Cygwin/X Contributor's Guide

Harold L Hunt, II

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by Harold L Hunt, II

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Chapter 1. Overview

The Cygwin/X project can use your help! We will do everything we can to make experienced contributors productive as soon as possible. We also want to make it as easy as possible for new contributers to make Cygwin/X their first open source project.

Anyone who despaired of touching the monolithic tree will find things much easier now with modular X. If you want to see Cygwin/X stay current and add new features, then WE NEED YOU.

Cygwin/X is part of the vast number of open source/free software programs that provide compatibility with closed source/commercial software products. Cygwin/X enables the coexistence of closed software and open software during the period of transition from an almost completely closed software market to an almost completely open software market.

Join in the excitement of opening your Windows machine to the X Window System.

We need programmers, documentation writers, and website maintainers.

Chapter 2. Programming

Overview

This chapter provides a consolidated overview of all of the information needed to begin making source code contributions to Cygwin/X. Creating a source code contribution for Cygwin/X requires an amazingly small amount of information; however, prior to this document that tiny amount of information was difficult to obtain, as it was scattered across several documents and source code files. New programmers with no open source project experience, as well as programming gurus, will be able to make source code contributions to Cygwin/X after reading this chapter. Programming gurus are great; our intention is to create more of them.

This document is primarily focused on the Cygwin/X server; most other components are extremely stable and work out-of-the-box on Cygwin

The primary source of information on developing for X is the X.Org developer startpage (http://www.x.org/wiki/DeveloperStart)

Downloading the X Window System source code tree can take anywhere from 10 minutes to 10 hours, depending upon the speed of your network connection. If you have an active network connection at your disposal you may want to skip ahead to the Section called *Obtaining the Source Code* and start downloading the source code tree now. You will find it advantageous to have a source code tree as you read the other sections.

Source Code Tree Layout

Descriptions of Important `xserver` Directories and Subdirectories

- `cfb*` contains deprecated *color framebuffer* drawing procedures that are not compatible with the *Shadow* drawing system that Cygwin/X depends upon. This directory is of no interest to Cygwin/X programmers.
- `dix` contains [drawing] *device independent X* routines. `main.c` contains the `main` entry-point function for the Cygwin/X X Server. The X Server startup procedure can be followed by examining `main`.
- `fb` contains the modern framebuffer drawing procedures used by Cygwin/X. This directory is maintained by Keith Packard and is only of interest to Cygwin/X programmers when it fails to build.
- `hw` contains [drawing] hardware dependent functions.
  - `vfb` contains the Virtual Framebuffer X Server. The vfb server draws to a system memory framebuffer with the primary purpose of allowing X clients to run on a machine that does not have display hardware.
  - `xfree86` contains source code for the X Window System servers that run on various operating systems that generally have low-level access to the graphics hardware. Cygwin/X does not have low-level access to the graphics hardware, thus Cygwin/X is not able to utilize the X Window System server.

    - `xnest` contains source code for the Nested X Server which runs inside of another X Server. xnest is not generally of interest to Cygwin/X programmers.
    - `xwin` contains the source code for the Cygwin/X X Server. This is the primary directory that Cygwin/X programmers are interested in.

- `include` contains header files specific to the X Server program, such as graphics context structures. This directory is useful to Cygwin/X programmers when they need to lookup the name or data type of members of various X Server structures.
- `mi` contains *machine independent* drawing routines. These drawing routines are used by the Cygwin/X Native GDI X Server engine. In turn, the machine independent routines depend in `winGetSpans`, `winFillSpans`, and `winSetSpans`, which are implemented in the Native GDI engine.
- `miext` contains various machine independent X extensions.
    - `layer` contains source code for the layer extension. This extension is supported by Cygwin/X, however, this directory will be of interest only when layer fails to build.
    - `shadow` contains source code for the shadow extension that the Cygwin/X X Server depends upon. This directory is of primary importance to Cygwin/X, but it is maintained by other programmers and is only of direct interest to Cygwin/X programmers when it fails to build. The shadow extension does three things:
        1. Allows the `fb` graphics routines to draw to an offscreen framebuffer.
        2. Keeps track of the regions of the offscreen framebuffer that have been drawn on.
        3. Calls one of Cygwin/X's engine dependent ShadowUpdate () functions to transfer the updated regions of the offscreen framebuffer to the screen.

- `os` contains *operating system dependent* X Server functions. However, the functions in the `os` have been written in such a way that they are actually compatible with most UNIX-style operating systems, include Cygwin.

Other components of interest

- `doc`
    - `hardcopy` contains precompiled PostScript documentation for various components of the X Window System. Cygwin/X-specific documentation is not contained in this directory. This directory is of little interest to Cygwin/X programmers.
    - `specs` contains the sources to build the documents in `hardcopy`. This directory is of little interest to Cygwin/X programmers.

- `fonts` contains font definition files used to compile fonts. This directory is of little interest to Cygwin/X programmers.
- `include` contains various X Window System headers that are not generally specific to any one client or library (i.e. `X.h`, `Xproto.h`, and `keysymdef.h`).

- `lib` contains both X client and X Server libraries. Cygwin/X does not generally call any functions in these libraries directly; however, we do have to link to several of these libraries to get our X Server to build. These libraries are maintained by various developers from the X Window System project and there are occasional synchronizations with The Open Group (http://www.opengroup.org/)'s X.org (http://www.x.org/). Cygwin/X programmers occasionally need to fix Cygwin-related build errors that occur in these libraries.

Cygwin/X X Server Architecture

Cygwin/X's X Server architecture was heavily inspired by Angebranndt94, the Definition of the Porting Layer for the X v11 Sample Server.

Server Privates

X Servers use various structures to pass information around to functions. Some of those structures are colormaps, *graphics contexts* (GCs), *pixmaps*, and *screens*. The X protocol defines the contents of each of these structures, however, the X Server implementation and various X Server libraries (*MI*, *FB*, *Shadow*, etc.) may require additional information to be associated with these internal structures. For example, the Cygwin/X X Server must associate a Windows window handle (hwnd) with each X Server screen that is open.

Privates are the mechanism provided by the X protocol for associating additional information with internal X Server structures. Privates originally consisted of a single pointer member contained in each structure, usually named *`devPrivate`* or *`devPriv`*. This original specification only allowed one of the X Server layers (mi, fb, shadow, etc.) to have privates associated with an internal structure. Privates have since been revised.

The current privates implementation requires that each X Server layer call a function on startup to indicate that that layer will require privates and to obtain an index into the array of privates that that layer's privates will be stored at. Modern privates are generally stored in an array of type DevUnion pointed to by a structure member named *`devPrivates`*; DevUnion is defined in `xserver/include/miscstruct.h`. There are two different memory allocation schemes for *`devPrivates`*.

Memory for privates structures can either be preallocated or allocated upon use. Preallocation, the preferred method for GCs, pixmaps, and windows, requires that the size of the privates memory needed be specified during X Server initialization. Preallocation allows the *DIX* layer to allocate all memory needed for a given internal structure, including all privates memory, as a single contiguous block of memory; this greatly reduces memory fragmentation. Allocation upon use, used by screens, requires the *DDX* structure creation function to allocate memory for the privates; `winScreenInit` calling `winAllocatePrivates`, which allocates screen privates memory directly, is an example of this. Allocation upon use can optionally and non-optimally be used by GCs, pixmaps, and windows.

Macros

Three macros are provided for each class of privates that make setting up and using the privates easier. The macros for screen privates are examined as an example.

```
winPrivScreenPtr winGetScreenPriv(ScreenPtr pScreen);
```

`winGetScreenPriv` takes a non-NULL pointer to a screen, a ScreenPtr, and returns the pointer stored in the DDX privates for that screen. Passing a NULL or invalid ScreenPtr to `winGetScreenPriv` will cause an access violation, crashing the Cygwin/X X Server.

```
void winSetScreenPriv(ScreenPtr pScreen, void * pvPrivates);
```

`winSetScreenPriv` takes a non-NULL pointer to a screen, a ScreenPtr, and sets the DDX privates pointer to the value of the *`pvPrivates`* parameter. Passing a NULL or invalid ScreenPtr to `winSetScreenPriv` will cause an access violation, crashing the Cygwin/X X Server.

```
void winScreenPriv(ScreenPtr pScreen);
```

`winScreenPriv` takes a non-NULL pointer to a screen, a ScreenPtr, and declares a local variable in the calling function named `pScreenPriv`. `winScreenPriv` may only be called at the top of a C function within the variable declaration block; calling the function elsewhere will break the ANSI C rule that all variables must be declared at the top of a scope block. Passing a NULL or invalid ScreenPtr to `winScreenPriv` will cause an access violation, crashing the Cygwin/X X Server.

Engine System

The Cygwin/X X Server uses several methods of drawing graphics on the display device; each of these different drawing methods is referred to as an engine. Each of the engines can be classified as either a Shadow FB engine, a Native GDI engine, or as a Primary FB engine. It should be noted that the Primary FB engine is deprecated and is discussed here only for completeness. The engines are discussed in the following sections, in order of importance.

Shadow FB Engines

The Shadow FB engines use Keith Packard's *FB* drawing procedures wrapped with his *Shadow* layer that allows drawing to an *offscreen framebuffer* with periodic updates of the *primary framebuffer*.

Native GDI Engine

The Native GDI engine will eventually translate individual X graphics calls into their GDI equivalent. Some X graphics calls do not translate directly to a GDI call so they may be passed through the MI layer to change them into a serious of lower level calls that are supported. Currently, the Native GDI engine passes all X graphics calls through the MI layer to convert them into three functions: `FillSpans`, `GetSpans`, and `SetSpans`. The functionality of those three functions, as of 2001-10-28, is limited to the functionality needed to draw the familiar X background pattern upon X Server startup.

Primary FB Engine

The Primary FB engine is deprecated. Primary FB works in the same manner that the original Cygwin/X X Server worked, namely, it uses `IDirectDrawSurface_Lock` to obtain a pointer to the *primary framebuffer* memory at server startup. This memory pointer is held until the X Server shuts down. This technique does not work on all versions of Windows.

Locking the primary framebuffer on Windows 95/98/Me causes the Win16Mutex to be obtained by the program that locks the primary framebuffer; the Win16Mutex is not released until the primary framebuffer is unlocked. The Win16Mutex is a semaphore introduced in Windows 95 that prevents 16 bit Windows code from being reentered by different threads or processes. For compatibility reasons, all GDI operations in Windows 95/98/Me are written in 16 bit code, thus requiring that the Win16Mutex be obtained before performing those operations. All of this leads to the following situation on Windows 95/98/Me:

1. The primary framebuffer is locked, causing the Cygwin/X X Server to hold the Win16Mutex.
2. Windows switches the Cygwin/X X Server out of the current process slot; another process is switched in.
3. The newly selected process makes a GDI function call.
4. The GDI function call must wait for the Win16Mutex to be released, but the Win16Mutex cannot be released until the Cygwin/X X Server releases the Win16Mutex. However, the Cygwin/X X Server will not release the Win16Mutex until it exits. The end result is that the Win16Mutex has been deadlocked and the Windows machine is frozen with no way to recover.

Windows NT/2000/XP do not contain any 16 bit code, so the Win16Mutex is not an issue; thus, the Primary FB engine works fine on those operating systems. However, drawing directly to the primary framebuffer suffers performance problems. For example, on some systems writing to the primary framebuffer requires doing memory reads and writes across the PCI bus which is only 32 bits wide and features a clock speed of 33 MHz, as opposed to accessing system memory, which is attached to a 64 bit wide bus that runs at between 100 and 266 (effective) MHz. Furthermore, accessing the primary framebuffer memory requires several synchronization steps that take many clock cycles to complete. The end result is that the Primary FB engine is several times slower than the Shadow FB engines.

The Primary FB engine also has several unique issues that are difficult to program around. Development of the Primary FB engine has ceased, due to the difficulty of maintaining it, coupled with the fact that Primary FB does not run on Windows 95/98/Me and with the poor performance of Primary FB. The Primary FB source code has been left in place so that future programmers can enable it and see the poor performance of the engine for themselves.

User Input

User input is processed using the *MI* layer's user input system. Any queued Win32 user input messages, as well as other Win32 messages, are handled when `hw/xwin/winwakeup.c`'s `winWakeupHandler` function is called by the *OS* layer `os/WaitFor.c`'s `WaitForSomething` function and when the *DIX* layer `dix/dispatch.c`'s `Dispatch` function calls `hw/xwin/InitInput.c`'s `ProcessInputEvents` function. Each Win32 user input message typically queues an input event, or several input events, using the MI layer's `mi/mieq.c`'s `mieqEnqueue` function. Enqueued MI input events are processed in

`ProcessInputEvents` by calling `mi/mieq.c`'s `mieqProcessInputEvents`; the cursor position is updated on the screen by calling `mipointer.c`'s `miPointerUpdate`.

Keyboard

Win32 keyboard messages are processed in `winwndproc.c`'s `winWindowProc`. The messages processed are:

- WM_SYSKEYDOWN
- WM_KEYDOWN
- WM_SYSKEYUP
- WM_KEYUP

The WM_SYSKEY* messages are generated when the user presses a key while holding down the **Alt** key or when the user presses a key after pressing and releasing the **F10** key. Processing for WM_SYSKEYDOWN and WM_KEYDOWN (respectively WM_SYSKEYUP, WM_KEYUP) messages are identical because the X Server does not distinguish between a normal key press and a key press when the **Alt** key is down.

Win32 uses virtual key codes to identify which key is being pressed or released. Virtual key codes follow the idea that the same virtual key code will be sent for keys with the same label printed on them. For example, the left and right **Ctrl** keys both generate the VK_CONTROL virtual key code. Virtual key codes are accompanied by other state information, such as the extended flag, that distinguishes between the multiple keys with the same label. For example, the left **Ctrl** key does not have the extended flag asserted, while the right **Ctrl** key does have the extended flag asserted. However, virtual key codes are not the way that key presses have traditionally been identified on personal computers and in the X Protocol.

Personal computers and the X Protocol use scan codes to identify which key is being pressed. Each key on the keyboard generates a specified number when that key is pressed or released; this number is called the scan code. Scan codes are always distinct for distinct keys. For example, the left and right **Ctrl** keys generate distinct scan codes, even though their functionality is the same. Scan codes do not have additional state information, as the multiple keys with the same label will each generate a unique scan code. There is some debate as to which of virtual key codes or scan codes is the better system.

The X Protocol expects that keyboard input will be based on a scan code system. There are two methods of sending a scan codes from a virtual key code message. The first method is to create a static table that links the normal and extended state of each virtual key code to a scan code. This method seems valid, but the method does not work reliably for users with non-U.S. keyboard layouts. The second method simply pulls the scan code out of the *`lParam`* of the keyboard messages; this method works reliably for non-U.S. keyboard layouts. However, there are further concerns for non-U.S. keyboard layouts.

Non-U.S. keyboard layouts typically use the right **Alt** key as a sort of shift key to access an additional row of symbols from the **‘**, **1**, **2**, ..., **0** keys, as well as accented forms of standard alphabetic characters, such as á, ä, å, ú and additional alphabetic characters, such as ß. Non-U.S. keyboards typically label the right **Alt** key as **AltGr** or **AltLang**; the Gr is short for “grave”, which is the name of one of the accent symbols. The X Protocol and Win32 methods of handling the **AltGr** key are not directly compatible with one another.

The X Protocol handles **AltGr** presses and releases in much the same way as any other key press and release. Win32, however, generates a fake **Ctrl** press and release for each **AltGr** press and release. The X

Protocol does not expect this fake **Ctrl** press and release, so care must be taken to discard the fake **Ctrl** press and release. Fake **Ctrl** presses and releases are detected and discarded by passing each keyboard message to `winkeybd.c`'s `winIsFakeCtrl_L` function. `winIsFakeCtrl_L` detects the fake key presses and releases by comparing the timestamps of the **AltGr** message with the timestamp of any preceding or trailing **Ctrl** message. Two real key events will never have the same timestamp, but the fake key events have the same timestamp as the **AltGr** messages, so the fake messages can be easily identified.

Special keyboard considerations must be handled the Cygwin/X X Server losses or gains the keyboard focus. For example, the user can switch out of Cygwin/X, toggle the **Num Lock** key, then switch back into Cygwin/X; in this case Cygwin/X would not have received the **Num Lock** toggle message, so it will continue to function as if **Num Lock** was in its previous state. Thus, the state of any mode keys such as **Num Lock**, **Caps Lock**, **Scroll Lock**, and **Kana Lock** must be stored upon loss of keyboard focus; the stored state of each mode key must then be compared to that key's current state, toggling the key if its state has changed.

Mouse

Win32 mouse messages are processed in `winwndproc.c`'s `winWindowProc`. The messages processed are:

- WM_MOUSEMOVE
- WM_NCMOUSEMOVE
- WM_LBUTTON*
- WM_MBUTTON*
- WM_RBUTTON*
- WM_MOUSEWHEEL

Handling mouse motion is relatively straight forward, with the special consideration that the Windows mouse cursor must be hidden when the mouse is moving over the client area of a Cygwin/X window; the Windows mouse cursor must be redisplayed when the mouse is moving over the non-client area of a Cygwin/X window. Win32 sends the absolute coordinates of the mouse, so we call `miPointerAbsoluteCursor` to change the position of the mouse.

Three-button mouse emulation is supported for users that do not have a three button mouse. When three-button mouse emulation is disabled, mouse button presses and releases are handled trivially in `winmouse.c`'s `winMouseButtonsHandle` by simply passing the event to `mieqEnqueue`. Three-button mouse emulation is quite complicated.

Three-button mouse emulation is handled by starting a timer when the left or right mouse buttons are pressed; the button event is sent as a left or right mouse button event if the other button is not pressed before the timer expires. The button event is sent as an emulated middle button event if the other mouse button is pressed before the timer runs out.

The mouse wheel is handled in `winmouse.c`'s `winMouseWheel` by generating sequences of button 4 and button 5 presses and releases corresponding to how much the mouse wheel has moved. Win32 uses variable resolution for the mouse wheel and passes the mouse wheel motion as a delta from the wheel's previous position. The number of button clicks to send is determined by dividing the wheel delta by the

distance that is considered by Win32 to be one unit of motion for the mouse wheel; any remainder of the wheel delta must be preserved and added to the next mouse wheel message.

Obtaining the Source Code

Cygwin/X source code is contained in, and distributed with, the X Window System source code tree.

The source code for the packages distributed via Cygwin setup is also available via Cygwin setup. This may have multiple patches applied on top of the X Window System source code, and should be the starting point for new developers.

Read-only git access to the X Window System source tree (http://xorg.freedesktop.org/wiki/) is also available.

The CYGWIN branch exists in git for historical reasons. Current development follows the mainline.

```
$ git clone git://git.freedesktop.org/git/xorg/xserver
```

Native Compiling

Compiling the Source Code

Compiling Cygwin/X doesn't have to be hard, although the X Window System source code tree is reasonably large. There are a few simple techniques that make building the source code, keeping the source code up to date, and keeping the source code organized much easier.

Required Packages for Compiling

Many developer libraries and developer tools are required to build Cygwin/X. Several packages are required in addition to the default packages installed by the Cygwin installer. Following is a list of additional packages that are required to compile Cygwin/X natively in Cygwin. Note that some of these packages are meta packages that will automatically cause several other packages to be selected for installation; do not unselect any of these automatically selected packages.

- autoconf
- automake
- binutils
- bzip2
- diffutils
- fileutils

- findutils
- flex
- gawk
- gcc
- git
- make
- patch
- sed
- tar
- zlib

Standard Build

Follow these steps to create a standard, non-debug, build:

1. Change the current directory to your X Window System development directory:

```
Username@CygwinHost ~
$ cd x-devel

Username@CygwinHost ~/xserver
$ ./configure --prefix=/usr
[lots of output]
$ make
[lots more output]
```

Standard build is now complete.

> **Note:** XXX: Add figures for normal diskspace occupied by source, additional diskspace occupied by build, and a benchmark time for the build to complete
>
> XXX: Describe configure option for specifying a builddir

Debug Build

Follow these steps to create a build with debugging information:

1. Change the current directory to your X Window System development directory:

```
Username@CygwinHost ~
$ cd x-devel

Username@CygwinHost ~/xserver
```

```
$ ./configure --prefix=/usr --enable-debug CFLAGS="-g -O0"
[lots of output]
$ make
[lots more
```

Debug build is now complete.

Running a local build

Follow these steps to run the built X server:

1. Change the current directory to your X Window System development directory:

   ```
   Username@CygwinHost ~
   $ cd xserver
   Username@CygwinHost ~/xserver
   $
   ```

2. Invoke the hw/xwin/Xwin executable:

   ```
   Username@CygwinHost ~/xserver
   $ hw/xwin/XWin
   ```

   The X server you have built will now attempt to run.

Installing a local build

Installing a local build enables you to verify that a build of the entire source tree is operational. It is wise to verify the operation of full builds of the source tree from time to time, as full builds will occasionally be broken by changes that other developers are making to the X Window System source code tree.

Installing a local build on top of an existing build is not a good idea, as this can mask problems that occurred during the build process, or it can cause problems that are unrelated to the build process; either situation is undesirable. It is generally a good idea to move your old installation out of the way before installing a local build, and these instructions will assume that you desire to do so. Follow the instructions below to install a local build:

1. Change the current directory to your desired X Window System build directory:

   ```
   Username@CygwinHost ~
   $ cd ~/xserver/build/build-prefix

   Username@CygwinHost ~/xserver/build/build-prefix
   $
   ```

2. Make the **`install`** target, which installs everything:

   ```
   Username@CygwinHost ~/xserver/build/build-prefix
   $ make install

   Username@CygwinHost ~/xserver/build/build-prefix
   $
   ```

Keeping your source code tree updated

git makes keeping your source code tree up to date easy. Consult the git documentation for details.

Cross Compiling

Cross compiling is the act of the building source code on one system, the build host, into executables or libraries to be run on a different host, the native host. The build host and the native host may differ in operating system and/or processor type. Cross compiling is done for several reasons:

- The native host is grossly under powered, such as a handheld computer.
- The user happens to have greatly more compiling power available on a platform other than the native host. For example, the user may have access to a 32 processor machine while their desktop machine may only be a uni-processor machine.

Cross compiling is much trickier than building on the native host. There are a whole new class of problems that can happen when cross compiling that are simply not an issue when building on Cygwin. You should be familiar with building Cygwin/X on Cygwin, as described in the Section called *Native Compiling*, before attempting to cross compile Cygwin/X.

Obtaining binutils and gcc Source

binutils and gcc source code releases that are known to compile on Cygwin are distributed by the Cygwin project. Therefore, it is highly recommended that you obtain the binutils and gcc sources from the Cygwin mirror network (http://cygwin.com/mirrors.html).

Follow these steps to download Cygwin/X binaries:

1. Create a directory to store the binutils and gcc sources in, such as `/home/my_login/cygwin/src/`
2. Visit the Cygwin mirrors page (http://cygwin.com/mirrors.html) to find your closest mirror
3. The ftp url for your mirror site should take you to the `cygwin/` directory on the mirror
4. Change current ftp directory to `cygwin/release/`.
5. Download the following files from `cygwin/release/`, saving them to `/home/my_login/cygwin/src/` The compressed file size appears after each file in the list below.

> **Downloading with a Web Browser:** Some web browsers automatically decompress saved files when you use the left mouse button to follow the link to a file; bunzip2 will report, “Data integrity error when decompressing.”, when attempting to decompress a file that has been decompressed by your web browser. Prevent your files from being automatically decompressed by clicking the right mouse button on a file link and choosing a command such as Save Target As... or Save Link As... from the context sensitive menu. Better yet, download your files with a stand alone ftp client.

- `binutils/binutils-20030901-1-src.tar.bz2` (10.5 MiB; required, necessary to build gcc and Cygwin/X)
- `gcc/gcc-3.3.1-1-src.tar.bz2` (21.9 MiB; required, necessary to build Cygwin/X)

Obtaining Cygwin Headers and Libs

The simplest method of building a cross compiler for Cygwin requires that you have the Cygwin headers and libraries available at the time of building the cross compiler. Cygwin headers and libraries are installed when Cygwin is installed, so the headers and libraries can be obtained from an existing Cygwin installation.

> **Don't simply copy the headers and libraries:** Some of the headers and libraries are symbolic links to other headers or libraries. Copying these files using a program that is not aware of Cygwin's symlink emulation will result in some of the header and library files being broken. The method described below will preserve the symbolic links used by the header and library files.

1. Launch your Cygwin environment, using either the icon on your Desktop, the icon in your Start Menu, or by running cygwin.bat from your Cygwin directory (e.g. `c:\cygwin`); you should see a window like the following:

   ```
   Username@CygwinHost ~
   $
   ```

2. Change the current directory to Cygwin root directory:

   ```
   Username@CygwinHost ~
   $ cd /

   Username@CygwinHost /
   $
   ```

3. Create an archive of the contents of the `/lib` directory:

   ```
   Username@CygwinHost /
   $ tar czf cygwin-lib.tgz lib/

   Username@CygwinHost /
   $
   ```

4. Change the current directory to the `usr` directory in your Cygwin root directory:

   ```
   Username@CygwinHost /
   $ cd /usr

   Username@CygwinHost /usr
   $
   ```

5. Create an archive of the contents of the `/usr/include` directory:

   ```
   Username@CygwinHost /usr
   ```

```
$ tar czf cygwin-include.tgz include/

Username@CygwinHost /usr
$
```

6. Transfer cygwin-lib.tgz and cygwin-include.tgz to your build host using any method that you have available (e.g. ftp, samba, diskette, etc.). Save the files in the `/home/my_login/cygwin/i686-pc-cygwin/` directory.
7. Open a shell on your cross compiling build host; you should see a window like the following:

   ```
   [harold@CrossHost harold]$
   ```

8. Change the current directory to the `/home/my_login/cygwin/i686-pc-cygwin/` directory in your build host root directory:

   ```
   [harold@CrossHost harold]$ cd /home/my_login/cygwin/i686-pc-cygwin/

   [harold@CrossHost /home/my_login/cygwin/i686-pc-cygwin/]$
   ```

9. Extract the cygwin-lib.tgz and cygwin-include.tgz archives:

   ```
   [harold@CrossHost /home/my_login/cygwin/i686-pc-cygwin/]$ tar xzf cygwin-lib.tgz

   [harold@CrossHost /home/my_login/cygwin/i686-pc-cygwin/]$ tar xzf cygwin-include.tgz
   ```

10. Obtaining Cygwin headers and libs is now complete.

Building binutils and gcc

1. Open a shell on your cross compiling build host; you should see a window like the following:

   ```
   [harold@CrossHost harold]$
   ```

2. Change the current directory to the `/home/my_login/cygwin/src/` directory in your build host root directory:

   ```
   [harold@CrossHost harold]$ cd /home/my_login/cygwin/src/

   [harold@CrossHost src]$
   ```

3. Extract the binutils-20030901-1-src.tar.bz2 and gcc-3.3.1-1-src.tar.bz2 archives:

   ```
   [harold@CrossHost src]$ bunzip2 binutils-20030901-1-src.tar.bz2

   [harold@CrossHost src]$ tar xf binutils-20030901-1-src.tar

   [harold@CrossHost src]$ bunzip2 gcc-3.3.1-1-src.tar.bz2

   [harold@CrossHost src]$ tar xf gcc-3.3.1-1-src.tar
   ```

4. Change the current directory to the `/home/my_login/cygwin/src/binutils-20030901-1` directory:

   ```
   [harold@CrossHost src]$ cd binutils-20030901-1

   [harold@CrossHost binutils-20030901-1]$
   ```

5. Create a `build` directory and change the current directory to that directory:

```
[harold@CrossHost binutils-20030901-1]$ mkdir build

[harold@CrossHost binutils-20030901-1]$ cd build

[harold@CrossHost build]$
```

6. Configure binutils:

```
[harold@CrossHost build]$ ../configure
--prefix=/home/my_login/cygwin --exec-prefix=/home/my_login/cygwin
--target=i686-pc-cygwin --host=i686-pc-linux > configure.log 2>&1

[harold@CrossHost build]$
```

7. Build binutils:

```
[harold@CrossHost build]$ make all > all.log 2>&1

[harold@CrossHost build]$
```

8. Install binutils:

```
[harold@CrossHost build]$ make install > install.log 2>&1

[harold@CrossHost build]$
```

9. Modify the PATH environment variable to include the directories that the binutils executables were installed in:

```
[harold@CrossHost build]$
PATH=$PATH:/home/my_login/cygwin/bin:/home/my_login/cygwin/i686-pc-cygwin/bin

[harold@CrossHost build]$
```

10. Change the current directory to the `/home/my_login/cygwin/src/gcc-3.3.1-1` directory:

```
[harold@CrossHost build]$ cd ../../gcc-3.3.1-1

[harold@CrossHost gcc-3.3.1-1]$
```

11. Create a `build` directory and change the current directory to that directory:

```
[harold@CrossHost gcc-3.3.1-1]$ mkdir build

[harold@CrossHost gcc-3.3.1-1]$ cd build

[harold@CrossHost build]$
```

12. Configure gcc:

```
[harold@CrossHost build]$ ../configure
--prefix=/home/my_login/cygwin --exec-prefix=/home/my_login/cygwin
--target=i686-pc-cygwin --host=i686-pc-linux
--enable-haifa > configure.log 2>&1

[harold@CrossHost build]$
```

13. Build gcc:

```
[harold@CrossHost build]$ make all > all.log 2>&1

[harold@CrossHost build]$
```

14. Install gcc:

```
[harold@CrossHost build]$ make install > install.log 2>&1

[harold@CrossHost build]$
```

15. Building binutils and gcc is now complete.

Creating Links for binutils and gcc

Links to the executables in `/home/my_login/cygwin/bin` must be created in the `/home/my_login/cygwin/i686-pc-cygwin/bin` directory; these are required for the build system to find the build executables (e.g. **gcc**, **cpp**, etc.). Each of the build executables in `/home/my_login/cygwin/bin` is prefixed with `i686-pc-cygwin` (e.g. **i686-pc-cygwin-cpp**) whereas the build system expects the executables to have no prefix (e.g. **cpp**).

Creating links to the build executables and dropping the prefix from the name of each build executables link is done by a script that was provided by the XFree86 cross-compiling community and slightly modified by Alexander Gottwald. The text of this script is below, save it in a file on your cross compiling host called `cross-links.sh`. Note that the location of the script does not matter, since it contains a reference to the location of the build tools in the CYGROOT variable.

```
#!/bin/bash

#
# This stuff is required for the Cross Compile Environment.
#
CYGROOT=/home/my_login/cygwin
TARGET=i686-pc-cygwin
mkdir -p $CYGROOT/$TARGET/bin
cd $CYGROOT/$TARGET/bin

for i in ../../bin/*; do
    if [ $i !=  ${i/$TARGET-/} ]; then
         ln -s $i ${i/.*$TARGET-/}
    fi
done

ln -s gcc cc
```

Finally, run the `cross-links.sh` script. There should now be several links in the `/home/my_login/cygwin/i686-pc-cygwin/bin` directory.

Building Cygwin/X

Building the source code when cross compiling X Window System is nearly identical to the process described below in the Section called *Native Compiling* of the Native Compiling section. One divergence

from the aforementioned instructions is that you will be using a **bash** shell on your cross compiling host, rather than on your native Cygwin host; other divergences follow.

> **Note:** XXX: THIS IS UNTESTED

1. When configuring, you must pass `--target=i686-pc-cygwin` to **./configure** to cause the build system to build for the target, Cygwin, platform:
2. When configuring, you must pass `--prefix=/stagingdir` to **./configure** to cause the build system to be configured to install the target platform build into `/stagingdir`.

   OR, when installing a build, you must pass `DESTDIR` to **make install** to install the target platform build into `/stagingdir`.

   > **Tip:** Never run **make install** on your host platform without the `DESTDIR` parameter, as that will cause the Cygwin build of X Window System to be installed over top of your local X Window System installation, which would completely destroy your host system's X Window System installation.

Packaging a Cygwin/X Distribution

Cygwin/X uses a cygport build and packaging script that automates all of the tasks required to build, create binary packages, and source code packages.

> **Note:** These instructions assume that you want to build a distribution from the source packages available from Cygwin's **setup.exe**.
>
> You can a similar technique to build a distribution from X.Org release tarballs instead.

1. Unpack `xorg-server-x.x.x-x-src.tar.bz2` (if you use setup to install this source package, it will be automatically unpacked under `/usr/src`)

   ```
   Username@CygwinHost /usr/src
   $ tar -jxf xorg-server-x.x.x-x-src.tar.bz2
   ```

2. Invoke cygport on the .cygport file contained in the source package unpacked above. This will create the source and binary packages `xorg-server-1.5.3-X-src.tar.bz2` and `xorg-server-1.5.3-X.tar.bz2`

   ```
   Username@CygwinHost /usr/src
   $ cygport xorg-server-x.x.x-x.cygport all
   ```

Chapter 3. Documentation

Overview

Cygwin/X documentation is written in XML according to the DocBook (http://docbook.org/) document type definition (DTD). These XML input files are then compiled using an autoconf and automake build system. We currently build the following output formats: HTML, PDF, PS, RTF, and TXT.

Obtaining the Source Code

Source of latest cygwin-x-doc release

To obtain the source of the latest release of the cygwin-x-doc package start the cygwin setup, select directories and mirror and select the package cygwin-x-doc from the category X11. Mark the checkbox labelled src and install. This will install the documentation source in /usr/src/cygwin-x-doc.

Source from CVS

The documentation source code is available from sourceware.org CVS. To obtain them please use the follow commands:

```
$ cvs -d :pserver:anoncvs@sourceware.org:/cvs/cygwin-xfree login
CVS password: <hit return>
$ cvs -d :pserver:anoncvs@sourceware.org:/cvs/cygwin-xfree co doc
```

You should now have the sources in an directory called doc.

If you just want to look at the Cygwin/X documentation source, use the CVSweb interface to the Cygwin/X documentation tree (http://sourceware.org/cgi-bin/cvsweb.cgi/doc/?cvsroot=cygwin-xfree).

Setting Up a DocBook Build Environment

Setup a DocBook build environment on Cygwin

Required Packages for building documentation

- openjade
- jadetex (no offical package for this)

- docbook-dsssl (no offical package for this and getting the stylesheets set up properly is a black art)

  Note: A useful, if slightly dated, introduction to setting up a docbook build environment and editing tools can be found in the SGML for Windows NT: Setting up a free SGML editing and publishing system on Windows NT/Cygwin (http://web.archive.org/web/20050320030737/http://ourworld.compuserve.com/homepages/hoenicka_markus/cygbook1 document.

Building the Documentation

Follow these instructions to build the Cygwin/X documentation source code:

1. Open a shell on your documentation build host; you should see a window like the following:

   ```
   Username@CygwinHost ~
   $
   ```

2. Change the current directory to the documentation source code directory:

   ```
   Username@CygwinHost ~
   $ cd cygwin-x-doc-1.0.0

   Username@CygwinHost ~/cygwin-x-doc-1.0.0
   $
   ```

3. Create a `build` directory and change the current directory to that directory:

   ```
   Username@CygwinHost ~/cygwin-x-doc-1.0.0
   $ mkdir build

   Username@CygwinHost ~/cygwin-x-doc-1.0.0
   $ cd build

   Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
   $
   ```

4. Configure the documentation source code:

   ```
   Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
   $ ../configure

   Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
   $
   ```

   Note: Use **./configure --enable-hardcopy** to enable building of all documentation formats, otherwise just HTML will be built

5. Build the documentation:

```
Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
$ make all
```

6. Building the documentation is now complete.

Packaging a Documentation Distribution

Follow these instructions to build a Cygwin/X documentation source code distribution:

1. Edit the version tag in the third line of the file `configure.in` to indicated a new version, or to add a branch name to the distribution. The line containing the version tag should look like:

   ```
   AM_INIT_AUTOMAKE(cygwin-x-doc, 1.0.0)
   ```

2. Open a shell on your documentation build host; you should see a window like the following:

   ```
   Username@CygwinHost ~
   $
   ```

3. Change the current directory to the documentation source code build directory:

   ```
   Username@CygwinHost ~
   $ cd cygwin-x-doc-1.0.0/build

   Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
   $
   ```

4. Build the documentation source code distribution:

   ```
   Username@CygwinHost ~/cygwin-x-doc-1.0.0/build
   $ make distcheck
   ```

5. The documentation source code distribution should now be contained in the current directory in a file called `cygwin-x-doc-1.0.0.tar.gz`.

6. Building the documentation is now complete.

Chapter 4. Web Site Maintenance

The Cygwin/X web site is stored in sourceware.org CVS. The CVS root is ext:sourceware.org:/cvs/cygwin/htdocs/xfree.

Updating the documentation on the web site

A simple way of updating the documentation from the cywin-x-doc package shown on the web site is to build the documentation directly into a CVS checkout of web-site and then check it in.

```
$ cvs co ext:user@sourceware.org:/cvs/cygwin/htdocs/xfree
[...]
$ cd xfree/docs
$ path-to-cygwin-x-doc/configure --enable-hardcopy
$ make
$ cvs up
[...]
$ cvs ci
```

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Glossary

B

Bitmap (Win32)

Windows pixel map.

Bitmap (X)

X pixel map with bit depth equal to one. X pixel maps of bit depth not equal to one are called *pixmaps*.

C

Color Framebuffer Layer

Deprecated X Server layer providing implementations of the X graphics functions to draw on an antiquated framebuffer device. CFB is optimized to minimize CPU instructions at the expense of additional memory accesses; this does not work well on modern machines because memory access is the system performance bottle neck. CFB can only be initialized to draw on one depth of framebuffer per instantiation; this was done to eliminate CPU instructions that checked the current framebuffer depth, thus saving processing time on early machines.

Colormap

X Server colormap. Contains a table translating index values to red, green, blue 3-tuples that will be displayed on the screen when a given index value is contained in a bitmap.

D

Device Dependent X Layer

X Server layer that depends on the hardware; but not the operating system.

Device Independent X Layer

X Server layer that does not depend on the hardware layer, nor the operating system.

F

Framebuffer Layer

X Server layer providing implementations of the X graphics functions to draw on a modern framebuffer device. FB is optimized to minimize memory accesses at the expense of additional CPU instructions; this works well on modern machines because memory access is the system performance bottle neck.

G

Graphics Context

X Server graphics context. Stores information describing a graphics operation to perform, such as the foreground and background colors, fill style, stipple, and tile.

git

git is an open source distributed version control system. More information can be found at the git project homepage (http://git.or.cz/).

M

Machine Independent Layer

X Server layer providing user input and graphics display functions that are independent of the machine used by the DDX layer. The MI drawing functions depend on only three DDX functions: `FillSpans`, `GetSpans`, and `SetSpans`.

O

Offscreen Framebuffer

Essentially a *bitmap*, in the Windows sense, of size and color format that can be displayed on the screen. An offscreen framebuffer may be identical in size and color format to the *primary framebuffer*, but this is not always required.

OS Layer

X Server layer that depends on the operating system; but not the hardware.

P

Pixmap

X pixel map with bit depth not equal to one. X pixel maps of bit depth one are called *bitmaps*.

Primary Framebuffer

The block of memory, essentially a *bitmap*, that describes what is currently being displayed on the screen. Any updates to the primary framebuffer will be displayed on the screen after the next screen refresh.

Privates

Additional information associated with internal X Server structures, such as *colormaps*, *GCs*, *pixmaps*, or *screens*.

S

Screen

X Server screen. A screen usually corresponds to a display device; however, Cygwin/X's X Server corresponds each screen to one Windows window. A single instance of the Cygwin/X X Server may have several screens.

Shadow

X Server shadow layer that allows *FB* to draw to an offscreen framebuffer and occasionally call a *DDX* function that transfers the updated regions to the screen.

X

X Display Manager

An X Display Manager presents a graphical login screen to X users. Often an XDM will allow the user to select a desktop environment or window manager to be for their login session. Some X Display Managers are xdm, gdm (Gnome Display Manager), and kdm (KDE Display Manager).

X Display Manager Control Protocol

XDMCP allows XDM to process logins for users remote to the machine that XDM is running on; login sessions will be run on the machine running XDM. For example, at a university you may use XDMCP to login to an X session running on an engineering department computer from your dorm room.

See Also: X Display Manager.

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Version 1.1, March 2000

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