
<td>XkbGroup3Index</td>
</tr>
<tr>
<td>XkbGroup4Index</td>
</tr>
</tbody>
</table>
If the Xkb extension has not been properly initialized, `XkbChangeTypesOfKey` returns `BadAccess`. If the `xkb` parameter it not valid (that is, it is `NULL` or it does not contain a valid client map), `XkbChangeTypesOfKey` returns `BadMatch`. If the `key` is not a valid key-code, `n_groups` is greater than `XkbNumKbdGroups`, or the `groups` mask does not contain any of the valid group mask bits, `XkbChangeTypesOfKey` returns `BadValue`. If it is necessary to resize the key symbols or key actions arrays and any allocation errors occur, `XkbChangeTypesOfKey` returns `BadAlloc`.

### 15.3.7 Changing the Number of Symbols Bound to a Key

To change the number of symbols bound to a key, use `XkbResizeKeySyms`.

```c
KeySym *XkbResizeKeySyms(xkb, key, needed)
    XkbDescRec * xkb;    /* keyboard description to be changed */
    int key;            /* keycode for key to modify */
    int needed;         /* new number of keysyms required for key */
```

`XkbResizeKeySyms` reserves the space needed for `needed` keysyms and returns a pointer to the beginning of the new array that holds the keysyms. It adjusts the `offset` field of the `key_sym_map` entry for the key if necessary and can also change the `sym`, `num_syms`, and `size_syms` fields of `xkb->map` if it is necessary to reallocate the `sym` array. `XkbResizeKeySyms` does not modify either the width or number of groups associated with the key.

If `needed` is greater than the current number of keysyms for the key, `XkbResizeKeySyms` initializes all new keysyms in the array to `NoSymbol`.

Because the number of symbols needed by a key is normally computed as `width * number of groups`, and `XkbResizeKeySyms` does not modify either the width or number of groups for the key, a discrepancy exists upon return from `XkbResizeKeySyms` between the space allocated for the keysyms and the number required. The unused entries in the list of symbols returned by `XkbResizeKeySyms` are not preserved across future calls to any of the map editing functions, so you must update the key symbol mapping (which updates the width and number of groups for the key) before calling another allocator function. A call to `XkbChangeTypesOfKey` will update the mapping.

If any allocation errors occur while resizing the number of symbols bound to the key, `XkbResizeKeySyms` returns `NULL`.

**Note**

A change to the number of symbols bound to a key should be accompanied by a change in the number of actions bound to a key. Refer to section 16.1.16 for more information on changing the number of actions bound to a key.

### 15.4 The Per-Key Modifier Map

The `modmap` entry of the client map is an array, indexed by keycode, specifying the real modifiers bound to a key. Each entry is a mask composed of a bitwise inclusive OR of the legal real modifiers: `ShiftMask`, `LockMask`, `ControlMask`, `Mod1Mask`, `Mod2Mask`, `Mod3Mask`, `Mod4Mask`, and `Mod5Mask`. If a bit is set in a `modmap` entry, the corresponding key is bound to that modifier.

Pressing or releasing the key bound to a modifier changes the modifier set and unset state. The particular manner in which the modifier set and unset state changes is determined by the behavior and actions assigned to the key (see Chapter 16).
15.4.1 Getting the Per-Key Modifier Map from the Server

To update the modifier map for one or more of the keys in a keyboard description, use \texttt{XkbGetKeyModifierMap}.

\textbf{Status} \texttt{XkbGetKeyModifierMap}(dpy, first, num, xkb)

\begin{verbatim}
Display * dpy; /* connection to X server */
unsigned int first; /* keycode of first key to get */
unsigned int num; /* number of keys for which information is desired */
XkbDescPtr xkb; /* keyboard description to update */
\end{verbatim}

\texttt{XkbGetKeyModifierMap} sends a request to the server for the modifier mappings for \textit{num} keys starting with the key whose keycode is \textit{first}. It waits for a reply and places the results in the \textit{xkb}->map->modmap array. If successful, \texttt{XkbGetKeyModifier} returns \texttt{Success}.

If the map component of the \textit{xkb} parameter has not been allocated, \texttt{XkbGetKeyModifierMap} allocates and initializes it.

If a compatible version of Xkb is not available in the server or the Xkb extension has not been properly initialized, \texttt{XkbGetKeySyms} returns \texttt{BadAccess}. If any allocation errors occur while obtaining the modifier map, \texttt{XkbGetKeyModifierMap} returns \texttt{BadAlloc}.
16  **Xkb Server Keyboard Mapping**

The *server* field of the complete Xkb keyboard description (see section 6.1) is a pointer to the Xkb server map.

Figure 16.1 shows the relationships between elements in the server map:

![Diagram of Xkb Server Map Relationships]

The Xkb server map contains the information the server needs to interpret key events and is of type `XkbServerMapRec`:

```c
#define XkbNumVirtualMods 16
typedef struct { /* Server Map */
    unsigned short num_acts; /* # of occupied entries in acts */
    unsigned short size_acts; /* # of entries in acts */
    XkbAction * acts; /* linear 2d tables of key actions, 1 per keycode */
    XkbBehavior * behaviors; /* key behaviors, 1 per keycode */
    unsigned short * key_acts; /* index into acts, 1 per keycode */
    unsigned char explicit; /* explicit overrides of core remapping, 1 per key */
    unsigned char vmods[XkbNumVirtualMods]; /* real mods bound to virtual mods */
} XkbServerMapRec.
```
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unsigned short * vmodmap; /* virtual mods bound to key, 1 per keycode*/
} XkbServerMapRec, *XkbServerMapPtr;

The \textit{num\_acts}, \textit{size\_acts}, \textit{acts}, and \textit{key\_acts} fields specify the key actions, defined in section 16.1. The \textit{behaviors} field describes the behavior for each key and is defined in section 16.2. The \textit{explicit} field describes the explicit components for a key and is defined in section 16.3. The \textit{vmods} and the \textit{vmodmap} fields describe the virtual modifiers and the per-key virtual modifier mapping and are defined in section 16.4.

16.1 Key Actions

A key action defines the effect key presses and releases have on the internal state of the server. For example, the expected key action associated with pressing the Shift key is to set the Shift modifier. There is zero or one key action associated with each keysym bound to each key.

Just as the entire list of key symbols for the keyboard mapping is held in the \textit{syms} field of the client map, the entire list of key actions for the keyboard mapping is held in the \textit{acts} array of the server map. The total size of \textit{acts} is specified by \textit{size\_acts}, and the number of entries is specified by \textit{num\_acts}.

The \textit{key\_acts} array, indexed by keycode, describes the actions associated with a key. The \textit{key\_acts} array has \textit{min\_key\_code} unused entries at the start to allow direct indexing using a keycode. If a \textit{key\_acts} entry is zero, it means the key does not have any actions associated with it. If an entry is not zero, the entry represents an index into the \textit{acts} field of the server map, much as the \textit{offset} field of a \textit{KeySymMapRec} structure is an index into the \textit{syms} field of the client map.

The reason the \textit{acts} field is a linear list of \textit{XkbActions} is to reduce the memory consumption associated with a keymap. Because Xkb allows individual keys to have multiple shift levels and a different number of groups per key, a single two-dimensional array of \textit{KeySyms} would potentially be very large and sparse. Instead, Xkb provides a small two-dimensional array of \textit{XkbActions} for each key. To store all of these individual arrays, Xkb concatenates each array together in the \textit{acts} field of the server map.

The key action structures consist only of fields of type char or unsigned char. This is done to optimize data transfer when the server sends bytes over the wire. If the fields are anything but bytes, the server has to sift through all of the actions and swap any nonbyte fields. Because they consist of nothing but bytes, it can just copy them out.

Xkb provides the following macros, to simplify accessing information pertaining to key actions:

\begin{verbatim}
Bool XkbKeyHasActions(xkb, keycode) /* macro */
   XkbDescPtr xkb; /* Xkb description of interest */
   KeyCode keycode; /* keycode of interest */

XkbKeyHasActions returns True if the key corresponding to \textit{keycode} has any actions associated with it; otherwise, it returns False.

int XkbKeyNumActions(xkb, keycode) /* macro */
   XkbDescPtr xkb; /* Xkb description of interest */
   KeyCode keycode; /* keycode of interest */
\end{verbatim}
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XkbKeyNumActions computes the number of actions associated with the key corresponding to keycode. This should be the same value as the result of XkbKeyNumSym (see section 15.3.3).

XkbKeyActionPtr XkbKeyActionsPtr(xkb, keycode) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */

XkbKeyActionsPtr returns a pointer to the two-dimensional array of key actions associated with the key corresponding to keycode. Use XkbKeyActionsPtr only if the key actually has some actions associated with it, that is, XkbKeyNumActions(xkb, keycode) returns something greater than zero.

XkbAction XkbKeyAction(xkb, keycode, idx) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
    int idx; /* index for group and shift level */

XkbKeyAction returns the key action indexed by idx in the two-dimensional array of key actions associated with the key corresponding to keycode. idx may be computed from the group and shift level of interest as follows:

    idx = group_index * key_width + shift_level

XkbAction XkbKeyActionEntry(xkb, keycode, shift, grp) /* macro */
    XkbDescPtr xkb; /* Xkb description of interest */
    KeyCode keycode; /* keycode of interest */
    int shift; /* shift level within group */
    int grp; /* group index for group of interest */

XkbKeyActionEntry returns the key action corresponding to group grp and shift level lvl from the two-dimensional table of key actions associated with the key corresponding to keycode.

16.1.1 The XkbAction Structure

The description for an action is held in an XkbAction structure, which is a union of all possible Xkb action types:

typedef union _XkbAction {
    XkbAnyAction any;
    XkbModAction mods;
    XkbGroupAction group;
    XkbISOAction iso;
    XkbPtrAction ptr;
    XkbPtrBtnAction btn;
    XkbPtrDfltAction dflt;
    XkbSwitchScreenAction screen;
    XkbCtrlsAction ctrls;
    XkbMessageAction msg;
    XkbRedirectKeyAction redirect;
    XkbDeviceBtnAction devbtn;
    XkbDeviceValuatorAction devval;
} XkbAction;
The type field is provided for convenience and is the same as the type field in the individual structures. The following sections describe the individual structures for each action in detail.

16.1.2 The XkbAnyAction Structure

The XkbAnyAction structure is a convenience structure that refers to any of the actions:

```c
#define XkbAnyActionDataSize 7
typedef struct _XkbAnyAction {
    unsigned char type; /* type of action; determines interpretation for data */
    unsigned char data[XkbAnyActionDataSize];
} XkbAnyAction;
```

The data field represents a structure for an action, and its interpretation depends on the type field. The valid values for the type field, and the data structures associated with them are shown in Table 16.1:

### Table 16.1 Action Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Structure for Data</th>
<th>XkbAction Union Member</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_NoAction</td>
<td>XkbSA_NoAction</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td>XkbSA_SetMods</td>
<td>XkbModAction</td>
<td>mods</td>
<td>16.1.3</td>
</tr>
<tr>
<td>XkbSA_LatchMods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_LatchGroup</td>
<td>XkbGroupAction</td>
<td>group</td>
<td>16.1.4</td>
</tr>
<tr>
<td>XkbSA_LockMods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_LockGroup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_MovePtr</td>
<td>XkbPtrAction</td>
<td>ptr</td>
<td>16.1.5</td>
</tr>
<tr>
<td>XkbSA_PtrBtn</td>
<td>XkbPtrBtnAction</td>
<td>btn</td>
<td>16.1.6</td>
</tr>
<tr>
<td>XkbSA_LockPtrBtn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_SetPtrDflt</td>
<td>XkbPtrDfltAction</td>
<td>dflt</td>
<td>16.1.7</td>
</tr>
<tr>
<td>XkbSA_ISOLock</td>
<td>XkbISOAction</td>
<td>iso</td>
<td>16.1.8</td>
</tr>
<tr>
<td>XkbSA_SwitchScreen</td>
<td>XkbSwitchScreenAction</td>
<td>screen</td>
<td>16.1.9</td>
</tr>
<tr>
<td>XkbSA_SetControls</td>
<td>XkbCtrlsAction</td>
<td>ctrl</td>
<td>16.1.10</td>
</tr>
<tr>
<td>XkbSA_LockControls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_ActionMessage</td>
<td>XkbMessageAction</td>
<td>msg</td>
<td>16.1.11</td>
</tr>
<tr>
<td>XkbSA_RedirectKey</td>
<td>XkbRedirectKeyAction</td>
<td>redirect</td>
<td>16.1.12</td>
</tr>
<tr>
<td>XkbSA_DeviceBtn</td>
<td>XkbDeviceBtnAction</td>
<td>devbtn</td>
<td>16.1.13</td>
</tr>
<tr>
<td>XkbSA_LockDeviceBtn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XkbSA_DeviceValuator</td>
<td>XkbDeviceValuatorAction</td>
<td>devval</td>
<td>16.1.14</td>
</tr>
</tbody>
</table>

16.1.3 Actions for Changing Modifiers’ State

Actions associated with the XkbModAction structure change the state of the modifiers when keys are pressed and released (see Chapter 7 for a discussion of modifiers):
typedef struct _XkbModAction {
    unsigned char type; /* XkbSA_{Set|Latch|Lock}Mods */
    unsigned char flags; /* with type, controls the effect on modifiers */
    unsigned char mask; /* same as mask field of a modifier description */
    unsigned char real_mods; /* same as real_mods field of a modifier description */
    unsigned char vmods1; /* derived from vmods field of a modifier description */
    unsigned char vmods2; /* derived from vmods field of a modifier description */
} XkbModAction;

In the following description, the term action modifiers means the real modifier bits associated with this action. Depending on the value of flags (see Table 16.3), these are designated either in the mask field of the XkbModAction structure itself or the real modifiers bound to the key for which the action is being used. In the latter case, this is the client map->modmap[keycode] field.

The type field can have any of the values shown in Table 16.2.

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_SetMods</td>
<td>• A key press adds any action modifiers to the keyboard’s base modifiers.&lt;br&gt;• A key release clears any action modifiers in the keyboard’s base modifiers, provided no other key affecting the same modifiers is logically down.&lt;br&gt;• If no other keys are physically depressed when this key is released, and XkbSA_ClearLocks is set in the flags field, the key release unlocks any action modifiers.</td>
</tr>
<tr>
<td>XkbSA_LatchMods</td>
<td>• Key press and key release events have the same effect as for XkbSA_SetMods; if no keys are physically depressed when this key is released, key release events have the following additional effects:&lt;br&gt;• Modifiers unlocked due to XkbSA_ClearLocks have no further effect.&lt;br&gt;• If XkbSA_LatchToLock is set in the flags field, a key release locks and then unlatches any remaining action modifiers that are already latched.&lt;br&gt;• A key release latches any action modifiers not used by the XkbSA_ClearLocks and XkbSA_LatchToLock flags.</td>
</tr>
<tr>
<td>XkbSA_LockMods</td>
<td>• A key press sets the base state of any action modifiers. If XkbSA_LockNoLock is set in the flags field, a key press also sets the locked state of any action modifiers.&lt;br&gt;• A key release clears any action modifiers in the keyboard’s base modifiers, provided no other key that affects the same modifiers is down. If XkbSA_LockNoUnlock is not set in the flags field, and any of the action modifiers were locked before the corresponding key press occurred, a key release unlocks them.</td>
</tr>
</tbody>
</table>
The flags field is composed of the bitwise inclusive OR of the masks shown in Table 16.3. A general meaning is given in the table, but the exact meaning depends on the action type.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_UseModMapMods</td>
<td>If set, the action modifiers are determined by the modifiers bound by the modifier mapping of the key. Otherwise, the action modifiers are set to the modifiers specified by the mask, real_mods, vmod1, and vmod2 fields.</td>
</tr>
<tr>
<td>XkbSA_ClearLocks</td>
<td>If set and no keys are physically depressed when this key transition occurs, the server unlocks any action modifiers.</td>
</tr>
<tr>
<td>XkbSA_LatchToLock</td>
<td>If set, and the action type is XkbSA_LatchMods, the server locks the action modifiers if they are already latched.</td>
</tr>
<tr>
<td>XkbSA_LockNoLock</td>
<td>If set, and the action type is XkbSA_LockMods, the server only unlocks the action modifiers.</td>
</tr>
<tr>
<td>XkbSA_LockNoUnlock</td>
<td>If set, and the action is XkbSA_LockMods, the server only locks the action modifiers.</td>
</tr>
</tbody>
</table>

If XkbSA_UseModMapMods is not set in the flags field, the mask, real_mods, vmods1, and vmods2 fields are used to determine the action modifiers. Otherwise they are ignored and the modifiers bound to the key (client map->modmap[keycode]) are used instead.

The mask, real_mods, vmods1, and vmods2 fields represent the components of an Xkb modifier description (see section 7.2). While the mask and real_mods fields correspond directly to the mask and real_mods fields of an Xkb modifier description, the vmods1 and vmods2 fields are combined to correspond to the vmods field of an Xkb modifier description. Xkb provides the following macros, to convert between the two formats:

```c
unsigned short XkbModActionVMods(act) /* macro */
XkbAction act; /* action from which to extract virtual mods */
```

`XkbModActionVMods` returns the vmods1 and vmods2 fields of `act` converted to the vmods format of an Xkb modifier description.

```c
void XkbSetModActionVMods(act, vmods) /* macro */
XkbAction act; /* action in which to set vmods */
unsigned short vmods; /* virtual mods to set */
```

`XkbSetModActionVMods` sets the vmods1 and vmods2 fields of `act` using the vmods format of an Xkb modifier description.

**Note** Despite the fact that the first parameter of these two macros is of type XkbAction, these macros may be used only with Actions of type XkbModAction and XkbISO-Action.

16.1.4 Actions for Changing Group State

Actions associated with the XkbGroupAction structure change the current group state when keys are pressed and released (see Chapter 5 for a description of groups and keyboard state):

```c
typedef struct _XkbGroupAction {
    unsigned char type; /* XkbSA_{Set|Latch|Lock}Group */
    unsigned char flags; /* with type, controls the effect on groups */
```
The type field can have any of the following values:

**Table 16.4 Group Action Types**

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_SetGroup</td>
<td>• If the XkbSA_GroupAbsolute bit is set in the flags field, key press</td>
</tr>
<tr>
<td></td>
<td>events change the base keyboard group to the group specified by the</td>
</tr>
<tr>
<td></td>
<td>group XXX field. Otherwise, key press events change the base key-</td>
</tr>
<tr>
<td></td>
<td>board group by adding the group XXX field to the base keyboard</td>
</tr>
<tr>
<td></td>
<td>group. In either case, the resulting effective keyboard group is</td>
</tr>
<tr>
<td></td>
<td>brought back into range depending on the value of the groups_wrap</td>
</tr>
<tr>
<td></td>
<td>field of the controls structure (see section 10.7.1).</td>
</tr>
<tr>
<td></td>
<td>• If a key with an XkbSA_ISOLock action (see section 16.1.8) is</td>
</tr>
<tr>
<td></td>
<td>pressed while this key is down, the key release of this key has no</td>
</tr>
<tr>
<td></td>
<td>effect. Otherwise, the key release cancels the effects of the key</td>
</tr>
<tr>
<td></td>
<td>press.</td>
</tr>
<tr>
<td></td>
<td>• If the XkbSA_ClearLocks bit is set in the flags field, and no keys</td>
</tr>
<tr>
<td></td>
<td>are physically depressed when this key is released, the key release</td>
</tr>
<tr>
<td></td>
<td>also sets the locked keyboard group to Group1.</td>
</tr>
<tr>
<td>XkbSA_LatchGroup</td>
<td>• Key press and key release events have the same effect as for</td>
</tr>
<tr>
<td></td>
<td>XkbSA_SetGroup; if no keys are physically depressed when this key</td>
</tr>
<tr>
<td></td>
<td>is released, key release events have the following additional effects.</td>
</tr>
<tr>
<td></td>
<td>• If the XkbSA_LatchToLock bit is set in the flags field and the</td>
</tr>
<tr>
<td></td>
<td>latched keyboard group index is nonzero, the key release adds the</td>
</tr>
<tr>
<td></td>
<td>delta applied by the corresponding key press to the locked keyboard</td>
</tr>
<tr>
<td></td>
<td>group and subtracts it from the latched keyboard group. The locked</td>
</tr>
<tr>
<td></td>
<td>and effective keyboard group are brought back into range according to</td>
</tr>
<tr>
<td></td>
<td>the value of the groups_wrap field of the controls structure.</td>
</tr>
<tr>
<td></td>
<td>• Otherwise, the key press adds the key press delta to the latched key-</td>
</tr>
<tr>
<td></td>
<td>board group.</td>
</tr>
<tr>
<td>XkbSA_LockGroup</td>
<td>• If the XkbSA_GroupAbsolute is set in the flags field, key press</td>
</tr>
<tr>
<td></td>
<td>events set the locked keyboard group to the group specified by the</td>
</tr>
<tr>
<td></td>
<td>group XXX field. Otherwise, key press events add the group specified</td>
</tr>
<tr>
<td></td>
<td>by the group XXX field to the locked keyboard group. In either case,</td>
</tr>
<tr>
<td></td>
<td>the resulting locked and effective keyboard groups are brought back</td>
</tr>
<tr>
<td></td>
<td>into range depending on the value of the groups_wrap field of the</td>
</tr>
<tr>
<td></td>
<td>controls structure.</td>
</tr>
<tr>
<td></td>
<td>• A key release has no effect.</td>
</tr>
</tbody>
</table>

The flags field is composed of the bitwise inclusive OR of the masks shown in Table 16.5. A general meaning is given in the table, but the exact meaning depends on the action type.

**Table 16.5 Group Action Flags**

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_ClearLocks</td>
<td>If set and no keys are physically depressed when this key transition</td>
</tr>
<tr>
<td></td>
<td>occurs, the server sets the locked keyboard group to Group1 on a key</td>
</tr>
<tr>
<td></td>
<td>release.</td>
</tr>
<tr>
<td>XkbSA_LatchToLock</td>
<td>If set, and the action type is SA_LatchGroup, the server locks the</td>
</tr>
<tr>
<td></td>
<td>action group if it is already latched.</td>
</tr>
<tr>
<td>XkbSA_GroupAbsolute</td>
<td>If set, the group XXX field represents an absolute group number.</td>
</tr>
<tr>
<td></td>
<td>Otherwise, it represents a group delta to be added to the current</td>
</tr>
<tr>
<td></td>
<td>group to determine the new group number.</td>
</tr>
</tbody>
</table>
The group_XXX field represents a signed character. Xkb provides the following macros to convert between a signed integer value and a signed character:

```c
int XkbSAGroup(act) /* macro */  
    XkbAction act; /* action from which to extract group */

XkbSAGroup returns the group_XXX field of act converted to a signed int.

void XkbSASetGroup(act, grp) /* macro */  
    XkbAction act; /* action from which to set group */  
    int grp; /* group index to set in group_XXX */

XkbSASetGroup sets the group_XXX field of act from the group index grp.

Note Despite the fact that the first parameter of these two macros is of type XkbAction, these macros may only be used with Actions of type XkbGroupAction and XkbImAction.

### 16.1.5 Actions for Moving the Pointer

Actions associated with the XkbPtrAction structure move the pointer when keys are pressed and released:

```c
typedef struct _XkbPtrAction {  
    unsigned char type; /* XkbSA_MovePtr */
    unsigned char flags; /* determines type of pointer motion */
    unsigned char high_XXX; /* x coordinate, high bits */
    unsigned char low_XXX; /* y coordinate, low bits */
    unsigned char high_YYY; /* x coordinate, high bits */
    unsigned char low_YYY; /* y coordinate, low bits */
} XkbPtrAction;
```

If the MouseKeys control is not enabled (see section 10.5.1), KeyPress and KeyRelease events are treated as though the action is XkbSA_NoAction.

If the MouseKeys control is enabled, a server action of type XkbSA_MovePtr instructs the server to generate core pointer MotionNotify events rather than the usual KeyPress event, and the corresponding KeyRelease event disables any mouse keys timers that were created as a result of handling the XkbSA_MovePtr action.

The type field of the XkbPtrAction structure is always XkbSA_MovePtr.

The flags field is a bitwise inclusive OR of the masks shown in Table 16.6.

<table>
<thead>
<tr>
<th>Action Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_NoAcceleration</td>
<td>If not set, and the MouseKeysAccel control is enabled (see section 10.5.2), the KeyPress initiates a mouse keys timer for this key; every time the timer expires, the cursor moves.</td>
</tr>
<tr>
<td>XkbSA_MoveAbsoluteX</td>
<td>If set, the X portion of the structure specifies the new pointer X coordinate. Otherwise, the X portion is added to the current pointer X coordinate to determine the new pointer X coordinate.</td>
</tr>
</tbody>
</table>
Each of the X and Y coordinates of the XkbPtrAction structure is composed of two signed 16-bit values, that is, the X coordinate is composed of high_XXX and low_XXX, and similarly for the Y coordinate. Xkb provides the following macros, to convert between a signed integer and two signed 16-bit values in XkbPtrAction structures:

```c
int XkbPtrActionX(act) /* macro */
    XkbPtrAction act; /* action from which to extract X */
XkbPtrActionX returns the high_XXX and low_XXX fields of act converted to a signed int.

int XkbPtrActionY(act) /* macro */
    XkbPtrAction act; /* action from which to extract Y */
XkbPtrActionY returns the high_YYY and low_YYY fields of act converted to a signed int.

void XkbSetPtrActionX(act, x) /* macro */
    XkbPtrAction act; /* action in which to set X */
    int x; /* new value to set */
XkbSetPtrActionX sets the high_XXX and low_XXX fields of act from the signed integer value x.

void XkbSetPtrActionY(act, y) /* macro */
    XkbPtrAction act; /* action in which to set Y */
    int y; /* new value to set */
XkbSetPtrActionY sets the high_YYY and low_YYY fields of act from the signed integer value y.

### 16.1.6 Actions for Simulating Pointer Button Press and Release

Actions associated with the XkbPtrBtnAction structure simulate the press and release of pointer buttons when keys are pressed and released:

```c
typedef struct XkbPtrBtnAction {
    unsigned char type; /* XkbSA_PtrBtn, XkbSA_LockPtrBtn */
    unsigned char flags; /* with type, controls the effect on pointer buttons */
    unsigned char count; /* controls number of ButtonPress and ButtonRelease events */
    unsigned char button; /* pointer button to simulate */
} XkbPtrBtnAction;
```

If the MouseKeys (see section 10.5.1) control is not enabled, KeyPress and KeyRelease events are treated as though the action is XkbSA_NoAction.
The *type* field can have any one of the values shown in Table 16.7.

**Table 16.7 Pointer Button Action Types**

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
</table>
| XkbSA_PtrBtn         | • If XkbSA_UseDfltButton is set in the flags field, the event is generated for the pointer button specified by the mk_dflt_btn attribute of the MouseKeys control (see section 10.5.1). Otherwise, the event is generated for the button specified by the button field.  
  • If the mouse button specified for this action is logically down, the key press and corresponding key release are ignored and have no effect. Otherwise, a key press causes one or more core pointer button events instead of the usual KeyPress event. If count is zero, a key press generates a single ButtonPress event; if count is greater than zero, a key press generates count pairs of ButtonPress and ButtonRelease events.  
  • If count is zero, a key release generates a core pointer ButtonRelease that matches the event generated by the corresponding KeyPress; if count is nonzero, a key release does not cause a ButtonRelease event. A key release never generates a key KeyRelease event. |
| XkbSA_LockPtrBtn     | • If the button specified by the MouseKeys default button or button is not locked, a key press causes a ButtonPress event instead of a KeyPress event and locks the button. If the button is already locked or if XkbSA_LockNoUnlock is set in the flags field, a key press is ignored and has no effect.  
  • If the corresponding key press was ignored, and if XkbSA_LockNoLock is not set in the flags field, a key release generates a ButtonRelease event instead of a KeyRelease event and unlocks the specified button. If the corresponding key press locked a button, the key release is ignored and has no effect. |

The *flags* field is composed of the bitwise inclusive OR of the masks shown in Table 16.8. A general meaning is given in the table, but the exact meaning depends on the action *type*:

**Table 16.8 Pointer Button Action Flags**

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_UseDfltButton</td>
<td>If set, the action uses the pointer button specified by the mk_dflt_btn attribute of the MouseKeys control (see section 10.5.1). Otherwise, the action uses the pointer button specified by the button field.</td>
</tr>
<tr>
<td>XkbSA_LockNoLock</td>
<td>If set, and the action type is XkbSA_LockPtrBtn, the server only unlocks the pointer button.</td>
</tr>
<tr>
<td>XkbSA_LockNoUnlock</td>
<td>If set, and the action type is XkbSA_LockPtrBtn, the server only locks the pointer button.</td>
</tr>
</tbody>
</table>

16.1.7 Actions for Changing the Pointer Button Simulated

Actions associated with the XkbPtrDfltAction structure change the mk_dflt_btn attribute of the MouseKeys control (see section 10.5.1):

```c
typedef struct _XkbPtrDfltAction {
    unsigned char type;   /* XkbSA_SetPtrDflt */
    unsigned char flags;  /* controls the pointer button number */
    unsigned char affect; /* XkbSA_AffectDfltBtn */
} XkbPtrDfltAction;
```
char valueXXX; /* new default button member */

} XkbPtrDfltAction;

If the MouseKeys control is not enabled, KeyPress and KeyRelease events are treated as though the action is XkbSA_NoAction. Otherwise, this action changes the mk_dflt_btn attribute of the MouseKeys control.

The type field of the XkbPtrDfltAction structure should always be XkbSA_SetPtrDflt.

The flags field is composed of the bitwise inclusive OR of the values shown in Table 16.9 (currently there is only one value defined).

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_DfltBtnAbsolute</td>
<td>If set, the value field represents an absolute pointer button. Otherwise, the value field represents the amount to be added to the current default button.</td>
</tr>
</tbody>
</table>

The affect field specifies what changes as a result of this action. The only valid value for the affect field is XkbSA_AffectDfltBtn.

The valueXXX field is a signed character that represents the new button value for the mk_dflt_btn attribute of the MouseKeys control (see section 10.5.1). If XkbSA_DfltBtnAbsolute is set in flags, valueXXX specifies the button to be used; otherwise, valueXXX specifies the amount to be added to the current default button. In either case, illegal button choices are wrapped back around into range. Xkb provides the following macros, to convert between the integer and signed character values in XkbPtrDfltAction structures:

```c
int XkbSAPtrDfltValue(act) /* macro */
    XkbAction act; /* action from which to extract group */
XkbSAPtrDfltValue returns the valueXXX field of act converted to a signed int.

void XkbSASetPtrDfltValue(act, val) /* macro */
    XkbPtrDfltAction act; /* action in which to set valueXXX */
    int val; /* value to set in valueXXX */
XkbSASetPtrDfltValue sets the valueXXX field of act from val.
```

### 16.1.8 Actions for Locking Modifiers and Group

Actions associated with the XkbISOAction structure lock modifiers and the group according to the ISO9995 specification.

Operated by itself, the XkbISOAction is just a caps lock. Operated simultaneously with another modifier key, it transforms the other key into a locking key. For example, press ISO_Lock, press and release Control_L, release ISO_Lock ends up locking the Control modifier.

The default behavior is to convert:

```
{Set,Latch}Mods to: LockMods
{Set,Latch}Group to: LockGroup
SetPtrBtn to: LockPtrBtn
```
SetControls to: LockControls

The affects field allows you to turn those effects on or off individually. Set
XkbSA_ISONoAffectMods to disable the first, XkbSA_ISONoAffectGroup to disable
the second, and so forth.

typedef struct _XkbISOAction {
    unsigned char type;  /* XkbSA_ISOLock */
    unsigned char flags; /* controls changes to group or modifier state */
    unsigned char mask; /* same as mask field of a modifier description */
    unsigned char real_mods; /* same as real_mods field of a modifier description */
    char group_XXX; /* group index or delta group */
    unsigned char affect; /* specifies whether to affect mods, group, ptrbtn, or controls */
    unsigned char vmods1; /* derived from vmods field of a modifier description */
    unsigned char vmods2; /* derived from vmods field of a modifier description */
} XkbISOAction;

The type field of the XkbISOAction structure should always be XkbSA_ISOLock.

The interpretation of the flags field depends on whether the XkbSA_ISODfltIsGroup is
set in the flags field or not.

If the XkbSA_ISODfltIsGroup is set in the flags field, the action is used to change the
group state. The remaining valid bits of the flags field are composed of a bitwise inclusive
OR using the masks shown in Table 16.10.

Table 16.10 ISO Action Flags when XkbSA_ISODfltIsGroup is Set

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_ISODfltIsGroup</td>
<td>If set, the action is used to change the base group state. Must be set for the remaining bits in this table to carry their interpretations. A key press sets the base group as specified by the group_XXX field and the XkbSA_GroupAbsolute bit of the flags field (see section Note). If no other actions are transformed by the XkbISO_Lock action, a key release locks the group. Otherwise, a key release clears group set by the key press.</td>
</tr>
<tr>
<td>XkbSA_GroupAbsolute</td>
<td>If set, the group_XXX field represents an absolute group number. Otherwise, it represents a group delta to be added to the current group to determine the new group number.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectMods</td>
<td>If not set, any XkbSA_SetMods or XkbSA_LatchMods actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockMod actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectGroup</td>
<td>If not set, any XkbSA_SetGroup or XkbSA_LatchGroup actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockGroup actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectPtr</td>
<td>If not set, any XkbSA_PtrBtn actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockPtrBtn actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectCtrls</td>
<td>If not set, any XkbSA_SetControls actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockControls actions instead.</td>
</tr>
</tbody>
</table>
If the XkbSA_ISODfltIsGroup is not set in the flags field, the action is used to change the modifier state and the remaining valid bits of the flags field are composed of a bitwise inclusive OR using the masks shown in Table 16.11.

### Table 16.11 ISO Action Flags when XkbSA_ISODfltIsGroup is Not Set

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_ISODfltIsGroup</td>
<td>If not set, action is used to change the base modifier state. Must not be set for the remaining bits in this table to carry their interpretations. A key press sets the action modifiers in the keyboard’s base modifiers using the mask, real_mods, vmods1, and vmods2 fields (see section 16.1.3). If no other actions are transformed by the XkbISO_Lock action, a key release locks the action modifiers. Otherwise, a key release clears the base modifiers set by the key press.</td>
</tr>
<tr>
<td>XkbSA_UseModMapMods</td>
<td>If set, the action modifiers are determined by the modifiers bound by the modifier mapping of the key. Otherwise, the action modifiers are set to the modifiers specified by the mask, real_mods, vmod1, and vmod2 fields.</td>
</tr>
<tr>
<td>XkbSA_LockNoLock</td>
<td>If set, the server only unlocks the action modifiers.</td>
</tr>
<tr>
<td>XkbSA_LockNoUnlock</td>
<td>If set, the server only locks the action modifiers.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectMods</td>
<td>If not set, any XkbSA_SetMods or XkbSA_LatchMods actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockMods actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectGroup</td>
<td>If not set, any XkbSA_SetGroup or XkbSA_LatchGroup actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockGroup actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectPtr</td>
<td>If not set, any XkbSA_PtrBtn actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockPtrBtn actions instead.</td>
</tr>
<tr>
<td>XkbSA_ISONoAffectCtrls</td>
<td>If not set, any XkbSA_SetControls actions that occur simultaneously with the XkbSA_ISOLock action are treated as XkbSA_LockControls actions instead.</td>
</tr>
</tbody>
</table>

The group_XXX field represents a signed character. Xkb provides macros to convert between a signed integer value and a signed character as shown in section Note.

The mask, real_mods, vmods1, and vmods2 fields represent the components of an Xkb modifier description (see section 7.2). While the mask and real_mods fields correspond directly to the mask and real_mods fields of an Xkb modifier description, the vmods1 and vmods2 fields are combined to correspond to the vmods field of an Xkb modifier description. Xkb provides macros to convert between the two formats as shown in section 16.1.3.

The affect field is composed of a bitwise inclusive OR using the masks shown in Table 16.11.

### Table 16.12 ISO Action Affect Field Values

<table>
<thead>
<tr>
<th>Affect</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_ISODNoAffectMods</td>
<td>If XkbSA_ISODNoAffectMods is not set, any SA_SetMods or SA_LatchMods actions occurring simultaneously with the XkbISOAction are treated as SA_LockMods instead.</td>
</tr>
</tbody>
</table>
The X Keyboard Extension

16 Xkb Server Keyboard Mapping

16.1.9 Actions for Changing the Active Screen

Actions associated with the XkbSwitchScreen action structure change the active screen on a multiscreen display:

**Note** This action is optional. Servers are free to ignore the action or any of its flags if they do not support the requested behavior. If the action is ignored, it behaves like XkbSA_NoAction. Otherwise, key press and key release events do not generate an event.

```c
typedef struct _XkbSwitchScreenAction {
    unsigned char type; /* XkbSA_SwitchScreen */
    unsigned char flags; /* controls screen switching */
    char screenXXX; /* screen number or delta */
} XkbSwitchScreenAction;
```

The `type` field of the XkbSwitchScreenAction structure should always be XkbSA_SwitchScreen.

The `flags` field is composed of the bitwise inclusive OR of the masks shown in Table 16.13.

### Table 16.13 Switch Screen Action Flags

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_SwitchAbsolute</td>
<td>If set, the <code>screenXXX</code> field represents the index of the new screen. Otherwise, it represents an offset from the current screen to the new screen.</td>
</tr>
<tr>
<td>XkbSA_SwitchApplication</td>
<td>If not set, the action should switch to another screen on the same server. Otherwise, it should switch to another X server or application that shares the same physical display.</td>
</tr>
</tbody>
</table>

The `screenXXX` field is a signed character value that represents either the relative or absolute screen index, depending on the state of the XkbSA_SwitchAbsolute bit in the `flags` field. Xkb provides the following macros to convert between the integer and signed character value for screen numbers in XkbSwitchScreenAction structures:

```c
int XkbSAScreen(act) /* macro */
    XkbSwitchScreenAction act; /* action from which to extract screen */
```

`XkbSAScreen` returns the `screenXXX` field of `act` converted to a signed int.
void XkbSASetScreen(act, s) /* macro */
    XkbSwitchScreenAction act; /* action in which to set screenXXX */
    int s; /* value to set in screenXXX */

XkbSASetScreen sets the screenXXX field of act from s.

### 16.1.10 Actions for Changing Boolean Controls State

Actions associated with the XkbCtrlsAction structure change the state of the boolean controls (see section 10.1):

```c
typedef struct XkbCtrlsAction {
    unsigned char type; /* XkbSA_SetControls, XkbSA_LockControls */
    unsigned char flags; /* with type, controls enabling and disabling of controls */
    unsigned char ctrls3; /* ctrls0 through ctrls3 represent the boolean controls */
    unsigned char ctrls2; /* ctrls0 through ctrls3 represent the boolean controls */
    unsigned char ctrls1; /* ctrls0 through ctrls3 represent the boolean controls */
    unsigned char ctrls0; /* ctrls0 through ctrls3 represent the boolean controls */
} XkbCtrlsAction;
```

The type field can have any one of the values shown in Table 16.14.

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
</table>
| XkbSA_SetControls  | • A key press enables any boolean controls specified in the ctrls fields that were not already enabled at the time of the key press.  
                      • A key release disables any controls enabled by the key press.  
                      • This action can cause XkbControlsNotify events (see section 10.1). |
| XkbSA_LockControls | • If the XkbSA_LockNoLock bit is not set in the flags field, a key press enables any controls specified in the ctrls fields that were not already enabled at the time of the key press.  
                      • If the XkbSA_LockNoUnlock bit is not set in the flags field, a key release disables any controls specified in the ctrls fields that were not already disabled at the time of the key press.  
                      • This action can cause XkbControlsNotify events (see section 10.1). |

The flags field is composed of the bitwise inclusive OR of the masks shown in Table 16.15.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_LockNoLock</td>
<td>If set, and the action type is XkbSA_LockControls, the server only disables controls.</td>
</tr>
<tr>
<td>XkbSA_LockNoUnlock</td>
<td>If set, and the action type is XkbSA_LockControls, the server only enables controls.</td>
</tr>
</tbody>
</table>

The XkbSA_SetControls action implements a key that enables a boolean control when pressed and disables it when released. The XkbSA_LockControls action is used to implement a key that toggles the state of a boolean control each time it is pressed and released. The XkbSA_LockNoLock and XkbSA_LockNoUnlock flags allow modifying the toggling behavior to only unlock or only lock the boolean control.
The `ctrls0`, `ctrls1`, `ctrls2`, and `ctrls3` fields represent the boolean controls in the `enabledCtrls` field of the controls structure (see section 10.1). Xkb provides the following macros, to convert between the two formats:

```c
unsigned int XkbActionCtrls(act) /* macro */
    XkbCtrlsAction act; /* action from which to extract controls */
XkbActionCtrls returns the `ctrls` fields of `act` converted to an unsigned int.

void XkbSAActionSetCtrls(act, ctrls) /* macro */
    XkbCtrlsAction act; /* action in which to set ctrls0-ctrls3 */
    unsigned int ctrls; /* value to set in ctrls0-ctrls3 */
XkbSAActionSetCtrls sets the `ctrls0` through `ctrls3` fields of `act` from `ctrls`.

16.1.11 Actions for Generating Messages

Actions associated with the `XkbMessageAction` structure generate `XkbActionMessage` events:

```c
#define XkbActionMessageLength 6

typedef struct _XkbMessageAction {
    unsigned char type;  /* XkbSA_ActionMessage */
    unsigned char flags; /* controls event generation via key presses and releases */
    unsigned char message[XkbActionMessageLength]; /* message */
} XkbMessageAction;
```

The `type` field of the `XkbMessageAction` structure should always be `XkbSA_ActionMessage`.

The `flags` field is composed of the bitwise inclusive OR of the masks shown in Table 16.16.

**Table 16.16 Message Action Flags**

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_MessageOnPress</td>
<td>If set, key press events generate an <code>XkbActionMessage</code> event that reports the keycode, event type, and contents of the <code>message</code> field.</td>
</tr>
<tr>
<td>XkbSA_MessageOnRelease</td>
<td>If set, key release events generate an <code>XkbActionMessage</code> event that reports the keycode, event type, and contents of the <code>message</code> field.</td>
</tr>
<tr>
<td>XkbSA_MessageGenKeyEvent</td>
<td>If set, key press and key release events generate <code>KeyPress</code> and <code>KeyRelease</code> events, regardless of whether they generate <code>XkbActionMessage</code> events.</td>
</tr>
</tbody>
</table>

The `message` field is an array of `XkbActionMessageLength` unsigned characters and may be set to anything the keymap designer wishes.

**Detecting Key Action Messages**

To receive `XkbActionMessage` events by calling either `XkbSelectEvents` or `XkbSelectEventDetails` (see section 4.3).

To receive `XkbActionMessage` events under all possible conditions, use `XkbSelectEvents` and pass `XkbActionMessageMask` in both `bits_to_change` and `values_for_bits`. 
The `XkbActionMessage` event has no event details. However, you can call `XkbSelectEventDetails` using `XkbActionMessage` as the `event_type` and specifying `XkbAllActionMessageMask` in `bits_to_change` and `values_for_bits`. This has the same effect as a call to `XkbSelectEvents`.

The structure for the `XkbActionMessage` event is defined as follows:

```c
typedef struct _XkbActionMessage {
    int type; /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time time; /* server time when event generated */
    int xkb_type; /* XkbActionMessage */
    int device; /* Xkb device ID, will not be XkbUseCoreKbd */
    KeyCode keycode; /* keycode of key triggering event */
    Bool press; /* True => key press, False => release */
    Bool key_event_follows; /* True => KeyPress/KeyRelease follows */
    char message[XkbActionMessageLength+1]; /* message text */
} XkbActionMessageEvent;
```

The `keycode` is the keycode of the key that was pressed or released. The `press` field specifies whether the event was the result of a key press or key release.

The `key_event_follows` specifies whether a `KeyPress` (if `press` is True) or `KeyRelease` (if `press` is False) event is also sent to the client. As with all other Xkb events, `XkbActionMessageEvents` are delivered to all clients requesting them, regardless of the current keyboard focus. However, the `KeyPress` or `KeyRelease` event that conditionally follows an `XkbActionMessageEvent` is sent only to the client selected by the current keyboard focus. `key_event_follows` is True only for the client that is actually sent the following `KeyPress` or `KeyRelease` event.

The `message` field is set to the message specified in the action and is guaranteed to be NULL-terminated; the Xkb extension forces a NULL into `message[XkbActionMessageLength]`.

**16.1.12 Actions for Generating a Different Keycode**

Actions associated with the `XkbRedirectKeyAction` structure generate `KeyPress` and `KeyRelease` events containing a keycode different from the key that was pressed or released:

```c
typedef struct _XkbRedirectKeyAction {
    unsigned char type; /* XkbSA_RedirectKey */
    unsigned char new_key; /* keycode to be put in event */
    unsigned char mods_mask; /* mask of real mods to be reset */
    unsigned char mods; /* mask of real mods to take values from */
    unsigned char vmods_mask0; /* first half of mask of virtual mods to be reset */
    unsigned char vmods_mask1; /* other half of mask of virtual mods to be reset */
    unsigned char vmods0; /* first half of mask of virtual mods to take values from */
    unsigned char vmods1; /* other half of mask of virtual mods to take values from */
} XkbRedirectKeyAction;
```
The type field for the XkbRedirectKeyAction structure should always be XkbSA_RedirectKey.

Key presses cause a KeyPress event for the key specified by the new_key field instead of the actual key. The state reported in this event reports the current effective modifiers changed as follows: any real modifiers selected by the mods_mask field are set to corresponding values from the mods field. Any real modifiers bound to the virtual modifiers specified by the vmods_mask0 and vmods_mask1 fields are either set or cleared, depending on the corresponding values in the vmods0 and vmods1 fields. If the real and virtual modifier definitions specify conflicting values for a single modifier, the real modifier definition has priority.

Key releases cause a KeyRelease event for the key specified by the new_key field instead of the actual key. The state for this event consists of the effective keyboard modifiers at the time of the release, changed as described previously.

The XkbSA_RedirectKey action normally redirects to another key on the same device as the key that caused the event, unless that device does not belong to the input extension KeyClass, in which case this action causes an event on the core keyboard device. (The input extension categorizes devices by breaking them into classes. Keyboards, and other input devices with keys, are classified as KeyClass devices by the input extension.)

The vmods_mask0 and vmods_mask1 fields actually represent one vmods_mask value, as described in Chapter 7. Xkb provides the following macros, to convert between the two formats:

```c
unsigned int XkbSARedirectVModsMask(act) /* macro */
    XkbRedirectKeyAction act; /* action from which to extract vmods */
XkbSARedirectVModsMask returns the vmods_mask0 and vmods_mask1 fields of act converted to an unsigned int.

void XkbSARedirectSetVModsMask(act, vm) /* macro */
    XkbRedirectKeyAction act; /* action in which to set vmods */
    unsigned int vm; /* new value for virtual modifier mask */
XkbSARedirectSetVModsMask sets the vmods_mask0 and vmods_mask1 fields of act from vm.
```

Similarly, the vmods0 and vmods1 fields actually represent one vmods value, as described in Chapter 7. To convert between the two formats, Xkb provides the following convenience macros:

```c
unsigned int XkbSARedirectVMods(act) /* macro */
    XkbRedirectKeyAction act; /* action from which to extract vmods */
XkbSARedirectVModsMask returns the vmods0 and vmods1 fields of act converted to an unsigned int.

void XkbSARedirectSetVMods(act, vm) /* macro */
    XkbRedirectKeyAction act; /* action in which to set vmods */
    unsigned int v; /* new value for virtual modifiers */
XkbSARedirectSetVModsMask sets the vmods0 and vmods1 of act from v.
```
16.1.13 Actions for Generating DeviceButtonPress and DeviceButtonRelease

Actions associated with XkbDeviceBtnAction structures generate DeviceButtonPress and DeviceButtonRelease events instead of normalKeyPress and KeyRelease events:

```c
typedef struct _XkbDeviceBtnAction {
    unsigned char type; /* XkbSA_DeviceBtn, XkbSA_LockDeviceBtn */
    unsigned char flags; /* with type, specifies locking or unlocking */
    unsigned char count; /* controls number of DeviceButtonPress and Release events */
    unsigned char button; /* index of button on device */
    unsigned char device; /* device ID of an X input extension device */
} XkbDeviceBtnAction;
```

The type field can have any one of the values shown in Table 16.17.

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
</table>
| XkbSA_DeviceBtn       | • If the button specified by this action is logically down, the key press and corresponding release are ignored and have no effect. If the device or button specified by this action are illegal, this action behaves like XkbSA_NoAction.  
                        | • Otherwise, key presses cause one or more input extension device events instead of the usual key press event. If the count field is zero, a key press generates a single DeviceButtonPress event. If count is greater than zero, a key press event generates count pairs of DeviceButtonPress and DeviceButtonRelease events. 
                        | • If count is zero, a key release generates an input extension DeviceButtonRelease event that matches the event generated by the corresponding key press. If count is nonzero, a key release does not cause a DeviceButtonRelease event. Key releases never cause KeyRelease events. |
| XkbSA_LockDeviceBtn   | • If the device or button specified by this action are illegal, this action behaves like XkbSA_NoAction.  
                        | • Otherwise, if the specified button is not locked and the XkbSA_LockNoLock bit is not set in the flags field, a key press generates an input extension DeviceButtonPress event instead of a KeyPress event and locks the button. If the button is already locked or if XkbSA_LockNoLock bit is set in the flags field, the key press is ignored and has no effect.  
                        | • If the corresponding key press was ignored, and if the XkbSA_LockNoUnlock bit is not set in the flags field, a key release generates an input extension DeviceButtonRelease event instead of a KeyRelease event and unlocks the button. If the corresponding key press locked a button, the key release is ignored and has no effect. |

The flags field is composed of the bitwise inclusive OR of the masks shown in Table 16.18.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_LockNoLock</td>
<td>If set, and the action type is XkbSA_LockDeviceBtn, the server only unlocks the button.</td>
</tr>
</tbody>
</table>
16.1.14 Actions for Simulating Events from Device Valuators

A *valuator* manipulates a range of values for some entity, like a mouse axis, a slider or a dial. Actions associated with XkbDeviceValuatorAction structures are used to simulate events from one or two input extension device valuators.

```c
typedef struct _XkbDeviceValuatorAction {
    unsigned char type; /* XkbSA_DeviceValuator */
    unsigned char device; /* device ID */
    unsigned char v1_what; /* determines how valuator is to behave for valuator 1 */
    unsigned char v1_ndx; /* specifies a real valuator */
    unsigned char v1_value; /* the value for valuator 1 */
    unsigned char v2_what; /* determines how valuator is to behave for valuator 2 */
    unsigned char v2_ndx; /* specifies a real valuator */
    unsigned char v2_value; /* the value for valuator 1 */
} XkbDeviceValuatorAction;
```

If `device` is illegal or if neither `v1_ndx` nor `v2_ndx` specifies a legal valuator, this action behaves like `XkbSA_NoAction`.

The low four bits of `v1_what` and `v2_what` specify the corresponding scale value (denoted `val<n>Scale` in Table 16.17), if needed. The high four bits of `v1_what` and `v2_what` specify the operation to perform to set the values. The high four bits of `v1_what` and `v2_what` can have the values shown in Table 16.17; the use of `val<n>Scale` is shown in that table also.

### Table 16.18 Device Button Action Flags

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_LockNoUnlock</td>
<td>If set, and the action type is XkbSA_LockDeviceBtn, the server only locks the button.</td>
</tr>
</tbody>
</table>

### Table 16.19 Device Valuator v<n>_what High Bits Values

<table>
<thead>
<tr>
<th>Value of high bits</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSA_IgnoreVal</td>
<td>No action</td>
</tr>
<tr>
<td>XkbSA_SetValMin</td>
<td><code>v&lt;n&gt;_value</code> is set to its minimum legal value.</td>
</tr>
<tr>
<td>XkbSA_SetValCenter</td>
<td><code>v&lt;n&gt;_value</code> is centered (to (max-min)/2).</td>
</tr>
<tr>
<td>XkbSA_SetValMax</td>
<td><code>v&lt;n&gt;_value</code> is set to its maximum legal value.</td>
</tr>
<tr>
<td>XkbSA_SetValRelative</td>
<td><code>v&lt;n&gt;_value</code> * (2^val&lt;n&gt;Scale) is added to <code>v&lt;n&gt;_value</code>.</td>
</tr>
<tr>
<td>XkbSA_SetValAbsolute</td>
<td><code>v&lt;n&gt;_value</code> is set to (2^val&lt;n&gt;Scale).</td>
</tr>
</tbody>
</table>

Illegal values for XkbSA_SetValRelative or XkbSA_SetValAbsolute are clamped into range. Note that all of these possibilities are legal for absolute valuators. For relative valuators, only XkbSA_SetValRelative is permitted. Part of the input extension description of a device is the range of legal values for all absolute valuators, whence the maximum and minimum legal values shown in Table 16.17.

The following two masks are provided as a convenience to select either portion of `v1_what` or `v2_what`:

```c
#define XkbSA_ValOpMask (0x70)
#define XkbSA_ValScaleMask (0x07)
```
$v1_{ndx}$ and $v2_{ndx}$ specify valuators that actually exist. For example, most mice have two valuators (x and y axes) so the only legal values for a mouse would be 0 and 1. For a dial box with eight dials, any value in the range 0..7 would be correct.

### 16.1.15 Obtaining Key Actions for Keys from the Server

To update the actions (the `key_acts` array) for a subset of the keys in a keyboard description, use `XkbGetKeyActions`.

**Status**

```c
XkbGetKeyActions(dpy, first, num, xkb)
```

- `dpy`: /* connection to X server */
- `first`: /* keycode of first key of interest */
- `num`: /* number of keys desired */
- `xkb`: /* pointer to keyboard description where result is stored */

`XkbGetKeyActions` sends a request to the server to obtain the actions for `num` keys on the keyboard starting with key `first`. It waits for a reply and returns the actions in the `server->key_acts` field of `xkb`. If successful, `XkbGetKeyActions` returns `Success`. The `xkb` parameter must be a pointer to a valid Xkb keyboard description.

If the `server` map in the `xkb` parameter has not been allocated, `XkbGetKeyActions` allocates and initializes it before obtaining the actions.

If the server does not have a compatible version of Xkb, or the Xkb extension has not been properly initialized, `XkbGetKeyActions` returns `BadAccess`. If `num` is less than 1 or greater than `XkbMaxKeyCount`, `XkbGetKeyActions` returns `BadValue`. If any allocation errors occur, `XkbGetKeyActions` returns `BadAlloc`.

### 16.1.16 Changing the Number of Actions Bound to a Key

To change the number of actions bound to a key, use `XkbResizeKeyAction`.

```c
XkbAction *XkbResizeKeyActions(xkb, key, needed)
```

- `xkb`: /* keyboard description to change */
- `key`: /* keycode of key to change */
- `needed`: /* new number of actions required */

The `xkb` parameter points to the keyboard description containing the `key` whose number of actions is to be changed. The `key` parameter is the keycode of the key to change, and `needed` specifies the new number of actions required for the key.

`XkbResizeKeyActions` reserves the space needed for the actions and returns a pointer to the beginning of the new array that holds the actions. It can change the `acts`, `num_acts`, and `size_acts` fields of `xkb->server` if it is necessary to reallocate the `acts` array.

If `needed` is greater than the current number of keyyms for the key, `XkbResizeKeyActions` initializes all new actions in the array to `NoAction`.

Because the number of actions needed by a key is normally computed as width * number of groups, and `XkbResizeKeyActions` does not modify either the width or number of groups for the key, a discrepancy exists on return from `XkbResizeKeyActions` between the space allocated for the actions and the number required. The unused entries in the list of actions returned by `XkbResizeKeyActions` are not preserved across future calls to any of the map editing functions, so you must update the key actions (which updates the width and num-
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ber of groups for the key) before calling another allocator function. A call to XkbChange-
TypesOfKey updates these.

If any allocation errors occur while resizing the number of actions bound to the key, XkbResizeKeyActions returns NULL.

**Note** A change to the number of actions bound to a key should be accompanied by a change in the number of symbols bound to a key. Refer to section 15.3.7 for more information on changing the number of symbols bound to a key.

### 16.2 Key Behavior

Key behavior refers to the demeanor of a key. For example, the expected behavior of the CapsLock key is that it logically locks when pressed, and then logically unlocks when pressed again.

#### 16.2.1 Radio Groups

Keys that belong to the same radio group have the XkbKB_RadioGroup type in the *type* field and the radio group index specified in the *data* field in the XkbBehavior structure. If the radio group has a name in the XkbNamesRec structure, the radio group index is the index into the radio_group array in the XkbNamesRec structure. A radio group key when pressed stays logically down until another key in the radio group is pressed, when the first key becomes logically up and the new key becomes logically down. Setting the XkbKB_RGAllowNone bit in the behavior for all of the keys of the radio group means that pressing the logically down member of the radio group causes it to logically release, in which case none of the keys of the radio group would be logically down. If XkbKB_RGAllowNone is not set, there is no way to release the logically down member of the group.

The low five bits of the *data* field of the XkbBehavior structure are the group number, the high three bits are flags. The only flag currently defined is:

```c
#define XkbRG_AllowNone 0x80
```

#### 16.2.2 The XkbBehavior Structure

The *behaviors* field of the server map is an array of XkbBehavior structures, indexed by keycode, and contains the behavior for each key. The XkbBehavior structure is defined as follows:

```c
typedef struct _XkbBehavior {
    unsigned char  type; /* behavior type + optional XkbKB_Permanent bit */
    unsigned char  data;
} XkbBehavior;
```

The *type* field specifies the Xkb behavior, and the value of the *data* field depends on the *type*. Xkb supports the key behaviors shown in Table 16.20.

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKB_Default</td>
<td>Press and release events are processed normally. The <em>data</em> field is unused.</td>
</tr>
</tbody>
</table>
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Xkb also provides the mask, XkbKB_Permanent, to specify whether the key behavior type should be simulated by Xkb or whether the key behavior describes an unalterable physical, electrical, or software aspect of the keyboard. If the XkbKB_Permanent bit is not set in the type field, Xkb simulates the behavior in software. Otherwise, Xkb relies upon the keyboard to implement the behavior.

16.2.3 Obtaining Key Behaviors for Keys from the Server

To obtain the behaviors (the behaviors array) for a subset of the keys in a keyboard description from the server, use XkbGetKeyBehaviors:

```c
Status XkbGetKeyBehaviors(dpy, first, num, xkb)
    Display * dpy;  /* connection to server */
    unsigned int first;  /* keycode of first key to get */
    unsigned int num;  /* number of keys for which behaviors are desired */
    XkbDescPtr xkb;  /* Xkb description to contain the result */
```

XkbGetKeyBehaviors sends a request to the server to obtain the behaviors for num keys on the keyboard starting with the key whose keycode is first. It waits for a reply and returns the behaviors in the server->behaviors field of xkb. If successful, XkbGetKeyBehaviors returns Success.

If the server map in the xkb parameter has not been allocated, XkbGetKeyBehaviors allocates and initializes it before obtaining the actions.

If the server does not have a compatible version of Xkb, or the Xkb extension has not been properly initialized, XkbGetKeyBehaviors returns BadAccess. If num is less than 1 or greater than XkbMaxKeyCount, XkbGetKeyBehaviors returns BadValue. If any allocation errors occur, XkbGetKeyBehaviors returns BadAlloc.

### Table 16.20 Key Behaviors

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKB_Lock</td>
<td>If a key is logically up (that is, the corresponding bit of the core key map is cleared) when it is pressed, the key press is processed normally and the corresponding release is ignored. If the key is logically down when pressed, the key press is ignored but the corresponding release is processed normally. The data field is unused.</td>
</tr>
<tr>
<td>XkbKB_RadioGroup</td>
<td>If another member of the radio group is logically down (all members of the radio group have the same index, specified in data) when a key is pressed, the server synthesizes a key release for the member that is logically down and then processes the new key press event normally. If the key itself is logically down when pressed, the key press event is ignored, but the processing of the corresponding key release depends on the value of the Xkb_RGAllowNone bit in flags. If it is set, the key release is processed normally; otherwise, the key release is also ignored. All other key release events are ignored.</td>
</tr>
<tr>
<td>XkbKB_Overlay1</td>
<td>If the Overlay1 control is enabled (see section 10.4), data is interpreted as a keycode, and events from this key are reported as if they came from data's keycode. Otherwise, press and release events are processed normally.</td>
</tr>
<tr>
<td>XkbKB_Overlay2</td>
<td>If the Overlay2 control is enabled (see section 10.4), data is interpreted as a keycode, and events from this key are reported as if they came from data's keycode. Otherwise, press and release events are processed normally.</td>
</tr>
</tbody>
</table>

Xkb also provides the mask, XkbKB_Permanent, to specify whether the key behavior type should be simulated by Xkb or whether the key behavior describes an unalterable physical, electrical, or software aspect of the keyboard. If the XkbKB_Permanent bit is not set in the type field, Xkb simulates the behavior in software. Otherwise, Xkb relies upon the keyboard to implement the behavior.
16.3 Explicit Components—Avoiding Automatic Remapping by the Server

Whenever a client remaps the keyboard using core protocol requests, Xkb examines the map to determine likely default values for the components that cannot be specified using the core protocol (see section 17.1.2 for more information on how Xkb chooses the default values).

This automatic remapping might replace definitions explicitly requested by an application, so the Xkb keyboard description defines an explicit components mask for each key. Any aspects of the automatic remapping listed in the explicit components mask for a key are not changed by the automatic keyboard mapping.

The explicit components masks are held in the *explicit* field of the server map, which is an array indexed by keycode. Each entry in this array is a mask that is a bitwise inclusive OR of the values shown in Table 16.21.

<table>
<thead>
<tr>
<th>Bit in Explicit Mask</th>
<th>Value</th>
<th>Protects Against</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExplicitKeyType1</td>
<td>(1&lt;&lt;0)</td>
<td>Automatic determiniation of the key type associated with Group1.</td>
</tr>
<tr>
<td>ExplicitKeyType2</td>
<td>(1&lt;&lt;1)</td>
<td>Automatic determiniation of the key type associated with Group2.</td>
</tr>
<tr>
<td>ExplicitKeyType3</td>
<td>(1&lt;&lt;2)</td>
<td>Automatic determiniation of the key type associated with Group3.</td>
</tr>
<tr>
<td>ExplicitKeyType4</td>
<td>(1&lt;&lt;3)</td>
<td>Automatic determiniation of the key type associated with Group4.</td>
</tr>
<tr>
<td>ExplicitInterpret</td>
<td>(1&lt;&lt;4)</td>
<td>Application of any of the fields of a symbol interpretation to the key in question.</td>
</tr>
<tr>
<td>ExplicitAutoRepeat</td>
<td>(1&lt;&lt;5)</td>
<td>Automatic determiniation of auto-repeat status for the key, as specified in a symbol interpretation.</td>
</tr>
<tr>
<td>ExplicitBehavior</td>
<td>(1&lt;&lt;6)</td>
<td>Automatic assignment of the XkbKB_Lock behavior to the key, if the XkbSI_LockingKey flag is set in a symbol interpretation.</td>
</tr>
<tr>
<td>ExplicitVModMap</td>
<td>(1&lt;&lt;7)</td>
<td>Automatic determiniation of the virtual modifier map for the key based on the actions assigned to the key and the symbol interpretations that match the key.</td>
</tr>
</tbody>
</table>

16.3.1 Obtaining Explicit Components for Keys from the Server

To obtain the explicit components (the *explicit* array) for a subset of the keys in a keyboard description, use XkbGetKeyExplicitComponents.

Status XkbGetKeyExplicitComponents(dpy, first, num, xkb)

XkbGetKeyExplicitComponents sends a request to the server to obtain the explicit components for *num* keys on the keyboard starting with key *first*. It waits for a reply and returns the explicit components in the *server->explicit* array of *xkb*. If successful, XkbGetKeyExplicitComponents returns Success. The *xkb* parameter must be a pointer to a valid Xkb keyboard description.
If the server map in the xkb parameter has not been allocated, \textit{XkbGetKeyExplicitComponents} allocates and initializes it before obtaining the actions.

If the server does not have a compatible version of Xkb, or the Xkb extension has not been properly initialized, \textit{XkbGetKeyExplicitComponents} returns \texttt{BadMatch}. If \texttt{num} is less than 1 or greater than \texttt{XkbMaxKeyCount}, \textit{XkbGetKeyExplicitComponents} returns \texttt{BadValue}. If any allocation errors occur, \textit{XkbGetKeyExplicitComponents} returns \texttt{BadAlloc}.

### 16.4 Virtual Modifier Mapping

The \texttt{vmods} member of the server map is a fixed-length array containing \texttt{XkbNumVirtualMods} entries. Each entry corresponds to a virtual modifier and provides the binding of the virtual modifier to the real modifier bits. Each entry in the \texttt{vmods} array is a bitwise inclusive OR of the legal modifier masks:

- \texttt{ShiftMask}
- \texttt{LockMask}
- \texttt{ControlMask}
- \texttt{Mod1Mask}
- \texttt{Mod2Mask}
- \texttt{Mod3Mask}
- \texttt{Mod4Mask}
- \texttt{Mod5Mask}

The \texttt{vmodmap} member of the server map is similar to the \texttt{modmap} array of the client map (see section 15.4), but is used to define the virtual modifier mapping for each key. Like the \texttt{modmap} member, it is indexed by keycode, and each entry is a mask representing the virtual modifiers bound to the corresponding key:

- Each of the bits in a \texttt{vmodmap} entry represents an index into the \texttt{vmods} member. That is, bit 0 of a \texttt{vmodmap} entry refers to index 0 of the \texttt{vmods} array, bit 1 refers to index 1, and so on.
- If a bit is set in the \texttt{vmodmap} entry for a key, that key is bound to the corresponding virtual modifier in the \texttt{vmods} array.

The \texttt{vmodmap} and \texttt{vmods} members of the server map are the “master” virtual modifier definitions. Xkb automatically propagates any changes to these fields to all other fields that use virtual modifier mappings.
The overall relationship of fields dealing with virtual modifiers in an Xkb keyboard description are shown in Figure 16.2.

**Figure 16.2 Virtual Modifier Relationships**

### 16.4.1 Obtaining Virtual Modifier Bindings from the Server

To obtain a subset of the virtual modifier bindings (the `vmods` array) in a keyboard description, use `XkbGetVirtualMods`:

```
Status XkbGetVirtualMods(dpy, which, xkb)
    Display * dpy;      /* connection to server */
    unsigned int which; /* mask indicating virtual modifier bindings to get */
    XkbDescPtr xkb;     /* Xkb description where results will be placed */
```

The `XkbGetVirtualMods` sends a request to the server to obtain the `vmods` entries for the virtual modifiers specified in the mask, `which`, and waits for a reply. See section 7.1 for a description of how to determine the virtual modifier mask. For each bit set in `which`, `XkbGetVirtualMods` updates the corresponding virtual modifier definition in the `server->vmods` array of `xkb`. The `xkb` parameter must be a pointer to a valid Xkb keyboard description. If successful, `XkbGetVirtualMods` returns `Success`.

If the `server` map has not been allocated in the `xkb` parameter, `XkbGetVirtualMods` allocates and initializes it before obtaining the virtual modifier bindings.
If the server does not have a compatible version of Xkb, or the Xkb extension has not been properly initialized, XkbGetVirtualMods returns BadMatch. Any errors in allocation cause XkbGetVirtualMods to return BadAlloc.

16.4.2 Obtaining Per-Key Virtual Modifier Mappings from the Server

To obtain the virtual modifier map (the vmodmap array) for a subset of the keys in a keyboard description, use XkbGetKeyVirtualModMap:

Status XkbGetKeyVirtualModMap(dpy, first, num, xkb)

Display * dpy; /* connection to server */
unsigned int first; /* keycode of first key to fetch */
unsigned int num; /* # keys for which virtual mod maps are desired */
XkbDescPtr xkb; /* Xkb description where results will be placed */

XkbGetKeyVirutalModmap sends a request to the server to obtain the virtual modifier mappings for num keys on the keyboard starting with key first. It waits for a reply and returns the virtual modifier mappings in the server->vmodmap array of xkb. If successful, XkbGetKeyVirtualModMap returns Success. The xkb parameter must be a pointer to a valid Xkb keyboard description.

If the server map in the xkb parameter has not been allocated, XkbGetKeyVirtualModMap allocates and initializes it before obtaining the virtual modifier mappings.

If the server does not have a compatible version of Xkb, or the Xkb extension has not been properly initialized, XkbGetKeyVirtualModMap returns BadMatch. If num is less than 1 or greater than XkbMaxKeyCount, XkbGetKeyVirtualModMap returns BadValue. If any allocation errors occur, XkbGetKeyVirtualModMap returns BadAlloc.
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17 The Xkb Compatibility Map

As shown in Figure 17.1, the X server is normally dealing with more than one client, each of which may be receiving events from the keyboard, and each of which may issue requests to modify the keyboard in some manner. Each client may be either Xkb-unaware, Xkb-capable, or Xkb-aware. The server itself may be either Xkb-aware or Xkb-unaware. If the server is Xkb-unaware, Xkb state and keyboard mappings are not involved in any manner, and Xkb-aware clients may not issue Xkb requests to the server. If the server is Xkb-aware, the server must be able to deliver events and accept requests in which the keyboard state and mapping are compatible with the mode in which the client is operating. Consequently, for some situations, conversions must be made between Xkb state / keyboard mappings and core protocol state / keyboard mappings, and vice versa.

Figure 17.1 Server Interaction with Types of Clients

In addition to these situations involving a single server, there are cases where a client that deals with multiple servers may need to configure keyboards on different servers to be similar and the different servers may not all be Xkb-aware. Finally, a client may be dealing with descriptions of keyboards (files, and so on) that are based on core protocol and therefore may need to be able to map these descriptions to Xkb descriptions.

An Xkb-aware server maintains keyboard state and mapping as an Xkb keyboard state and an Xkb keyboard mapping plus a compatibility map used to convert from Xkb components to core components and vice versa. In addition, the server also maintains a core keyboard mapping that approximates the Xkb keyboard mapping. The core keyboard mapping may be updated piecemeal, on a per-key basis. When the server receives a core protocol ChangeKeyboardMapping or SetModifierMapping request, it updates its core keyboard mapping, then uses the compatibility map to update its Xkb keyboard map-
ping. When the server receives an `XkbSetMap` request, it updates those portions of its Xkb keyboard mapping specified by the request, then uses its compatibility map to update the corresponding parts of its core keyboard map. Consequently, the server’s Xkb keyboard map and also its core keyboard map may contain components that were set directly and others that were computed. Figure 17.2 illustrates these relationships.

**Note** The core keyboard map is contained only in the server, not in any client-side data structures.

![Diagram of X Keyboard Extension]

**Figure 17.2 Server Derivation of State and Keyboard Mapping Components**

There are three kinds of compatibility transformations made by the server:

1. **Xkb State to Core State**

   Keyboard state information reported to a client in the state field of various core events may be translated from the Xkb keyboard state maintained by the server, which includes a group number, to core protocol state, which does not.

   In addition, whenever the Xkb state is retrieved, the `compat_state`, `compat_grab_mods`, and `compat_lookup_mods` fields of the `XkbStateRec` returned indicate the result of applying the compatibility map to the current Xkb state in the server.

2. **Core Keyboard Mapping to Xkb Keyboard Mapping**

   After core protocol requests received by the server to change the keyboard mapping (`ChangeKeyboardMapping` and `SetModifierMapping`) have been applied to the server’s core keyboard map, the results must be transformed to achieve an equivalent change of the Xkb keyboard mapping maintained by the server.

3. **Xkb Keyboard Mapping to Core Keyboard Mapping**

   After Xkb protocol requests received by the server to change the keyboard mapping (`XkbSetMap`) have been applied to the server’s Xkb keyboard map, the results are
transformed to achieve an approximately equivalent change to the core keyboard mapping maintained by the server.

This chapter discusses how a client may modify the compatibility map so that subsequent transformations have a particular result.

17.1 The XkbCompatMap Structure

All configurable aspects of mapping Xkb state and configuration to and from core protocol state and configuration are defined by a compatibility map, contained in an XkbCompatMap structure; plus a set of explicit override controls used to prevent particular components of type 2 (core-to-Xkb keyboard mapping) transformations from automatically occurring. These explicit override controls are maintained in a separate data structure discussed in section 16.3.

The compat member of an Xkb keyboard description (XkbDescRec) points to the XkbCompatMap structure:

```c
typedef struct _XkbCompatMapRec {
    XkbSymInterpretPtr sym_interpret; /* symbol based key semantics*/
    XkbModsRec groups[XkbNumKbdGroups]; /* group => modifier map */
    unsigned short num_si; /* # structures used in sym_interpret */
    unsigned short size_si; /* # structures allocated in sym_interpret */
} XkbCompatMapRec, *XkbCompatMapPtr;
```

Figure 17.3 Xkb Compatibility Data Structures

The subsections that follow discuss how the compatibility map and explicit override controls are used in each of the three cases where compatibility transformations are made.

17.1.1 Xkb State to Core Protocol State Transformation

As shown in Figure 17.3, there are four group compatibility maps (contained in groups [0..3]) in the XkbCompatMapRec structure, one per possible Xkb group. Each group compatibility map is a modifier definition (see section 7.2 for a description of modifier defini-
tions). The *mask* component of the definition specifies which real modifiers should be set in the core protocol state field when the corresponding group is active. Because only one group is active at any one time, only one of the four possible transformations is ever applied at any one point in time. If the device described by the *XkbDescRec* does not support four groups, the extra groups fields are present, but undefined.

Normally, the Xkb-aware server reports keyboard state in the *state* member of events such as a *KeyPress* event and *ButtonPress* event, encoded as follows:

<table>
<thead>
<tr>
<th>bits</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>13-14</td>
<td>Group index</td>
</tr>
<tr>
<td>8-12</td>
<td>Pointer Buttons</td>
</tr>
<tr>
<td>0-7</td>
<td>Modifiers</td>
</tr>
</tbody>
</table>

For Xkb-unaware clients, only core protocol keyboard information may be reported. Because core protocol does not define the group index, the group index is mapped to modifier bits as specified by the *groups*[group index] field of the compatibility map (the bits set in the compatibility map are ORed into bits 0-7 of the state), and bits 13-14 are reported in the event as zero.

### 17.1.2 Core Keyboard Mapping to Xkb Keyboard Mapping Transformation

When a core protocol keyboard mapping request is received by the server, the server’s core keyboard map is updated, and then the Xkb map maintained by the server is updated. Because a client may have explicitly configured some of the Xkb keyboard mapping in the server, this automatic regeneration of the Xkb keyboard mapping from the core protocol keyboard mapping should not modify any components of the Xkb keyboard mapping that were explicitly set by a client. The client must set explicit override controls to prevent this from happening (see section 16.3). The core-to-Xkb mapping is done as follows:

1. Map the symbols from the keys in the core keyboard map to groups and symbols on keys in the Xkb keyboard map. The core keyboard mapping is of fixed width, so each key in the core mapping has the same number of symbols associated with it. The Xkb mapping allows a different number of symbols to be associated with each key; those symbols may be divided into a different number of groups (1-4) for each key. For each key, this process therefore involves partitioning the fixed number of symbols from the core mapping into a set of variable-length groups with a variable number of symbols in each group. For example, if the core protocol map is of width five, the partition for one key might result in one group with two symbols and another with three symbols. A different key might result in two groups with two symbols plus a third group with one symbol. The core protocol map requires at least two symbols in each of the first two groups.

1a. For each changed key, determine the number of groups represented in the new core keyboard map. This results in a tentative group count for each key in the Xkb map.

1b. For each changed key, determine the number of symbols in each of the groups found in step 1a. There is one explicit override control associated with each of the four possible groups for each Xkb key, *ExplicitKeyType1* through *ExplicitKeyType4*. If no explicit override control is set for a group, the number of symbols used for that group from the core map is two. If the explicit override control is set for a group on the key, the number of symbols used for that Xkb
group from the core map is the width of the Xkb group with one exception: because of the core protocol requirement for at least two symbols in each of groups one and two, the number of symbols used for groups one and two is the maximum of 2 or the width of the Xkb group.

1c. For each changed key, assign the symbols in the core map to the appropriate group on the key. If the total number of symbols required by the Xkb map for a particular key needs more symbols than the core protocol map contains, the additional symbols are taken to be `NoSymbol` keysyms appended to the end of the core set. If the core map contains more symbols than are needed by the Xkb map, trailing symbols in the core map are discarded. In the absence of an explicit override for group one or two, symbols are assigned in order by group; the first symbols in the core map are assigned to group one, in order, followed by group two, and so on. For example, if the core map contained eight symbols per key, and a particular Xkb map contained 2 symbols for G1 and G2 and three for G3, the symbols would be assigned as (G is group, L is shift level):

```
G1L1 G1L2 G2L1 G2L2 G3L1 G3L2 G3L3
```

If an explicit override control is set for group one or two, the symbols are taken from the core set in a somewhat different order. The first four symbols from the core set are assigned to G1L1, G1L2, G2L1, G2L2, respectively. If group one requires more symbols, they are taken next, and then any additional symbols needed by group two. Group three and four symbols are taken in complete sequence after group two. For example, a key with four groups and three symbols in each group would take symbols from the core set in the following order:

```
G1L1 G1L2 G2L1 G2L2 G1L3 G2L3 G3L1 G3L2 G3L3 G4L1 G4L2 G4L3
```

As previously noted, the core protocol map requires at least two symbols in groups one and two. Because of this, if an explicit override control for an Xkb key is set and group one and / or group two is of width one, it is not possible to generate the symbols taken from the core protocol set and assigned to position G1L2 and / or G2L2.

1d. For each group on each changed key, assign a key type appropriate for the symbols in the group.

1e. For each changed key, remove any empty or redundant groups.

At this point, the groups and their associated symbols have been assigned to the corresponding key definitions in the Xkb map.

2. Apply symbol interpretations to modify key operation. This phase is completely skipped if the `ExplicitInterpret` override control bit is set in the explicit controls mask for the Xkb key (see section 16.3).

2a. For each symbol on each changed key, attempt to match the symbol and modifiers from the Xkb map to a symbol interpretation describing how to generate the symbol.

2b. When a match is found in step 2a, apply the symbol interpretation to change the semantics associated with the symbol in the Xkb key map. If no match is found, apply a default interpretation.
Symbol interpretations result in key semantics being set. When a symbol interpretation is applied, the following components of server key event processing may be modified for the particular key involved:

- Virtual modifier map
- Auto repeat
- Key behavior (may be set to XkbKB_Lock)
- Key action (see section 16.1)

The `XkbSymInterpretRec` structure specifies a symbol interpretation:

```c
typedef struct {
    KeySym sym; /* keysym of interest or NULL */
    unsigned char flags; /* XkbSI_AutoRepeat, XkbSI_LockingKey */
    unsigned char match; /* specifies how mods is interpreted */
    unsigned char mods; /* modifier bits, correspond to eight real modifiers */
    unsigned char virtual_mod; /* 1 modifier to add to key virtual mod map */
    XkbAnyAction act; /* action to bind to symbol position on key */
} XkbSymInterpretRec,*XkbSymInterpretPtr;
```

If `sym` is not NULL, it limits the symbol interpretation to keys on which that particular keysym is selected by the modifiers matching the criteria specified by `mods` and `match`. If `sym` is NULL, the interpretation may be applied to any symbol selected on a key when the modifiers match the criteria specified by `mods` and `match`.

`match` must be one of the values shown in Table 17.1 and specifies how the real modifiers specified in `mods` are to be interpreted.

<table>
<thead>
<tr>
<th>Match Criteria</th>
<th>Value</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSI_NoneOf</td>
<td>(0)</td>
<td>None of the bits that are on in <code>mods</code> can be set, but other bits can be.</td>
</tr>
<tr>
<td>XkbSI_AnyOfOrNone</td>
<td>(1)</td>
<td>Zero or more of the bits that are on in <code>mods</code> can be set, as well as others.</td>
</tr>
<tr>
<td>XkbSI_AnyOf</td>
<td>(2)</td>
<td>One or more of the bits that are on in <code>mods</code> can be set, as well as any others.</td>
</tr>
<tr>
<td>XkbSI_AllOf</td>
<td>(3)</td>
<td>All of the bits that are on in <code>mods</code> must be set, but others may be set as well.</td>
</tr>
<tr>
<td>XkbSI_Exactly</td>
<td>(4)</td>
<td>All of the bits that are on in <code>mods</code> must be set, and no other bits may be set.</td>
</tr>
</tbody>
</table>

In addition to the above bits, `match` may contain the `XkbSI_LevelOneOnly` bit, in which case the modifier match criteria specified by `mods` and `match` applies only if `sym` is in level...
one of its group; otherwise, \textit{mods} and \textit{match} are ignored and the symbol matches a condition where no modifiers are set.

```c
#define XkbSI_LevelOneOnly (0x80) /* use mods + match only if sym is level 1 */
```

If no matching symbol interpretation is found, the server uses a default interpretation where:

- `sym = 0`
- `flags = XkbSI_AutoRepeat`
- `match = XkbSI_AnyOfOrNone`
- `mods = 0`
- `virtual_mod = XkbNoModifier`
- `act = SA_NoAction`

When a matching symbol interpretation is found in step 2a, the interpretation is applied to modify the Xkb map as follows.

The \textit{act} field specifies a single action to be bound to the symbol position; any key event that selects the symbol causes the action to be taken. Valid actions are defined in section 16.1.

If the Xkb keyboard map for the key does not have its \texttt{ExplicitVModMap} control set, the \texttt{XkbSI_LevelOneOnly} bit and symbol position are examined. If the \texttt{XkbSI_LevelOneOnly} bit is not set in \textit{match} or the symbol is in position G1L1, the \textit{virtual_mod} field is examined. If \textit{virtual_mod} is not \texttt{XkbNoModifier}, \textit{virtual_mod} specifies a single virtual modifier to be added to the virtual modifier map for the key. \textit{virtual_mod} is specified as an index in the range [0..15].

If the matching symbol is in position G1L1 of the key, two bits in the \textit{flags} field potentially specify additional behavior modifications:

```c
#define XkbSI_AutoRepeat (1<<0) /* key repeats if sym is in position G1L1 */
#define XkbSI_LockingKey (1<<1) /* set KB_Lock behavior if sym is in psn G1L1 */
```

If the Xkb keyboard map for the key does not have its \texttt{ExplicitAutoRepeat} control set, its auto repeat behavior is set based on the value of the \texttt{XkbSI_AutoRepeat} bit. If the \texttt{XkbSI_AutoRepeat} bit is set, the auto-repeat behavior of the key is turned on; otherwise, it is turned off.

If the Xkb keyboard map for the key does not have its \texttt{ExplicitBehavior} control set, its locking behavior is set based on the value of the \texttt{XkbSI_LockingKey} bit. If \texttt{XkbSI_LockingKey} is set, the key behavior is set to \texttt{KB_Lock}; otherwise, it is turned off (see section 16.3).

### 17.1.3 Xkb Keyboard Mapping to Core Keyboard Mapping Transformations

Whenever the server processes Xkb requests to change the keyboard mapping, it discards the affected portion of its core keyboard mapping and regenerates it based on the new Xkb mapping.

When the Xkb mapping for a key is transformed to a core protocol mapping, the symbols for the core map are taken in the following order from the Xkb map:

- G1L1 G1L2 G2L1 G2L2 G1L3-n G2L3-n G3L1-n G4L1-n
If group one is of width one in the Xkb map, G1L2 is taken to be NoSymbol; similarly, if group two is of width one in the Xkb map, G2L2 is taken to be NoSymbol.

If the Xkb key map for a particular key has fewer groups than the core keyboard, the symbols for group one are repeated to fill in the missing core components. For example, an Xkb key with a single width-three group would be mapped to a core mapping counting three groups as:

G1L1 G1L2 G1L1 G1L2 G1L3 G1L3 G1L1 G1L2 G1L3

When a core keyboard map entry is generated from an Xkb keyboard map entry, a modifier mapping is generated as well. The modifier mapping contains all of the modifiers affected by any of the actions associated with the key combined with all of the real modifiers associated with any of the virtual modifiers bound to the key. In addition, if any of the actions associated with the key affect any component of the keyboard group, all of the modifiers in the mask field of all of the group compatibility maps are added to the modifier mapping as well. While an XkbSA_ISOLock action can theoretically affect any modifier, if the Xkb mapping for a key specifies an XkbSA_ISOLock action, only the modifiers or group that are set by default are added to the modifier mapping.

17.2 Getting Compatibility Map Components From the Server

Use XkbGetCompatMap to fetch any combination of the current compatibility map components from the server. When another client modifies the compatibility map, you are notified if you have selected for XkbCompatMapNotify events (see section 17.5). XkbGetCompatMap is particularly useful when you receive an event of this type, as it allows you to update your program’s version of the compatibility map to match the modified version now in the server. If your program is dealing with multiple servers and needs to configure them all in a similar manner, the updated compatibility map may be used to reconfigure other servers.

Note To make a complete matching configuration you must also update the explicit override components of the server state.

Status XkbGetCompatMap(display, which, xkb)

Display * display; /* connection to server */
unsigned int which; /* mask of compatibility map components to fetch */
XkbDescRec * xkb; /* keyboard description where results placed */

XkbGetCompatMap fetches the components of the compatibility map specified in which from the server specified by display and places them in the compat structure of the keyboard description xkb. Valid values for which are an inclusive OR of the values shown in Table 17.2.

Table 17.2 Compatibility Map Component Masks

<table>
<thead>
<tr>
<th>Mask</th>
<th>Value</th>
<th>Affecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbSymInterpMask</td>
<td>(1&lt;&lt;0)</td>
<td>Symbol interpretations</td>
</tr>
<tr>
<td>XkbGroupCompatMask</td>
<td>(1&lt;&lt;1)</td>
<td>Group maps</td>
</tr>
<tr>
<td>XkbAllCompatMask</td>
<td>(0x3)</td>
<td>All compatibility map components</td>
</tr>
</tbody>
</table>

If no compatibility map structure is allocated in xkb upon entry, XkbGetCompatMap allocates one. If one already exists, its contents are overwritten with the returned results.
**XkbGetCompatMap** fetches compatibility map information for the device specified by the `device_spec` field of `xkb`. Unless you have specifically modified this field, it is the default keyboard device. **XkbGetCompatMap** returns `Success` if successful, `BadAlloc` if it is unable to obtain necessary storage for either the return values or work space, `BadMatch` if the `dpy` field of the `xkb` argument is non-NULL and does not match the `display` argument, and `BadLength` under certain conditions caused by server or Xkb implementation errors.

### 17.3 Using the Compatibility Map

Xkb provides several functions that make it easier to apply the compatibility map to configure a client-side Xkb keyboard mapping, given a core protocol representation of part or all of a keyboard mapping. Obtain a core protocol representation of a keyboard mapping from an actual server (by using `XGetKeyboardMapping`, for example), a data file, or some other source.

To update a local Xkb keyboard map to reflect the mapping expressed by a core format mapping by calling the function **XkbUpdateMapFromCore**.

```c
Bool XkbUpdateMapFromCore(xkb, first_key, num_keys, map_width, core_keysyms, changes)
    XkbDescPtr xkb; /* keyboard description to update */
    KeyCode first_key; /* keycode of first key description to update */
    int num_keys; /* number of key descriptions to update */
    int map_width; /* width of core protocol keymap */
    KeySym * core_keysyms; /* symbols in core protocol keymap */
    XkbChangesPtr changes; /* backfilled with changes made to Xkb */
```

**XkbUpdateMapFromCore** interprets input argument information representing a keyboard map in core format to update the Xkb keyboard description passed in `xkb`. Only a portion of the Xkb map is updated — the portion corresponding to keys with keycodes in the range `first_key` through `first_key + num_keys - 1`. If **XkbUpdateMapFromCore** is being called in response to a MappingNotify event, `first_key` and `num_keys` are reported in the MappingNotify event. `core_keysyms` contains the keysyms corresponding to the keycode range being updated, in core keyboard description order. `map_width` is the number of keysyms per key in `core_keysyms`. Thus, the first `map_width` entries in `core_keysyms` are for the key with keycode `first_key`, the next `map_width` entries are for key `first_key + 1`, and so on.

In addition to modifying the Xkb keyboard mapping in `xkb`, **XkbUpdateMapFromCore** backfills the changes structure whose address is passed in `changes` to indicate the modifications that were made. You may then use `changes` in subsequent calls such as **XkbSetMap**, to propagate the local modifications to a server.
When dealing with core keyboard mappings or descriptions, it is sometimes necessary to determine the Xkb key types appropriate for the symbols bound to a key in a core keyboard mapping. Use XkbKeyTypesForCoreSymbols for this purpose:

```c
int XkbKeyTypesForCoreSymbols(map_width, core_syms, protected, types_inout, xkb_syms_rtrn)
```

- `map_width`: /* keyboard description in which to place symbols*/
- `core_syms`: /* core protocol format array of KeySyms */
- `protected`: /* explicit key types */
- `types_inout`: /* backfilled with the canonical types bound to groups one and two for the key */
- `xkb_syms_rtrn`: /* backfilled with symbols bound to the key in the Xkb mapping */

XkbKeyTypesForCoreSymbols expands the symbols in core_syms and types in types_inout according to the rules specified in section 12 of the core protocol, then chooses canonical key types (canonical key types are defined in section 15.2.1) for groups 1 and 2 using the rules specified by the Xkb protocol and places them in xkb_syms_rtrn, which will be non-NULL.

A core keymap is a two-dimensional array of keysyms. It has `map_width` columns and `max_key_code` rows. XkbKeyTypesForCoreSymbols takes a single row from a core keymap, determines the number of groups associated with it, the type of each group, and the symbols bound to each group. The return value is the number of groups, types_inout has the types for each group, and xkb_syms_rtrn has the symbols in Xkb order (that is, groups are contiguous, regardless of size).

`protected` contains the explicitly protected key types. There is one explicit override control associated with each of the four possible groups for each Xkb key, ExplicitKeyType1 through ExplicitKeyType4; protected is an inclusive OR of these controls. `map_width` is the width of the core keymap and is not dependent on any Xkb definitions. types_inout is an array of four type indices. On input, types_inout contains the indices of any types already assigned to the key, in case they are explicitly protected from change.

Upon return, types_inout contains any automatically selected (that is, canonical) types plus any protected types. Canonical types are assigned to all four groups if there are enough symbols to do so. The four entries in types_inout correspond to the four groups for the key in question.

If the groups mapping does not change, but the symbols assigned to an Xkb keyboard compatibility map do change, the semantics of the key may be modified. To apply the new compatibility mapping to an individual key to get its semantics updated, use XkbApplyCompatMapToKey.

```c
Bool XkbApplyCompatMapToKey(xkb, key, changes)
```

- `xkb`: /* keyboard description to be updated */
- `key`: /* key to be updated */
- `changes`: /* notes changes to the Xkb keyboard description */

XkbApplyCompatMapToKey essentially performs the operation described in section 17.1.2 to a specific key. This updates the behavior, actions, repeat status, and virtual modifier bindings of the key.
17.4 Changing the Server’s Compatibility Map

To modify the server’s compatibility map, first modify a local copy of the Xkb compatibility map, then call \texttt{XkbSetCompatMap}. You may allocate a new compatibility map for this purpose using \texttt{XkbAllocCompatMap} (see section 17.6). You may also use a compatibility map from another server, although you need to adjust the \texttt{device\_spec} field in the \texttt{XkbDescRec} accordingly. Note that symbol interpretations in a compatibility map (\texttt{sym\_interpret}, the vector of \texttt{XkbSymInterpretRec} structures) are also allocated using this same function.

\begin{verbatim}
Bool XkbSetCompatMap(display, which, xkb, update_actions)
    Display * display; /* connection to server */
    unsigned int which; /* mask of compat map components to set */
    XkbDescPtr xkb; /* source for compat map components */
    Bool update_actions; /* True => apply to server's keyboard map */
\end{verbatim}

\texttt{XkbSetCompatMap} copies compatibility map information from the keyboard description in \texttt{xkb} to the server specified in \texttt{display}'s compatibility map for the device specified by the \texttt{device\_spec} field of \texttt{xkb}. Unless you have specifically modified this field, it is the default keyboard device. \texttt{which} specifies the compatibility map components to be set, and is an inclusive OR of the bits shown in Table 17.2.

After updating its compatibility map for the specified device, if \texttt{update\_actions} is \texttt{True}, the server applies the new compatibility map to its entire keyboard for the device to generate a new set of key semantics, compatibility state, and a new core keyboard map. If \texttt{update\_actions} is \texttt{False}, the new compatibility map is not used to generate any modifications to the current device semantics, state, or core keyboard map. One reason for not applying the compatibility map immediately would be if one server was being configured to match another on a piecemeal basis; the map should not be applied until everything is updated. To force an update at a later time, use \texttt{XkbSetCompatMap} specifying \texttt{which} as zero and \texttt{update\_actions} as \texttt{True}.

\texttt{XkbSetCompatMap} returns \texttt{True} if successful and \texttt{False} if unsuccessful. The server may report problems it encounters when processing the request subsequently via protocol errors.

To add a symbol interpretation to the list of symbol interpretations in an \texttt{XkbCompatRec}, use \texttt{XkbAddSymInterpret}.

\begin{verbatim}
XkbSymInterpretPtr XkbAddSymInterpret(xkb, si, updateMap, changes)
    XkbDescPtr xkb; /* keyboard description to be updated */
    XkbSymInterpretPtr si; /* symbol interpretation to be added */
    Bool updateMap; /* True => apply compatibility map to keys */
    XkbChangesPtr changes; /* changes are put here */
\end{verbatim}

\texttt{XkbAddSymInterpret} adds \texttt{si} to the list of symbol interpretations in \texttt{xkb}. If \texttt{updateMap} is \texttt{True}, it (re)applies the compatibility map to all of the keys on the keyboard. If \texttt{changes} is non-\texttt{NULL}, it reports the parts of the keyboard that were affected (unless \texttt{updateMap} is \texttt{True}, not much changes). \texttt{XkbAddSymInterpret} returns a pointer to the actual new symbol interpretation in the list or \texttt{NULL} if it failed.
The X Keyboard Extension 17   The Xkb Compatibility Map

17.5 Tracking Changes to the Compatibility Map

The server automatically generates MappingNotify events when the keyboard mapping changes. If you wish to be notified of changes to the compatibility map, you should select for XkbCompatMapNotify events. If you select for XkbMapNotify events, you no longer receive the automatically generated MappingNotify events. If you subsequently deselect XkbMapNotifyEvent delivery, you again receive MappingNotify events.

To receive XkbCompatMapNotify events under all possible conditions, use XkbSelect-Events (see section 4.3) and pass XkbCompatMapNotifyMask in both bits_to_change and values_for_bits.

To receive XkbCompatMapNotify events only under certain conditions, use XkbSelect-EventDetails using XkbCompatMapNotify as the event_type and specifying the desired map changes in bits_to_change and values_for_bits using mask bits from Table 17.2.

Note that you are notified of changes you make yourself, as well as changes made by other clients.

The structure for the XkbCompatMapNotifyEvent is:

    typedef struct {
        int type; /* Xkb extension base event code */
        unsigned long serial; /* X server serial number for event */
        Bool send_event; /* True => synthetically generated */
        Display * display; /* server connection where event generated */
        Time time; /* server time when event generated */
        int xkb_type; /* XkbCompatMapNotify */
        int device; /* Xkb device ID, will not be XkbUseCoreKbd */
        unsigned int changed_groups; /* number of group compatibility maps that have changed */
        int first_si; /* index to 1st changed symbol interpretation */
        int num_si; /* number of changed symbol interpretations */
        int num_total_si; /* total number of valid symbol interpretations */
    } XkbCompatMapNotifyEvent;

changed_groups is the number of group compatibility maps that have changed. If you are maintaining a corresponding copy of the compatibility map, or get a fresh copy from the server using XkbGetCompatMap, changed_groups references groups[0..changed_groups-1] in the XkbCompatMapRec structure.

first_si is the index of the first changed symbol interpretation, num_si is the number of changed symbol interpretations, and num_total_si is the total number of valid symbol interpretations. If you are maintaining a corresponding copy of the compatibility map, or get a fresh copy from the server using XkbGetCompatMap, first_si, num_si, and num_total_si are appropriate for use with the compat.sym_interpret vector in this structure.
### 17.6 Allocating and Freeing the Compatibility Map

If you are modifying the compatibility map, you need to allocate a new compatibility map if you do not already have one available. To do so, use `XkbAllocCompatMap`.

**Status** `XkbAllocCompatMap(xkb, which, num_si)`

- `XkbDescPtr xkb; /* keyboard description in which to allocate compat map */`
- `unsigned int which; /* mask of compatibility map components to allocate */`
- `unsigned int num_si; /* number of symbol interpretations to allocate */`

*xkb* specifies the keyboard description for which compatibility maps are to be allocated. The compatibility map is the `compat` field in this structure.

*which* specifies the compatibility map components to be allocated (see `XkbGetCompatMap`, in section 17.2). *which* is an inclusive OR of the bits shown in Table 17.2.

*num_si* specifies the total number of entries to allocate in the symbol interpretation vector (`xkb.compat.sym_interpret`).

Note that symbol interpretations in a compatibility map (the `sym_interpret` vector of `XkbSymInterpretRec` structures) are also allocated using this same function. To ensure that there is sufficient space in the symbol interpretation vector for entries to be added, use `XkbAllocCompatMap` specifying *which* as `XkbSymInterpretMask` and the number of free symbol interpretations needed in `num_si`.

`XkbAllocCompatMap` returns `Success` if successful, `BadMatch` if *xkb* is NULL, or `BadAlloc` if errors are encountered when attempting to allocate storage.

To free an entire compatibility map or selected portions of one, use `XkbFreeCompatMap`.

**void XkbFreeCompatMap(xkb, which, free_map)**

- `XkbDescPtr xkb; /* Xkb description in which to free compatibility map */`
- `unsigned int which; /* mask of compatibility map components to free */`
- `Bool free_map; /* True => free XkbCompatMap structure itself */`

*which* specifies the compatibility map components to be freed (see `XkbGetCompatMap`, in section 17.2). *which* is an inclusive OR of the bits shown in Table 17.2.

*free_map* indicates whether the `XkbCompatMap` structure itself should be freed. If *free_map* is True, *which* is ignored, all non-NULL compatibility map components are freed, and the `compat` field in the `XkbDescRec` referenced by *xkb* is set to NULL.
18 Symbolic Names

The core protocol does not provide any information to clients other than that actually used to interpret events. This makes it difficult to write an application that presents the keyboard to a user in an easy-to-understand way. Such applications have to examine the vendor string and keycodes to determine the type of keyboard connected to the server and then examine keysyms and modifier mappings to determine the effects of most modifiers (the Shift, Lock and Control modifiers are defined by the core protocol but no semantics are implied for any other modifiers).

To make it easier for applications to present a keyboard to the user, Xkb supports symbolic names for most components of the keyboard extension. Most of these symbolic names are grouped into the names component of the keyboard description.

18.1 The XkbNamesRec Structure

The names component of the keyboard description is defined as follows:

```c
#define XkbKeyNameLength 4
#define XkbKeyNumVirtualMods 16
#define XkbKeyNumIndicators 32
#define XkbKeyNumKbdGroups 4
#define XkbMaxRadioGroups 32
typedef struct {
    char name[XkbKeyNameLength]; /* symbolic key names */
} XkbKeyNameRec, *XkbKeyNamePtr;
typedef struct {
    char real[XkbKeyNameLength]; /* this key name must be in the keys array */
    char alias[XkbKeyNameLength]; /* symbolic key name as alias for the key */
} XkbKeyAliasRec, *XkbKeyAliasPtr;
typedef struct _XkbNamesRec {
    Atom keycodes; /* identifies range and meaning of keycodes */
    Atom geometry; /* identifies physical location, size, and shape of keys */
    Atom symbols; /* identifies the symbols logically bound to the keys */
    Atom types; /* identifies the set of key types */
    Atom compat; /* identifies actions for keys using core protocol */
    Atom vmods[XkbKeyNumVirtualMods]; /* symbolic names for virtual modifiers */
    Atom indicators[XkbKeyNumIndicators]; /* symbolic names for indicators */
    Atom groups[XkbKeyNumKbdGroups]; /* symbolic names for keyboard groups */
    XkbKeyNamePtr keys; /* symbolic key name array */
    XkbKeyAliasPtr key_aliases; /* real/alias symbolic name pairs array */
    Atom * radio_groups; /* radio group name array */
    Atom phys_symbols; /* identifies the symbols engraved on the keyboard */
    unsigned char num_keys; /* number of keys in the keys array */
    unsigned char num_key_aliases;/* number of keys in the key_aliases array */
    unsigned short num_rg; /* number of radio groups */
} XkbNamesRec, *XkbNamesPtr;
```

The `keycodes` name identifies the range and meaning of the keycodes returned by the keyboard in question. The `geometry` name, on the other hand, identifies the physical location,
size and shape of the various keys on the keyboard. As an example to distinguish between these two names, consider function keys on PC-compatible keyboards. Function keys are sometimes above the main keyboard and sometimes to the left of the main keyboard, but the same keycode is used for the key that is logically F1 regardless of physical position. Thus, all PC-compatible keyboards share a similar keycodes name but may have different geometry names.

**Note** The keycodes name is intended to be a very general description of the keycodes returned by a keyboard; a single keycodes name might cover keyboards with differing numbers of keys provided all keys have the same semantics when present. For example, 101 and 102 key PC keyboards might use the same name. In these cases, applications can use the keyboard geometry name to determine which subset of the named keycodes is in use.

The *symbols* name identifies the symbols logically bound to the keys. The symbols name is a human or application-readable description of the intended locale or usage of the keyboard with these symbols. The *phys_symbols* name, on the other hand, identifies the symbols actually engraved on the keyboard. Given this, the *symbols* name and *phys_symbols* names might be different. For example, the description for a keyboard that has English US engravings, but that is using Swiss German symbols might have a *phys_symbols* name of “en_US” and a *symbols* name of “de_CH.”

The *types* name provides some information about the set of key types (see section 15.2) that can be associated with the keyboard. In addition, each key type can have a name, and each shift level of a type can have a name. Although these names are stored in the map description with each of the types, they are accessed using the same methods as the other symbolic names.

The *compat* name provides some information about the rules used to bind actions to keys that are changed using core protocol requests.

Xkb provides symbolic names for each of the 4 keyboard groups, 16 virtual modifiers, 32 keyboard indicators, and 4 keyboard groups. These names are held in the *vmods*, *indicators*, and *groups* fixed-length arrays.

Each key has a four-byte symbolic name. All of the symbolic key names are held in the *keys* array, and *num_keys* reports the number of entries that are in the keys array. For each key, the key name links keys with similar functions or in similar positions on keyboards that report different keycodes. For example, the F1 key may emit keycode 23 on one keyboard and keycode 86 on another. By naming this key “FK01” on both keyboards, the keyboard layout designer can reuse parts of keyboard descriptions for different keyboards.

Key aliases allow the keyboard layout designer to assign multiple key names to a single key. This allows the keyboard layout designer to refer to keys using either their position or their “function.” For example, a keyboard layout designer may wish to refer to the left arrow key on a PC keyboard using the ISO9995-5 positional specification of A31 or using the functional specification of LEFT. The *key_aliases* field holds a variable-length array of real and alias key name pairs, and the total number of entries in the *key_aliases* array is held in *num_key_aliases*. For each real and alias key name pair, the *real* field refers to the a name in the keys array, and the *alias* field refers to the alias for that key. Using the previous example, the keyboard designer may use the name A31 in the keys array, but also define the name LEFT as an alias for A31 in the *key_aliases* array.
**Note** Key aliases defined in the geometry component of a keyboard mapping (see Chapter 13) override those defined in the keycodes component of the server database, which are stored in the `XkbNamesRec` (`xkb->names`). Therefore, consider the key aliases defined by the geometry before considering key aliases supplied by the `XkbNamesRec`.

A radio group is a set of keys whose behavior simulates a set of radio buttons. Once a key in a radio group is pressed, it stays logically depressed until another key in the group is pressed, at which point the previously depressed key is logically released. Consequently, at most one key in a radio group can be logically depressed at one time.

Each radio group in the keyboard description can have a name. These names are held in the variable-length array `radio_groups`, and `num_rg` tells how many elements are in the `radio_groups` array.

### 18.2 Symbolic Names Masks

`Xkb` provides several functions that work with symbolic names. Each of these functions uses a mask to specify individual fields of the structures described above. These masks and their relationships to the fields in a keyboard description are shown in Table 18.1.

<p>| <strong>Table 18.1 Symbolic Names Masks</strong> |</p>
<table>
<thead>
<tr>
<th><strong>Mask Bit</strong></th>
<th><strong>Value</strong></th>
<th><strong>Keyboard Component</strong></th>
<th><strong>Field</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>XkbKeycodesNameMask</code></td>
<td><code>(1&lt;&lt;0)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>keycodes</td>
</tr>
<tr>
<td><code>XkbGeometryNameMask</code></td>
<td><code>(1&lt;&lt;1)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>geometry</td>
</tr>
<tr>
<td><code>XkbSymbolsNameMask</code></td>
<td><code>(1&lt;&lt;2)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>symbols</td>
</tr>
<tr>
<td><code>XkbPhysSymbolsNameMask</code></td>
<td><code>(1&lt;&lt;3)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>phys_symbols</td>
</tr>
<tr>
<td><code>XkbTypesNameMask</code></td>
<td><code>(1&lt;&lt;4)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>type</td>
</tr>
<tr>
<td><code>XkbCompatNameMask</code></td>
<td><code>(1&lt;&lt;5)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>compat</td>
</tr>
<tr>
<td><code>XkbKeyTypeNamesMask</code></td>
<td><code>(1&lt;&lt;6)</code></td>
<td><code>Xkb-&gt;map.type[*].name</code></td>
<td></td>
</tr>
<tr>
<td><code>XkbKTLevelNamesMask</code></td>
<td><code>(1&lt;&lt;7)</code></td>
<td><code>Xkb-&gt;map.type[*].lvl_names[*]</code></td>
<td></td>
</tr>
<tr>
<td><code>XkbIndicatorNamesMask</code></td>
<td><code>(1&lt;&lt;8)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>indicators[*]</td>
</tr>
<tr>
<td><code>XkbKeyNamesMask</code></td>
<td><code>(1&lt;&lt;9)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>keys[*], num_keys</td>
</tr>
<tr>
<td><code>XkbKeyAliasesMask</code></td>
<td><code>(1&lt;&lt;10)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>key_aliases[*], num_key_aliases</td>
</tr>
<tr>
<td><code>XkbVirtualModNamesMask</code></td>
<td><code>(1&lt;&lt;11)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>vmods[*]</td>
</tr>
<tr>
<td><code>XkbGroupNamesMask</code></td>
<td><code>(1&lt;&lt;12)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>groups[*]</td>
</tr>
<tr>
<td><code>XkbRGNamesMask</code></td>
<td><code>(1&lt;&lt;13)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>radio_groups[*], num_rg</td>
</tr>
<tr>
<td><code>XkbComponentNamesMask</code></td>
<td><code>(0x3f)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>keycodes, geometry, symbols, physical symbols, types, and compatibility map</td>
</tr>
<tr>
<td><code>XkbAllNamesMask</code></td>
<td><code>(0x3fff)</code></td>
<td><code>Xkb-&gt;names</code></td>
<td>all name components</td>
</tr>
</tbody>
</table>
18.3 Getting Symbolic Names From the Server

To obtain symbolic names from the server, use XkbGetNames.

Status XkbGetNames (dpy, which, xkb)

Display * dpy; /* connection to the X server */
unsigned int which; /* mask of names or map components to be updated */
XkbDescPtr xkb; /* keyboard description to be updated */

XkbGetNames retrieves symbolic names for the components of the keyboard extension from the X server. The which parameter specifies the name components to be updated in the xkb parameter, and is the bitwise inclusive OR of the valid names mask bits defined in Table 18.1.

If the names field of the keyboard description xkb is NULL, XkbGetNames allocates and initializes the names component of the keyboard description before obtaining the values specified by which. If the names field of xkb is not NULL, XkbGetNames obtains the values specified by which and copies them into the keyboard description Xkb.

If the map component of the xkb parameter is NULL, XkbGetNames does not retrieve type or shift level names, even if XkbKeyTypeNamesMask or XkbKTLevelNamesMask are set in which.

XkbGetNames can return Success, or BadAlloc, BadLength, BadMatch, and BadImplementation errors.

To free symbolic names, use XkbFreeNames (see section 18.6)

18.4 Changing Symbolic Names on the Server

To change the symbolic names in the server, first modify a local copy of the keyboard description and then use either XkbSetNames, or, to save network traffic, use a XkbNameChangesRec structure and call XkbChangeNames to download the changes to the server. XkbSetNames and XkbChangeNames can generate BadAlloc, BadAtom, BadLength, BadMatch, and BadImplementation errors.

Bool XkbSetNames (dpy, which, first_type, num_types, xkb)

Display * dpy; /* connection to the X server */
unsigned int which; /* mask of names or map components to be changed */
unsigned int first_type; /* first type whose name is to be changed */
unsigned int num_types; /* number of types for which names are to be changed */
XkbDescPtr xkb; /* keyboard description from which names are to be taken */

Use XkbSetNames to change many names at the same time. For each bit set in which, XkbSetNames takes the corresponding value (or values in the case of arrays) from the keyboard description xkb and sends it to the server.

The first_type and num_types arguments are used only if XkbKeyTypeNamesMask or XkbKTLevelNamesMask is set in which and specify a subset of the types for which the corresponding names are to be changed. If either or both of these mask bits are set but the specified types are illegal, XkbSetNames returns False and does not update any of the names specified in which. The specified types are illegal if xkb does not include a map component or if first_type and num_types specify types that are not defined in the keyboard description.
The `XkbNameChangesRec` Structure

The `XkbNameChangesRec` allows applications to identify small modifications to the symbolic names and effectively reduces the amount of traffic sent to the server:

```c
typedef struct _XkbNameChanges {
    unsigned int changed; /* name components that have changed */
    unsigned char first_type; /* first key type with a new name */
    unsigned char num_types; /* number of types with new names */
    unsigned char first_lvl; /* first key type with new level names */
    unsigned char num_lvls; /* number of key types with new level names */
    unsigned char num_aliases; /* if key aliases changed, total number of key aliases */
    unsigned char num_rg; /* if radio groups changed, total number of radio groups */
    unsigned char first_key; /* first key with a new name */
    unsigned char num_keys; /* number of keys with new names */
    unsigned short changed_vmods; /* mask of virtual modifiers for which names have changed */
    unsigned long changed_indicators; /* mask of indicators for which names were changed */
    unsigned char changed_groups; /* mask of groups for which names were changed */
} XkbNameChangesRec, *XkbNameChangesPtr
```

The `changed` field specifies the name components that have changed and is the bitwise inclusive OR of the valid names mask bits defined in Table 18.1. The rest of the fields in the structure specify the ranges that have changed for the various kinds of symbolic names, as shown in Table 18.2.

### Table 18.2 XkbNameChanges Fields

<table>
<thead>
<tr>
<th>Mask</th>
<th>Fields</th>
<th>Component</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbKeyTypeNamesMask</td>
<td>first_type, num_types</td>
<td>Xkb-&gt;map type[*].name</td>
<td></td>
</tr>
<tr>
<td>XkbKTLevelNamesMask</td>
<td>first_lvl, num_lvls</td>
<td>Xkb-&gt;map type[<em>].lvl_names[</em>]</td>
<td></td>
</tr>
<tr>
<td>XkbKeyAliasesMask</td>
<td>num_aliases</td>
<td>Xkb-&gt;names key_aliases[*]</td>
<td></td>
</tr>
<tr>
<td>XkbRGNamesMask</td>
<td>num_rg</td>
<td>Xkb-&gt;names radio_groups[*]</td>
<td></td>
</tr>
<tr>
<td>XkbKeyNamesMask</td>
<td>first_key, num_keys</td>
<td>Xkb-&gt;names keys[*]</td>
<td></td>
</tr>
<tr>
<td>XkbVirtualModNamesMask</td>
<td>changed_vmods</td>
<td>Xkb-&gt;names vmods[*]</td>
<td></td>
</tr>
<tr>
<td>XkbIndicatorNamesMask</td>
<td>changed_indicators</td>
<td>Xkb-&gt;names indicators[*]</td>
<td></td>
</tr>
<tr>
<td>XkbGroupNamesMask</td>
<td>changed_groups</td>
<td>Xkb-&gt;names groups[*]</td>
<td></td>
</tr>
</tbody>
</table>

`XkbChangeNames` provides a more flexible method for changing symbolic names than `XkbSetNames` and requires the use of an `XkbNameChangesRec` structure.

```c
#include <X11/XKBlib.h>

Bool XkbChangeNames(dpy, xkb, changes)
    Display * dpy;    /* connection to the X server */
    XkbDescPtr xkb;   /* keyboard description from which names are to be taken */
    XkbNameChangesPtr changes; /* names map components to be updated on the server */

XkbChangeNames copies any names specified by `changes` from the keyboard description, `xkb`, to the X server specified by `dpy`. `XkbChangeNames` aborts and returns `False` if any illegal type names or type shift level names are specified by `changes`. 

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18.5 Tracking Name Changes

Whenever a symbolic name changes in the server’s keyboard description, the server sends a `XkbNamesNotify` event to all interested clients. To receive name notify events, use `XkbSelectEvents` (see section 4.3) with `XkbNamesNotifyMask` in both the `bits_to_change` and `values_for_bits` parameters.

To receive events for only specific names, use `XkbSelectEventDetails`. Set the `event_type` parameter to `XkbNamesNotify`, and set both the `bits_to_change` and `values_for_bits` detail parameter to a mask composed of a bitwise OR of masks in Table 18.1.

The structure for the `XkbNamesNotify` event is defined as follows:

```c
typedef struct {
    int type; /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated */
    Display * display; /* server connection where event generated */
    Time time; /* server time when event generated */
    int xkb_type; /* XkbNamesNotify */
    int device; /* Xkb device ID, will not be XkbUseCoreKbd */
    unsigned int changed; /* mask of name components that have changed */
    int first_type; /* first key type with a new name */
    int num_types; /* number of types with new names */
    int first_lvl; /* first key type with new level names */
    int num_lvls; /* number of key types with new level names */
    int num_aliases; /* if key aliases changed, total number of key aliases */
    int num_radio_groups; /* if radio groups changed, total number of radio groups */
    unsigned int changed_vmods; /* mask of virtual modifiers for which names have changed */
    unsigned int changed_groups; /* mask of groups for which names were changed */
    unsigned int changed_indicators; /* mask of indicators for which names were changed */
    int first_key; /* first key with a new name */
    int num_keys; /* number of keys with new names */
} XkbNamesNotifyEvent;
```

The `changed` field specifies the name components that have changed and is the bitwise inclusive OR of the valid names mask bits defined in Table 18.1. The other fields in this event are interpreted as the like-named fields in an `XkbNameChangesRec`, as previously defined.

When your application receives a `XkbNamesNotify` event, you can note the changed names in a changes structure using `XkbNoteNameChanges`.

```c
void XkbNoteNameChanges(old, new, wanted)
    XkbNameChangesPtr old; /* XkbNameChanges structure to be updated */
    XkbNamesNotifyEvent *new; /* event from which changes are to be copied */
    unsigned int wanted; /* types of names for which changes are to be noted */
```

The `wanted` parameter is the bitwise inclusive OR of the valid names mask bits shown in Table 18.1. `XkbNoteNameChanges` copies any changes that are reported in `new` and specified in `wanted` into the changes record specified by `old`.
To update the local copy of the keyboard description with the actual values, pass to `Xkb-GetNameChanges` the results of one or more calls to `XkbNoteNameChanges`.

**Status** `XkbGetNameChanges(dpy, xkb, changes)`
- `Display * dpy; /* connection to the X server */`
- `XkbDescPtr xkb; /* keyboard description to which names are copied */`
- `XkbNameChangesPtr changes; /* names components to be obtained from the server */`

`XkbGetNameChanges` examines the `changes` parameter, retrieves the necessary information from the server, and places the results into the `xkb` keyboard description.

`XkbGetNameChanges` can generate BadAlloc, BadImplementation, and BadMatch errors.

### 18.6 Allocating and Freeing Symbolic Names

Most applications do not need to directly allocate symbolic names structures. Do not allocate a names structure directly using `malloc` or `Xmalloc` if your application changes the number of key aliases or radio groups or constructs a symbolic names structure without loading the necessary components from the X server. Instead use `XkbAllocNames`.

**Status** `XkbAllocNames(xkb, which, num_rg, num_key_aliases)`
- `XkbDescPtr xkb; /* keyboard description for which names are to be allocated */`
- `unsigned int which; /* mask of names to be allocated */`
- `int num_rg; /* total number of radio group names needed */`
- `int num_key_aliases; /* total number of key aliases needed */`

`XkbAllocNames` can return BadAlloc, BadMatch, and BadValue errors. The `which` parameter is the bitwise inclusive OR of the valid names mask bits defined in Table 18.1.

Do not free symbolic names structures directly using `free` or `XFree`. Use `XkbFreeNames` instead.

**void XkbFreeNames(xkb, which, free_map)**
- `XkbDescPtr xkb; /* keyboard description for which names are to be freed */`
- `unsigned int which; /* mask of names components to be freed */`
- `Bool free_map; /* True => XkbNamesRec structure itself should be freed */`

The `which` parameter is the bitwise inclusive OR of the valid names mask bits defined in Table 18.1.
19 Replacing a Keyboard “On the Fly”

Some operating system and X server implementations allow “hot plugging” of input devices. When using these implementations, input devices can be unplugged and new ones plugged in without restarting the software that is using those devices. There is no provision in the standard X server for notification of client programs if input devices are unplugged and/or new ones plugged in. In the case of the X keyboard, this could result in the X server having a keymap that does not match the new keyboard.

If the X server implementation supports the X input device extension, a client program may also change the X keyboard programmatically. The XChangeKeyboardDevice input extension request allows a client to designate an input extension keyboard device as the X keyboard, in which case the old X keyboard device becomes inaccessible except via the input device extension. In this case, core protocol XMappingNotify and input extension XChangeDeviceNotify events are generated to notify all clients that a new keyboard with a new keymap has been designated.

When a client opens a connection to the X server, the server reports the minimum and maximum keycodes. The server keeps track of the minimum and maximum keycodes last reported to each client. When delivering events to a particular client, the server filters out any events that fall outside of the valid range for the client.

Xkb provides an XkbNewKeyboardNotify event that reports a change in keyboard geometry and/or the range of supported keycodes. The server can generate an XkbNewKeyboardNotify event when it detects a new keyboard or in response to an XkbGetKeyboardByName request that loads a new keyboard description. Selecting for XkbNewKeyboardNotify events allows Xkb-aware clients to be notified whenever a keyboard change occurs that may affect the keymap.

When a client requests XkbNewKeyboardNotify events, the server compares the range of keycodes for the current keyboard to the range of keycodes that are valid for the client. If they are not the same, the server immediately sends the client an XkbNewKeyboardNotify event. Even if the “new” keyboard is not new to the server, it is new to this particular client.

When the server sends an XkbNewKeyboardNotify event to a client to inform it of a new keycode range, it resets the stored range of legal keycodes for the client to the keycode range reported in the event; it does not reset this range for the client if it does not sent an XkbNewKeyboardNotify event to a client. Because Xkb-unaware clients and Xkb-aware clients that do not request XkbNewKeyboardNotify events are never sent these events, the server’s notion of the legal keycode range never changes, and these clients never receive events from keys that fall outside of their notion of the legal keycode range.

Clients that have not selected to receive XkbNewKeyboardNotify events do, however, receive the XkbNewKeyboardNotify event when a keyboard change occurs. Clients that have not selected to receive this event also receive numerous other events detailing the individual changes that occur when a keyboard change occurs.

Clients wishing to track changes in min_key_code and max_key_code must watch for both XkbNewKeyboardNotify and XkbMapNotify events, because a simple mapping change causes an XkbMapNotify event and may change the range of valid keycodes, but does not cause an XkbNewKeyboardNotify event. If a client does not select for
XkbNewKeyboardNotify events, the server restricts the range of keycodes reported to the client.

In addition to filtering out-of-range key events, Xkb:

- Adjusts core protocol MappingNotify events to refer only to keys that match the stored legal range.
- Reports keyboard mappings for keys that match the stored legal range to clients that issue a core protocol GetKeyboardMapping request.
- Reports modifier mappings only for keys that match the stored legal range to clients that issue a core protocol GetModifierMapping request.
- Restricts the core protocol ChangeKeyboardMapping and SetModifierMapping requests to keys that fall inside the stored legal range.

In short, Xkb does everything possible to hide from Xkb-unaware clients the fact that the range of legal keycodes has changed, because such clients cannot be expected to deal with them. Xkb events and requests are not modified in this manner; all Xkb events report the full range of legal keycodes. No requested Xkb events are discarded, and no Xkb requests have their keycode range clamped.

The structure for the XkbNewKeyboardNotify event is defined as follows:

```c
typedef struct _XkbNewKeyboardNotify {
    int type;           /* Xkb extension base event code */
    unsigned long serial;  /* X server serial number for event*/
    Bool send_event;    /* True => synthetically generated */
    Display * display;  /* server connection where event generated */
    Time time;          /* server time when event generated */
    int xkb_type;       /* XkbNewKeyboardNotify */
    int device;         /* device ID of new keyboard */
    int old_device;     /* device ID of old keyboard */
    int min_key_code;   /* min keycode of new keyboard */
    int max_key_code;   /* max keycode of new keyboard */
    int old_min_key_code; /* min keycode of old keyboard */
    int old_max_key_code; /* max keycode of old keyboard */
    unsigned int changed; /* changed aspects - see masks below */
    char req_major;     /* major request that caused change */
    char req_minor;     /* minor request that caused change */
} XkbNewKeyboardNotifyEvent;
```

To receive name notify events, use XkbSelectEvents (see section 4.3) with XkbNewKeyboardNotifyMask in both the bits_to_change and values_for_bits parameters. To receive events for only specific names, use XkbSelectEventDetails. Set the event_type parameter to XkbNewKeyboardNotify, and set both the bits_to_change and values_for_bits detail parameter to a mask composed of a bitwise OR of masks in Table 19.1.

<table>
<thead>
<tr>
<th>XkbNewKeyboardNotify Event Details</th>
<th>Value</th>
<th>Circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbNKN_KeycodesMask</td>
<td>(1L&lt;&lt;0)</td>
<td>Notification of keycode range changes wanted</td>
</tr>
<tr>
<td>XkbNKN_GeometryMask</td>
<td>(1L&lt;&lt;1)</td>
<td>Notification of geometry changes wanted</td>
</tr>
<tr>
<td>XkbNKN_DeviceIDMask</td>
<td>(1L&lt;&lt;2)</td>
<td>Notification of device ID changes wanted</td>
</tr>
</tbody>
</table>
The \textit{req\_major} and \textit{req\_minor} fields indicate what type of keyboard change has occurred. If \textit{req\_major} and \textit{req\_minor} are zero, the device change was not caused by a software request to the server — a spontaneous change has occurred, such as hot-plugging a new device. In this case, \textit{device} is the device identifier for the new, current X keyboard device, but no implementation-independent guarantee can be made about \textit{old\_device}. \textit{old\_device} may be identical to \textit{device} (an implementor is permitted to reuse the device specifier when the device changes); or it may be different. Note that \textit{req\_major} and \textit{req\_minor} being zero do not necessarily mean that the physical keyboard device has changed; rather, they only imply a spontaneous change outside of software control (some systems have keyboards that can change personality at the press of a key).

If the keyboard change is the result of an X Input Extension \texttt{ChangeKeyboardDevice} request, \textit{req\_major} contains the input extension major opcode, and \textit{req\_minor} contains the input extension request number for \texttt{X\_ChangeKeyboardDevice}. In this case, \textit{device} and \textit{old\_device} are different, with \textit{device} being the identifier for the new, current X keyboard device, and \textit{old\_device} being the identifier for the former device.

If the keyboard change is the result of an \texttt{XkbGetKeyboardByName} function call, which generates an \texttt{X\_kbGetKbdByName} request, \textit{req\_major} contains the Xkb extension base event code (see section 2.4), and \textit{req\_minor} contains the event code for the Xkb extension request \texttt{X\_kbGetKbdByName}. \textit{device} contains the device identifier for the new device, but nothing definitive can be said for \textit{old\_device}; it may be identical to \textit{device}, or it may be different, depending on the implementation.

\begin{table}
\centering
\begin{tabular}{|c|c|c|}
\hline
\textit{XkbNewKeyboardNotify} & \textit{Event Details} & \textit{Value} & \textit{Circumstances} \\
\hline
\textit{XkbNKN\_AllChangesMask} & \texttt{(0x7)} & & \text{Includes all of the above masks} \\
\hline
\end{tabular}
\end{table}
## 20 Server Database of Keyboard Components

The X server maintains a database of keyboard components, identified by component type. The database contains all the information necessary to build a complete keyboard description for a particular device, as well as to assemble partial descriptions. Table 20.1 identifies the component types and the type of information they contain.

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Component Primary Contents</th>
<th>May also contain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keymap</td>
<td>Complete keyboard description Normally assembled using a complete component from each of the other types</td>
<td>Aliases for some keys Symbolic names for indicators Description of indicators physically present</td>
</tr>
<tr>
<td>Keycodes</td>
<td>Symbolic name for each key Minimum and maximum legal keycodes</td>
<td></td>
</tr>
<tr>
<td>Types</td>
<td>Key types</td>
<td>Real modifier bindings and symbolic names for some virtual modifiers</td>
</tr>
<tr>
<td>Compatibility</td>
<td>Rules used to assign actions to keysyms</td>
<td>Maps for some indicators Real modifier bindings and symbolic names for some virtual modifiers</td>
</tr>
<tr>
<td>Symbols</td>
<td>Symbol mapping for keyboard keys Modifier mapping Symbolic names for groups</td>
<td>Explicit actions and behaviors for some keys Real modifier bindings and symbolic names for some virtual modifiers</td>
</tr>
<tr>
<td>Geometry</td>
<td>Layout of the keyboard</td>
<td>Aliases for some keys; overrides keycodes component aliases Symbolic names for some indicators Description of indicators physically present</td>
</tr>
</tbody>
</table>

While a keymap is a database entry for a complete keyboard description, and therefore logically different from the individual component database entries, the rules for processing keymap entries are identical to those for the individual components. In the discussion that follows, the term component is used to refer to either individual components or a keymap.

There may be multiple entries for each of the component types. An entry may be either complete or partial. Partial entries describe only a piece of the corresponding keyboard component and are designed to be combined with other entries of the same type to form a complete entry.

For example, a partial symbols map might describe the differences between a common ASCII keyboard and some national layout. Such a partial map is not useful on its own because it does not include those symbols that are the same on both the ASCII and national layouts (such as function keys). On the other hand, this partial map can be used to configure any ASCII keyboard to use a national layout.

When a keyboard description is built, the components are processed in the order in which they appear in Table 20.1; later definitions override earlier ones.
20.1 Component Names

Component names have the form “class(member)” where class describes a subset of the available components for a particular type and the optional member identifies a specific component from that subset. For example, the name “atlantis(acme)” for a symbols component might specify the symbols used for the atlantis national keyboard layout by the vendor “acme.” Each class has an optional default member — references that specify a class but not a member refer to the default member of the class, if one exists. Xkb places no constraints on the interpretation of the class and member names used in component names.

The class and member names are both specified using characters from the Latin-1 character set. Xkb implementations must accept all alphanumeric characters, minus (‘-’) and underscore (‘_’) in class or member names, and must not accept parentheses, plus, vertical bar, percent sign, asterisk, question mark, or white space. The use of other characters is implementation-dependent.

20.2 Listing the Known Keyboard Components

You may ask the server for a list of components for one or more component types. The request takes the form of a set of patterns, one pattern for each of the component types, including a pattern for the complete keyboard description. To obtain this list, use XkbListComponents.

XkbComponentListPtr XkbListComponents(dpy, device_spec, ptrns, max_inout)
    Display * dpy; /* connection to X server */
    unsigned int device_spec; /* device ID, or XkbUseCoreKbd */
    XkbComponentNamesPtr ptrns; /* namelist for components of interest */
    int * max_inout; /* max # returned names, # left over */

XkbListComponents queries the server for a list of component names matching the patterns specified in ptrns. It waits for a reply and returns the matching component names in an XkbComponentListRec structure. When you are done using the structure, you should free it using XkbFreeComponentList. device_spec indicates a particular device in which the caller is interested. A server is allowed (but not required) to restrict its reply to portions of the database that are relevant for that particular device.

ptrns is a pointer to an XkbComponentNamesRec, described below. Each of the fields in ptrns contains a pattern naming the components of interest. Each of the patterns is composed of characters from the ISO Latin1 encoding, but can contain only parentheses, the wildcard characters ‘?’ and ‘*’, and characters permitted in a component class or member name (see section 20.1). A pattern may be NULL, in which case no components for that type is returned. Pattern matches with component names are case sensitive. The ‘?’ wildcard matches any single character, except a left or right parenthesis; the ‘*’ wildcard matches any number of characters, except a left or right parenthesis. If an implementation allows additional characters in a component class or member name other than those required by the Xkb extension (see section 20.1), the result of comparing one of the additional characters to either of the wildcard characters is implementation-dependent.

If a pattern contains illegal characters, the illegal characters are ignored. The matching process is carried out as if the illegal characters were omitted from the pattern.

max_inout is used to throttle the amount of data passed to and from the server. On input, it specifies the maximum number of names to be returned (the total number of names in all
component categories). Upon return from _XkbListComponents, _max_inout contains the number of names that matched the request but were not returned because of the limit.

The component name patterns used to describe the request are passed to _XkbListComponents using an _XkbComponentNamesRec structure. This structure has no special allocation constraints or interrelationships with other structures; allocate and free this structure using standard _malloc and _free calls or their equivalent:

```c
typedef struct _XkbComponentNames {
    char * keymap; /* keymap names */
    char * keycodes; /* keycode names */
    char * types; /* type names */
    char * compat; /* compatibility map names */
    char * symbols; /* symbol names */
    char * geometry; /* geometry names */
} _XkbComponentNamesRec, *XkbComponentNamesPtr;
```

_XkbListComponents returns a pointer to an _XkbComponentListRec:

```c
typedef struct _XkbComponentList {
    int num_keymaps; /* number of entries in keymap */
    int num_keycodes; /* number of entries in keycodes */
    int num_types; /* number of entries in types */
    int num_compat; /* number of entries in compat */
    int num_symbols; /* number of entries in symbols */
    int num_geometry; /* number of entries in geometry;
    XkbComponentNamePtr keymap; /* keymap names */
    XkbComponentNamePtr keycodes; /* keycode names */
    XkbComponentNamePtr types; /* type names */
    XkbComponentNamePtr compat; /* compatibility map names */
    XkbComponentNamePtr symbols; /* symbol names */
    XkbComponentNamePtr geometry; /* geometry names */
} _XkbComponentListRec, *XkbComponentListPtr;
```

```c
typedef struct _XkbComponentName {
    unsigned short flags; /* hints regarding component name */
    char * name; /* name of component */
} _XkbComponentNameRec, *XkbComponentNamePtr;
```

Note that the structure used to specify patterns on input is an _XkbComponentNamesRec, and that used to hold the individual component names upon return is an _XkbComponentNameRec (no trailing ‘s’ in Name).

When you are done using the structure returned by _XkbListComponents, free it using _XkbFreeComponentList.

```c
void _XkbFreeComponentList(list) 
    XkbComponentListPtr list; /* pointer to XkbComponentListRec to free */
```

### 20.3 Component Hints

A set of flags is associated with each component; these flags provide additional hints about the component’s use. These hints are designated by bit masks in the flags field of the _XkbComponentNameRec structures contained in the _XkbComponentListRec
returned from `XkbListComponents`. The least significant byte of the flags field has the same meaning for all types of keyboard components; the interpretation of the most significant byte is dependent on the type of component. The flags bits are defined in Table 20.2. The symbols hints in Table 20.2 apply only to partial symbols components (those with `XkbLC_Partial` also set); full symbols components are assumed to specify all of the pieces.

The alphanumeric, modifier, keypad or function keys symbols hints should describe the primary intent of the component designer and should not be simply an exhaustive list of the kinds of keys that are affected. For example, national keyboard layouts affect primarily alphanumeric keys, but many affect a few modifier keys as well; such mappings should set only the `XkbLC_AlphanumericKeys` hint. In general, symbols components should set only one of the four flags (`XkbLC_AlternateGroup` may be combined with any of the other flags).

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Component Hints (flags)</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Components</td>
<td><code>XkbLC_Hidden</code></td>
<td>Do not present to user</td>
<td>(1L«0)</td>
</tr>
<tr>
<td></td>
<td><code>XkbLC_Default</code></td>
<td>Default member of class</td>
<td>(1L«1)</td>
</tr>
<tr>
<td></td>
<td><code>XkbLC_Partial</code></td>
<td>Partial component</td>
<td>(1L«2)</td>
</tr>
<tr>
<td>Keymap none</td>
<td><code>XkbLC_AlphanumericKeys</code></td>
<td>Bindings primarily for alphanumeric keyboard section</td>
<td>(1L«8)</td>
</tr>
<tr>
<td>Keycodes none</td>
<td><code>XkbLC_ModifierKeys</code></td>
<td>Bindings primarily for modifier keys</td>
<td>(1L«9)</td>
</tr>
<tr>
<td>Types none</td>
<td><code>XkbLC_KeypadKeys</code></td>
<td>Bindings primarily for numeric keypad keys</td>
<td>(1L«10)</td>
</tr>
<tr>
<td>Compatibility</td>
<td><code>XkbLC_FunctionKeys</code></td>
<td>Bindings primarily for function keys</td>
<td>(1L«11)</td>
</tr>
<tr>
<td>Symbols</td>
<td><code>XkbLC_AlternateGroup</code></td>
<td>Bindings for an alternate group</td>
<td>(1L«12)</td>
</tr>
<tr>
<td>Geometry none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 20.4 Building a Keyboard Description Using the Server Database

A client may request that the server fetch one or more components from its database and use those components to build a new server keyboard description. The new keyboard description may be built from scratch, or it may be built starting with the current keyboard description for a particular device. Once the keyboard description is built, all or part of it may be returned to the client. The parts returned to the client need not include all of the parts used to build the description. At the time it requests the server to build a new keyboard description, a client may also request that the server use the new description internally to replace the current keyboard description for a specific device, in which case the behavior of the device changes accordingly.
To build a new keyboard description from a set of named components, and to optionally have the server use the resulting description to replace an active one, use \texttt{XkbGetKeyboardByName}.

\texttt{XkbDescPtr XkbGetKeyboardByName} dpy, device_spec, names, want, need, load)

\begin{itemize}
\item \texttt{Display * dpy}; /* connection to X server */
\item \texttt{unsigned int device_spec}; /* device ID, or XkbUseCoreKbd */
\item \texttt{XkbComponentNamesPtr names}; /* names of components to fetch */
\item \texttt{unsigned int want}; /* desired structures in returned record */
\item \texttt{unsigned int need}; /* mandatory structures in returned record */
\item \texttt{Bool load}; /* True => load into device_spec */
\end{itemize}

\texttt{names} contains a set of expressions describing the keyboard components the server should use to build the new keyboard description. \texttt{want} and \texttt{need} are bit fields describing the parts of the resulting keyboard description that should be present in the returned \texttt{XkbDescRec}.

The individual fields in \texttt{names} are \textit{component expressions} composed of keyboard component names (no wildcards as may be used in \texttt{XkbListComponents}), the special component name symbol ‘%’, and the special operator characters ‘+’ and ‘|’. A component expression is parsed left to right, as follows:

\begin{itemize}
\item The special component name “\texttt{computed}” may be used in \texttt{keycodes} component expressions and refers to a component consisting of a set of keycodes computed automatically by the server as needed.
\item The special component name “\texttt{canonical}” may be used in \texttt{types} component expressions and refers to a partial component defining the four standard key types: ALPHABETIC, ONE_LEVEL, TWO_LEVEL, and KEYPAD.
\item The special component name ‘%’ refers to the keyboard description for the device specified in \texttt{device_spec} or the keymap names component. If a keymap names component is specified that does not begin with ‘+’ or ‘|’ and does not contain ‘%’, then ‘%’ refers to the description generated by the keymap names component. Otherwise, it refers to the keyboard description for \texttt{device_spec}.
\item The ‘+’ operator specifies that the following component should \textit{override} the currently assembled description; any definitions that are present in both components are taken from the second.
\item The ‘|’ operator specifies that the next specified component should \textit{augment} the currently assembled description; any definitions that are present in both components are taken from the first.
\item If the component expression begins with an operator, a leading ‘%’ is implied.
\item If any unknown or illegal characters appear anywhere in the expression, the entire expression is invalid and is ignored.
\end{itemize}

For example, if \texttt{names->symbols} contained the expression “+de”, it specifies that the default member of the “de” class of symbols should be applied to the current keyboard mapping, overriding any existing definitions (it could also be written “+de(default)”).

Here is a slightly more involved example: the expression “acme(ascii)+de(basic)|iso9995-3” constructs a German (de) mapping for the ASCII keyboard supplied by the “acme” vendor. The new definition begins with the symbols for the ASCII keyboard for Acme (\texttt{acme(ascii)}), overrides them with definitions for the basic German keyboard (\texttt{de(basic)}), and then applies the definitions from the default iso9995-3 keyboard (\texttt{iso9995-3}) to any undefined keys or groups of keys (part three of the iso9995 standard defines a common set of bindings for the secondary group, but allows national layouts to override those definitions where necessary).
Note  The interpretation of the above expression components (acme, ascii, de, basic, iso9995-3) is not defined by Xkb; only the operations and their ordering are.

Note that the presence of a keymap names component that does not contain ‘%’ (either explicit or implied by virtue of an expression starting with an operator) indicates a description that is independent of the keyboard description for the device specified in device_spec. The same is true of requests in which the keymap names component is empty and all five other names components contain expressions void of references to ‘%’.

Requests of this form allow you to deal with keyboard definitions independent of any actual device.

The server parses all non-NULL fields in names and uses them to build a keyboard description. However, before parsing the expressions in names, the server ORs the bits in want and need together and examines the result in relationship to the expressions in names. Table 20.3 identifies the components that are required for each of the possible bits in want or need. If a required component has not been specified in the names structure (the corresponding field is NULL), the server substitutes the expression “%”, resulting in the component values being taken from device_spec. In addition, if load is True, the server modifies names if necessary (again using a “%” entry) to ensure all of the following fields are non-NULL: types, keycodes, symbols, and compat.

Table 20.3 Want and Need Mask Bits and Required Names Components

<table>
<thead>
<tr>
<th>want or need mask bit</th>
<th>Required names Components</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbGBN_TypesMask</td>
<td>Types</td>
<td>(1L&lt;0)</td>
</tr>
<tr>
<td>XkbGBN_CompatMapMask</td>
<td>Compat</td>
<td>(1L&lt;1)</td>
</tr>
<tr>
<td>XkbGBN_ClientSymbolsMask</td>
<td>Types + Symbols + Keycodes</td>
<td>(1L&lt;2)</td>
</tr>
<tr>
<td>XkbGBN_ServerSymbolsMask</td>
<td>Types + Symbols + Keycodes</td>
<td>(1L&lt;3)</td>
</tr>
<tr>
<td>XkbGBN_SymbolsMask</td>
<td>Symbols</td>
<td>(1L&lt;1)</td>
</tr>
<tr>
<td>XkbGBN_IndicatorMapMask</td>
<td>Compat</td>
<td>(1L&lt;4)</td>
</tr>
<tr>
<td>XkbGBN_KeyNamesMask</td>
<td>Keycodes</td>
<td>(1L&lt;5)</td>
</tr>
<tr>
<td>XkbGBN_GeometryMask</td>
<td>Geometry</td>
<td>(1L&lt;6)</td>
</tr>
<tr>
<td>XkbGBN_OtherNamesMask</td>
<td>Types + Symbols + Keycodes + Comp + Geometry</td>
<td>(1L&lt;7)</td>
</tr>
<tr>
<td>XkbGBN_AllComponentsMask</td>
<td></td>
<td>(0xff)</td>
</tr>
</tbody>
</table>

need specifies a set of keyboard components that the server must be able to resolve in order for XkbGetKeyboardByName to succeed; if any of the components specified in need cannot be successfully resolved, XkbGetKeyboardByName fails.

want specifies a set of keyboard components that the server should attempt to resolve, but that are not mandatory. If the server is unable to resolve any of these components, XkbGetKeyboardByName still succeeds. Bits specified in want that are also specified in need have no effect in the context of want.

If load is True, the server updates its keyboard description for device_spec to match the result of the keyboard description just built. If load is False, the server’s description for device device_spec is not updated. In all cases, the parts specified by want and need from the just-built keyboard description are returned.

The names structure in an XkbDescRec keyboard description record (see Chapter 18) contains one field for each of the five component types used to build a keyboard descrip-
tion. When a keyboard description is built from a set of database components, the corresponding fields in this *names* structure are set to match the expressions used to build the component.

The entire process of building a new keyboard description from the server database of components and returning all or part of it is diagrammed in Figure 20.1:

**Figure 20.1 Building a New Keyboard Description from the Server Database**

The information returned to the client in the *XkbDescRec* is essentially the result of a series of calls to extract information from a fictitious device whose description matches
the one just built. The calls corresponding to each of the mask bits are summarized in Table 20.4, together with the XkbDescRec components that are filled in.

<table>
<thead>
<tr>
<th>Request (want+need)</th>
<th>Fills in Xkb components</th>
<th>Equivalent Function Call</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbGBN_TypesMask</td>
<td>map.types</td>
<td>XkbGetUpdatedMap(dpy, XkbTypesMask, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_ServerSymbolsMask</td>
<td>server</td>
<td>XkbGetUpdatedMap(dpy, XkbAllClientInfoMask, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_ClientSymbolsMask</td>
<td>map, including map.types</td>
<td>XkbGetUpdatedMap(dpy, XkbAllServerInfoMask, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_IndicatorMaps</td>
<td>indicators</td>
<td>XkbGetIndicatorMap(dpy, XkbAllIndicators, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_CompatMapMask</td>
<td>compat</td>
<td>XkbGetCompatMap(dpy, XkbAllCompatMask, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_GeometryMask</td>
<td>geom</td>
<td>XkbGetGeometry(dpy, Xkb)</td>
</tr>
<tr>
<td>XkbGBN_KeyNamesMask</td>
<td>names.keys</td>
<td>XkbGetNames(dpy, XkbKeyNamesMask</td>
</tr>
<tr>
<td></td>
<td>names.key_aliases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.types</td>
<td></td>
</tr>
<tr>
<td></td>
<td>map.types[<em>].lvl_names[</em>]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.compat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.vmodes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.indicators</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.radio_groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>names.phys_symbols</td>
<td></td>
</tr>
</tbody>
</table>

Table 20.4 XkbDescRec Components Returned for Values of Want & Needs

There is no way to determine which components specified in want (but not in need) were actually fetched, other than breaking the call into successive calls to XkbGetKeyboardByName and specifying individual components.

XkbGetKeyboardByName always sets min_key_code and max_key_code in the returned XkbDescRec structure.

XkbGetKeyboardByName is synchronous; it sends the request to the server to build a new keyboard description and waits for the reply. If successful, the return value is non-NULL. XkbGetKeyboardByName generates a BadMatch protocol error if errors are encountered when building the keyboard description.

If you simply want to obtain information about the current keyboard device, rather than generating a new keyboard description from elements in the server database, use XkbGetKeyboard (see section 6.2).

XkbDescPtr XkbGetKeyboard(dpy, which, device_spec)

This function is used to read the current description for one or more components of a keyboard device. It calls XkbGetKeyboardByName as follows:

XkbGetKeyboardByName(dpy, device_spec, NULL, which, which, False).
21 Attaching Xkb Actions to X Input Extension Devices

The X input extension allows an X server to support multiple keyboards, as well as other input devices, in addition to the core X keyboard and pointer. The input extension categorizes devices by grouping them into classes. Keyboards and other input devices with keys are classified as KeyClass devices by the input extension. Other types of devices supported by the input extension include, but are not limited to: mice, tablets, touchscreens, barcode readers, button boxes, trackballs, identifier devices, data gloves, and eye trackers. Xkb provides additional control over all X input extension devices, whether they are KeyClass devices or not, as well as the core keyboard and pointer.

If an X server implements support for both the input extension and Xkb, the server implementor determines whether interaction between Xkb and the input extension is allowed. Implementors are free to restrict the effects of Xkb to only the core X keyboard device or allow interaction between Xkb and the input extension.

Several types of interaction between Xkb and the input extension are defined by Xkb. Some or all may be allowed by the X server implementation.

Regardless of whether the server allows interaction between Xkb and the input extension, the following access is provided:

- Xkb functionality for the core X keyboard device and its mapping is accessed via the functions described in the other chapters of this specification.
- Xkb functionality for the core X pointer device is accessed via the XkbGetDeviceInfo and XkbSetDeviceInfo functions described in this chapter.

If all types of interaction are allowed between Xkb and the input extension, the following additional access is provided:

- If allowed, Xkb functionality for additional KeyClass devices supported by the input extension is accessed via those same functions.
- If allowed, Xkb functionality for non-KeyClass devices supported by the input extension is also accessed via the XkbGetDeviceInfo and XkbSetDeviceInfo functions described in this chapter.

Each device has an X Input Extension device ID. Each device may have several classes of feedback. For example, there are two types of feedbacks that can generate bells: bell feedback and keyboard feedback (BellFeedbackClass and KbdFeedbackClass). A device can have more than one feedback of each type; the feedback ID identifies the particular feedback within its class.

A keyboard feedback has:

- Auto-repeat status (global and per key)
- 32 LEDs
- A bell

An indicator feedback has:

- Up to 32 LEDs

If the input extension is present and the server allows interaction between the input extension and Xkb, then the core keyboard, the core keyboard indicators, and the core keyboard bells may each be addressed using an appropriate device spec, class, and ID. The constant XkbXIDFltID may be used as the device ID to specify the core keyboard indicators for the core indicator feedback. The particular device ID corresponding to the core keyboard
feedback and the core indicator feedback may be obtained by calling `XkbGetDeviceInfo` and specifying `XkbUseCoreKbd` as the `device_spec`; the values will be returned in `dflt_kbd_id` and `dflt_led_id`.

If the server does not allow Xkb access to input extension `KeyClass` devices, attempts to use Xkb requests with those devices fail with a `BadKeyboard` error. Attempts to access non-`KeyClass` input extension devices via `XkbGetDeviceInfo` and `XkbSetDeviceInfo` fail silently if Xkb access to those devices is not supported by the X server.

### 21.1 XkbDeviceInfoRec

Information about X Input Extension devices is transferred between a client program and the X server in an `XkbDeviceInfoRec` structure:

```c
typedef struct {
    char * name; /* name for device */
    Atom type; /* name for class of devices */
    unsigned short device_spec; /* device of interest */
    Bool has_own_state; /* True => this device has its own state */
    unsigned short supported; /* bits indicating supported capabilities */
    unsigned short unsupported; /* bits indicating unsupported capabilities */
    unsigned short num_btns; /* number of entries in btn_acts */
    XkbAction * btn_acts; /* button actions */
    unsigned short sz_leds; /* total number of entries in LEDs vector */
    unsigned short num_leds; /* number of valid entries in LEDs vector */
    unsigned short dflt_kbd_fb; /* input extension ID of default (core kbd) indicator */
    unsigned short dflt_led_fb; /* input extension ID of default indicator feedback */
    XkbDeviceLedInfoPtr leds; /* LED descriptions */
} XkbDeviceInfoRec, *XkbDeviceInfoPtr;
```

The `type` field is a registered symbolic name for a class of devices (for example, “TABLET”). If a device is a keyboard (that is, is a member of `KeyClass`), it has its own state, and `has_own_state` is `True`. If `has_own_state` is `False`, the state of the core keyboard is used. The `supported` and `unsupported` fields are masks where each bit indicates a capability. The meaning of the mask bits is listed in Table 21.1, together with the fields in the `XkbDeviceInfoRec` structure that are associated with the capability represented by each bit. The same bits are used to indicate the specific information desired in many of the functions described subsequently in this section.
21.2 Querying Xkb Features for Non-KeyClass Input Extension Devices

To determine whether the X server allows Xkb access to particular capabilities of input devices other than the core X keyboard, or to determine the status of indicator maps, indicator names or button actions on a non-KeyClass extension device, use XkbGetDeviceInfo.

XkbDeviceInfoPtr XkbGetDeviceInfo(dpy, which, device_spec, ind_class, ind_id)

Display * dpy;   /* connection to X server */
unsigned int which;   /* mask indicating information to return */
unsigned int device_spec;   /* device ID, or XkbUseCoreKbd */
unsigned int ind_class;   /* feedback class for indicator requests */
unsigned int ind_id;   /* feedback ID for indicator requests */

XkbGetDeviceInfo returns information about the input device specified by device_spec. Unlike the device_spec parameter of most Xkb functions, device_spec does not need to be

Table 21.1 XkbDeviceInfoRec Mask Bits

<table>
<thead>
<tr>
<th>Name</th>
<th>XkbDeviceInfoRec Fields Effected</th>
<th>Value</th>
<th>Capability If Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbXI_KeyboardMask</td>
<td>Fields Effected</td>
<td>1L &lt;&lt; 0</td>
<td>Clients can use all Xkb requests and events with KeyClass devices supported by the input device extension.</td>
</tr>
<tr>
<td>XkbXI_ButtonActionsMask</td>
<td>num_btns btn_acts</td>
<td>1L &lt;&lt; 1</td>
<td>Clients can assign key actions to buttons on non-KeyClass input extension devices.</td>
</tr>
<tr>
<td>XkbXI_IndicatorNamesMask</td>
<td>leds-&gt;names</td>
<td>1L &lt;&lt; 2</td>
<td>Clients can assign names to indicators on non-KeyClass input extension devices.</td>
</tr>
<tr>
<td>XkbXI_IndicatorMapsMask</td>
<td>leds-&gt;maps</td>
<td>1L &lt;&lt; 3</td>
<td>Clients can assign indicator maps to indicators on non-KeyClass input extension devices.</td>
</tr>
<tr>
<td>XkbXI_IndicatorStateMask</td>
<td>leds-&gt;state</td>
<td>1L &lt;&lt; 4</td>
<td>Clients can request the status of indicators on non-KeyClass input extension devices.</td>
</tr>
<tr>
<td>XkbXI_IndicatorsMask</td>
<td>sz_leds num_licks leds-&gt;*</td>
<td>0x1c</td>
<td>XkbXI_IndicatorNamesMask</td>
</tr>
<tr>
<td>XkbXI_UnsupportedFeaturesMask</td>
<td>unsupported</td>
<td>1L &lt;&lt; 15</td>
<td>XkbXI_IndicatorsMask</td>
</tr>
<tr>
<td>XkbXI_AllDeviceFeaturesMask</td>
<td>Those selected by Value column masks</td>
<td>0x1e</td>
<td>XkbXI_IndicatorsMask</td>
</tr>
<tr>
<td>XkbXI_AllFeaturesMask</td>
<td>Those selected by Value column masks</td>
<td>0x1f</td>
<td>XkbSI_AllFeaturesMask</td>
</tr>
<tr>
<td>XkbXI_AllDetailsMask</td>
<td>Those selected by Value column masks</td>
<td>0x801f</td>
<td>XkbXI_AllDetailsMask</td>
</tr>
</tbody>
</table>

The name, type, has_own_state, supported, and unsupported fields are always filled in when a valid reply is returned from the server involving an XkbDeviceInfoRec. All of the other fields are modified only if the particular function asks for them.
a keyboard device. It must, however, indicate either the core keyboard or a valid X Input Extension device.

The which parameter is a mask specifying optional information to be returned. It is an inclusive OR of one or more of the values from Table 21.1 and causes the returned XkbDeviceInfoRec to contain values for the corresponding fields specified in the table.

The XkbDeviceInfoRec returned by XkbGetDeviceInfo always has values for name (may be a null string, ""), type, supported, unsupported, has_own_state, dflt_kbd_fd, and dflt_kbd_fb. Other fields are filled in as specified by which.

Upon return, the supported field will be set to the inclusive OR of zero or more bits from Table 21.1; each bit set indicates an optional Xkb extension device feature supported by the server implementation, and a client may modify the associated behavior.

If the XkbButtonActionsMask bit is set in which, the XkbDeviceInfoRec returned will have the button actions (btn_acts field) filled in for all buttons.

If which includes one of the bits in XkbXI_IndicatorsMask, the feedback class of the indicators must be specified in ind_class, and the feedback ID of the indicators must be specified in ind_id. If the request does not include any of the bits in XkbXI_IndicatorsMask, the ind_class and ind_id parameters are ignored. The class and ID can be obtained via the input device extension XListInputDevices request.

If any of the XkbXI_IndicatorsMask bits are set in which, the XkbDeviceInfoRec returned will have filled in the portions of the leds structure corresponding to the indicator feedback identified by ind_class and ind_id. The leds vector of the XkbDeviceInfoRec is allocated if necessary and sz_leds and num_leds filled in. The led_class, led_id and phys_indicators fields of the leds entry corresponding to ind_class and ind_id are always filled in. If which contains XkbXI_IndicatorNamesMask, the names_present and names fields of the leds structure corresponding to ind_class and ind_id are returned. If which contains XkbXI_IndicatorStateMask, the corresponding state field is updated. If which contains XkbXI_IndicatorMapsMask, the maps_present and maps fields are updated.

Xkb provides convenience functions to request subsets of the information available via XkbGetDeviceInfo. These convenience functions mirror some of the mask bits. The functions all take an XkbDeviceInfoPtr as an input argument and operate on the X Input Extension device specified by the device_spec field of the structure. Only the parts of the structure indicated in the function description are updated. The XkbDeviceInfoRec structure used in the function call can be obtained by calling XkbGetDeviceInfo or can be allocated by calling XkbAllocDeviceInfo (see section 21.3).

These convenience functions are described as follows.

To query the button actions associated with an X Input Extension device, use XkbGetDeviceButtonActions.

Status XkbGetDeviceButtonActions(dpy, device_info, all_buttons, first_button, num_buttons)

Display * dpy; /* connection to X server */
XkbDeviceInfoPtr device_info; /* structure to update with results */
Bool all_buttons; /* True => get information for all buttons */
unsigned int first_button; /* number of first button for which info is desired */
unsigned int num_buttons; /* number of buttons for which info is desired */
The X Keyboard Extension

**XkbGetDeviceButtonActions** queries the server for the desired button information for the device indicated by the `device_spec` field of `device_info` and waits for a reply. If successful, `XkbGetDeviceButtonActions` backfills the button actions (`btnActs` field of `device_info`) for only the requested buttons, updates the `name`, `type`, `supported`, and `unsupported` fields, and returns `Success`.

`all_buttons`, `first_button` and `num_buttons` specify the device buttons for which actions should be returned. Setting `all_buttons` to `True` requests actions for all device buttons; if `all_buttons` is `False`, `first_button` and `num_buttons` specify a range of buttons for which actions are requested.

If a compatible version of Xkb is not available in the server or the Xkb extension has not been properly initialized, `XkbGetDeviceButtonActions` returns `BadAccess`. If allocation errors occur, a `BadAlloc` status is returned. If the specified device (`device_info->device_spec`) is invalid, a `BadKeyboard` status is returned. If the device has no buttons, a `BadMatch` status is returned. If `first_button` and `num_buttons` specify illegal buttons, a `BadValue` status is returned.

To query the indicator names, maps, and state associated with an LED feedback of an input extension device, use `XkbGetDeviceLedInfo`.

**Status XkbGetDeviceLedInfo**

```c
Display * dpy; /* connection to X server */
XkbDeviceInfoPtr device_info; /* structure to update with results */
unsigned int led_class; /* LED feedback class assigned by input extension */
unsigned int led_id; /* LED feedback ID assigned by input extension */
unsigned int which; /* mask indicating desired information */
```

`XkbGetDeviceLedInfo` queries the server for the desired LED information for the feedback specified by `led_class` and `led_id` for the X input extension device indicated by `device_info->device_spec` and waits for a reply. If successful, `XkbGetDeviceLedInfo` backfills the relevant fields of `device_info` as determined by `which` with the results and returns `Success`. Valid values for `which` are the inclusive OR of any of `XkbXI_IndicatorNamesMask`, `XkbXI_IndicatorMapsMask`, and `XkbXI_IndicatorStateMask`.

The fields of `device_info` that are filled in when this request succeeds are `name`, `type`, `supported`, and `unsupported`, and portions of the `leds` structure corresponding to `led_class` and `led_id` as indicated by the bits set in `which`. The `device_info->leds` vector is allocated if necessary and `sz_leds` and `num_leds` filled in. The `led_class`, `led_id` and `phys_indicators` fields of the `device_info->leds` entry corresponding to `led_class` and `led_id` are always filled in.

If `which` contains `XkbXI_IndicatorNamesMask`, the `names_present` and `names` fields of the `device_info->leds` structure corresponding to `led_class` and `led_id` are updated, if `which` contains `XkbXI_IndicatorStateMask`, the corresponding `state` field is updated, and if `which` contains `XkbXI_IndicatorMapsMask`, the `maps_present` and `maps` fields are updated.

If a compatible version of Xkb is not available in the server or the Xkb extension has not been properly initialized, `XkbGetDeviceLedInfo` returns `BadAccess`. If allocation errors occur, a `BadAlloc` status is returned. If the device has no indicators, a `BadMatch` error is returned. If `ledClass` or `ledID` have illegal values, a `BadValue` error is returned. If they...
have legal values but do not specify a feedback that contains LEDs and is associated with the specified device, a BadMatch error is returned.

### 21.3 Allocating, Initializing, and Freeing the XkbDeviceInfoRec Structure

To obtain an XkbDeviceInfoRec structure, use XkbGetDeviceInfo or XkbAllocDeviceInfo.

```
XkbDeviceInfoPtr XkbAllocDeviceInfo(device_spec, n_buttons, sz_leds)
    unsigned int device_spec; /* device ID with which structure will be used */
    unsigned int n_buttons; /* number of button actions to allocate space for */
    unsigned int sz_leds; /* number of LED feedbacks to allocate space for */
```

XkbAllocDeviceInfo allocates space for an XkbDeviceInfoRec structure and initializes that structure’s device_spec field with the device ID specified by device_spec. If n_buttons is nonzero, n_buttons XkbActions are linked into the XkbDeviceInfoRec structure and initialized to zero. If sz_leds is nonzero, sz_leds XkbDeviceLedInfoRec structures are also allocated and linked into the XkbDeviceInfoRec structure. If you request XkbDeviceLedInfoRec structures be allocated using this request, you must initialize them explicitly.

To obtain an XkbDeviceLedInfoRec structure, use XkbAllocDeviceLedInfo.

```
Status XkbAllocDeviceLedInfo(devi, num_needed)
    XkbDeviceInfoPtr device_info; /* structure in which to allocate LED space */
    int num_needed; /* number of indicators to allocate space for */
```

XkbAllocDeviceLedInfo allocates space for an XkbDeviceLedInfoRec and places it in device_info. If num_needed is nonzero, num_needed XkbIndicatorMapRec structures are also allocated and linked into the XkbDeviceLedInfoRec structure. If you request XkbIndicatorMapRec structures be allocated using this request, you must initialize them explicitly. All other fields are initialized to zero.

To initialize an XkbDeviceLedInfoRec structure, use XkbAddDeviceLedInfo.

```
XkbDeviceLedInfoPtr XkbAddDeviceLedInfo(device_info, led_class, led_id)
    XkbDeviceInfoPtr device_info; /* structure in which to add LED info */
    unsigned int led_class; /* input extension class for LED device of interest */
    unsigned int led_id; /* input extension ID for LED device of interest */
```

XkbAddDeviceLedInfo first checks to see whether an entry matching led_class and led_id already exists in the device_info->leds array. If it finds a matching entry, it returns a pointer to that entry. Otherwise, it checks to be sure there is at least one empty entry in device_info->leds and extends it if there is not enough room. It then increments device_info->num_leds and fills in the next available entry in device_info->leds with led_class and led_id.

If successful, XkbAddDeviceLedInfo returns a pointer to the XkbDeviceLedInfoRec structure that was initialized. If unable to allocate sufficient storage, or if device_info points to an invalid XkbDeviceInfoRec structure, or if led_class or led_id are inappropriate, XkbAddDeviceLedInfo returns NULL.
To allocate additional space for button actions in an XkbDeviceInfoRec structure, use XkbResizeDeviceButtonActions.

Status XkbResizeDeviceButtonActions(device_info, new_total)

    XkbDeviceInfoPtr device_info; /* structure in which to allocate button actions */
    unsigned int new_total; /* new total number of button actions needed */

XkbResizeDeviceButton reallocates space, if necessary, to make sure there is room for a total of new_total button actions in the device_info structure. Any new entries allocated are zeroed. If successful, XkbResizeDeviceButton returns Success. If new_total is zero, all button actions are deleted, device_info->num_btns is set to zero, and device_info->btn_acts is set to NULL. If device_info is invalid or new_total is greater than 255, BadValue is returned. If a memory allocation failure occurs, a BadAlloc is returned.

To free an XkbDeviceInfoRec structure, use XkbFreeDeviceInfo.

void XkbFreeDeviceInfo(device_info, which, free_all)

    XkbDeviceInfoPtr device_info; /* pointer to XkbDeviceInfoRec in which to free items */
    unsigned int which; /* mask of components of device_info to free */
    Bool free_all; /* True => free everything, including device_info */

If free_all is True, the XkbFreeDeviceInfo frees all components of device_info and the XkbDeviceInfoRec structure pointed to by device_info itself. If free_all is False, the value of which determines which subcomponents are freed. which is an inclusive OR of one or more of the values from Table 21.1. If which contains

XkbXI_ButtonActionsMask, all button actions associated with device_info are freed, device_info->btn_acts is set to NULL, and device_info->num_btns is set to zero. If which contains all bits in XkbXI_IndicatorsMask, all XkbDeviceLedInfoRec structures associated with device_info are freed, device_info->leds is set to NULL, and device_info->sz_leds and device_info->num_leds are set to zero. If which contains XkbXI_IndicatorMapsMask, all indicator maps associated with device_info are cleared, but the number of LEDs and the leds structures themselves are preserved. If which contains XkbXI_IndicatorNamesMask, all indicator names associated with device_info are cleared, but the number of LEDs and the leds structures themselves are preserved. If which contains XkbXI_IndicatorStateMask, the indicator state associated with the device_info leds are set to zeros but the number of LEDs and the leds structures themselves are preserved.

21.4 Setting Xkb Features for Non-KeyClass Input Extension Devices

The Xkb extension allows clients to assign any key action to either core pointer or input extension device buttons. This makes it possible to control the keyboard or generate keyboard key events from extension devices or from the core pointer.

Key actions assigned to core X pointer buttons or input extension device buttons cause key events to be generated as if they had originated from the core X keyboard.

Xkb implementations are required to support key actions for the buttons of the core pointer device, but support for actions on extension devices is optional. Implementations that do not support button actions for extension devices must not set the XkbXI_ButtonActionsMask bit in the supported field of an XkbDeviceInfoRec structure.
If a client attempts to modify valid characteristics of a device using an implementation that does not support modification of those characteristics, no protocol error is generated. Instead, the server reports a failure for the request; it also sends an XkbExtensionDeviceNotify event to the client that issued the request if the client has selected to receive these events.

To change characteristics of an X Input Extension device in the server, first modify a local copy of the device structure and then use either XkbSetDeviceInfo, or, to save network traffic, use an XkbDeviceChangesRec structure (see section 21.6) and call XkbChangeDeviceInfo to download the changes to the server.

To modify some or all of the characteristics of an X Input Extension device, use XkbSetDeviceInfo.

```
Bool XkbSetDeviceInfo(dpy, which, device_info)
    Display * dpy; /* connection to X server */
    unsigned int which; /* mask indicating characteristics to modify */
    XkbDeviceInfoPtr device_info; /* structure defining the device and modifications */
```

XkbSetDeviceInfo sends a request to the server to modify the characteristics of the device specified in the device_info structure. The particular characteristics modified are identified by the bits set in which and take their values from the relevant fields in device_info (see Table 21.1). XkbSetDeviceInfo returns True if the request was successfully sent to the server. If the X server implementation does not allow interaction between the X input extension and the Xkb Extension, the function does nothing and returns False.

The which parameter specifies which aspects of the device should be changed and is a bitmask composed of an inclusive OR or one or more of the following bits: XkbXI_ButtonActionsMask, XkbXI_IndicatorNamesMask, XkbXI_IndicatorMapsMask. If the features requested to be manipulated in which are valid for the device, but the server does not support assignment of one or more of them, that particular portion of the request is ignored.

If the device specified in device_info->device_spec does not contain buttons and a request affecting buttons is made, or the device does not contain indicators and a request affecting indicators is made, a BadMatch protocol error results.

If the XkbXI_ButtonActionsMask bit is set in the supported mask returned by XkbGetDeviceInfo, the Xkb extension allows applications to assign key actions to buttons on input extension devices other than the core keyboard device. If the XkbXI_ButtonActionsMask is set in which, the actions for all buttons specified in device_info are set to the XkbActions specified in device_info->btn_acts. If the number of buttons requested to be updated is not valid for the device, XkbSetDeviceInfo returns False and a BadValue protocol error results.

If the XkbXI_IndicatorMaps and / or XkbXI_IndicatorNamesMask bit is set in the supported mask returned by XkbGetDeviceInfo, the Xkb extension allows applications to assign maps and / or names to the indicators of nonkeyboard extension devices. If supported, maps and / or names can be assigned to all extension device indicators, whether they are part of a keyboard feedback or part of an indicator feedback.

If the XkbXI_IndicatorMapsMask and / or XkbXI_IndicatorNamesMask flag is set in which, the indicator maps and / or names for all device_info->num_leds indicator devices specified in device_info->leds are set to the maps and / or names specified in
**device_info->leds. device_info->leds->led_class** and **led_id** specify the input extension class and device ID for each indicator device to modify; if they have invalid values, a **BadValue** protocol error results and **XkbSetDeviceInfo** returns **False**. If they have legal values but do not specify a keyboard or indicator class feedback for the device in question, a **BadMatch** error results. If any of the values in **device_info->leds->names** are not a valid **Atom** or **None**, a **BadAtom** protocol error results.

**Xkb** provides convenience functions to modify subsets of the information accessible via **XkbSetDeviceInfo**. Only the parts of the structure indicated in the function description are modified. These convenience functions are described as follows.

To change only the button actions for an input extension device, use **XkbSetDeviceButtonActions**.

```c
Bool XkbSetDeviceButtonActions(Display *dpy, device_info, first_button, num_buttons, actions)
```

**XkbSetDeviceButtonActions** assigns actions to the buttons of the device specified in **device_info->device_spec**. Actions are assigned to **num_buttons** buttons beginning with **first_button** and are taken from the actions specified in **device_info->btn_acts**.

If the server does not support assignment of Xkb actions to extension device buttons, **XkbSetDeviceButtonActions** has no effect and returns **False**. If the device has no buttons or if **first_button** or **num_buttons** specify buttons outside of the valid range as determined by **device_info->num_btns**, the function has no effect and returns **False**. Otherwise, **XkbSetDeviceButtonActions** sends a request to the server to change the actions for the specified buttons and returns **True**.

If the actual request sent to the server involved illegal button numbers, a **BadValue** protocol error is generated. If an invalid device identifier is specified in **device_info->device_spec**, a **BadKeyboard** protocol error results. If the actual device specified in **device_info->device_spec** does not contain buttons and a request affecting buttons is made, a **BadMatch** protocol error is generated.

### 21.5 XkbExtensionDeviceNotify Event

The Xkb extension generates **XkbExtensionDeviceNotify** events when the status of an input extension device changes or when an attempt is made to use an Xkb feature that is not supported by a particular device.

**Note** Events indicating an attempt to use an unsupported feature are delivered only to the client requesting the event.

To track changes to the status of input extension devices or attempts to use unsupported features of a device, select to receive **XkbExtensionDeviceNotify** events by calling either **XkbSelectEvents** or **XkbSelectEventDetails** (see section 4.3).

To receive **XkbExtensionDeviceNotify** events under all possible conditions, call **XkbSelectEvents** and pass **XkbExtensionDeviceNotifyMask** in both **bits_to_change** and **values_for_bits**.
The XkbExtensionDeviceNotify event has no event details. However, you can call XkbSelectEventDetails using XkbExtensionDeviceNotify as the event_type and specifying XkbAllExtensionDeviceMask in bits_to_change and values_for_bits. This has the same effect as a call to XkbSelectEvents.

The structure for XkbExtensionDeviceNotify events is:

```c
typedef struct {
    int type; /* Xkb extension base event code */
    unsigned long serial; /* X server serial number for event */
    Bool send_event; /* True => synthetically generated*/
    Display * display; /* server connection where event generated */
    Time time; /* server time when event generated */
    int xkb_type; /* XkbExtensionDeviceNotifyEvent */
    int device; /* Xkb device ID, will not be XkbUseCoreKbd */
    unsigned int reason; /* reason for the event */
    unsigned int supported; /* mask of supported features */
    unsigned int unsupported; /* unsupported features this client attempted to use */
    int first_btn; /* first button that changed */
    int num_btns; /* number of buttons that changed */
    unsigned int leds_defined; /* indicators with names or maps */
    unsigned int led_state; /* current state of the indicators */
    int led_class; /* feedback class for LED changes */
    int led_id; /* feedback ID for LED changes */
} XkbExtensionDeviceNotifyEvent;
```

The XkbExtensionDeviceNotify event has fields enabling it to report changes in the state (on/off) of all of the buttons for a device, but only for one LED feedback associated with a device. You will get multiple events when more than one LED feedback changes state or configuration.

### 21.6 Tracking Changes to Extension Devices

Changes to an Xkb extension device may be tracked by listening to XkbDeviceExtensionNotify events and accumulating the changes in an XkbDeviceChangesRec structure. The changes noted in the structure may then be used in subsequent operations to update either a server configuration or a local copy of an Xkb extension device configuration. The changes structure is defined as follows:

```c
typedef struct _XkbDeviceChanges {
    unsigned int changed; /* bits indicating what has changed */
    unsigned short first_btn; /* number of first button which changed, if any */
    unsigned short num_btns; /* number of buttons that have changed */
    XkbDeviceLedChangesRec leds;
} XkbDeviceChangesRec,*XkbDeviceChangesPtr;

typedef _XkbDeviceLedChangesRec {
    unsigned short led_class; /* class of this indicator feedback bundle */
    unsigned short led_id; /* ID of this indicator feedback bundle */
    unsigned int names; /* bits indicating which names have changed */
    unsigned int maps; /* bits indicating which maps have changed */
    struct _XkbDeviceLedChangesRec *next; /* link to indicator change record for next set */
} XkbDeviceLedChangesRec,*XkbDeviceLedChangesPtr;
```
A local description of the configuration and state of a device may be kept in an `XkbDeviceInfoRec` structure. The actual state or configuration of the device may change because of `XkbSetDeviceInfo` and `XkbSetButtonActions` requests made by clients or by user interaction with the device. The X server sends an `XkbExtensionDeviceNotify` event to all interested clients when the state of any buttons or indicators or the configuration of the buttons or indicators on the core keyboard or any input extension device changes. The event reports the state of indicators for a single indicator feedback, and the state of up to 128 buttons. If more than 128 buttons or more than one indicator feedback are changed, the additional buttons and indicator feedbacks are reported in subsequent events. Xkb provides functions with which you can track changes to input extension devices by noting the changes that were made and then requesting the changed information from the server.

To note device changes reported in an `XkbExtensionDeviceNotify` event, use `XkbNoteDeviceChanges`.

```c
void XkbNoteDeviceChanges (old, new, wanted)
    XkbDeviceChangesPtr old; /* structure tracking state changes */
    XkbExtensionDeviceNotifyEvent * new; /* event indicating state changes */
    unsigned int wanted; /* mask indicating changes to note */
```

The `wanted` field specifies the changes that should be noted in `old`, and is composed of the bitwise inclusive OR of one or more of the masks from Table 21.1. The `reason` field of the event in `new` indicates the types of changes the event is reporting. `XkbNoteDeviceChanges` updates the `XkbDeviceChangesRec` specified by `old` with the changes that are both specified in `wanted` and contained in `new->reason`.

To update a local copy of the state and configuration of an X input extension device with the changes previously noted in an `XkbDeviceChangesRec` structure, use `XkbGetDeviceInfoChanges`.

To query the changes that have occurred in the button actions or indicator names and indicator maps associated with an input extension device, use `XkbGetDeviceInfoChanges`.

```c
Status XkbGetDeviceInfoChanges(dpy, device_info, changes)
    Display * dpy; /* connection to X server */
    XkbDeviceInfoPtr device_info; /* structure to update with results */
    XkbDeviceChangesPtr changes; /* contains notes of changes that have occurred */
```

The `changes->changed` field indicates which attributes of the device specified in `changes->device` have changed. The parameters describing the changes are contained in the other fields of `changes`. `XkbGetDeviceInfoChanges` uses that information to call `XkbGetDeviceInfo` to obtain the current status of those attributes that have changed. It then updates the local description of the device in `device_info` with the new information.

To update the server’s description of a device with the changes noted in an `XkbDeviceChangesRec`, use `XkbChangeDeviceInfo`.

```c
Bool XkbChangeDeviceInfo (dpy, device_info, changes)
    Display * dpy; /* connection to X server */
    XkbDeviceInfoPtr device_info; /* local copy of device state and configuration */
    XkbDeviceChangesPtr changes; /* note specifying changes in device_info */
```
`XkbChangeDeviceInfo` updates the server’s description of the device specified in `device_info->device_spec` with the changes specified in `changes` and contained in `device_info`. The update is made by an `XkbSetDeviceInfo` request.
22 Debugging Aids

The debugging aids are intended for use primarily by Xkb implementors and are optional in any implementation.

There are two bitmasks that may be used to control debugging. One bitmask controls the output of debugging information, and the other controls behavior. Both bitmasks are initially all zeros.

To change the values of any of the debug controls, use XkbSetDebuggingFlags.

Bool XkbSetDebuggingFlags(display, mask, flags, msg, ctrls_mask, ctrls, ret_flags, ret_ctrls)

Display * display; /* connection to X server */
unsigned int mask; /* mask selecting debug output flags to change */
unsigned int flags; /* values for debug output flags selected by mask */
char * msg; /* message to print right now */
unsigned int ctrls_mask; /* mask selecting debug controls to change */
unsigned int ctrls; /* values for debug controls selected by ctrls_mask */
unsigned int * ret_flags; /* resulting state of all debug output flags */
unsigned int * ret_ctrls; /* resulting state of all debug controls */

XkbSetDebuggingFlags modifies the debug output flags as specified by mask and flags, modifies the debug controls flags as specified by ctrls_mask and ctrls, prints the message msg, and backfills ret_flags and ret_ctrls with the resulting debug output and debug controls flags.

When bits are set in the debug output masks, mask and flags, Xkb prints debug information corresponding to each bit at appropriate points during its processing. The device to which the output is written is implementation-dependent, but is normally the same device to which X server error messages are directed; thus the bits that can be set in mask and flags is implementation-specific. To turn on a debug output selection, set the bit for the output in the mask parameter and set the corresponding bit in the flags parameter. To turn off event selection for an event, set the bit for the output in the mask parameter and do not set the corresponding bit in the flags parameter.

When bits are set in the debug controls masks, ctrls_mask and ctrls, Xkb modifies its behavior according to each controls bit. ctrls_mask and ctrls are related in the same way that mask and flags are. The valid controls bits are defined in Table 22.1.

<table>
<thead>
<tr>
<th>Debug Control Mask</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>XkbDF_DisableLocks</td>
<td>(1 &lt;&lt; 0)</td>
<td>Disable actions that lock modifiers</td>
</tr>
</tbody>
</table>

XkbSetDebuggingFlags returns True if successful and False otherwise. The only protocol error it may generate is BadAlloc, if for some reason it is unable to allocate storage.

XkbSetDebuggingFlags is intended for developer use and may be disabled in production X servers. If it is disabled, XkbSetDebuggingFlags has no effect and does not generate any protocol errors.

The message in msg is written immediately. The device to which it is written is implementation dependent but is normally the same device where X server error messages are directed.
The X Keyboard Extension

Glossary

Allocator
Xkb provides functions, known as allocators, to create and initialize Xkb data structures.

Audible Bell
An audible bell is the sound generated by whatever bell is associated with the keyboard or input extension device, as opposed to any other audible sound generated elsewhere in the system.

Autoreset Controls
The autoreset controls configure the boolean controls to automatically be enabled or disabled at the time a program exits.

Base Group
The group in effect as a result of all actions other than a previous lock or latch request; the base group is transient. For example, the user pressing and holding a group shift key that shifts to Group2 would result in the base group being group 2 at that point in time. Initially, base group is always Group1.

Base Modifiers
Modifiers that are turned on as a result of some actions other than previous lock or latch requests; base modifiers are transient. For example, the user pressing and holding a key bound to the Shift modifier would result in Shift being a base modifier at that point in time.

Base Event Code
A number assigned by the X server at run time that is assigned to the extension to identify events from that extension.

Base State
The base group and base modifiers represent keys that are physically or logically down; these constitute the base state.

Boolean Controls
Global keyboard controls that may be selectively enabled and disabled under program control and that may be automatically set to an on or off condition upon client program exit.

Canonical Key Types
The canonical key types are predefined key types that describe the types of keys available on most keyboards. The definitions for the canonical key types are held in the first XkbNumRequiredTypes entries of the types field of the client map and are indexed using the following constants:

XkbOneLevelIndex
XkbTwoLevelIndex
XkbAlphabeticIndex
XkbKeypadIndex

Client Map
The key mapping information needed to convert arbitrary keycodes to symbols.
Compat Name
The *compat* name is a string that provides some information about the rules used to bind actions to keys that are changed using core protocol requests.

Compatibility State
When an Xkb-extended X server connects to an Xkb-unaware client, the compatibility state remaps the keyboard group into a core modifier whenever possible.

Compatibility Grab State
The grab state that results from applying the compatibility map to the Xkb grab state.

Compatibility Map
The definition of how to map core protocol keyboard state to Xkb keyboard state.

Component Expression
An expression used to describe server keyboard database components to be loaded. It describes the order in which the components should be loaded and the rules by which duplicate attributes should be resolved.

Compose Processing
The process of mapping a series of keysyms to a string is known as compose processing.

Consumed Modifier
Xkb normally consumes modifiers in determining the appropriate symbol for an event, that is, the modifiers are not considered during any of the later stages of event processing. For those rare occasions when a modifier should be considered despite having been used to look up a symbol, key types include an optional *preserve* field.

Core Event
An event created from the core X server.

Detectable Auto-Repeat
Detectable auto-repeat allows a client to detect an auto-repeating key. If a client requests and the server supports detectable auto-repeat, Xkb generates *KeyRelease* events only when the key is physically released. Thus the client receives a number of *KeyPress* events for that key without intervening *KeyRelease* events until the key is finally released, when a *KeyRelease* event is received.

Effective Group
The effective group is the arithmetic sum of the locked, latched, and base groups. The effective keyboard group is always brought back into range depending on the value of the *GroupsWrap* control for the keyboard. If an event occurs with an effective group that is legal for the keyboard as a whole, but not for the key in question, the group for that event only is normalized using the algorithm specified by the *group_info* member of the key symbol map (*XkbSymMapRec*).

Effective Mask
An Xkb modifier definition consists of a set of bit masks corresponding to the eight real modifiers; a similar set of bitmasks corresponding to the 16 named virtual modifiers; and an effective mask. The effective mask represents the set of all real modifiers that can logically be set either by setting any of the real modifiers or by setting any of the virtual modifiers in the definition.
Effective Modifier
The effective modifiers are the bitwise union of the base, latched and locked modifiers.

Extension Device
Any keyboard or other input device recognized by the X input extension.

Global Keyboard Controls
Controls that affect the way Xkb generates key events. The controls affect all keys, as opposed to per-key controls that are for a single key. Global controls include
- RepeatKeys Control
- DetectableAuto-repeat
- SlowKeys
- BounceKeys
- StickyKeys
- MouseKeys
- MouseKeysAccel
- AccessXKeys
- AccessXTimesout
- AccessXFeedback
- Overlay1
- Overlay2
- EnabledControls

Grab State
The grab state is the state used when matching events to passive grabs. It consists of the grab group and the grab modifiers.

Group
See Keysym Group

Group Index
A number used as the internal representation for a group number. Group1 through Group 4 have indices of 0 through 3.

Groups Wrap Control
If a group index exceeds the maximum number of groups permitted for the specified keyboard, it is wrapped or truncated back into range as specified by the global GroupsWrap control. GroupsWrap can have the following values:
- WrapIntoRange
- ClampIntoRange
- RedirectIntoRange

Key Type
An attribute of a key that identifies which modifiers affect the shift level of a key and the number of groups on the key.

Key Width
The maximum number of shift levels in any group for the key type associated with a key.
**Keysym Group**
A keysym group is a logical state of the keyboard providing access to a collection of characters. A group usually contains a set of characters that logically belong together and that may be arranged on several shift levels within that group. For example, Group1 could be the English alphabet, and Group2 could be Greek. Xkb supports up to four different groups for an input device or keyboard. Groups are in the range 1-4 (Group1 - Group4), and are often referred to as G1 - G4 and indexed as 0 - 3.

**Indicator**
An indicator is a feedback mechanism such as an LED on an input device. Using Xkb, a client application can determine the names of the various indicators, determine and control the way that the individual indicators should be updated to reflect keyboard changes, and determine which of the 32 keyboard indicators reported by the protocol are actually present on the keyboard.

**Indicator Feedback**
An indicator feedback describes the state of a bank of up to 32 lights. It has a mask where each bit corresponds to a light and an associated value mask that specifies which lights are on or off.

**Indicator Map**
An indicator has its own set of attributes that specify whether clients can explicitly set its state and whether it tracks the keyboard state. The indicator map is the collection of these attributes for each indicator and is held in the maps array, which is an array of XkbIndicatorRec structures.

**Input Extension**
An extension to the core X protocol that allows an X server to support multiple keyboards, as well as other input devices, in addition to the core X keyboard and pointer. Other types of devices supported by the input extension include, but are not limited to: mice, tablets, touchscreens, barcode readers, button boxes, trackballs, identifier devices, data gloves, and eye trackers.

**Key Action**
A key action consists of an operator and some optional data. Once the server has applied the global controls and per-key behavior and has decided to process a key event, it applies key actions to determine the effects of the key on the internal state of the server. Xkb supports actions that do the following:
- Change base, latched, or locked modifiers or group
- Move the core pointer or simulate core pointer button events
- Change most aspects of keyboard behavior
- Terminate or suspend the server
- Send a message to interested clients
- Simulate events on other keys

**Key Alias**
A key alias is a symbolic name for a specific physical key. Key aliases allow the keyboard layout designer to assign multiple key names to a single key. This allows the keyboard layout designer to refer to keys using either their position or their “function.” Key aliases can be specified both in the symbolic names component and in the keyboard geometry.
Both sets of aliases are always valid, but key alias definitions in the keyboard geometry have priority; if both symbolic names and geometry include aliases, you should consider the definitions from the geometry before considering the definitions from the symbolic names section.

**Key Behavior**

The *behaviors* field of the server map is an array of XkbBehavior, indexed by keycode, and contains the behavior for each key. The X server uses key behavior to determine whether to process or filter out any given key event; key behavior is independent of keyboard modifier or group state. Each key has exactly one behavior.

Key behaviors include:
- XkbKB_Default
- XkbKB_Lock
- XkbKB_RadioGroup
- XkbKB_Overlay1
- XkbKB_Overlay2

**Key Symbol Map**

A key symbol map describes the symbols bound to a key and the rules to be used to interpret those symbols. It is an array of XkbSymMapRec structures indexed by keycode.

**Key Type**

Key types are used to determine the shift level of a key given the current state of the keyboard. There is one key type for each group for a key. Key types are defined using the XkbKeyTypeRec and XkbKMapEntryRec structures. Xkb allows up to XkbMaxKeyTypes (255) key types to be defined, but requires at least XkbNumRequiredTypes (4) predefined types to be in a key map.

**Keyboard Bells**

The sound the default bell makes when rung is the system bell or the default keyboard bell. Some input devices may have more than one bell, identified by bell_class and bell_id.

**Keyboard Components**

There are five types of components stored in the X server database of keyboard components. They correspond to the symbols, geometry, keycodes, compat, and types symbolic names associated with a keyboard.

**Keyboard Feedback**

A keyboard feedback includes the following:
- Keyclick volume
- Bell volume
- Bell pitch
- Bell duration
- Global auto-repeat
- Per key auto-repeat
- 32 LEDs

**Key Width, Key Type Width**

The maximum number of shift levels for a type is referred to as the width of a key type.
Keyboard Geometry
Keyboard geometry describes the physical appearance of the keyboard, including the shape, location, and color of all keyboard keys or other visible keyboard components such as indicators and is stored in a `XkbGeometryRec` structure. The information contained in a keyboard geometry is sufficient to allow a client program to draw an accurate two-dimensional image of the keyboard.

Keyboard Geometry Name
The keyboard geometry name describes the physical location, size, and shape of the various keys on the keyboard and is part of the `XkbNamesRec` structure.

Keyboard State
Keyboard state encompasses all of the transitory information necessary to map a physical key press or release to an appropriate event.

Keycode
A numeric value returned to the X server when a key on a keyboard is pressed or released, indicating which key is being modulated. Keycode numbers are in the range 1 <= keycode <= max, where max is the number of physical keys on the device.

Keycode Name
The keycode name describes the range and meaning of the keycodes returned by the keyboard and is part of the `XkbNamesRec` structure.

Latched Group
A latched group is a group index that is combined with the base and locked group to form the effective group. It applies only to the next key event that does not change the keyboard state. The latched group can be changed by keyboard activity or via Xkb extension library functions.

Latched Modifier
Latched modifiers are the set of modifiers that are combined with the base modifiers and the locked modifiers to form the effective modifiers. It applies only to the next key event that does not change the keyboard state.

LED
A light emitting diode. However, for the purposes of the X keyboard extension specification, a LED is any form of visual two-state indicator that is either on or off.

Locked Group
A locked group is a group index that is combined with the base and latched group to form the effective group. When a group is locked, it supersedes any previous locked group and remains the locked group for all future key events, until a new group is locked. The locked group can be changed by keyboard activity or via Xkb extension library functions.

Locked Modifiers
Locked modifiers are the set of modifiers that are combined with the base modifiers and the latched modifiers to form the effective modifiers. A locked modifier applies to all future key events until it is explicitly unlocked.
Lookup State
The lookup state is composed of the lookup group and the lookup modifiers, and it is the state an Xkb-capable or Xkb-aware client should use to map a keycode to a keysym.

Modifier
A modifier is a logical condition that is either set or unset. The modifiers control the Shift Level selected when a key event occurs. Xkb supports the core protocol eight modifiers (Shift, Lock, Control, and Mod1 through Mod5), called the real modifiers. In addition, Xkb extends modifier flexibility by providing a set of sixteen named virtual modifiers, each of which can be bound to any set of the eight real modifiers.

Modifier Key
A modifier key is a key whose operation has no immediate effect, but that, for as long as it is held down, modifies the effect of other keys. A modifier key may be, for example, a shift key or a control key.

Modifier Definition
An Xkb modifier definition, held in an XkbModsRec, consists of a set of real modifiers, a set of virtual modifiers, and an effective mask. The mask is the union of the real modifiers and the set of real modifiers to which the virtual modifiers map; the mask cannot be explicitly changed.

Nonkeyboard Extension Device
An input extension device that is not a keyboard. Other types of devices supported by the input extension include, but are not limited to: mice, tablets, touchscreens, barcode readers, button boxes, trackballs, identifier devices, data gloves, and eye trackers.

Outlines
An outline is a list of one or more points that describes a single closed polygon, used in the geometry specification for a keyboard.

Physical Indicator Mask
The physical indicator mask is a field in the XkbIndicatorRec that indicates which indicators are bound to physical LEDs on the keyboard; if a bit is set in phys_indicators, then the associated indicator has a physical LED associated with it. This field is necessary because some indicators may not have corresponding physical LEDs on the keyboard.

Physical Symbol Keyboard Name
The symbols keyboard name identifies the symbols logically bound to the keys. The symbols name is a human or application-readable description of the intended locale or usage of the keyboard with these symbols. The phys_symbols keyboard name, on the other hand, identifies the symbols actually engraved on the keyboard.

Preserved Modifier
Xkb normally consumes modifiers in determining the appropriate symbol for an event, that is, the modifiers are not considered during any of the later stages of event processing. For those rare occasions when a modifier should be considered despite having been used to look up a symbol, key types include an optional preserve field. If a modifier is present in the preserve list, it is a preserved modifier.
Radio Group
A radio group is a set of keys whose behavior simulates a set of radio buttons. Once a key in a radio group is pressed, it stays logically depressed until another key in the group is pressed, at which point the previously depressed key is logically released. Consequently, at most one key in a radio group can be logically depressed at one time.

Real Modifier
Xkb supports the eight core protocol modifiers (Shift, Lock, Control, and Mod1 through Mod5); these are called the real modifiers, as opposed to the set of sixteen named virtual modifiers that can be bound to any set of the eight real modifiers.

Server Internal Modifiers
Modifiers that the server uses to determine the appropriate symbol for an event; internal modifiers are normally consumed by the server.

Shift Level
One of several states (normally 2 or 3) governing which graphic character is produced when a key is actuated.

Symbol Keyboard Name
The symbols keyboard name identifies the symbols logically bound to the keys. The symbols name is a human or application-readable description of the intended locale or usage of the keyboard with these symbols. The phys_symbols keyboard name, on the other hand, identifies the symbols actually engraved on the keyboard.

Symbolic Name
Xkb supports symbolic names for most components of the keyboard extension. Most of these symbolic names are grouped into the names component of the keyboard description.

State Field
The portion of a client-side core protocol event that holds the modifier, group, and button state information pertaining to the event.

Types Name
The types name provides some information about the set of key types that can be associated with the keyboard. In addition, each key type can have a name, and each shift level of a type can have a name.

Valuator
A valuator reports a range of values for some entity, like a mouse axis, a slider, or a dial.

Virtual Modifier
Xkb provides a set of sixteen named virtual modifiers that can be bound to any set of the eight real modifiers. Each virtual modifier can be bound to any set of the real modifiers (Shift, Lock, Control, and Mod1-Mod5).

Virtual Modifier Mapping
Xkb maintains a virtual modifier mapping, which lists the virtual modifiers associated with each key.
Xkb-aware Client
A client application that initializes Xkb extension and is consequently bound to an Xlib that includes the Xkb extension.

Xkb-capable Client
A client application that makes no Xkb extension Xlib calls but is bound to an Xlib that includes the Xkb extension.

Xkb-unaware Client
A client application that makes no Xkb extension Xlib calls and is bound to an Xlib that does not include the Xkb extension.
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