Cygwin User's Guide

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Abstract

Cygwin User’s Guide

Chapter 1

Cygwin Overview

1.1 What is it?

Cygwin is a Linux-like environment for Windows. It consists of a DLL (`cygwin1.dll`), which acts as an emulation layer providing substantial POSIX (Portable Operating System Interface) system call functionality, and a collection of tools, which provide a Linux look and feel. The Cygwin DLL works with all AMD64 versions of Windows NT since Windows Vista/Server 2008. The API follows the Single Unix Specification as much as possible, and then Linux practice. The major differences between Cygwin and Linux is the C library (`newlib` instead of `glibc`).

With Cygwin installed, users have access to many standard UNIX utilities. They can be used from one of the provided shells such as **bash** or from the Windows Command Prompt. Additionally, programmers may write Win32 console or GUI applications that make use of the standard Microsoft Win32 API and/or the Cygwin API. As a result, it is possible to easily port many significant UNIX programs without the need for extensive changes to the source code. This includes configuring and building most of the available GNU software (including the development tools included with the Cygwin distribution).

1.2 Quick Start Guide for those more experienced with Windows

If you are new to the world of UNIX, you may find it difficult to understand at first. This guide is not meant to be comprehensive, so we recommend that you use the many available Internet resources to become acquainted with UNIX basics (search for "UNIX basics" or "UNIX tutorial").

To install a basic Cygwin environment, run the Cygwin Setup program from the Cygwin homepage and click `Next` at each page. The default settings are correct for most users. If you want to know more about what each option means, see Section 2.1. Use the Cygwin Setup program any time you want to update or install a Cygwin package. If you are installing Cygwin for a specific purpose, use it to install the tools that you need. For example, if you want to compile C++ programs, you need the `gcc-g++` package and probably a text editor like `nano`. When running Cygwin Setup, clicking on categories and packages in the package installation screen will provide you with the ability to control what is installed or updated.

After installation, you can find Cygwin-specific documentation in the `/usr/share/doc/Cygwin/` directory.

Developers coming from a Windows background will be able to write console or GUI executables that rely on the Microsoft Win32 API instead of Cygwin using the mingw32 or mingw64 cross-compiler toolchains. The **-shared** option to GCC allows to write Windows Dynamically Linked Libraries (DLLs). The resource compiler **windres** is also provided.

1.3 Quick Start Guide for those more experienced with UNIX

If you are an experienced UNIX user who misses a powerful command-line environment, you will enjoy Cygwin. Developers coming from a UNIX background will find a set of utilities they are already comfortable using, including a working UNIX shell. The compiler tools are the standard GNU compilers most people will have previously used under UNIX, only ported to the

Windows host. Programmers wishing to port UNIX software to Windows NT will find that the Cygwin library provides an easy way to port many UNIX packages, with only minimal source code changes.

Note that there are some workarounds that cause Cygwin to behave differently than most UNIX-like operating systems; these are described in more detail in Section 3.9.

Use the graphical Cygwin Setup program (available from the Cygwin homepage) any time you want to update or install a Cygwin package. This program must be run manually every time you want to check for updated packages since Cygwin does not currently include a mechanism for automatically detecting package updates.

By default, the Cygwin Setup program only installs a minimal subset of packages. Add any other packages by clicking on the + next to the Category name and selecting the package from the displayed list. You may search for specific tools by using the Setup Package Search at the Cygwin web site.

After installation, you can find Cygwin-specific documentation in the `/usr/share/doc/Cygwin/` directory.

For more information about what each option in Cygwin Setup means, see Section 2.1.

1.4 Are the Cygwin tools free software?

Yes. Parts are GNU software (**gcc**, **gas**, **ld**, etc.), parts are covered by the standard X11 license, some of it is public domain, some of it was written by Red Hat and placed under the GNU General Public License (GPL) or GNU Lesser General Public License (LGPL). None of it is shareware. You don't have to pay anyone to use it but you should be sure to read the copyright section of the FAQ for more information on how the GNU GPL may affect your use of these tools.

1.5 A brief history of the Cygwin project

Note
A historical look into the first years of Cygwin development is Geoffrey J. Noer's 1998 paper, "Cygwin32: A Free Win32 Porting Layer for UNIX® Applications" which can be found at the 2nd USENIX Windows NT Symposium Online Proceedings.

Cygwin began development in 1995 at Cygnus Solutions (now part of Red Hat, Inc.). The first thing done was to enhance the development tools (**gcc**, **gdb**, **gas**, etc.) so that they could generate and interpret Win32 native object files. The next task was to port the tools to Win NT/9x. We could have done this by rewriting large portions of the source to work within the context of the Win32 API. But this would have meant spending a huge amount of time on each and every tool. Instead, we took a substantially different approach by writing a shared library (the Cygwin DLL) that adds the necessary UNIX-like functionality missing from the Win32 API (`fork`, `spawn`, `signals`, `select`, `sockets`, etc.). We call this new interface the Cygwin API. Once written, it was possible to build working Win32 tools using UNIX-hosted cross-compilers, linking against this library.

From this point, we pursued the goal of producing Windows-hosted tools capable of rebuilding themselves under Windows 9x and NT (this is often called self-hosting). Since neither OS ships with standard UNIX user tools (fileutils, textutils, bash, etc...), we had to get the GNU equivalents working with the Cygwin API. Many of these tools were previously only built natively so we had to modify their configure scripts to be compatible with cross-compilation. Other than the configuration changes, very few source-level changes had to be made since Cygwin provided a UNIX-like API. Running bash with the development tools and user tools in place, Windows 9x and NT looked like a flavor of UNIX from the perspective of the GNU configure mechanism. Self hosting was achieved as of the beta 17.1 release in October 1996.

The entire Cygwin toolset was available as a monolithic install. In April 2000, the project announced a New Cygwin Net Release which provided a graphical non-Cygwin Setup program to install and upgrade each package separately. Since then, the Cygwin DLL and the Setup tool have seen continuous development.

The biggest major improvement in this development was the 1.7 release in 2009, which dropped Windows 95/98/Me support in favor of using Windows NT features more extensively. It adds a lot of new features like case-sensitive filenames, NFS interoperability, IPv6 support and much more.

The latest big improvement is the 64 bit Cygwin DLL which allows to run natively on AMD64 Windows machines. The first release available in a 64 bit version was 1.7.19.

1.6 Highlights of Cygwin Functionality

1.6.1 Introduction

When a binary linked against the library is executed, the Cygwin DLL is loaded into the application's text segment. Because we are trying to emulate a UNIX kernel which needs access to all processes running under it, the first Cygwin DLL to run creates shared memory areas and global synchronization objects that other processes using separate instances of the DLL can access. This is used to keep track of open file descriptors and to assist fork and exec, among other purposes. Every process also has a per_process structure that contains information such as process id, user id, signal masks, and other similar process-specific information.

The DLL is implemented as a standard DLL in the Win32 subsystem. Under the hood it's using the Win32 API, as well as the native NT API, where appropriate.

Note
Some restrictions apply for calls to the Win32 API. For details, see Section 2.2.2, as well as Section 3.1.8.

The native NT API is used mainly for speed, as well as to access NT capabilities which are useful to implement certain POSIX features, but are hidden to the Win32 API.

Due to some restrictions in Windows, it's not always possible to strictly adhere to existing UNIX standards like POSIX.1. Fortunately these are mostly corner cases.

Note that many of the things that Cygwin does to provide POSIX compatibility do not mesh well with the native Windows API. If you mix POSIX calls with Windows calls in your program it is possible that you will see uneven results. In particular, Cygwin signals will not work with Windows functions which block and Windows functions which accept filenames may be confused by Cygwin's support for long filenames.

1.6.2 Permissions and Security

Windows NT includes a sophisticated security model based on Access Control Lists (ACLs). Cygwin maps Win32 file ownership and permissions to ACLs by default, on file systems supporting them (usually NTFS). Solaris style ACLs and accompanying function calls are also supported. The chmod call maps UNIX-style permissions back to the Win32 equivalents. Because many programs expect to be able to find the `/etc/passwd` and `/etc/group` files, we provide utilities that can be used to construct them from the user and group information provided by the operating system.

Users with Administrator rights are permitted to chown files. With version 1.1.3 Cygwin introduced a mechanism for setting real and effective UIDs. This is described in Section 3.6. As of version 1.5.13, the Cygwin developers are not aware of any feature in the Cygwin DLL that would allow users to gain privileges or to access objects to which they have no rights under Windows. However there is no guarantee that Cygwin is as secure as the Windows it runs on. Cygwin processes share some variables and are thus easier targets of denial of service type of attacks.

1.6.3 File Access

Cygwin supports both POSIX- and Win32-style paths, using either forward or back slashes as the directory delimiter. Paths coming into the DLL are translated from POSIX to native NT as needed. From the application perspective, the file system is a POSIX-compliant one. The implementation details are safely hidden in the Cygwin DLL. UNC pathnames (starting with two slashes) are supported for network paths.

The layout of this POSIX view of the Windows file system space is stored in the `/etc/fstab` file. Actually, there is a system-wide `/etc/fstab` file as well as a user-specific fstab file `/etc/fstab.d/${USER}`.

At startup the DLL has to find out where it can find the `/etc/fstab` file. The mechanism used for this is simple. First it retrieves it's own path, for instance `C:\Cygwin\bin\cygwin1.dll`. From there it deduces that the root path is `C:\Cygwin`. So it looks for the `fstab` file in `C:\Cygwin\etc\fstab`. The layout of this file is very similar to the layout of

the `fstab` file on Linux. Just instead of block devices, the mount points point to Win32 paths. On installation, a default `fstab` file is created, which can easily be changed using the editor of your choice.

The `fstab` file allows mounting arbitrary Win32 paths into the POSIX file system space. A special case is the so-called cygdrive prefix. It's the path under which every available drive in the system is mounted under its drive letter. The default value is `/cygdrive`, so you can access the drives as `/cygdrive/c`, `/cygdrive/d`, etc... The cygdrive prefix can be set to some other value (`/mnt` for instance) in the `fstab` file(s).

The library exports several Cygwin-specific functions that can be used by external programs to convert a path or path list from Win32 to POSIX or vice versa. Shell scripts and Makefiles cannot call these functions directly. Instead, they can do the same path translations by executing the **cygpath** utility program that we provide with Cygwin.

Win32 applications handle filenames in a case preserving, but case insensitive manner. Cygwin supports case sensitivity on file systems supporting that. Windows only supports case sensitivity when a specific registry value is changed. Therefore, case sensitivity is not usually the default.

Cygwin supports creating and reading symbolic links, even on Windows filesystems and OS versions which don't support them. See Section 3.1.6 for details.

Hard links are fully supported on NTFS and NFS file systems. On FAT and other file systems which don't support hardlinks, the call returns with an error, just like on other POSIX systems.

On file systems which don't support unique persistent file IDs (FAT, older Samba shares) the inode number for a file is calculated by hashing its full Win32 path. The inode number generated by the stat call always matches the one returned in `d_ino` of the `dirent` structure. It is worth noting that the number produced by this method is not guaranteed to be unique. However, we have not found this to be a significant problem because of the low probability of generating a duplicate inode number.

Cygwin supports Extended Attributes (EAs) via the linux-specific function calls `getxattr`, `setxattr`, `listxattr`, and `removexattr`. All EAs on Samba or NTFS are treated as user EAs, so, if the name of an EA is "foo" from the Windows perspective, it's transformed into "user.foo" within Cygwin. This allows Linux-compatible EA operations and keeps tools like **attr**, or **setfattr** happy.

`chroot` is supported. Kind of. Chroot is not a concept known by Windows. This implies some serious restrictions. First of all, the `chroot` call isn't a privileged call. Any user may call it. Second, the chroot environment isn't safe against native windows processes. Given that, chroot in Cygwin is only a hack which pretends security where there is none. For that reason the usage of chroot is discouraged. Don't use it unless you really, really know what you're doing.

1.6.4 Text Mode vs. Binary Mode

It is often important that files created by native Windows applications be interoperable with Cygwin applications. For example, a file created by a native Windows text editor should be readable by a Cygwin application, and vice versa.

Unfortunately, UNIX and Win32 have different end-of-line conventions in text files. A UNIX text file will have a single newline character (LF) whereas a Win32 text file will instead use a two character sequence (CR+LF). Consequently, the two character sequence must be translated on the fly by Cygwin into a single character newline when reading in text mode.

This solution addresses the newline interoperability concern at the expense of violating the POSIX requirement that text and binary mode be identical. Consequently, processes that attempt to lseek through text files can no longer rely on the number of bytes read to be an accurate indicator of position within the file. For this reason, Cygwin allows you to choose the mode in which a file is read in several ways.

1.6.5 ANSI C Library

We chose to include Red Hat's own existing ANSI C library "newlib" as part of the library, rather than write all of the lib C and math calls from scratch. Newlib is a BSD-derived ANSI C library, previously only used by cross-compilers for embedded systems development. Other functions, which are not supported by newlib have been added to the Cygwin sources using BSD implementations as much as possible.

The reuse of existing free implementations of such things as the glob, regexp, and getopt libraries saved us considerable effort. In addition, Cygwin uses Doug Lea's free malloc implementation that successfully balances speed and compactness. The library accesses the malloc calls via an exported function pointer. This makes it possible for a Cygwin process to provide its own malloc if it so desires.

1.6.6 Process Creation

The `fork` call in Cygwin is particularly interesting because it does not map well on top of the Win32 API. This makes it very difficult to implement correctly. Currently, the Cygwin fork is a non-copy-on-write implementation similar to what was present in early flavors of UNIX.

As the child process is created as new process, both the main executable and all the dlls loaded either statically or dynamically have to be identical as to when the parent process has started or loaded a dll. While Windows does not allow to remove binaries in use from the file system, they still can be renamed or moved into the recycle bin, as outlined for unlink(2) in Section 1.7.51.2. To allow an existing process to fork, the original binary files need to be available via their original file names, but they may reside in a different directory when using the DotLocal (.local) Dll Redirection feature. Since NTFS does support hardlinks, when the fork fails we try again, but create a private directory containing hardlinks to the original files as well as the `.local` file now. The base directory for the private hardlink directory is `/var/run/cygfork/`, which you have to create manually for now if you need to protect fork against updates to executables and dlls on your Cygwin instance. As hardlinks cannot be used across multiple NTFS file systems, please make sure your executable and dll replacing operations operate on the same single NTFS file system as your Cygwin instance and the `/var/run/cygfork/` directory. Note that this private hardlink directory also does help for when a wrong dll is found in the parent process' current working directory. To enable creating the hardlinks, you need to stop all currently running Cygwin processes after creating this directory, once per Cygwin installation:

```
$ mkdir --mode=a=rwxt /var/run/cygfork
```

We create one hardlink directory per user, application and application age, and remove it when no more processes use that directory. To indicate whether a directory still is in use, we define a mutex name similar to the directory name. As mutexes are destroyed when no process holds a handle open any more, we can clean up even after power loss or similar: Both the parent and child process, at exit they lock the mutex with almost no timeout and close it, to get the closure promoted synchronously. If the lock succeeded before closing, directory cleanup is started: For each directory found, the corresponding mutex is created with lock. If that succeeds, the directory is removed, as it is unused now, and the corresponding mutex handle is closed.

Before fork, when about to create hardlinks for the first time, the mutex is opened and locked with infinite timeout, to wait for the cleanup that may run at the same time. Once locked, the mutex is unlocked immediately, but the mutex handle stays open until exit, and the hardlinks are created. It is fine for multiple processes to concurrently create the same hardlinks, as the result really should be identical. Once the mutex is open, we can create more hardlinks within this one directory without the need to lock the mutex again.

The first thing that happens when a parent process forks a child process is that the parent initializes a space in the Cygwin process table for the child. It then creates a suspended child process using the Win32 CreateProcess call. Next, the parent process calls setjmp to save its own context and sets a pointer to this in a Cygwin shared memory area (shared among all Cygwin tasks). It then fills in the child's .data and .bss sections by copying from its own address space into the suspended child's address space. After the child's address space is initialized, the child is run while the parent waits on a mutex. The child discovers it has been forked and longjumps using the saved jump buffer. The child then sets the mutex the parent is waiting on and blocks on another mutex. This is the signal for the parent to copy its stack and heap into the child, after which it releases the mutex the child is waiting on and returns from the fork call. Finally, the child wakes from blocking on the last mutex, recreates any memory-mapped areas passed to it via the shared area, and returns from fork itself.

While we have some ideas as to how to speed up our fork implementation by reducing the number of context switches between the parent and child process, fork will almost certainly always be inefficient under Win32. Fortunately, in most circumstances the spawn family of calls provided by Cygwin can be substituted for a fork/exec pair with only a little effort. These calls map cleanly on top of the Win32 API. As a result, they are much more efficient. Changing the compiler's driver program to call spawn instead of fork was a trivial change and increased compilation speeds by twenty to thirty percent in our tests.

However, spawn and exec present their own set of difficulties. Because there is no way to do an actual exec under Win32, Cygwin has to invent its own Process IDs (PIDs). As a result, when a process performs multiple exec calls, there will be multiple Windows PIDs associated with a single Cygwin PID. In some cases, stubs of each of these Win32 processes may linger, waiting for their exec'd Cygwin process to exit.

1.6.6.1 Problems with process creation

The semantics of `fork` require that a forked child process have *exactly* the same address space layout as its parent. However, Windows provides no native support for cloning address space between processes and several features actively undermine a reliable `fork` implementation. Three issues are especially prevalent:

- DLL base address collisions. Unlike *nix shared libraries, which use "position-independent code", Windows shared libraries assume a fixed base address. Whenever the hard-wired address ranges of two DLLs collide (which occurs quite often), the Windows loader must "rebase" one of them to a different address. However, it may not resolve collisions consistently, and may rebase a different dll and/or move it to a different address every time. Cygwin can usually compensate for this effect when it involves libraries opened dynamically, but collisions among statically-linked dlls (dependencies known at compile time) are resolved before `cygwin1.dll` initializes and cannot be fixed afterward. This problem can only be solved by removing the base address conflicts which cause the problem, usually using the `rebaseall` tool.
- Address space layout randomization (ASLR). Starting with Vista, Windows implements ASLR, which means that thread stacks, heap, memory-mapped files, and statically-linked dlls are placed at different (random) locations in each process. This behaviour interferes with a proper `fork`, and if an unmovable object (process heap or system dll) ends up at the wrong location, Cygwin can do nothing to compensate (though it will retry a few times automatically).
- DLL injection by BLODA. Badly-behaved applications which inject dlls into other processes often manage to clobber important sections of the child's address space, leading to base address collisions which rebasing cannot fix. The only way to resolve this problem is to remove (usually uninstall) the offending app.

In summary, current Windows implementations make it impossible to implement a perfectly reliable fork, and occasional fork failures are inevitable.

1.6.7 Signals

When a Cygwin process starts, the library starts a secondary thread for use in signal handling. This thread waits for Windows events used to pass signals to the process. When a process notices it has a signal, it scans its signal bitmask and handles the signal in the appropriate fashion.

Several complications in the implementation arise from the fact that the signal handler operates in the same address space as the executing program. The immediate consequence is that Cygwin system functions are interruptible unless special care is taken to avoid this. We go to some lengths to prevent the sig_send function that sends signals from being interrupted. In the case of a process sending a signal to another process, we place a mutex around sig_send such that sig_send will not be interrupted until it has completely finished sending the signal.

In the case of a process sending itself a signal, we use a separate semaphore/event pair instead of the mutex. sig_send starts by resetting the event and incrementing the semaphore that flags the signal handler to process the signal. After the signal is processed, the signal handler signals the event that it is done. This process keeps intraprocess signals synchronous, as required by POSIX.

Most standard UNIX signals are provided. Job control works as expected in shells that support it.

1.6.8 Sockets

Socket-related calls in Cygwin basically call the functions by the same name in Winsock, Microsoft's implementation of Berkeley sockets, but with lots of tweaks. All sockets are non-blocking under the hood to allow to interrupt blocking calls by POSIX signals. Additional bookkeeping is necessary to implement correct socket sharing POSIX semantics and especially for the select call. Some socket-related functions are not implemented at all in Winsock, as, for example, socketpair. Starting with Windows Vista, Microsoft removed the legacy calls `rcmd(3)`, `rexec(3)` and `rresvport(3)`. Recent versions of Cygwin now implement all these calls internally.

An especially troublesome feature of Winsock is that it must be initialized before the first socket function is called. As a result, Cygwin has to perform this initialization on the fly, as soon as the first socket-related function is called by the application. In order to support sockets across fork calls, child processes initialize Winsock if any inherited file descriptor is a socket.

AF_UNIX (AF_LOCAL) sockets are not available in Winsock. They are implemented in Cygwin by using local AF_INET sockets instead. This is completely transparent to the application. Cygwin's implementation also supports the getpeereid BSD extension. However, Cygwin does not yet support descriptor passing.

1.6.9 Select

The UNIX `select` function is another call that does not map cleanly on top of the Win32 API. Much to our dismay, we discovered that the Win32 select in Winsock only worked on socket handles. Our implementation allows select to function normally when given different types of file descriptors (sockets, pipes, handles, and a custom /dev/windows Windows messages pseudo-device).

Upon entry into the select function, the first operation is to sort the file descriptors into the different types. There are then two cases to consider. The simple case is when at least one file descriptor is a type that is always known to be ready (such as a disk file). In that case, select returns immediately as soon as it has polled each of the other types to see if they are ready. The more complex case involves waiting for socket or pipe file descriptors to be ready. This is accomplished by the main thread suspending itself, after starting one thread for each type of file descriptor present. Each thread polls the file descriptors of its respective type with the appropriate Win32 API call. As soon as a thread identifies a ready descriptor, that thread signals the main thread to wake up. This case is now the same as the first one since we know at least one descriptor is ready. So select returns, after polling all of the file descriptors one last time.

1.7 What's new and what changed in Cygwin

1.7.1 What's new and what changed in 3.6

- New API calls: tcgetwinsize, tcsetwinsize.
- New API call: getlocalename_l.
- New API calls: fdclosedir, posix_getdents.
- New API call: setproctitle.
- New API call: timespec_get.
- New API calls: tcgetwinsize, tcsetwinsize.
- New API call: posix_close.
- New POSIX-defined entry points posix_spawn_file_actions_addchdir and posix_spawn_file_actions_addfchdir. These are the same as the already exported posix_spawn_file_actions_addchdir_np and posix_spawn_file_actions_addfchdir_np.
- Add FS_IOC_[GS]ETFLAGS FS_PINNED_FL and FS_UNPINNED_FL flags to handle Windows attributes FILE_ATTRIBUTE_PIN and FILE_ATTRIBUTE_UNPINNED. Add matching 'p' and 'u' mode bits in chattr(1) and lsattr(1).
- New libaio.a provided for projects checking for POSIX aio support by looking for this library at configure time.
- cygpath -r option allows to generate all Windows paths with root-local path prefix \\?\.
- ps -f now prints the commandline rather than the full path to the executable.
- Drop workarounds for connecting with NT4 and Samba < 3.0.22 shares.
- Now that SMBv1 is ultimately deprecated and not installed by default on latest Windows versions, use Network Discovery (i. e. WSD, "Web Service Discovery") for enumerating network servers in //, just like Windows Explorer.
- If "server" is given as FQDN, and if "server" is an NFS server, ls //server now also enumerates NFS shares. If "server" is given as a flat name, only SMB shares are enumerated.
- Expose WebDav shares, //tsclient (Microsoft Terminal Services) shares as well as //wsl$ (Plan 9 Network Provider) shares, i. e., WSL installation root dirs.
- Redesign pipe handling to minimize toggling blocking mode. The query_hdl stuff is no longer needed in new implementation.
- Now using AVX/AVX2/AVX-512 instructions in signal handler does not break their context.

- nice(2), setpriority(2) and sched_setparam(2) now fail with EACCES or EPERM if Windows would silently set a lower priority (HIGH_PRIORITY_CLASS instead of REALTIME_PRIORITY_CLASS) due to missing administrator privileges.
- nice(2) now returns the new nice value instead of 0 on success and sets errno to EPERM instead of EACCES on failure. This confirms to POSIX and Linux (glibc >= 2.2.4) behavior.
- sched_setscheduler(2) now emulates changes between SCHED_OTHER, SCHED_BATCH, SCHED_IDLE, SCHED_FIFO and SCHED_RR. If SCHED_OTHER or SCHED_BATCH is selected, the Windows priority is set according to the nice value where SCHED_BATCH sets a one step lower priority. If SCHED_IDLE is selected, the nice value is preserved and the Windows priority is set to IDLE_PRIORITY_CLASS. If SCHED_FIFO or SCHED_RR is selected, the nice value is preserved and the Windows priority is set according to the realtime priority. If the SCHED_RESET_ON_FORK flag is set, SCHED_FIFO and SCHED_RR are reset to SCHED_OTHER and negative nice values are reset to zero in each child process created with fork(2). Note: Windows does not offer alternative scheduling policies so this could only emulate API behavior.
- If SCHED_FIFO or SCHED_RR is selected, the /proc/<PID>/stat field '(18) priority' is now set to the negated sched_policy minus one. If SCHED_IDLE is selected, this field is set to 39. The '(19) nice' field is now set to the originally requested nice value.
- Raise maximum pid from 65536 to 4194304 to account for scenarios with lots of CPUs and lots of tasks.
- Allow mmap with MAP_FIXED to succeed on an address range contained in the chunk of an existing anonymous mapping, provided the MAP_SHARED/MAP_PRIVATE flags agree and MAP_NORESERVE is not set for either mapping.
- Fix a long-standing hang issue when running on ARM64 under emulation. This was due to a thread being terminated while the emulation was holding an internal lock.
- Add a host machine tag to uname(2)'s sysname field. This echoes what used to be done with -WOW64 (when that was supported), but now with -ARM64 when running on an ARM64 host under emulation. The Cygwin DLL's own architecture continues to be reported in the machine field.
- Escape special characters in /proc/<PID>/mount*. This allows the contents to be parsed consistently, and matches what is done on Linux.
- Expose all Windows volume mount points via getmntent(3). This also exposes them via /proc/>PID>/mount*. A change in behavior from previous Cygwin versions is that volumes whose root is mounted explicitly in Cygwin will now also show up as mounted under the cygdrive prefix, whereas before that entry would have been suppressed.

1.7.2 What's new and what changed in 3.5

- Drop support for Windows 7, Windows 8, Server 2008 R2 and Server 2012.
- Console devices (/dev/consN) are now accessible by processes attached to other consoles or ptys. Thanks to this new feature, GNU screen and tmux now work in the console.
- newgrp(1) tool.
- cygcheck has new options searching for available packages in the cygwin distro, as well as getting extended info on available and installed packages.
- fnmatch(3) and glob(3) now support named character classes, equivalence class expressions, and collating symbols in the search pattern, i.e., [:alnum:], [=a=], [.aa.].
- Introduce /dev/disk directory with various by-* subdirectories which provide symlinks to disk and partition raw devices:

```
by-drive/DRIVE_LETTER ->  ../../sdXN
by-label/VOLUME_LABEL ->  ../../sdXN
by-id/BUSTYPE-[VENDOR_]PRODUCT_[SERIAL|0xHASH][-partN] -> ../../sdX[N]
by-partuuid/MBR_SERIAL-OFFSET -> ../../sdXN
by-partuuid/GPT_GUID -> ../../sdXN
by-uuid/VOLUME_SERIAL -> ../../sdXN
by-voluuid/MBR_SERIAL-OFFSET -> ../../sdXN
by-voluuid/VOLUME_GUID -> ../../sdXN
```

The subdirectories by-drive and by-voluuid are Cygwin specific.

- Introduce /proc/codesets and /proc/locales with information on supported codesets and locales for all interested parties. Locale(1) opens these files and uses the info for printing locale info like any other process could do.
- Add support for GB18030 codeset.
- Add support for lseek flags SEEK_DATA and SEEK_HOLE, a GNU extension.
- New API calls: posix_spawn_file_actions_addchdir_np, posix_spawn_file_actions_addfchdir_np.
- New API calls: c8rtomb, c16rtomb, c32rtomb, mbrtoc8, mbrtoc16, mbrtoc32.
- New API call: close_range (available on FreeBSD and Linux).
- New API call: fallocate (Linux-specific).
- posix_spawnp no longer falls back to starting the shell for unrecognized files as execvp. For the reasoning, see https://www.austingroup
- FIFOs now also work on NFS filesystems.
- Enable automatic sparsifying of files on SSDs, independent of the "sparse" mount mode.
- When RLIMIT_CORE is more than 1MB, a core dump file which can be loaded by gdb is now written on a fatal error. Otherwise, if it's greater than zero, a text format .stackdump file is written, as previously.
- The default RLIMIT_CORE is now 0, disabling the generation of core dump or stackdump files. Use e.g. `ulimit -c unlimited` or `ulimit -c 1024` to enable them again.

1.7.3 What's new and what changed in 3.4

- Drop support for Vista and Server 2008.
- Drop support for 32 bit Windows and WOW64.
- Allow to run with full ASLR enabled and enable on Cygwin DLL by default.
- Remove any special handling for the .com filename suffix. It has to be used always explicitely.
- Add code to handle setrlimit(RLIMIT_AS).
- Add code to handle signal masks in /proc/<PID>/status.
- The CYGWIN=pipe_byte option is now set by default, so that pipes are opened in byte mode rather than message mode.
- Handle UDP_SEGMENT and UDP_GRO socket options.
- The stdio input functions no longer try again to read after EOF.
- The default values of FD_SETSIZE and NOFILE are now 1024 and 3200, respectively.

1.7.4 What's new and what changed in 3.3

- An IP-sampling profiler named 'profiler' has been added. It can be used to profile any Cygwin program along with any DLLs loaded.
- A new tool 'gmondump' has been added. It can dump the raw information of any "gmon.out" file created by profiler, ssp, or use of the gcc/g++ option '-pg'. (Continue using gprof to get symbolic profile displays.)
- New GNU-specific APIs, slated to become part of the next POSIX standard: pthread_cond_clockwait, pthread_mutex_clocklock, pthread_rwlock_clockrdlock, pthread_rwlock_clockwrlock, sem_clockwait.
- New Solaris-specific APIs, slated to become part of the next POSIX standard: sig2str, str2sig.
- The speed argument to cfsetspeed(3) can now be a numerical baud rate rather than a Bnnn constant, as on Linux.
- The internal implementation of pipes has been overhauled; this should result in improved performance.

1.7.5 What's new and what changed in 3.2

- Revamped pseudo console support. Conditionally activating it only when a non-cygwin application is run.
- New C11 threads API: call_once, cnd_broadcast, cnd_destroy, cnd_init, cnd_signal, cnd_timedwait, cnd_wait, mtx_destroy, mtx_init, mtx_lock, mtx_timedlock, mtx_trylock, mtx_unlock, thrd_create, thrd_current, thrd_detach, thrd_equal, thrd_exit, thrd_join, thrd_sleep, thrd_yield, tss_create, tss_delete, tss_get, tss_set.
- In cygwin console, new thread which handles special keys/signals such as Ctrl-Z (VSUSP), Ctrl-\ (VQUIT), Ctrl-S (VSTOP), Ctrl-Q (VSTART) and SIGWINCH has been introduced. There have been a long standing issue that these keys/signals are handled only when app calls read() or select(). Now, these work even if app does not call read() or select().
- Allow ~5000 child processes per process on 64 bit, ~1200 child processes per process on 32 bit. So far, only 256 child processes per process were supported.
- A few FAQ updates.
- Have tmpfile(3) make use of Win32 FILE_ATTRIBUTE_TEMPORARY via open(2) flag O_TMPFILE.
- Utilize Windows 10 1809 FILE_DISPOSITION_IGNORE_READONLY_ATTRIBUTE flag to allow simpler unlink of files with DOS readonly flags set.
- fchmodat(2) now has limited support for the AT_SYMLINK_NOFOLLOW flag.
- getdtablesize(3), sysconf(_SC_OPEN_MAX), and getrlimit(RLIMIT_NOFILE) now return the true limit on the number of open descriptors, 3200. Previously they returned the current size of Cygwin's internal file descriptor table, which can grow dynamically.
- Cygwin now recognizes native Windows AF_UNIX sockets (as regular files, not as socket files). This allows tools like 'ls' and 'rm' to work.
- facl(2) now fails with EBADF on a file opened with O_PATH.
- Allow to start Windows Store executables via their "app execution aliases". Handle these aliases (which are special reparse points) as symlinks to the actual executables.
- The speed argument to cfsetspeed(3) can now be a numerical baud rate rather than a Bnnn constant, as on Linux.

1.7.6 What's new and what changed in 3.1

- FIFOs can now be opened multiple times for writing.
- Add 24 bit color support using xterm compatibility mode in Windows 10 1703 or later. Add fake 24 bit color support for legacy console, which uses the nearest color from 16 system colors.
- Support pseudo console in PTY. Pseudo console is a new feature in Windows 10 1809, which provides console APIs on virtual terminal. With this patch, native console applications can work in PTYs such as mintty, ssh, gnu screen or tmux.
- Eliminate a header file name collision with <X11/XLocale.h> on case insensitive filesystems by reverting <xlocale.h> back to <sys/_locale.h>.
- If a SA_SIGINFO signal handler changes the ucontext_t pointed to by the third parameter, follow it after returning from the handler.
- New APIs: sched_getaffinity, sched_setaffinity, pthread_getaffinity_np, pthread_setaffinity_np, plus CPU_SET macros.
- New APIs: dbm_clearerr, dbm_close, dbm_delete, dbm_dirfno, dbm_error, dbm_fetch, dbm_firstkey, dbm_nextkey, dbm_open, dbm_store.
- Allow times(2) to have a NULL argument, as on Linux.
- Improve /proc/cpuinfo output and align more closely with Linux.

- Allow symlinks to be opened with O_PATH | O_NOFOLLOW.
- Allow the pathname argument to readlinkat(2) to be an empty string, provided the dirfd argument refers to a symlink opened with O_PATH | O_NOFOLLOW. The readlinkat call then operates on that symlink.
- Support the Linux-specific AT_EMPTY_PATH flag for fchownat(2) and fstatat(2).
- Allow AF_LOCAL sockets to be opened with O_PATH. If that flag is not set, or if an attempt is made to open a different type of socket, the errno is now EOPNOTSUPP instead of ENXIO.
- The new locale modifier @cjksingle allows enforcing of single-width character property for usually double-widthed characters. This will be supported by upcoming mintty releases. For the reasoning, see https://gitlab.freedesktop.org/terminal-wg/specifications/issues/9.
- Support WSL symlinks. Create those by default now.
- FIFOs can now be opened multiple times for reading.
- Support more IPPROTO_TCP socket options: TCP_FASTOPEN, TCP_KEEPIDLE, TCP_KEEPCNT, TCP_KEEPINTVL, TCP_QUICKACK, TCP_USER_TIMEOUT.

1.7.7 What's new and what changed in 3.0

- Updated era and message locale data, in particular add era data for the new Tennō.
- Support for CLOCK_REALTIME_COARSE, CLOCK_MONOTONIC_COARSE, CLOCK_MONOTONIC_RAW, CLOCK_BOOTT CLOCK_REALTIME_ALARM, CLOCK_BOOTTIME_ALARM clocks.
- Support for case sensitive directories via chattr(1). This feature requires Windows 10 1803 or later and WSL installed.
- New file ioctls's FS_IOC_GETFLAGS and FS_IOC_SETFLAGS. The actual inode flags are Cygwin-specific. This allows to set or reset DOS attributes, file sparseness, FS level encryption and compression, as well as directory case sensitivity programatically.
- New tools chattr(1) and lsattr(1) to utilize setting and viewing the aforementioned new ioctl's on the command line.
- Support for exFAT.
- Support Linux-specific open(2) flag O_PATH.
- Support Linux-specific linkat(2) flag AT_EMPTY_PATH.
- Support overrun counter for posix timers (via timer_getoverrun() or siginfo_t::si_overrun).
- New APIs: secure_getenv, signalfd, timerfd_create, timerfd_gettime, timerfd_settime, timer_getoverrun.
- clock_nanosleep, pthread_condattr_setclock and timer_create now support all clocks, except CLOCK_PROCESS_CPUTIME_ID and CLOCK_THREAD_CPUTIME_ID.
- clock_setres is a no-op now.
- Use the new POSIX unlink semantics on NTFS starting with Windows 10 1709. Deleting an in-use file now actually removes the file, rather than moving it to the recycler bin.
- Use the new POSIX rename semantics on NTFS starting with Windows 10 1809. Renaming a file to another in-use file now actually removes the other file, rather than moving it to the recycler bin.
- open(..., O_TMPFILE) now moves the file to the trash bin immediately, to free the parent directory.
- Wctype functions updated to Unicode 11.0.
- Remove matherr, and SVID and X/Open math library configurations. Default math library configuration is now IEEE.
- Improve uname(2) for newly built applications.

- Kerberos/MSV1_0 S4U authentication replaces two old methods: Creating a token from scratch and Cygwin LSA authentication package.
- Cygwin PIDs have been decoupled from Windows PID. Cygwin PIDs are now incrementally dealt in the range from 2 up to 65535, POSIX-like. Native Windows processes not started by Cygwin processes are mapped into the range beyond 65535.
- fork(2) now is able to recover from when an in-use executable/dll is removed or replaced during process runtime. This feature is disabled by default and limited to exes/dlls on the same NTFS partition as the Cygwin installation. For more information and how to enable, please refer to Section 1.6.6.
- Improve /proc/<PID>/cmdline and /proc/<PID>/stat handling to allow all processes access to basic process information of foreign processes.

1.7.8 What's new and what changed in 2.11

- SO_RCVTIMEO and SO_SNDTIMEO socket options are now honored.
- /proc/cpuinfo now reports L3 cache size on Intel CPUs.
- New APIs: clearenv, pthread_tryjoin_np, pthread_timedjoin_np, sched_getcpu.
- New APIs for POSIX Asynchronous I/O: aio_cancel, aio_error, aio_fsync, aio_read, aio_return, aio_suspend, aio_write, lio_listio. New Header: <aio.h>.
- Drop denormal-operand exception from FE_ALL_EXCEPT, as on Linux.
- Rename the --file option of setfacl(1) to --set-file, as on Linux.
- Support Unicode 10.
- Following glibc, `union wait' has now been removed. Applications using union wait and these macros will have to migrate to the POSIX-specified int status type.

1.7.9 What's new and what changed in 2.10

- New open(2) flags O_TMPFILE and O_NOATIME.
- scanf/wscanf now handle the POSIX %m modifier.
- scanf now handles the %l[conversion.
- Improved hostprogs compatibility for cross-compiling the Linux kernel. New headers: <asm/bitsperlong.h>, <asm/posix_types.h>.
- Built-in implementation of Stack Smashing Protection compiler feature. New APIs: __stack_chk_fail, __stack_chk_guard.
- Built-in implementation of _FORTIFY_SOURCE guards for functions in <stdio.h>, <stdlib.h>, <string.h>, <strings.h>, <unistd.h>, <wchar.h>, <sys/poll.h>, and <sys/socket.h>. New APIs: __chk_fail, __gets_chk, __memcpy_chk, __memmove_chk, __mempcpy_chk, __memset_chk, __snprintf_chk, __sprintf_chk, __stpcpy_chk, __stpncpy_chk, __strcat_chk, __strcpy_chk, __strncat_chk, __strncpy_chk, __vsnprintf_chk, __vsprintf_chk.
- Built-in implementation of POSIX.1-2001 message catalog support. New APIs: catclose, catgets, catopen. New tool: gencat.
- New APIs: sigtimedwait, wmempcpy.

1.7.10 What's new and what changed in 2.9

- New APIs: explicit_bzero, strnstr.
- New APIs: pthread_mutex_timedwait, pthread_rwlock_timedrdlock, pthread_rwlock_timedwrlock.
- New API: renameat2.
- Improved implementation of <elf.h>.
- strptime(3) supports %s (seconds since Epoch) now, analogue to strftime.

1.7.11 What's new and what changed in 2.8

- New API: timingsafe_bcmp, timingsafe_memcmp
- New API: dladdr
- New API: getloadavg
- Cygcheck and strace now always generate output with Unix LF line endings, rather than with DOS/Windows CR LF line endings.
- Fork now preserves the load order of unrelated dlopen'd modules.
- Pthread_cond_wait now acts like Linux and BSD: Resume waiting for the condition variable as if it was not interrupted, rather than returning 0.
- The internal <sys/_locale.h> header was renamed to <xlocale.h> for source compatibility with other systems.
- Try harder supporting Netapp drives.

1.7.12 What's new and what changed in 2.7

- Support for /proc/<PID>/environ.
- New API: getentropy, getrandom.

1.7.13 What's new and what changed in 2.6

- Support for POSIX-1.2008 locale objects and per-thread locales.

  New API per POSIX-1.2008: newlocale, freelocale, duplocale, uselocale, nl_langinfo_l, isalnum_l, isalpha_l, isblank_l, iscntrl_l, isdigit_l, isgraph_l, islower_l, isprint_l, ispunct_l, isspace_l, isupper_l, iswalnum_l, iswalpha_l, iswblank_l, iswcntrl_l, iswctype_l, iswdigit_l, iswgraph_l, iswlower_l, iswprint_l, iswpunct_l, iswspace_l, iswupper_l, iswxdigit_l, isxdigit_l, tolower_l, toupper_l, towctrans_l, towlower_l, towupper_l, wctrans_l, wctype_l, strcasecmp_l, strcoll_l, strerror_l, strfmon_l, strftime_l, strncasecmp_l, strxfrm_l, wcscasecmp_l, wcscoll_l, wcstrncasecmp_l, wcstrxfrm_l.

  New API, GNU extensions: isascii_l, toascii_l, strptime_l, strtod_l, strtof_l, strtol_l, strtold_l, strtoll_l, strtoul_l, strtoull_l, wcsftime_l, wcstod_l, wcstof_l, wcstol_l, wcstold_l, wcstoll_l, wcstoul_l, wcstoull_l.
- locale(1) now supports a -i/--input option to fetch the current input locale (this is basically equivalent to the current keyboard layout setting).
- Drop support for Windows XP and Windows Server 2003/2003 R2.
- Drop support for very old SUNWNFS filesystem.
- Raise number of supported partitions per disk (for raw access) to 63.
- Further header file improvements in terms of feature test macros.
- Add a workaround for filesystems not supporting the FileAllInformation info class.
- Support AzureAD accounts.
- "nobody" account support for WinFSP.
- New API: pthread_getname_np, pthread_setname_np.

1.7.14 What's new and what changed in 2.5

- Full set of POSIX.1e ACL API functions now implemented. New APIs: acl_add_perm, acl_calc_mask, acl_clear_perms, acl_copy_entry, acl_copy_ext, acl_copy_int, acl_create_entry, acl_delete_def_file, acl_delete_entry, acl_delete_perm, acl_dup, acl_free, acl_from_text, acl_get_entry, acl_get_fd, acl_get_file, acl_get_permset, acl_get_qualifier, acl_get_tag_type, acl_init, acl_set_fd, acl_set_file, acl_set_permset, acl_set_qualifier, acl_set_tag_type, acl_size, acl_to_text, acl_valid.
- Most libacl extensions now implemented, too: New APIs: acl_check, acl_cmp, acl_entries, acl_equiv_mode, acl_error, acl_extended_fd, acl_extended_file, acl_extended_file_nofollow, acl_from_mode, acl_get_perm, acl_to_any_text.
- Including <sys/acl.h> now *only* includes the POSIX ACL API. To include the old Solaris API, include <cygwin/acl.h>.
- First implementation of pthread_barrier/pthread_barrierattr functions. New APIs: pthread_barrierattr_init, pthread_barrierattr_setpsha pthread_barrierattr_getpshared, pthread_barrierattr_destroy, pthread_barrier_init, pthread_barrier_destroy, pthread_barrier_wait.
- Enabled console reports requested by escape sequences: Requesting primary and secondary device attributes, requesting cursor position report; see https://cygwin.com/ml/cygwin-patches/2012-q3/msg00019.html
- New APIs: clog10, clog10f, nexttoward, nexttowardf, nexttowardl.
- Add missing long double functions. New APIs: acoshl, acosl, asinhl, asinl, atan2l, atanhl, atanl, cacoshl, cacosl, cargl, casinhl, casinl, catanhl, catanl, ccoshl, ccosl, ceill, cexpl, clog10l, clogl, conjl, copysignl, coshl, cosl, cpowl, cprojl, csinhl, csinl, csqrtl, ctanhl, ctanl, dreml, erfcl, erfl, exp10l, exp2l, expl, expm1l, fabsl, fdiml, floorl, fmal, fmaxl, fminl, fmodl, frexpl, ilogbl, isinfl, isnanl, ldexpl, lgammal, lgammal_r, llroundl, log10l, log1pl, log2l, logbl, logl, lroundl, modfl, nearbyintl, nextafterl, pow10l, powl, remainderl, remquol, roundl, scalbl, scalblnl, scalbnl, sincosl, sinhl, sinl, tanhl, tanl, tgammal, truncl.
- In calls to chmod treat ACLs with extra ACEs *only* for Admins and SYSTEM like a trivial ACL.
- Bump POSIX option macros to POSIX.1-2008.
- Profiling data, specifically pc sampling, now covers all threads of a program and not just the main thread. Environment variable GMON_OUT_PREFIX enables multiple gmon.out files to preserve profiling data after fork or from multiple program runs.
- Feature test macros, which control which symbols are exposed in the standard headers, have been completely overhauled for compatibility with glibc.
- The isinf, isinff, and isinfl functions are signed, returning -1 for negative infinity for compatibility with glibc.

1.7.15 What's new and what changed in 2.4

- New, unified implementation of POSIX permission and ACL handling. The new ACLs now store the POSIX ACL MASK/-CLASS_OBJ permission mask, and they allow to inherit the S_ISGID bit. ACL inheritance now really works as desired, in a limited, but theoretically equivalent fashion even for non-Cygwin processes.

  To accommodate standard Windows ACLs, the POSIX permissions of the owner and all other users in the ACL are computed using the Windows AuthZ API. This may slow down the computation of POSIX permissions noticably in some circumstances, but is generally more correct. The new code also ignores SYSTEM and Administrators group permissions when computing the MASK/CLASS_OBJ permission mask on old ACLs, and it doesn't deny access to SYSTEM and Administrators group based on the value of MASK/CLASS_OBJ when creating the new ACLs.

  The new code now handles the S_ISGID bit on directories as on Linux: Setting S_ISGID on a directory causes new files and subdirs created within to inherit its group, rather than the primary group of the user who created the file. This only works for files and directories created by Cygwin processes.
- cygpath has a new -U option, which creates cygdrive paths using the unambiguous /proc/cygdrive prefix.
- New API: rpmatch.
- Align setfacl(1) usage a bit closer to the usage on Linux. Rename -d option to -x, --substitute to --set. Add --no-mask and --mask options. Allow to use the -b and -k option combined to allow reducing an ACL to only reflect standard POSIX permissions.
- Fix (numeric and monetary) decimal point and thousands separator in fa_IR and ps_AF locales to be aligned with Linux.
- utmpname/utmpxname are now defined as int functions as on Linux.

1.7.16 What's new and what changed in 2.3

- strftime(3) supports %s (seconds since Epoch) now.
- posix_madvise(POSIX_MADV_WILLNEED) now utilizes OS functionality available starting with Windows 8/Server 2012.
  posix_madvise(POSIX_MADV_DONTNEED) now utilizes OS functionality available starting with Windows 8.1/Server 2012R2.
- sysconf() now supports returning CPU cache information:

```
_SC_LEVEL1_ICACHE_SIZE, _SC_LEVEL1_ICACHE_ASSOC, _SC_LEVEL1_ICACHE_LINESIZE,
_SC_LEVEL1_DCACHE_SIZE, _SC_LEVEL1_DCACHE_ASSOC, _SC_LEVEL1_DCACHE_LINESIZE,
_SC_LEVEL2_CACHE_SIZE, _SC_LEVEL2_CACHE_ASSOC, _SC_LEVEL2_CACHE_LINESIZE,
_SC_LEVEL3_CACHE_SIZE, _SC_LEVEL3_CACHE_ASSOC, _SC_LEVEL3_CACHE_LINESIZE,
_SC_LEVEL4_CACHE_SIZE, _SC_LEVEL4_CACHE_ASSOC, _SC_LEVEL4_CACHE_LINESIZE
```

- New API: aligned_alloc, at_quick_exit, quick_exit.
- Add support for Parallels Desktop FS (prlfs).

1.7.17 What's new and what changed in 2.2

- New APIs: getcontext, setcontext, makecontext, swapcontext.
- New functions: sigsetjmp, siglongjmp.
  These were only available as macros up to now, but POSIX requires that siglongjmp has to be available as function.

1.7.18 What's new and what changed in 2.1

- Handle pthread stacksizes as in GLibc: Default to RLIMIT_STACK resource. Allow to set RLIMIT_STACK via setrlimit. Default RLIMIT_STACK to value from executable header as described on the MSDN website Thread Stack Size Default stacksize to 2 Megs in case RLIMIT_STACK is set to RLIM_INFINITY.
- First cut of an implementation to allow signal handlers running on an alternate signal stack.
- New API sigaltstack, plus definitions for SA_ONSTACK, SS_ONSTACK, SS_DISABLE, MINSIGSTKSZ, SIGSTKSZ.
- New API: sethostname.

1.7.19 What's new and what changed in 2.0

- basename(3) now comes in two flavors, POSIX and GNU. The POSIX version is the default. You get the GNU version after

```
#define _GNU_SOURCE
#include <string.h>
```

1.7.20 What's new and what changed in 1.7.35

- Performance improvements of the new account DB handling.
- Since 1.7.34, chmod does not always affect the POSIX permission mask as returned by stat(2) or printed by ls(1), due to the improved POSIX ACL handling. However, that's still far from perfect, so, as a temporary workaround, chmod now checks if secondary groups and users in the ACL have more permissions than the primary group. If so, the permissions of the secondary users and groups will be reduced according to the mask given by the new primary group permissions. I.e, chmod 600 will remove all permissions from the primary group as well as all secondary user and group entries in the ACL.
- Change handling of group permissions if owner SID == group SID. Now the group permissions don't mirror the user permissions anymore, thus leading to less hassle with security-conscious applications.

- Allow group SID to be the same as owner SID for "Microsoft Accounts". Those have the group in their user token set to the owner SID by default. Drop the workaround to change their primary group to "Users". It's not required anymore due to the aforementioned changes.
- Change getfacl long options from --all to --access and from --dir to --default, along the lines of the Linux getfacl tool.
- Don't raise a SIGSYS signal in the XSI IPC functions if cygserver is not running. Just return -1 with errno set to ENOSYS.
- New APIs: cabsl, cimagl, creall, finitel, hypotl, sqrtl.
- New API: issetugid.

1.7.21 What's new and what changed in 1.7.34

- Cygwin can now generate passwd/group entries directly from Windows user databases (local SAM or Active Directory), thus allowing to run Cygwin without having to create /etc/passwd and /etc/group files. Introduce /etc/nsswitch.conf file to configure passwd/group handling.

  For bordercase which require to use /etc/passwd and /etc/group files, change mkpasswd/mkgroup to generate passwd/group entries compatible with the entries read from SAM/AD.

  For a description of this exciting new feature see Section 3.6.
- Add -b/--remove-all option to setfacl to reduce the ACL to only the entries representing POSIX permission bits.
- Add -k/--remove-default option to setfacl to remove all default ACL entries from an ACL.
- Add restore action to regtool.
- Make gethostbyname2 handle numeric host addresses as well as the reserved domain names "localhost" and "invalid" per RFC 6761.
- Revamp Solaris ACL implementation to more closely work like POSIX ACLs are supposed to work. Finally implement a CLASS_OBJ emulation. Update getfacl(1)/setfacl(1) accordingly.
- The xdr functions are no longer exported for newly built executables. Use libtirpc-devel instead.
- 32 bit only: Change default values for socket buffer size to raise performance on 10Gb networks.
- When spawning a process under another user account, merge the user's default Windows environment into the new process' environment.
- New APIs: qsort_r, __bsd_qsort_r.
- New API: wcstold.
- New APIs: __fbufsize, __flbf, __fpending, __freadable, __freading, __fsetlocking, __fwritable, __fwriting.
- New APIs: clearerr_unlocked, feof_unlocked, ferror_unlocked, fflush_unlocked, fgetc_unlocked, fgets_unlocked, fgetwc_unlocked, fgetws_unlocked, fileno_unlocked, fputc_unlocked, fputs_unlocked, fputwc_unlocked, fputws_unlocked, fread_unlocked, fwrite_unlo getwc_unlocked, getwchar_unlocked, putwc_unlocked, putwchar_unlocked.
- New API: sockatmark.

1.7.22 What's new and what changed in 1.7.33

- /proc/cygdrive is a new symlink pointing to the current cygdrive prefix. This can be utilized in scripts to access paths via cygdrive prefix, even if the cygdrive prefix has been changed by the user.
- /proc/partitions now prints the windows mount points the device is mounted on. This allows to recognize the underlying Windows devices of the Cygwin raw device names.
- New API: quotactl, designed after the Linux/BSD function, but severely restricted: Windows only supports user block quotas on NTFS, no group quotas, no inode quotas, no time constraints.

- New APIs: ffsl, ffsll (glibc extensions).
- New API: stime (SVr4).
- Provide Cygwin documentation (PDFs and HTML) for offline usage in `/usr/share/doc/cygwin-${version}`.
- New internal exception handling based on SEH on 64 bit Cygwin.
- When exec'ing applications, check if $PATH exists and is non-empty. If not, add PATH variable with Cygwin installation directory as content to Windows environment to allow loading of Cygwin system DLLs.
- Disable CYGWIN "dosfilewarning" option by default.
- Improve various header files for C++- and standards-compliance.
- Doug Lea malloc implementation update from 2.8.3 to the latest 2.8.6.
- atexit(3) is now exported as statically linked function from libcygwin.a. This allows reliable access to the DSO handle of the caller for newly built executables. The former atexit entry point into the DLL remains for backward compatibility only.

1.7.23 What's new and what changed in 1.7.32

- Export __cxa_atexit and __cxa_finalize to allow C++ standards-compliant destructor handling in libstdc++ and g++ compiled code. Please note that, in order to benefit from this new feature, C++ code must be recompiled with the upcoming gcc 4.8.3-3 release which will enable the -fuse-cxa-atexit flag by default, and that C++ applications using this feature will not run on older Cygwin releases.
- Support more recent CPU flags in /proc/cpuinfo.

1.7.24 What's new and what changed in 1.7.31

- Improve performance of send(2), sendto(2), sendmsg(2) when using small input buffers.
- The default pthread_mutex type is now PTHREAD_MUTEX_NORMAL, rather than PTHREAD_MUTEX_ERRORCHECK, just as on Linux.
- Align pthread_attr stack functions more closely to Linux.
- Mark pthread_attr_getstackaddr and pthread_attr_setstackaddr as deprecated, as on Linux.

1.7.25 What's new and what changed in 1.7.29

- Allow quoting of arguments to the CYGWIN environment variable, i.e., set CYGWIN=error_start="c:\bin\someprogram -T"
- Console screen clearing works more like xterm or mintty.

1.7.26 What's new and what changed in 1.7.28

- popen now supports the Glibc 'e' flag to set the FD_CLOEXEC flag on the pipe in a thread-safe way.
- New netinet/ip6.h header.
- Switch to BSD FILE stream fopen/exit semantics, as in all BSD variants and Linux/GLibc: Don't fflush/lseek a FILE stream on fclose and exit, if it only has been read from.

1.7.27 What's new and what changed in 1.7.27

- Don't create native symlinks with target paths having long path prefixes "\\?\" if the target path is shorter than MAX_PATH characters. This works around a Windows 8.1 bug: The ShellExecuteW fails if the lpFile parameter points to a native NTFS symlink with a target path prefixed with "\\?\".

1.7.28 What's new and what changed in 1.7.26

- getaddrinfo now supports glibc-specific International Domain Name (IDN) extension flags: AI_IDN, AI_CANONIDN, AI_IDN_ALL
  AI_IDN_USE_STD3_ASCII_RULES.
- getnameinfo now supports glibc-specific International Domain Name (IDN) extension flags: NI_IDN, NI_IDN_ALLOW_UNASSIGN
  NI_IDN_USE_STD3_ASCII_RULES.
- Slightly improve randomness of /dev/random emulation.
- Allow to use advisory locking on any device. POSIX fcntl and lockf locking works with any device, BSD flock locking only with devices backed by an OS handle. Right now this excludes console windows on pre Windows 8, as well as almost all virtual files under /proc from BSD flock locking.
- The header /usr/include/exceptions.h, containing implementation details for 32 bit Windows' exception handling only, has been removed.
- Preliminary, experimental support of the posix_spawn family of functions. New associated header /usr/include/spawn.h.

1.7.29 What's new and what changed in 1.7.25

- Change magic number associated with process information block so that 32-bit Cygwin processes don't try to interpret 64-bit information and vice-versa.
- Redefine content of mtget tape info struct to allow fetching the number of partitions on a tape.

1.7.30 What's new and what changed in 1.7.24

- Allow application override of posix_memalign.

1.7.31 What's new and what changed in 1.7.23

- Added CYGWIN environment variable keyword "wincmdln" which causes Cygwin to send the full windows command line to any subprocesses.

1.7.32 What's new and what changed in 1.7.22

- Support for /dev/mem, /dev/kmem and /dev/port removed, since OS support was limited to 32 bit Windows XP only.
- Added cygwin GetCommandLine wrappers which will allow Cygwin programs to (appear to) use the Windows command line functions.
- regcomp(3) now allows character values >= 0x80 if the current codeset is ASCII (default codeset in the "C"/"POSIX" locale). This allows patterns containing arbitrary byte values as GLibc's regcomp.

1.7.33 What's new and what changed in 1.7.21

- New API: rawmemchr.

1.7.34 What's new and what changed in 1.7.19

- Drop support for Windows 2000 and Windows XP pre-SP3.
- Add support for building a 64 bit version of Cygwin on x86_64 natively.
- Add support for creating native NTFS symlinks starting with Windows Vista by setting the CYGWIN=winsymlinks:native or CYGWIN=winsymlinks:nativestrict option.
- Add support for AFS filesystem.
- Preliminary support for mandatory locking via fcntl/flock/lockf, using Windows locking semantics. New F_LCK_MANDATORY fcntl command.
- New APIs: __b64_ntop, __b64_pton, arc4random, arc4random_addrandom, arc4random_buf, arc4random_stir, arc4random_uniform.

1.7.35 What's new and what changed in 1.7.18

- Added Windows console cursor appearance support.
  - Show/Hide Cursor mode (DECTCEM): "ESC[?25h" / "ESC[?25l"
  - Set cursor style (DECSCUSR): "ESC[n q" (note the space before the q); where n is 0, 1, 2 for block cursor, 3, 4 for underline cursor (all disregarding blinking mode), or > 4 to set the cursor height to a percentage of the cell height.
- For performance reasons, Cygwin does not try to create sparse files automatically anymore, unless you use the new "sparse" mount option.
- New API: cfsetspeed.

1.7.36 What's new and what changed in 1.7.17

- Support the "e" flag to fopen(3). This is a Glibc extension which allows to fopen the file with the O_CLOEXEC flag set.
- Support the "x" flag to fopen(3). This is a Glibc/C11 extension which allows to open the file with the O_EXCL flag set.

1.7.37 What's new and what changed in 1.7.16

- New API: getmntent_r, memrchr.
- Recognize ReFS filesystem.

1.7.38 What's new and what changed in 1.7.15

- CYGWIN=pipe_byte option now forces the opening of pipes in byte mode rather than message mode.

1.7.39 What's new and what changed in 1.7.14

- Add mouse reporting modes 1005, 1006 and 1015 to console window.

1.7.40 What's new and what changed in 1.7.13

- mkpasswd and mkgroup now try to print an entry for the TrustedInstaller account existing since Windows Vista/Server 2008.
- Terminal typeahead when switching from canonical to non-canonical mode is now properly flushed.

1.7.41 What's new and what changed in 1.7.12

- Cygwin now automatically populates the /dev directory with all existing POSIX devices.
- Add virtual /proc/PID/mountinfo file.
- flock now additionally supports the following scenario, which requires to propagate locks to the parent process:

```
(
  flock -n 9 || exit 1
  # ... commands executed under lock ...
} 9>/var/lock/mylockfile
```

  Only propagation to the direct parent process is supported so far, not to grand parents or sibling processes.
- Add a "detect_bloda" setting for the CYGWIN environment variable to help finding potential BLODAs.

1.7.42 What's new and what changed in 1.7.11

- New **pldd** command for listing DLLs loaded by a process.
- New API: scandirat.
- Change the way remote shares mapped to drive letters are recognized when creating the cygdrive directory. If Windows claims the drive is unavailable, don't show it in the cygdrive directory listing.
- Raise default stacksize of pthreads from 512K to 1 Meg. It can still be changed using the pthread_attr_setstacksize call.

1.7.43 What's new and what changed in 1.7.10

- Drop support for Windows NT4.
- The CYGWIN environment variable options "envcache", "strip_title", "title", "tty", and "upcaseenv" have been removed.
- If the executable (and the system) is large address aware, the application heap will be placed in the large memory area. The **peflags** tool from the `rebase` package can be used to set the large address awareness flag in the executable file header.
- The registry setting "heap_chunk_in_mb" has been removed, in favor of a new per-executable setting in the executable file header which can be set using the **peflags** tool. See Section 2.3 for more information.
- The CYGWIN=tty mode using pipes to communicate with the console in a pseudo tty-like mode has been removed. Either just use the normal Windows console as is, or use a terminal application like **mintty**.
- New **getconf** command for querying confstr(3), pathconf(3), sysconf(3), and limits.h configuration.
- New **tzset** utility to generate a POSIX-compatible TZ environment variable from the Windows timezone settings.
- The passwd command now allows an administrator to use the -R command for other user accounts: passwd -R username.
- Pthread spinlocks. New APIs: pthread_spin_destroy, pthread_spin_init, pthread_spin_lock, pthread_spin_trylock, pthread_spin_unloc
- Pthread stack address management. New APIs: pthread_attr_getstack, pthread_attr_getstackaddr, pthread_attr_getguardsize, pthread_attr_setstack, pthread_attr_setstackaddr, pthread_attr_setguardsize, pthread_getattr_np.
- POSIX Clock Selection option. New APIs: clock_nanosleep, pthread_condattr_getclock, pthread_condattr_setclock.
- clock_gettime(3) and clock_getres(3) accept per-process and per-thread CPU-time clocks, including CLOCK_PROCESS_CPUTIME_ and CLOCK_THREAD_CPUTIME_ID. New APIs: clock_getcpuclockid, pthread_getcpuclockid.
- GNU/glibc error.h error reporting functions. New APIs: error, error_at_line. New exports: error_message_count, error_one_per_line, error_print_progname. Also, perror and strerror_r no longer clobber strerror storage.
- C99 <tgmath.h> type-generic macros.

- /proc/loadavg now shows the number of currently running processes and the total number of processes.
- Added /proc/devices and /proc/misc, which lists supported device types and their device numbers.
- Added /proc/swaps, which shows the location and size of Windows paging file(s).
- Added /proc/sysvipc/msg, /proc/sysvipc/sem, and /proc/sysvipc/shm which provide information about System V IPC message queues, semaphores, and shared memory.
- /proc/version now shows the username of whomever compiled the Cygwin DLL as well as the version of GCC used when compiling.
- dlopen now supports the Glibc-specific RTLD_NODELETE and RTLD_NOOPEN flags.
- The printf(3) and wprintf(3) families of functions now handle the %m conversion flag.
- Other new API: clock_settime, __fpurge, getgrouplist, get_current_dir_name, getpt, ppoll, psiginfo, psignal, ptsname_r, sys_siglist, pthread_setschedprio, pthread_sigqueue, sysinfo.

1.7.44 What's new and what changed in 1.7.9

- New API: strchrnul.

1.7.45 What's new and what changed in 1.7.8

- Drop support for Windows NT4 prior to Service Pack 4.
- Reinstantiate Cygwin's ability to delete an empty directory which is the current working directory of the same or another process. Same for any other empty directory which has been opened by the same or another process.
- Cygwin now ships the C standard library fenv.h header file, and implements the related APIs (including GNU/glibc extensions): feclearexcept, fedisableexcept, feenableexcept, fegetenv, fegetexcept, fegetexceptflag, fegetprec, fegetround, feholdexcept, feraiseexcept, fesetenv, fesetexceptflag, fesetprec, fesetround, fetestexcept, feupdateenv, and predefines both default and no-mask FP environments. See the GNU C Library manual for full details of this functionality.
- Support for the C99 complex functions, except for the "long double" implementations. New APIs: cacos, cacosf, cacosh, cacoshf, carg, cargf, casin, casinf, casinh, casinhf, catan, catanf, catanh, catanhf, ccos, ccosf, ccosh, ccoshf, cexp, cexpf, cimag, cimagf, clog, clogf, conj, conjf, cpow, cpowf, cproj, cprojf, creal, crealf, csin, csinf, csinh, csinhf, csqrt, csqrtf, ctan, ctanf, ctanh, ctanhf.
- Fix the width of "CJK Ambiguous Width" characters to 1 for singlebyte charsets and 2 for East Asian multibyte charsets. (For UTF-8, it remains dependent on the specified language, and the "@cjknarrow" locale modifier can still be used to force width 1.)
- The strerror_r interface now has two flavors; if _GNU_SOURCE is defined, it retains the previous behavior of returning char * (but the result is now guaranteed to be NUL-terminated); otherwise it now obeys POSIX semantics of returning int.
- /proc/sys now allows unfiltered access to the native NT namespace. Access restrictions still apply. Direct device access via /proc/sys is not yet supported. File system access via block devices works. For instance (note the trailing slash!)

```
bash$ cd /proc/sys/Device/HarddiskVolumeShadowCopy1/
```

- Other new APIs: llround, llroundf, madvise, pthread_yield. Export program_invocation_name, program_invocation_short_name. Support TIOCGPGRP, TIOCSPGRP ioctls.

1.7.46 What's new and what changed in 1.7.7

- Partially revert the 1.7.6 change to set the Win32 current working directory (CWD) always to an invalid directory, since it breaks backward compatibility too much. The Cygwin CWD and the Win32 CWD are now kept in sync again, unless the Cygwin CWD is not usable as Win32 CWD. See the reworked Section 3.1.8 for details.
- Make sure to follow the Microsoft security advisory concerning DLL hijacking. See the Microsoft Security Advisory (2269637) "Insecure Library Loading Could Allow Remote Code Execution" for details.
- Allow to link against -lbinmode instead of /lib/binmode.o. Same for -ltextmode, -ltextreadmode and -lautomode. See Section 3.2.4 for details.

1.7.47 What's new and what changed in 1.7.6

- Add new mount options "dos" and "ihash" to allow overriding Cygwin default behaviour on broken filesystems not recognized by Cygwin.
- Add new mount option "bind" to allow remounting parts of the POSIX file hirarchy somewhere else.
- Ttys and ptys are handled as securable objects using file-like permissions and owner/group information. **chmod** and **chown** now work on ttys/ptys. A new mechanism is used to propagate pty handles safely to other processes, which does not require to use Cygserver.
- Pass on coresize settings made with setrlimit(2). This allows shells to disable creating stackdump files in child processes via

```
ulimit -c 0
```

  in bash or

```
limit coredumpsize 0
```

  in tcsh.
- Locale categories contain all localization strings additionally as wide-char strings. locale(1) prints these values just as on Linux. nl_langinfo(3) allows to fetch them.
- New interfaces mkostemp(3) and mkostemps(3) are added.
- New virtual file /proc/filesystems.
- clock_gettime(3) and clock_getres(3) accept CLOCK_MONOTONIC.
- DEPRECATED with 1.7.7: Cygwin handles the current working directory entirely on its own. The Win32 current working directory is set to an invalid path to be out of the way. [...]

1.7.48 What's new and what changed in 1.7.5

- Support for DEC Backarrow Key Mode escape sequences (ESC [? 67 h, ESC [? 67 l) in Windows console.

1.7.49 What's new and what changed in 1.7.3

- Support for GB2312/EUC-CN. These charsets are implemented as aliases to GBK. GB2312 is now the default charset name for the locales zh_CN and zh_SG, just as on Linux.
- Modification and access timestamps of devices reflect the current time.

1.7.50 What's new and what changed in 1.7.2

- Localization support has been much improved.
  - Cygwin now handles locales using the underlying Windows locale support. The locale must exist in Windows to be recognized. Locale aliases from the file /usr/share/locale/locale.alias are also allowed, as long as their replacement is supported by the underlying Windows.
  - New tool "locale" to fetch locale information and default locales based on the Windows default settings as well as lists of all supported locales and character sets.
  - Default charset for locales without explicit charset is now chosen from a list of Linux-compatible charsets.
    For instance: en_US -> ISO-8859-1, ja_JP -> EUC-JP, zh_TW -> Big5.
  - Added support for the charsets GEORGIAN-PS, PT154, and TIS-620.
  - Support for the various locale modifiers to switch charsets as on Linux.
  - Default charset in the "C" or "POSIX" locale has been changed back from UTF-8 to ASCII, to avoid problems with applications expecting a singlebyte charset in the "C"/"POSIX" locale. Still use UTF-8 internally for filename conversion in this case.
  - LC_COLLATE, LC_MONETARY, LC_NUMERIC, and LC_TIME localization is enabled via Windows locale support. LC_MESSAGES is enabled via a big table with localized strings.
  - fnmatch(3), regcomp(3), regexec(3) calls are now multibyte-aware.
  - printf(3), wprintf(3) families of functions now handle the grouping flag, the apostrophe `'`, per POSIX-1.2008. The integer portion of the result of a decimal conversion (%i, %d, %u, %f, %F, %g, %G) will be formatted with thousands' grouping characters.
  - strftime(3), wcsftime(3), and strptime(3) now handle the E and O format modifiers to print/scan alternative date and time representations or to use alternative digits in locales which support this. Additionally these functions now also support the padding modifiers '0' and '+', as well as a field width per POSIX-1.2008.
  - New strfmon(3) call.
- Support open(2) flags O_CLOEXEC and O_TTY_INIT flags. Support fcntl flag F_DUPFD_CLOEXEC. Support socket flags SOCK_CLOEXEC and SOCK_NONBLOCK. Add new Linux-compatible API calls accept4(2), dup3(2), and pipe2(2). Support the signal SIGPWR.
- Enhanced Windows console support.
  - The console's backspace keycode can be changed using 'stty erase'.
  - Function keys send distinguished escape sequences compatible with rxvt. Keypad keys send distinguished escape sequences, xterm-style.
  - Support of combining Alt and AltGr modifiers in console window (compatible with xterm and mintty), so that e.g. Alt-@ sends ESC @ also on keyboards where @ is mapped to an AltGr combination.
  - Report mouse wheel scroll events in mouse reporting mode 1000 (note: this doesn't seem to work on all systems, assumedly due to driver interworking issues). Add mouse reporting mode 1002 to report mouse drag movement. Add mouse reporting mode 1003 to report any mouse movement. Add focus event reporting (mode 1004), compatible with xterm and mintty.
  - Add escape sequences for not bold (22), not invisible (28), not blinking (25) (compatible with xterm and mintty).
  - Support VT100 line drawing graphics mode in console window (compatible with xterm and mintty).
- Handle native DOS paths always as if mounted with "posix=0,noacl".
- Handle UNC paths starting with slashes identical to /cygdrive paths. In other words, use the /cygdrive mount flags for these paths as well.
- Recognize NWFS filesystem and workaround broken OS call.
- New support for eXtensible Data Record (XDR) encoding and decoding, as defined by RFCs 1014, 1832, and 4506. The XDR protocol and functions are useful for cross-platfrom data exchange, and are commonly used as the core data interchange format for Remote Procedure Call (RPC) and NFS.

1.7.51 What's new and what changed from 1.5 to 1.7

1.7.51.1 OS related changes

- Windows 95, 98 and Me are not supported anymore. The new Cygwin 1.7 DLL will not run on any of these systems.
- Add support for Windows 7 and Windows Server 2008 R2.

1.7.51.2 File Access related changes

- Mount points are no longer stored in the registry. Use /etc/fstab and /etc/fstab.d/$USER instead. Mount points created with mount(1) are only local to the current session and disappear when the last Cygwin process in the session exits.
- Cygwin creates the mount points for /, /usr/bin, and /usr/lib automatically from it's own position on the disk. They don't have to be specified in /etc/fstab.
- If a filename cannot be represented in the current character set, the character will be converted to a sequence Ctrl-X + UTF-8 representation of the character. This allows to access all files, even those not having a valid representation of their filename in the current character set. To always have a valid string, use the UTF-8 charset by setting the environment variable $LANG, $LC_ALL, or $LC_CTYPE to a valid POSIX value, such as "en_US.UTF-8".
- PATH_MAX is now 4096. Internally, path names can be as long as the underlying OS can handle (32K).
- struct dirent now supports d_type, filled out with DT_REG or DT_DIR. All other file types return as DT_UNKNOWN for performance reasons.
- The CYGWIN environment variable options "ntsec" and "smbntsec" have been replaced by the per-mount option "acl"/"noacl".
- The CYGWIN environment variable option "ntea" has been removed without substitute.
- The CYGWIN environment variable option "check_case" has been removed in favor of real case-sensitivity on file systems supporting it.
- Creating filenames with special DOS characters '"', '*', ':', '<', '>', '|' is supported.
- Creating files with special DOS device filename components ("aux", "nul", "prn") is supported.
- File names are case sensitive if the OS and the underlying file system supports it. Works on NTFS and NFS. Does not work on FAT and Samba shares. Requires to change a registry key (see the User's Guide). Can be switched off on a per-mount basis.
- Due to the above changes, managed mounts have been removed.
- Incoming DOS paths are always handled case-insensitive and get no POSIX permission, as if they are mounted with noacl,posix=0 mount flags.
- unlink(2) and rmdir(2) try very hard to remove files/directories even if they are currently accessed or locked. This is done by utilizing the hidden recycle bin directories and marking the files for deletion.
- rename(2) rewritten to be more POSIX conformant.
- access(2) now performs checks using the real user ID, as required by POSIX; the old behavior of querying based on effective user ID is available through the new faccessat(2) and euidaccess(2) APIs.
- Add st_birthtim member to struct stat.
- File locking is now advisory, not mandatory anymore. The fcntl(2) and the new lockf(2) APIs create and maintain locks with POSIX semantics, the flock(2) API creates and maintains locks with BSD semantics. POSIX and BSD locks are independent of each other.
- Implement atomic O_APPEND mode.
- New open(2) flags O_DIRECTORY, O_EXEC and O_SEARCH.

- Make the "plain file with SYSTEM attribute set" style symlink default again when creating symlinks. Only create Windows shortcut style symlinks if CYGWIN=winsymlinks is set in the environment.
- Symlinks now use UTF-16 encoding for the target filename for better internationalization support. Cygwin 1.7 can read all old style symlinks, but the new style is not compatible with older Cygwin releases.
- Handle NTFS native symlinks available since Vista/2008 as symlinks (but don't create Vista/2008 symlinks due to unfortunate OS restrictions).
- Recognize NFS shares and handle them using native mechanisms. Recognize and create real symlinks on NFS shares. Get correct stat(2) information and set real mode bits on open(2), mkdir(2) and chmod(2).
- Recognize MVFS and workaround problems manipulating metadata and handling DOS attributes.
- Recognize Netapp DataOnTap drives and fix inode number handling.
- Recognize Samba version beginning with Samba 3.0.28a using the new extended version information negotiated with the Samba developers.
- Stop faking hardlinks by copying the file on filesystems which don't support hardlinks natively (FAT, FAT32, etc.). Just return an error instead, just like Linux.
- List servers of all accessible domains and workgroups in // instead of just the servers in the own domain/workgroup.
- Support Linux-like extended attributes ([fl]getxattr, [fl]listxattr, [fl]setxattr, [fl]removexattr).
- New file conversion API for conversion from Win32 to POSIX path and vice versa (cygwin_conv_path, cygwin_create_path, cygwin_conv_path_list).
- New openat family of functions: openat, faccessat, fchmodat, fchownat, fstatat, futimesat, linkat, mkdirat, mkfifoat, mknodat, readlinkat, renameat, symlinkat, unlinkat.
- Other new APIs: posix_fadvise, posix_fallocate, funopen, fopencookie, open_memstream, open_wmemstream, fmemopen, fdopendir, fpurge, mkstemps, eaccess, euidaccess, canonicalize_file_name, fexecve, execvpe.

1.7.51.3 Network related changes

- New implementation for blocking sockets and select on sockets which is supposed to allow POSIX-compatible sharing of sockets between threads and processes.
- send/sendto/sendmsg now send data in 64K chunks to circumvent an internal buffer problem in WinSock (KB 201213).
- New send/recv option MSG_DONTWAIT.
- IPv6 support. New APIs getaddrinfo, getnameinfo, freeaddrinfo, gai_strerror, in6addr_any, in6addr_loopback. On IPv6-less systems, replacement functions are available for IPv4. On systems with IPv6 enabled, the underlying WinSock functions are used. While I tried hard to get the functionality as POSIXy as possible, keep in mind that a *fully* conformant implementation of getaddrinfo and other stuff is only available starting with Windows Vista/2008.
- Resolver functions (res_init, res_query, res_search, res_querydomain, res_mkquery, res_send, dn_comp, dn_expand) are now part of Cygwin. Applications don't have to link against minires anymore. Actually, this *is* the former libminires.a.
- rcmd is now implemented inside of Cygwin, instead of calling the WinSock function. This allows rsh(1) usage on Vista/2008 and later, which dropped this function from WinSock.
- Define multicast structures in netinet/in.h. Note that fully conformant multicast support is only available beginning with Vista/2008.
- Improve get_ifconf. Redefine struct ifreq and subsequent datastructures to be able to keep more information. Support SIOCGIFINDEX, SIOCGIFDSTADDR and the Cygwin specific SIOCGIFFRNDLYNAM. Support real interface flags on systems supporting them.
- Other new APIs: bindresvport, bindresvport_sa, gethostbyname2, iruserok_sa, rcmd_af, rresvport_af. getifaddrs, freeifaddrs, if_nametoindex, if_indextoname, if_nameindex, if_freenameindex.
- Add /proc/net/if_inet6.

1.7.51.4 Device related changes

- Reworked pipe implementation which uses overlapped IO to create more reliable interruptible pipes and fifos.
- The CYGWIN environment variable option "binmode" has been removed.
- Improved fifo handling by using native Windows named pipes.
- Detect when a stdin/stdout which looks like a pipe is really a tty. Among other things, this allows a debugged application to recognize that it is using the same tty as the debugger.
- Support UTF-8 in console window.
- In the console window the backspace key now emits DEL (0x7f) instead of BS (0x08), Alt-Backspace emits ESC-DEL (0x1b,0x7f) instead of DEL (0x7f), same as the Linux console and xterm. Control-Space now emits an ASCII NUL (0x0) character.
- Support up to 64 serial interfaces using /dev/ttyS0 - /dev/ttyS63.
- Support up to 128 raw disk drives /dev/sda - /dev/sddx.
- New API: cfmakeraw, get_avphys_pages, get_nprocs, get_nprocs_conf, get_phys_pages, posix_openpt.

1.7.51.5 Other POSIX related changes

- A lot of character sets are supported now via a call to setlocale(). The setting of the environment variables $LANG, $LC_ALL or $LC_CTYPE will be used. For instance, setting $LANG to "de_DE.ISO-8859-15" before starting a Cygwin session will use the ISO-8859-15 character set in the entire session. The default locale in the absence of one of the aforementioned environment variables is "C.UTF-8".

  The full list of supported character sets: "ASCII", "ISO-8859-x" with x in 1-16, except 12, "UTF-8", Windows codepages "CPxxx", with xxx in (437, 720, 737, 775, 850, 852, 855, 857, 858, 862, 866, 874, 1125, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258), "KOI8-R", "KOI8-U", "SJIS", "GBK", "eucJP", "eucKR", and "Big5".
- Allow multiple concurrent read locks per thread for pthread_rwlock_t.
- Implement pthread_kill(thread, 0) as per POSIX.
- New API for POSIX IPC: Named semaphores: sem_open, sem_close, sem_unlink. Message queues: mq_open, mq_getattr, mq_setattr, mq_notify, mq_send, mq_timedsend, mq_receive, mq_timedreceive, mq_close, mq_unlink. Shared memory: shm_open, shm_unlink.
- Only declare expected functions in <strings.h>, don't include <string.h> from here.
- Support for WCONTINUED, WIFCONTINUED() added to waitpid and wait4.
- New APIs: _Exit, confstr, insque, remque, sys_sigabbrev, posix_madvise, posix_memalign, reallocf, exp10, exp10f, pow10, pow10f, lrint, lrintf, rint, rintf, llrint, llrintf, llrintl, lrintl, rintl, mbsnrtowcs, strcasestr, stpcpy, stpncpy, wcpcpy, wcpncpy, wcsnlen, wcsnrtombs, wcsftime, wcstod, wcstof, wcstoimax, wcstok, wcstol, wcstoll, wcstoul, wcstoull, wcstoumax, wcsxfrm, wcscasecmp, wcsncasecmp, fgetwc, fgetws, fputwc, fputws, fwide, getwc, getwchar, putwc, putwchar, ungetwc, asnprintf, dprintf, vasnprintf, vdprintf, wprintf, fwprintf, swprintf, vwprintf, vfwprintf, vswprintf, wscanf, fwscanf, swscanf, vwscanf, vfwscanf, vswscanf.

1.7.51.6 Security related changes

- Getting a domain user's groups is hopefully more bulletproof now.
- Cygwin now comes with a real LSA authentication package. This must be manually installed by a privileged user using the /bin/cyglsa-config script. The advantages and disadvantages are noted in https://cygwin.com/ml/cygwin-developers/2006-11/msg00000.html

- Cygwin now allows storage and use of user passwords in a hidden area of the registry. This is tried first when Cygwin is called by privileged processes to switch the user context. This allows, for instance, ssh public key sessions with full network credentials to access shares on other machines.
- New options have been added to the mkpasswd and mkgroup tools to ease use in multi-machine and multi-domain environments. The existing options have a slightly changed behaviour.

1.7.51.7 Miscellaneous

- New ldd utility, similar to Linux.
- New link libraries libdl.a, libresolv.a, librt.a.
- Fallout from the long path names: If the current working directory is longer than 260 bytes, or if the current working directory is a virtual path (like /proc, /cygdrive, //server), don't call native Win32 programs since they don't understand these paths.
- On the first usage of a DOS path (C:\foo, \\foo\bar), the Cygwin DLL emits a scary warning that DOS paths shouldn't be used. This warning may be disabled via the new CYGWIN=nodosfilewarning setting.
- The CYGWIN environment variable option "server" has been removed. Cygwin automatically uses cygserver if it's available.
- Allow environment of arbitrary size instead of a maximum of 32K.
- Don't force uppercase environment when started from a non-Cygwin process. Except for certain Windows and POSIX variables which are always uppercased, preserve environment case. Switch back to old behaviour with the new CYGWIN=upcaseenv setting.
- Detect and report a missing DLL on process startup.
- Add /proc/registry32 and /proc/registry64 paths to access 32 bit and 64 bit registry on 64 bit systems.
- Add the ability to distinguish registry keys and registry values with the same name in the same registry subtree. The key is called "foo" and the value will be called "foo%val" in this case.
- Align /proc/cpuinfo more closly to Linux content.
- Add /proc/$PID/mounts entries and a symlink /proc/mounts pointing to /proc/self/mounts as on Linux.
- Optimized strstr and memmem implementation.
- Remove backwards compatibility with old signal masks. (Some *very* old programs which use signal masks may no longer work correctly).
- Cygwin now exports wrapper functions for libstdc++ operators new and delete, to support the toolchain in implementing full C++ standards conformance when working with shared libraries.
- Different Cygwin installations in different paths can be run in parallel without knowing of each other. The path of the Cygwin DLL used in a process is a key used when creating IPC objects. So different Cygwin DLLs are running in different namespaces.
- Each Cygwin DLL stores its path and installation key in the registry. This allows troubleshooting of problems which could be a result of having multiple concurrent Cygwin installations.

Chapter 2

Setting Up Cygwin

2.1 Internet Setup

To install the Cygwin net release, go to `https://cygwin.com/` and run setup-x86_64.exe to install the 64 bit version of Cygwin. This will download a GUI installer which can be run to download a complete cygwin installation via the internet. Follow the instructions on each screen to install Cygwin.

The **setup** installer is designed to be easy for new users to understand while remaining flexible for the experienced. The volunteer development team is constantly working on **setup**; before requesting a new feature, check the wishlist in the Git `README` . It may already be present in the Git version!

On Windows Vista and later, **setup** will check by default if it runs with administrative privileges and, if not, will try to elevate the process. If you want to avoid this behaviour and install under an unprivileged account just for your own usage, run **setup** with the `--no-admin` option.

Since the default value for each option is the logical choice for most installations, you can get a working minimal Cygwin environment installed by simply clicking the `Next` button at each page. The only exception to this is choosing a Cygwin mirror, which you can choose by experimenting with those listed at `https://cygwin.com/mirrors.html`. For more details about each of page of the **setup** installation, read on below. Please note that this guide assumes that you have a basic understanding of Unix (or a Unix-like OS). If you are new to Unix, you will also want to make use of other resources.

2.1.1 Download Source

Cygwin uses packages to manage installing various software. When the default `Install from Internet` option is chosen, **setup** creates a local directory to store the packages before actually installing the contents. `Download from Internet` performs only the first part (storing the packages locally), while `Install from Local Directory` performs only the second (installing the contents of the packages).

The `Download from Internet` option is mainly for creating a base Cygwin package tree on one computer for installation on several machines with `Install from Local Directory`; copy the entire local package tree to another machine with the directory tree intact. For example, you might create a `C:\cache\` directory and place **setup** in it. Run **setup** to `Install from Internet` or `Download from Internet`, then copy the whole `C:\cache\` to each machine and instead choose `Install from Local Directory`.

Though this provides some basic mirroring functionality, if you are managing a large Cygwin installation, to keep up to date we recommend using a mirroring tool such as **wget**. A helpful user on the Cygwin mailing list created a simple demonstration script to accomplish this; search the list for **mkcygwget** for ideas.

2.1.2 Selecting an Install Directory

The `Root Directory` for Cygwin (default `C:\cygwin`) will become `/` within your Cygwin installation. You must have write access to the parent directory, and any ACLs on the parent directory will determine access to installed files.

The Install For options of All Users or Just Me should always be left on the default All Users, unless you do not have write access to HKEY_LOCAL_MACHINE in the registry or the All Users Start Menu. This is true even if you are the only user planning to use Cygwin on the machine. Note that selecting Just Me will cause problems for Cygwin applications running as service, such as **crond** or **sshd**. If you do not have the necessary permissions, but still want to use these programs, consult the Cygwin mailing list archives about others' experiences.

2.1.3 Local Package Directory

The Local Package Directory is the cache where **setup** stores the packages before they are installed. The cache must not be the same folder as the Cygwin root. Within the cache, a separate directory is created for each Cygwin mirror, which allows **setup** to use multiple mirrors and custom packages. After installing Cygwin, the cache is no longer necessary, but you may want to retain the packages as backups, for installing Cygwin to another system, or in case you need to reinstall a package.

2.1.4 Connection Method

The Direct Connection method of downloading will directly connect. If your system is configured to use a proxy server or auto-configuration scripts, the Use System Proxy Settings method uses those settings. Alternatively, you can manually enter proxy settings into the Use HTTP/FTP Proxy section.

2.1.5 Choosing Mirrors

Since there is no way of knowing from where you will be downloading Cygwin, you need to choose at least one mirror site. Cygwin mirrors are geographically distributed around the world; check the list at https://cygwin.com/mirrors.html to find one near you. You can select multiple mirrors by holding down CTRL and clicking on each one. If you have the URL of an unlisted mirror (for example, if your organization has an internal Cygwin mirror) you can add it.

2.1.6 Choosing Packages

For each selected mirror site, **setup** downloads a small text file called setup.bz2 that contains a list of packages available from that site along with some basic information about each package which **setup** parses and uses to create the chooser window. For details about the format of this file, see the setup homepage.

The chooser is the most complex part of **setup**. Packages are grouped into categories, and one package may belong to multiple categories (assigned by the volunteer package maintainer). Each package can be found under any of those categories in the hierarchical chooser view. By default, **setup** will install only the packages in the Base category and their dependencies, resulting in a minimal Cygwin installation. However, this will not include many commonly used tools such as **gcc** (which you will find in the Devel category). Since **setup** automatically selects dependencies, be careful not to unselect any required packages. In particular, everything in the Base category is required.

You can change **setup**'s view style, which is helpful if you know the name of a package you want to install but not which category it is in. Click on the View button and it will rotate between Category (the default), Full (all packages), and Pending (only packages to be installed, removed or upgraded). If you are familiar with Unix, you will probably want to at least glance through the Full listing for your favorite tools.

Once you have an existing Cygwin installation, the **setup** chooser is also used to manage your Cygwin installation. Information on installed packages is kept in the /etc/setup/ directory of your Cygwin installation; if **setup** cannot find this directory it will act as if you have no Cygwin installation. If **setup** finds a newer version of an installed package available, it will automatically mark it to be upgraded. To Uninstall, Reinstall, or get the Source for an existing package, click on Keep to toggle it. Also, to avoid the need to reboot after upgrading, make sure to close all Cygwin windows and stop all Cygwin processes before **setup** begins to install the upgraded package.

To avoid unintentionally upgrading, use the Pending view to see which packages have been marked for upgrading. If you don't want to upgrade a package, click on the new version number to toggle it until it says Keep. All packages can be set to stay at the installed version by pressing the Keep button in the top right part of the chooser window.

A previous version of each package is usually available, in case downgrading is required to avoid a serious bug in the current version of the package. Packages also occasionally have testing (or "experimental") versions available. Previous and experimental versions can be chosen by clicking on the package's `New` column until the required version appears.

All available experimental packages can be selected by pressing the `Exp` in the top right part of the chooser window. Be warned, however, that the next time you run **setup** it will try to replace all old or experimental versions with the current version, unless told otherwise.

2.1.7 Download and Installation Progress

First, **setup** will download all selected packages to the local directory chosen earlier. Before installing, **setup** performs a checksum on each package. If the local directory is a slow medium (such as a network drive) this can take a long time. During the download and installation, **setup** shows progress bars for the current task and total remaining disk space.

2.1.8 Shortcuts

You may choose to install "Cygwin Terminal" shortcuts on the Desktop and/or Start Menu. These shortcuts run **mintty**, which will start your default shell as specified in `/etc/passwd`.

2.1.9 Post-Install Scripts

Last of all, **setup** will run any post-install scripts to finish correctly setting up installed packages. When the last post-install script is completed, **setup** will display a box announcing the completion. A few packages, such as the OpenSSH server, require some manual site-specific configuration. Relevant documentation can be found in the `/usr/doc/Cygwin/` or `/usr/share/doc/Cygwi` directory.

2.1.10 Troubleshooting

Unfortunately, the complex setup process means that odd problems can occur. If you're having trouble downloading packages, it may be network congestion, so try a different mirror and/or a different protocol (i.e., HTTP instead of FTP). If you notice something is not working after running setup, you can check the **setup** log file at `/var/log/setup.log.full`. Make a backup of this file before running **setup** again, and follow the steps for Reporting Problems with Cygwin.

2.2 Environment Variables

2.2.1 Overview

All Windows environment variables are imported when Cygwin starts. Apart from that, you may wish to specify settings of several important environment variables that affect Cygwin's operation.

The `CYGWIN` variable is used to configure a few global settings for the Cygwin runtime system. Typically you can leave `CYGWIN` unset, but if you want to set one ore more options, you can set it using a syntax like this, depending on the shell in which you're setting it. Here is an example in CMD syntax:

```
C:\> set CYGWIN=error_start:C:\cygwin\bin\gdb.exe glob
```

This is, of course, just an example. For the recognized settings of the `CYGWIN` environment variable, see Section 3.5.

Locale support is controlled by the `LANG` and `LC_xxx` environment variables. For a more detailed description see Section 2.4.

The `PATH` environment variable is used by Cygwin applications as a list of directories to search for executable files to run. This environment variable is converted from Windows format (e.g. `C:\Windows\system32;C:\Windows`) to UNIX format (e.g., `/cygdrive/c/Windows/system32:/cygdrive/c/Windows`) when a Cygwin process first starts. Set it so that

it contains at least the `x:\cygwin\bin` directory where "`x:\cygwin` is the "root" of your cygwin installation if you wish to use cygwin tools outside of bash. This is usually done by the batch file you're starting your shell with.

The `HOME` environment variable is used by many programs to determine the location of your home directory. This environment variable, if it exists, is converted from Windows format when a Cygwin process first starts. However, it's usually set in the shell profile scripts in the /etc directory, and it's **not** recommended to set the variable in your Windows environment.

The `TERM` environment variable specifies your terminal type. It is automatically set to `cygwin` if you have not set it to something else.

The `LD_LIBRARY_PATH` environment variable is used by the Cygwin function `dlopen ()` as a list of directories to search for .dll files to load. This environment variable is converted from Windows format to UNIX format when a Cygwin process first starts. Most Cygwin applications do not make use of the `dlopen ()` call and do not need this variable.

The `GMON_OUT_PREFIX` environment variable is helpful in some situations when profiling Cygwin programs. For more information, see Section 4.5.3.2. Only software developers with a need to profile their programs have a use for this variable.

In addition to `PATH`, `HOME`, `LD_LIBRARY_PATH`, and `GMON_OUT_PREFIX`, there are three other environment variables which, if they exist in the Windows environment, are converted to UNIX format: `TMPDIR`, `TMP`, and `TEMP`. The first is not set by default in the Windows environment but the other two are, and they point to the default Windows temporary directory. If set, these variables will be used by some Cygwin applications, possibly with unexpected results. You may therefore want to unset them by adding the following two lines to your `~/.bashrc` file:

```
unset TMP
unset TEMP
```

This is done in the default `~/.bashrc` file. Alternatively, you could set `TMP` and `TEMP` to point to `/tmp` or to any other temporary directory of your choice. For example:

```
export TMP=/tmp
export TEMP=/tmp
```

2.2.2 Restricted Win32 environment

There is a restriction when calling Win32 API functions which require a fully set up application environment. Cygwin maintains its own environment in POSIX style. The Win32 environment is usually stripped to a bare minimum and not at all kept in sync with the Cygwin POSIX environment.

If you need the full Win32 environment set up in a Cygwin process, you have to call

```
#include <sys/cygwin.h>

cygwin_internal (CW_SYNC_WINENV);
```

to synchronize the Win32 environment with the Cygwin environment. Note that this only synchronizes the Win32 environment once with the Cygwin environment. Later changes using the `setenv` or `putenv` calls are not reflected in the Win32 environment. In these cases, you have to call the aforementioned `cygwin_internal` call again.

2.3 Changing Cygwin's Maximum Memory

Cygwin's heap is extensible. However, it does start out at a fixed size and attempts to extend it may run into memory which has been previously allocated by Windows. In some cases, this problem can be solved by changing a field in the file header which is utilized by Cygwin since to keep the initial size of the application heap. If the field contains 0, which is the default, the application heap defaults to a size of 384 Megabyte on 32 bit Cygwin, 512 Megabyte on 64 bit Cygwin. If the field is set to any other value between 4 and 2048, Cygwin tries to reserve as much Megabytes for the application heap. The field used for this is the "LoaderFlags" field in the NT-specific PE header structure (`(IMAGE_NT_HEADER)->OptionalHeader.LoaderFlags`).

This value can be changed for any executable by using a more recent version of the **peflags** tool from the `rebase` Cygwin package. Example:

```
$ peflags --cygwin-heap foo.exe
foo.exe: initial Cygwin heap size: 0 (0x0) MB
$ peflags --cygwin-heap=500 foo.exe
foo.exe: initial Cygwin heap size: 500 (0x1f4) MB
```

Heap memory can be allocated up to the size of the biggest available free block in the processes virtual memory (VM). By default, the VM per process is 2 GB for 32 processes. To get more VM for a process, the executable must have the "large address aware" flag set in the file header. You can use the aforementioned **peflags** tool to set this flag. On 64 bit systems this results in a 4 GB VM for a process started from that executable. On 32 bit systems you also have to prepare the system to allow up to 3 GB per process. See the Microsoft article 4-Gigabyte Tuning for more information.

2.4 Internationalization

2.4.1 Overview

Internationalization support is controlled by the `LANG` and `LC_xxx` environment variables. You can set all of them but Cygwin itself only honors the variables `LC_ALL`, `LC_CTYPE`, and `LANG`, in this order, according to the POSIX standard. The content of these variables should follow the POSIX standard for a locale specifier. The correct form of a locale specifier is

```
language[[_TERRITORY][.charset][@modifier]]
```

"language" is a lowercase two character string per ISO 639-1, or, if there is no ISO 639-1 code for the language (for instance, "Lower Sorbian"), a three character string per ISO 639-3.

"TERRITORY" is an uppercase two character string per ISO 3166, charset is one of a list of supported character sets. The modifier doesn't matter here (though some are recognized, see below). If you're interested in the exact description, you can find it in the online publication of the POSIX manual pages on the homepage of the Open Group.

Typical locale specifiers are

```
"de_CH"    language = German, territory = Switzerland, default charset
"fr_FR.UTF-8"    language = french, territory = France, charset = UTF-8
"ko_KR.eucKR"    language = korean, territory = South Korea, charset = eucKR
"syr_SY"         language = Syriac, territory = Syria, default charset
```

If the locale specifier does not follow the above form, Cygwin checks if the locale is one of the locale aliases defined in the file `/usr/share/locale/locale.alias`. If so, and if the replacement localename is supported by the underlying Windows, the locale is accepted, too. So, given the default content of the `/usr/share/locale/locale.alias` file, the below examples would be valid locale specifiers as well.

```
"catalan"        defined as "ca_ES.ISO-8859-1" in locale.alias
"japanese"       defined as "ja_JP.eucJP"      in locale.alias
"turkish"        defined as "tr_TR.ISO-8859-9" in locale.alias
```

The file `/usr/share/locale/locale.alias` is provided by the gettext package under Cygwin.

At application startup, the application's locale is set to the default "C" or "POSIX" locale. This locale defaults to the ASCII character set on the application level. If you want to stick to the "C" locale and only change to another charset, you can define this by setting one of the locale environment variables to "C.charset". For instance

```
"C.ISO-8859-1"
```

Note
The default locale in the absence of the aforementioned locale environment variables is "C.UTF-8".

Windows uses the UTF-16 charset exclusively to store the names of any object used by the Operating System. This is especially important with filenames. Cygwin uses the setting of the locale environment variables `LC_ALL`, `LC_CTYPE`, and `LANG`, to determine how to convert Windows filenames from their UTF-16 representation to the singlebyte or multibyte character set used by Cygwin.

The setting of the locale environment variables at process startup is effective for Cygwin's internal conversions to and from the Windows UTF-16 object names for the entire lifetime of the current process. Changing the environment variables to another value changes the way filenames are converted in subsequently started child processes, but not within the same process.

However, even if one of the locale environment variables is set to some other value than "C", this does *only* affect how Cygwin itself converts filenames. As the POSIX standard requires, it's the application's responsibility to activate that locale for its own purposes, typically by using the call

```
setlocale (LC_ALL, "");
```

early in the application code. Again, so that this doesn't get lost: If the application calls setlocale as above, and there is none of the important locale variables set in the environment, the locale is set to the default locale, which is "C.UTF-8".

But what about applications which are not locale-aware? Per POSIX, they are running in the "C" or "POSIX" locale, which implies the ASCII charset. The Cygwin DLL itself, however, will nevertheless use the locale set in the environment (or the "C.UTF-8" default locale) for converting filenames etc.

When the locale in the environment specifies an ASCII charset, for example "C" or "en_US.ASCII", Cygwin will still use UTF-8 under the hood to translate filenames. This allows for easier interoperability with applications running in the default "C.UTF-8" locale.

The language and territory are used to fetch locale-dependent information from Windows. If the language and territory are not known to Windows, the `setlocale` function fails.

The following modifiers are recognized. Any other modifier is simply ignored for now.

- For locales which use the Euro (EUR) as currency, the modifier "@euro" can be added to enforce usage of the ISO-8859-15 character set, which includes a character for the "Euro" currency sign.
- The default script used for all Serbian language locales (sr_BA, sr_ME, sr_RS, and the deprecated sr_CS and sr_SP) is cyrillic. With the "@latin" modifier it gets switched to the latin script with the respective collation behaviour.
- The default charset of the "be_BY" locale (Belarusian/Belarus) is CP1251. With the "@latin" modifier it's UTF-8.
- The default charset of the "tt_RU" locale (Tatar/Russia) is ISO-8859-5. With the "@iqtelif" modifier it's UTF-8.
- The default charset of the "uz_UZ" locale (Uzbek/Uzbekistan) is ISO-8859-1. With the "@cyrillic" modifier it's UTF-8.
- There's a class of characters in the Unicode character set, called the "CJK Ambiguous Width" characters. For these characters, the width returned by the wcwidth/wcswidth functions is usually 1. This can be a problem with East-Asian languages, which historically use character sets where these characters have a width of 2. Therefore, wcwidth/wcswidth return 2 as the width of these characters when an East-Asian charset such as GBK or SJIS is selected, or when UTF-8 is selected and the language is specified as "zh" (Chinese), "ja" (Japanese), or "ko" (Korean). This is not correct in all circumstances, hence the locale modifier "@cjknarrow" can be used to force wcwidth/wcswidth to return 1 for the ambiguous width characters.
- For the same class of "CJK Ambiguous Width" characters, it may be desirable to handle them as double-width even when a non-CJK language setting is selected. This supports e.g. certain graphic symbols used by "Powerline" and provided by "Powerline fonts". Some terminals have options to enforce this width handling (xterm -cjk_width, mintty -o Charwidth=ambig-wide, putty configuration) but that alone makes character rendering and locale information inconsistent for those characters. The locale modifier "@cjkwide" supports consistent locale response with this option; it forces wcwidth/wcswidth to return 2 for the ambiguous width characters.
- As an alternative preference, CJK single-width may be enforced. This feature is a proposal in the Terminals Working Group Specifications. The mintty terminal implements it as an option with proper glyph scaling. The locale modifier "@cjksingle" supports consistent locale response with this option; it forces wcwidth/wcswidth to account at most 1 for all characters.

2.4.2 How to set the locale

- Assume that you've set one of the aforementioned environment variables to some valid POSIX locale value, other than "C" and "POSIX". Assume further that you're living in Japan. You might want to use the language code "ja" and the territory "JP", thus setting, say, `LANG` to "ja_JP". You didn't set a character set, so what will Cygwin use now? The default character set is determined by the default Windows ANSI codepage for this language and territory. Cygwin uses a character set which is the typical Unix-equivalent to the Windows ANSI codepage. For instance:

```
"en_US"   ISO-8859-1
"el_GR"   ISO-8859-7
"pl_PL"   ISO-8859-2
"pl_PL@euro"    ISO-8859-15
"ja_JP"   EUCJP
"ko_KR"   EUCKR
"te_IN"   UTF-8
```

- You don't want to use the default character set? In that case you have to specify the charset explicitly. For instance, assume you're from Japan and don't want to use the japanese default charset EUC-JP, but the Windows default charset SJIS. What you can do, for instance, is to set the `LANG` variable in the **mintty** Cygwin Terminal in the "Text" section of its "Options" dialog. If you're starting your Cygwin session via a batch file or a shortcut to a batch file, you can also just set LANG there:

```
@echo off

C:
chdir C:\cygwin\bin
set LANG=ja_JP.SJIS
bash --login -i
```

Note
For a list of locales supported by your Windows machine, use the new **locale -a** command, which is part of the Cygwin package. For a description see locale(1)

Note
For a list of supported character sets, see Section 2.4.5

- Last, but not least, most singlebyte or doublebyte charsets have a big disadvantage. Windows filesystems use the Unicode character set in the UTF-16 encoding to store filename information. Not all characters from the Unicode character set are available in a singlebyte or doublebyte charset. While Cygwin has a workaround to access files with unusual characters (see Section 3.4.4), a better workaround is to use always the UTF-8 character set.

  UTF-8 is the only multibyte character set which can represent every Unicode character.

```
set LANG=es_MX.UTF-8
```

  For a description of the Unicode standard, see the homepage of the Unicode Consortium.

2.4.3 The Windows Console character set

Sometimes the Windows console is used to run Cygwin applications. While terminal emulations like the Cygwin Terminal **mintty** or **xterm** have a distinct way to set the character set used for in- and output, the Windows console hasn't such a way, since it's not an application in its own right.

This problem is solved in Cygwin as follows. When a Cygwin process is started in a Windows console (either explicitly from cmd.exe, or implicitly by, for instance, running the `C:\cygwin\Cygwin.bat` batch file), the Console character set is determined by the setting of the aforementioned internationalization environment variables, the same way as described in Section 2.4.2.

What is that good for? Why not switch the console character set with the applications requirements? After all, the application knows if it uses localization or not. However, what if a non-localized application calls a remote application which itself is localized? This can happen with **ssh** or **rlogin**. Both commands don't have and don't need localization and they never call `setlocale`. Setting one of the internationalization environment variable to the same charset as the remote machine before starting **ssh** or **rlogin** fixes that problem.

2.4.4 Potential Problems when using Locales

You can set the above internationalization variables not only when starting the first Cygwin process, but also in your Cygwin shell on the fly, even switch to yet another character set, and yet another. In bash for instance:

```
bash$ export LC_CTYPE="nl_BE.UTF-8"
```

However, here's a problem. At the start of the first Cygwin process in a session, the Windows environment is converted from UTF-16 to UTF-8. The environment is another of the system objects stored in UTF-16 in Windows.

As long as the environment only contains ASCII characters, this is no problem at all. But if it contains native characters, and you're planning to use, say, GBK, the environment will result in invalid characters in the GBK charset. This would be especially a problem in variables like `PATH`. To circumvent the worst problems, Cygwin converts the `PATH` environment variable to the charset set in the environment, if it's different from the UTF-8 charset.

Note
Per POSIX, the name of an environment variable should only consist of valid ASCII characters, and only of uppercase letters, digits, and the underscore for maximum portability.

Very old symbolic links may pose a problem when switching charsets on the fly. A symbolic link contains the filename of the target file the symlink points to. When a symlink had been created with versions of Cygwin prior to Cygwin 1.7, the current ANSI or OEM character set had been used to store the target filename, dependent on the old `CYGWIN` environment variable setting `codepage` (see Section 3.5.2. If the target filename contains non-ASCII characters and you use another character set than your default ANSI/OEM charset, the target filename of the symlink is now potentially an invalid character sequence in the new character set. This behaviour is not different from the behaviour in other Operating Systems. Recreate the symlink if that happens to you.

2.4.5 List of supported character sets

Last but not least, here's the list of currently supported character sets. The left-hand expression is the name of the charset, as you would use it in the internationalization environment variables as outlined above. Note that charset specifiers are case-insensitive. `EUCJP` is equivalent to `eucJP` or `eUcJp`. Writing the charset in the exact case as given in the list below is a good convention, though.

The right-hand side is the number of the equivalent Windows codepage as well as the Windows name of the codepage. They are only noted here for reference. Don't try to use the bare codepage number or the Windows name of the codepage as charset in locale specifiers, unless they happen to be identical with the left-hand side. Especially in case of the "CPxxx" style charsets, always use them with the trailing "CP".

This works:

```
set LC_ALL=en_US.CP437
```

This does *not* work:

```
set LC_ALL=en_US.437
```

You can find a full list of Windows codepages on the Microsoft MSDN page Code Page Identifiers.

```
Charset               Codepage
-------------------   ------------------------------------------
ASCII                 20127 (US_ASCII)

CP437                   437 (OEM United States)
CP720                   720 (DOS Arabic)
CP737                   737 (OEM Greek)
CP775                   775 (OEM Baltic)
CP850                   850 (OEM Latin 1, Western European)
CP852                   852 (OEM Latin 2, Central European)
CP855                   855 (OEM Cyrillic)
CP857                   857 (OEM Turkish)
CP858                   858 (OEM Latin 1 + Euro Symbol)
CP862                   862 (OEM Hebrew)
CP866                   866 (OEM Russian)
CP874                   874 (ANSI/OEM Thai)
CP932       932 (Shift_JIS, not exactly identical to SJIS)
CP1125                 1125 (OEM Ukraine)
CP1250                 1250 (ANSI Central European)
CP1251                 1251 (ANSI Cyrillic)
CP1252                 1252 (ANSI Latin 1, Western European)
CP1253                 1253 (ANSI Greek)
CP1254                 1254 (ANSI Turkish)
CP1255                 1255 (ANSI Hebrew)
CP1256                 1256 (ANSI Arabic)
CP1257                 1257 (ANSI Baltic)
CP1258                 1258 (ANSI/OEM Vietnamese)

ISO-8859-1            28591 (ISO-8859-1)
ISO-8859-2            28592 (ISO-8859-2)
ISO-8859-3            28593 (ISO-8859-3)
ISO-8859-4            28594 (ISO-8859-4)
ISO-8859-5            28595 (ISO-8859-5)
ISO-8859-6            28596 (ISO-8859-6)
ISO-8859-7            28597 (ISO-8859-7)
ISO-8859-8            28598 (ISO-8859-8)
ISO-8859-9            28599 (ISO-8859-9)
ISO-8859-10             -   (not available)
ISO-8859-11             -   (not available)
ISO-8859-13           28603 (ISO-8859-13)
ISO-8859-14             -   (not available)
ISO-8859-15           28605 (ISO-8859-15)
ISO-8859-16             -   (not available)

Big5                    950 (ANSI/OEM Traditional Chinese)
EUCCN or euc-CN         936 (ANSI/OEM Simplified Chinese)
EUCJP or euc-JP       20932 (EUC Japanese)
EUCKR or euc-KR         949 (EUC Korean)
GB2312                  936 (ANSI/OEM Simplified Chinese)
GBK                     936 (ANSI/OEM Simplified Chinese)
GEORGIAN-PS             -   (not available)
KOI8-R                20866 (KOI8-R Russian Cyrillic)
KOI8-U                21866 (KOI8-U Ukrainian Cyrillic)
PT154                   -   (not available)
SJIS                    -   (not available, almost, but not exactly CP932)
TIS620 or TIS-620       874 (ANSI/OEM Thai)

UTF-8 or utf8         65001 (UTF-8)
```

2.5 Customizing bash

To set up bash so that cut and paste work properly, click on the "Properties" button of the window, then on the "Misc" tab. Make sure that "QuickEdit mode" and "Insert mode" are checked. These settings will be remembered next time you run bash from that shortcut.

Your home directory should contain three initialization files that control the behavior of bash. They are `.profile`, `.bashrc` and `.inputrc`. The Cygwin base installation creates stub files when you start bash for the first time.

`.profile` (other names are also valid, see the bash man page) contains bash commands. It is executed when bash is started as login shell, e.g. from the command **bash --login**. This is a useful place to define and export environment variables and bash functions that will be used by bash and the programs invoked by bash. It is a good place to redefine `PATH` if needed. We recommend adding a ":." to the end of `PATH` to also search the current working directory (contrary to DOS, the local directory is not searched by default). Also to avoid delays you should either **unset** `MAILCHECK` or define `MAILPATH` to point to your existing mail inbox.

`.bashrc` is similar to `.profile` but is executed each time an interactive bash shell is launched. It serves to define elements that are not inherited through the environment, such as aliases. If you do not use login shells, you may want to put the contents of `.profile` as discussed above in this file instead.

```
shopt -s nocaseglob
```

will allow bash to glob filenames in a case-insensitive manner. Note that `.bashrc` is not called automatically for login shells. You can source it from `.profile`.

`.inputrc` controls how programs using the readline library (including **bash**) behave. It is loaded automatically. For full details see the `Function and Variable Index` section of the GNU `readline` manual. Consider the following settings:

```
# Ignore case while completing
set completion-ignore-case on
# Make Bash 8bit clean
set meta-flag on
set convert-meta off
set output-meta on
```

The first command makes filename completion case insensitive, which can be convenient in a Windows environment. The next three commands allow **bash** to display 8-bit characters, useful for languages with accented characters. Note that tools that do not use `readline` for display, such as **less** and **ls**, require additional settings, which could be put in your `.bashrc`:

```
alias less='/bin/less -r'
alias ls='/bin/ls -F --color=tty --show-control-chars'
```

Chapter 3

Using Cygwin

This chapter explains some key differences between the Cygwin environment and traditional UNIX systems. It assumes a working knowledge of standard UNIX commands.

3.1 Mapping path names

3.1.1 Introduction

The Cygwin DLL supports both POSIX- and Win32-style paths. Directory delimiters may be either forward slashes or backslashes. Paths using backslashes or starting with a drive letter are always handled as Win32 paths. POSIX paths must only use forward slashes as delimiter, otherwise they are treated as Win32 paths and file access might fail in surprising ways.

Note
Although the Cygwin DLL supports Win32 paths, not all Cygwin applications support them. Moreover, the usage of Win32 paths circumvents important internal path handling mechanisms. This usage is therefore strongly deprecated and may be removed in a future release of Cygwin. See Section 3.1.7 and Section 3.1.8 for more information.

POSIX operating systems (such as Linux) do not have the concept of drive letters. Instead, all absolute paths begin with a slash (instead of a drive letter such as "c:") and all file systems appear as subdirectories (for example, you might buy a new disk and make it be the `/disk2` directory).

Because many programs written to run on UNIX systems assume the existence of a single unified POSIX file system structure, Cygwin maintains a special internal POSIX view of the Win32 file system that allows these programs to successfully run under Windows. Cygwin uses this mapping to translate from POSIX to Win32 paths as necessary.

3.1.2 The Cygwin Mount Table

The `/etc/fstab` file is used to map Win32 drives and network shares into Cygwin's internal POSIX directory tree. This is a similar concept to the typical UNIX fstab file. The mount points stored in `/etc/fstab` are globally set for all users. Sometimes there's a requirement to have user specific mount points. The Cygwin DLL supports user specific fstab files. These are stored in the directory `/etc/fstab.d` and the name of the file is the Cygwin username of the user, as it's created from the Windows account database or stored in the `/etc/passwd` file (see Section 3.6.2). The structure of the user specific file is identical to the system-wide `fstab` file.

The file fstab contains descriptive information about the various file systems. fstab is only read by programs, and not written; it is the duty of the system administrator to properly create and maintain this file. Each filesystem is described on a separate line; fields on each line are separated by tabs or spaces. Lines starting with '#' are comments.

The first field describes the block special device or remote filesystem to be mounted. On Cygwin, this is the native Windows path which the mount point links in. As path separator you MUST use a slash. Usage of a backslash might lead to unexpected results. UNC paths (using slashes, not backslashes) are allowed. If the path contains spaces these can be escaped as `'\040'`.

The second field describes the mount point for the filesystem. If the name of the mount point contains spaces these can be escaped as '\040'.

The third field describes the type of the filesystem. Cygwin supports any string here, since the file system type is usually not evaluated. So it doesn't matter if you write `FAT` into this field even if the filesystem is NTFS. Cygwin figures out the filesystem type and its capabilities by itself.

The only two exceptions are the file system types cygdrive and usertemp. The cygdrive type is used to set the cygdrive prefix. For a description of the cygdrive prefix see Section 3.1.4, for a description of the usertemp file system type see Section 3.1.5

The fourth field describes the mount options associated with the filesystem. It is formatted as a comma separated list of options. It contains at least the type of mount (binary or text) plus any additional options appropriate to the filesystem type. The list of the options, including their meaning, follows.

```
acl       - Cygwin uses the filesystem's access control lists (ACLs) to
            implement real POSIX permissions (default).  This flag only
      affects filesystems supporting ACLs (NTFS, for instance) and
      is ignored otherwise.
auto      - Ignored.
binary    - Files default to binary mode (default).
bind      - Allows to remount part of the file hierarchy somewhere else.
            In contrast to other entries, the first field in the fstab
      line specifies an absolute POSIX path.  This path is remounted
      to the POSIX path specified as the second path.  The conversion
      to a Win32 path is done on the fly.  Only the root path and
      paths preceding the bind entry in the fstab file are used to
      convert the POSIX path in the first field to an absolute Win32
      path.  Note that symlinks are ignored while performing this path
      conversion.
cygexec   - Treat all files below mount point as cygwin executables.
dos       - Always convert leading spaces and trailing dots and spaces to
      characters in the UNICODE private use area.  This allows to use
      broken filesystems which only allow DOS filenames, even if they
      are not recognized as such by Cygwin.
exec      - Treat all files below mount point as executable.
ihash     - Always fake inode numbers rather than using the ones returned
      by the filesystem.  This allows to use broken filesystems which
      don't return unambiguous inode numbers, even if they are not
      recognized as such by Cygwin.
noacl     - Cygwin ignores filesystem ACLs and only fakes a subset of
      permission bits based on the DOS readonly attribute.  This
      behaviour is the default on FAT and FAT32.  The flag is
      ignored on NFS filesystems.
nosuid    - No suid files are allowed (currently unimplemented).
notexec   - Treat all files below mount point as not executable.
nouser    - Mount is a system-wide mount.
override  - Force the override of an immutable mount point (currently "/").
posix=0   - Switch off case sensitivity for paths under this mount point
      (default for the cygdrive prefix).
posix=1   - Switch on case sensitivity for paths under this mount point
      (default for all other mount points).
sparse    - Switch on support for sparse files.  This option only makes
            sense on NTFS and then only if you really need sparse files.
      This flag is always silently enabled on SSD drives.
      Cygwin does not try to create sparse files by default for
      performance reasons.
text      - Files default to CRLF text mode line endings.
user      - Mount is a user mount.
```

While normally the execute permission bits are used to evaluate executability, this is not possible on filesystems which don't support permissions at all (like FAT/FAT32), or if ACLs are ignored on filesystems supporting them (see the aforementioned `acl` mount option). In these cases, the following heuristic is used to evaluate if a file is executable: Files ending in certain extensions (.exe, .com, .lnk) are assumed to be executable. Files whose first two characters are "#!", "MZ", or ":\n" are also considered to be executable. The `exec` option is used to instruct Cygwin that the mounted file is "executable". If the `exec` option is used with a directory then all files in the directory are executable. This option allows other files to be marked as executable and avoids the overhead of opening each file to check for "magic" bytes. The `cygexec` option is very similar to `exec`, but also prevents Cygwin from setting up commands and environment variables for a normal Windows program, adding another small performance gain. The opposite of these options is the `notexec` option, which means that no files should be marked as executable under that mount point.

A correct root directory is quite essential to the operation of Cygwin. A default root directory is evaluated at startup so a `fstab` entry for the root directory is not necessary. If it's wrong, nothing will work as expected. Therefore, the root directory evaluated by Cygwin itself is treated as an immutable mount point and can't be overridden in /etc/fstab... unless you think you really know what you're doing. In this case, use the `override` flag in the options field in the `/etc/fstab` file. Since this is a dangerous thing to do, do so at your own risk.

`/usr/bin` and `/usr/lib` are by default also automatic mount points generated by the Cygwin DLL similar to the way the root directory is evaluated. `/usr/bin` points to the directory the Cygwin DLL is installed in, `/usr/lib` is supposed to point to the `/lib` directory. This choice is safe and usually shouldn't be changed. An fstab entry for them is not required.

`nouser` mount points are not overridable by a later call to **mount**. Mount points given in `/etc/fstab` are by default `nouser` mount points, unless you specify the option `user`. This allows the administrator to set certain paths so that they are not overridable by users. In contrast, all mount points in the user specific fstab file are `user` mount points.

The fifth and sixth field are ignored. They are so far only specified to keep a Linux-like fstab file layout.

Note that you don't have to specify an fstab entry for the root dir, unless you want to have the root dir pointing to somewhere entirely different (hopefully you know what you're doing), or if you want to mount the root dir with special options (for instance, as text mount).

Example entries:

- Just a normal mount point:

```
c:/foo /bar fat32 binary 0 0
```

- A mount point for a textmode mount with case sensitivity switched off:

```
C:/foo /bar/baz ntfs text,posix=0 0 0
```

- A mount point for a Windows directory with spaces in it:

```
C:/Documents\040and\040Settings /docs ext3 binary 0 0
```

- A mount point for a remote directory, don't store POSIX permissions in ACLs:

```
//server/share/subdir /srv/subdir smbfs binary,noacl 0 0
```

- This is just a comment:

```
# This is just a comment
```

- Set the cygdrive prefix to /mnt:

```
none /mnt cygdrive binary 0 0
```

- Remount /var to /usr/var:

```
/var /usr/var none bind
```

  Assuming `/var` points to `C:/cygwin/var`, `/usr/var` now also points to `C:/cygwin/var`. This is equivalent to the Linux `bind` option available since Linux 2.4.0.

Whenever Cygwin generates a Win32 path from a POSIX one, it uses the longest matching prefix in the mount table. Thus, if `C:` is mounted as `/c` and also as `/`, then Cygwin would translate `C:/foo/bar` to `/c/foo/bar`. This translation is normally only used when trying to derive the POSIX equivalent current directory. Otherwise, the handling of MS-DOS filenames bypasses the mount table.

If you want to see the current set of mount points valid in your session, you can invoke the Cygwin tool **mount** without arguments:

Example 3.1 Displaying the current set of mount points

```
bash$ mount
F:/cygwin/bin on /usr/bin type ntfs (binary,auto)
F:/cygwin/lib on /usr/lib type ntfs (binary,auto)
F:/cygwin on / type ntfs (binary,auto)
E:/src on /usr/src type vfat (binary)
C: on /cygdrive/c type ntfs (binary,posix=0,user,noumount,auto)
E: on /cygdrive/e type vfat (binary,posix=0,user,noumount,auto)
```

Starting with Cygwin 3.6.0, the `getmntent(3)` function exposes Windows mount points of partitions mounted into a directory of another drive as if they are cygdrive mounts. This affects the content of `/proc/mounts` as well as the output of **mount**.

For instance, consider you have two local disks, one containing the `C:` drive, the other disk has one partition mounted into `C:\docs`. The output from mount will now show this mount point like this:

Example 3.2 Displaying Windows mount points as cygdrives

```
bash$ mount | grep cygdrive
C: on /cygdrive/c type ntfs (binary,posix=0,user,noumount,auto)
C:/docs on /cygdrive/c/docs type ntfs (binary,posix=0,user,noumount,auto)
```

You can also use the **mount** command to add new mount points, and the **umount** to delete them. However, since they are only stored in memory, these mount points will disappear as soon as your last Cygwin process ends. See mount(1) and umount(1) for more information.

3.1.3 UNC paths

Apart from the unified POSIX tree starting at the `/` directory, UNC pathnames starting with two slashes and a server name (`//machine/share/...`) are supported as well. They are handled as POSIX paths if only containing forward slashes. There's also a virtual directory `//` which allows to enumerate the fileservers known to the local machine with **ls**. Same goes for the UNC paths of the type `//machine`, which allow to enumerate the shares provided by the server `machine`. For often used UNC paths it makes sense to add them to the mount table (see Section 3.1.2 so they are included in the unified POSIX path tree.

3.1.4 The cygdrive path prefix

As already outlined in Section 1.6.3, you can access arbitary drives on your system by using the cygdrive path prefix. The default value for this prefix is `/cygdrive`, and a path to any drive can be constructed by using the cygdrive prefix and appending the drive letter as subdirectory, like this:

```
bash$ ls -l /cygdrive/f/somedir
```

This lists the content of the directory F:\somedir.

The cygdrive prefix is a virtual directory under which all drives on a system are subsumed. The mount options of the cygdrive prefix is used for all file access through the cygdrive prefixed drives. For instance, assuming the cygdrive mount options are `binary,posix=0`, then any file `/cygdrive/x/file` will be opened in binary mode by default (mount option `binary`), and the case of the filename doesn't matter (mount option `posix=0`).

The cygdrive prefix flags are also used for all UNC paths starting with two slashes, unless they are accessed through a mount point. For instance, consider these `/etc/fstab` entries:

```
//server/share /mysrv    ntfs     posix=1,acl   0 0
none           /cygdrive cygdrive posix=0,noacl 0 0
```

Consider a file `\\server\share\foo`. When opening the file as `/mysrv/foo`, the flags `posix=1,acl` of the /mysrv mount point are used. When opening the file as `//server/share/foo`, the flags `posix=0,noacl` for the cygdrive prefix are used.

Note
This only applies to UNC paths using forward slashes. When using backslashes the flags for native paths are used. See Section 3.1.7.

The cygdrive prefix may be changed in the fstab file to another path and mode:

```
none /mnt cygdrive posix=1,sparse 0 0
```

Please note that you cannot use the cygdrive prefix for any other mount point to change modes. For instance, these mount table entries...

```
none /cygdrive cygdrive binary 0 0
D:   /cygdrive/d somefs text 0 0
```

...will not open files using the `/cygdrive/d` path prefix in textmode by default, but in binary mode per the cygdrive prefix mode. If you want to mount any drive explicitly in another mode than the cygdrive prefix, use a different path prefix:

```
none /cygdrive cygdrive binary 0 0
D:   /mnt/d somefs text 0 0
```

To simplify scripting, Cygwin also provides a `/proc/cygdrive` symlink, which allows to use a fixed path in scripts, even if the actual cygdrive prefix has been changed, or is different between different users. So, in scripts, conveniently use the `/proc/cygdrive` symlink to successfully access files independently from the current cygdrive prefix:

```
$ mount -p
Prefix              Type         Flags
/mnt                user         binmode
$ cat > x.sh <<EOF
cd /proc/cygdrive/c/Windows/System32/Drivers/etc
ls -l hosts
EOF
$ sh -c ./x.sh
-rwxrwx---+ 1 SYSTEM SYSTEM 826 Sep  4 22:43 hosts
```

3.1.5 The usertemp file system type

On Windows, the environment variable `TEMP` specifies the location of the temp folder. It serves the same purpose as the /tmp/ directory in Unix systems. In contrast to /tmp/, it is by default a different folder for every Windows user. By using the special purpose usertemp file system, that temp folder can be mapped to /tmp/. This is particularly useful in setups where the administrator wants to write-protect the entire Cygwin directory. The usertemp file system can be configured in /etc/fstab like this:

```
none /tmp usertemp binary,posix=0 0 0
```

3.1.6 Symbolic links

Symbolic links are supported by Windows only on NTFS and have a lot of quirks making them (almost) unusable in a POSIX context. POSIX applications are rightfully expecting to use symlinks and the `symlink(2)` system call, so Cygwin has worked around the Windows shortcomings.

Cygwin creates symbolic links potentially in multiple different ways.

- The default symlinks created by Cygwin are:
  - special reparse points shared with WSL (on NTFS on Windows 10 1607 or later)
  - plain files with the `system` attribute, containing a magic cookie followed by the path to which the link points.

    Note
    Symlinks of this type created by really old Cygwin releases (prior to Cygwin 1.7.0) are usually readable. However, you could run into problems if you're now using another character set than the one you used when creating these symlinks (see Section 2.4.4).

- On filesystems mounted via Microsoft's NFS client, Cygwin always creates real NFS symlinks.
- Native Windows symlinks are only created on filesystems supporting reparse points. Due to their weird restrictions and behaviour, they are only created if the user explicitely requests creating them. This is done by setting the environment variable `CYGWIN` to contain the string `winsymlinks:native` or `winsymlinks:nativestrict`. For the difference between these two settings, see Section 3.5. On AFS, native symlinks are the only supported type of symlink due to AFS lacking support for DOS attributes. This is independent from the `winsymlinks` setting.

  Creation of native symlinks follows special rules to ensure the links are usable outside of Cygwin. This includes dereferencing any Cygwin-only symlinks that lie in the target path.
- Shortcut style symlinks are Windows `.lnk` shortcut files with a special header and the DOS READONLY attribute set. This symlink type is created if the environment variable `CYGWIN` (see Section 3.5) is set to contain the string `winsymlinks` or `winsymlinks:lnk`. On the MVFS filesystem, which does not support the DOS SYSTEM attribute, this is the one and only supported symlink type, independently from the `winsymlinks` setting.

All of the above symlink types are recognized and used as symlinks under all circumstances. However, if the default plain file symlink type is lacking its DOS SYSTEM bit, or if the shortcut file is lacking the DOS READONLY attribute, they are not recognized as symlink.

Apart from these types, there's also a Windows native type, so called directory junctions. They are recognized as symlink but never generated by Cygwin. Filesystem junctions on the other hand are not handled as symlinks, otherwise they would not be recognized as filesystem borders by commands like **find -xdev**.

3.1.7 Using native Win32 paths

Using native Win32 paths in Cygwin, while often possible, is generally inadvisable. Those paths circumvent all internal integrity checking and bypass the information given in the Cygwin mount table.

The following paths are treated as native Win32 paths by the Cygwin DLL (but not necessarily by Cygwin applications):

- All paths starting with a drive specifier

```
C:\foo
C:/foo
```

- All paths containing at least one backslash as path component

```
C:/foo/bar\baz/...
```

- UNC paths using backslashes

```
\\server\share\...
```

When accessing files using native Win32 paths as above, Cygwin uses a default setting for the mount flags. All paths using DOS notation will be treated as case insensitive, and permissions are just faked as if the underlying drive is a FAT drive. This also applies to NTFS and other filesystems which usually are capable of case sensitivity and storing permissions.

3.1.8 Using the Win32 file API in Cygwin applications

Special care must be taken if your application uses Win32 file API functions like `CreateFile` to access files using relative pathnames, or if your application uses functions like `CreateProcess` or `ShellExecute` to start other applications.

When a Cygwin application is started, the Windows idea of the current working directory (CWD) is not necessarily the same as the Cygwin CWD. There are a couple of restrictions in the Win32 API, which disallow certain directories as Win32 CWD:

- The Windows subsystem only supports CWD paths of up to 258 chars. This restriction doesn't apply for Cygwin processes, at least not as long as they use the POSIX API (chdir, getcwd). This means, if a Cygwin process has a CWD using an absolute path longer than 258 characters, the Cygwin CWD and the Windows CWD differ.
- The Win32 API call to set the current directory, `SetCurrentDirectory`, fails for directories for which the user has no permissions, even if the user is an administrator. This restriction doesn't apply for Cygwin processes, if they are running under an administrator account.
- `SetCurrentDirectory` does not support case-sensitive filenames.
- Last, but not least, `SetCurrentDirectory` can't work on virtual Cygwin paths like /proc or /cygdrive. These paths only exists in the Cygwin realm so they have no meaning to a native Win32 process.

As long as the Cygwin CWD is usable as Windows CWD, the Cygwin and Windows CWDs are in sync within a process. However, if the Cygwin process changes its working directory into one of the directories which are unusable as Windows CWD, we're in trouble. If the process uses the Win32 API to access a file using a relative pathname, the resulting absolute path would not match the expectations of the process. In the worst case, the wrong files are deleted.

To workaround this problem, Cygwin sets the Windows CWD to a special directory in this case. This special directory points to a virtual filesystem within the native NT namespace (`\??\PIPE\`). Since it's not a real filesystem, the deliberate effect is that a call to, for instance, `CreateFile ("foo", ...);` will fail, as long as the processes CWD doesn't work as Windows CWD.

So, in general, don't use the Win32 file API in Cygwin applications. If you **really** need to access files using the Win32 API, or if you **really** have to use `CreateProcess` to start applications, rather than the POSIX `exec(3)` family of functions, you have to make sure that the Cygwin CWD is set to some directory which is valid as Win32 CWD.

3.1.9 Additional Path-related Information

The **cygpath** program provides the ability to translate between Win32 and POSIX pathnames in shell scripts. See cygpath(1) for the details.

The `HOME`, `PATH`, and `LD_LIBRARY_PATH` environment variables are automatically converted from Win32 format to POSIX format (e.g. from `c:/cygwin\bin` to `/bin`, if there was a mount from that Win32 path to that POSIX path) when a Cygwin process first starts.

Symbolic links can also be used to map Win32 pathnames to POSIX. For example, the command **ln -s //pollux/home/joe/data /data** would have about the same effect as creating a mount point from `//pollux/home/joe/data` to `/data` using **mount**, except that symbolic links cannot set the default file access mode. Other differences are that the mapping is distributed throughout the file system and proceeds by iteratively walking the directory tree instead of matching the longest prefix in a kernel table. Note that symbolic links will only work on network drives that are properly configured to support the "system" file attribute. Many do not do so by default (the Unix Samba server does not by default, for example).

3.2 Text and Binary modes

3.2.1 The Issue

On a UNIX system, when an application reads from a file it gets exactly what's in the file on disk and the converse is true for writing. The situation is different in the DOS/Windows world where a file can be opened in one of two modes, binary or text. In the binary mode the system behaves exactly as in UNIX. However on writing in text mode, a NL (\n, ^J) is transformed into the sequence CR (\r, ^M) NL.

This can wreak havoc with the seek/fseek calls since the number of bytes actually in the file may differ from that seen by the application.

The mode can be specified explicitly as explained in the Programming section below. In an ideal DOS/Windows world, all programs using lines as records (such as **bash**, **make**, **sed** ...) would open files (and change the mode of their standard input and output) as text. All other programs (such as **cat**, **cmp**, **tr** ...) would use binary mode. In practice with Cygwin, programs that deal explicitly with object files specify binary mode (this is the case of **od**, which is helpful to diagnose CR problems). Most other programs (such as **sed**, **cmp**, **tr**) use the default mode.

3.2.2 The default Cygwin behavior

The Cygwin system gives us some flexibility in deciding how files are to be opened when the mode is not specified explicitly. The rules are evolving, this section gives the design goals.

a. If the filename is specified as a POSIX path and it appears to reside on a file system that is mounted (i.e. if its pathname starts with a directory displayed by **mount**), then the default is specified by the mount flag. If the file is a symbolic link, the mode of the target file system applies.

b. If the file is specified via a MS-DOS pathname (i.e., it contains a backslash or a colon), the default is binary.

c. Pipes, sockets and non-file devices are opened in binary mode. For pipes opened through the pipe() system call you can use the setmode() function (see Section 3.2.4 to switch to textmode. For pipes opened through popen(), you can simply specify text or binary mode just like in calls to fopen().

d. Sockets and other non-file devices are always opened in binary mode.

e. When redirecting, the Cygwin shells uses rules (a-d). Non-Cygwin shells always pipe and redirect with binary mode. With non-Cygwin shells the commands **cat filename | program** and **program < filename** are not equivalent when `filename` is on a text-mounted partition.

   The programs **u2d** and **d2u** can be used to add or remove CR's from a file. **u2d** add's CR's before a NL. **d2u** removes CR's. Use the --help option to these commands for more information.

3.2.3 Binary or text?

UNIX programs that have been written for maximum portability will know the difference between text and binary files and act appropriately under Cygwin. Most programs included in the official Cygwin distributions should work well in the default mode.

Binmode is the best choice usually since it's faster and easier to handle, unless you want to exchange files with native Win32 applications. It makes most sense to keep the Cygwin distribution and your Cygwin home directory in binmode and generate text files in binmode (with UNIX LF lineendings). Most Windows applications can handle binmode files just fine. A notable exception is the mini-editor **Notepad**, which handles UNIX lineendings incorrectly and only produces output files with DOS CRLF lineendings.

You can convert files between CRLF and LF lineendings by using certain tools in the Cygwin distribution like **dos2unix** and **unix2dos** from the dos2unix package. You can also specify a directory in the mount table to be mounted in textmode so you can use that directory for exchange purposes.

As application programmer you can decide on a file by file base, or you can specify default open modes depending on the purpose for which the application open files. See the next section for a description of your choices.

3.2.4 Programming

In the `open()` function call, binary mode can be specified with the flag `O_BINARY` and text mode with `O_TEXT`. These symbols are defined in `fcntl.h`.

The `mkstemp()` and `mkstemps()` calls force binary mode. Use `mkostemp()` or `mkostemps()` with the same flags as `open()` for more control on temporary files.

In the `fopen()` and `popen()` function calls, binary mode can be specified by adding a `b` to the mode string. Text mode is specified by adding a `t` to the mode string.

The mode of a file can be changed by the call `setmode(fd,mode)` where `fd` is a file descriptor (an integer) and `mode` is `O_BINARY` or `O_TEXT`. The function returns `O_BINARY` or `O_TEXT` depending on the mode before the call, and `EOF` on error.

There's also a convenient way to set the default open modes used in an application by just linking against various object files provided by Cygwin. For instance, if you want to make sure that all files are always opened in binary mode by an application, regardless of the mode of the underlying mount point, just add the file `/lib/binmode.o` to the link stage of the application in your project, like this:

```
$ gcc my_tiny_app.c /lib/binmode.o -o my_tiny_app
```

Even simpler:

```
$ gcc my_tiny_app.c -lbinmode -o my_tiny_app
```

This adds code which sets the default open mode for all files opened by **my_tiny_app** to binary for reading and writing.

Cygwin provides the following libraries and object files to set the default open mode just by linking an application against them:

- ```
  /lib/libautomode.a      -  Open files for reading in textmode,
  /lib/automode.o            open files for writing in binary mode
  ```
- ```
  /lib/libbinmode.a       -  Open files for reading and writing in binary mode
  /lib/binmode.o
  ```
- ```
  /lib/libtextmode.a      -  Open files for reading and writing in textmode
  /lib/textmode.o
  ```
- ```
  /lib/libtextreadmode.a  -  Open files for reading in textmode,
  /lib/textreadmode.o        keep default behaviour for writing.
  ```

3.3 File permissions

On FAT or FAT32 filesystems, files are always readable, and Cygwin uses the DOS read-only attribute to determine if they are writable. Files are considered to be executable if the filename ends with .bat, .com or .exe, or if its content starts with #!. Consequently **chmod** can only affect the "w" mode, it silently ignores actions involving the other modes. This means that **ls -l** needs to open and read files. It can thus be relatively slow.

On NTFS, file permissions are evaluated using the Access Control Lists (ACLs) attached to a file. This can be switched off by using the "noacl" option to the respective mount point in the `/etc/fstab` or `/etc/fstab.d/$USER` file. For more information on file permissions, see Section 3.6.

On NFS shares, file permissions are exactly the POSIX permissions transmitted from the server using the NFSv3 protocol, if the NFS client is the one from Microsoft's "Services For Unix", or the one built into Windows Vista or later.

Only the user and group ownership is not necessarily correct.

3.4 Special filenames

3.4.1 Special files in /etc

Certain files in Cygwin's `/etc` directory are read by Cygwin before the mount table has been established. The list of files is

```
/etc/fstab
/etc/fstab.d/$USER
/etc/passwd
/etc/group
```

These file are read using native Windows NT functions which have no notion of Cygwin symlinks or POSIX paths. For that reason there are a few requirements as far as `/etc` is concerned.

To access these files, the Cygwin DLL evaluates it's own full Windows path, strips off the innermost directory component and adds "\etc". Let's assume the Cygwin DLL is installed as `C:\cygwin\bin\cygwin1.dll`. First the DLL name as well as the innermost directory (`bin`) is stripped off: `C:\cygwin\`. Then "etc" and the filename to look for is attached: `C:\cygwin\etc\fstab`. So the /etc directory must be parallel to the directory in which the cygwin1.dll exists and `/etc` must not be a Cygwin symlink pointing to another directory. Consequentially none of the files from the above list, including the directory `/etc/fstab.d` is allowed to be a Cygwin symlink either.

However, native NTFS symlinks and reparse points are transparent when accessing the above files so all these files as well as `/etc` itself may be NTFS symlinks.

Last but not least, make sure that these files are world-readable. Every process of any user account has to read these files potentially, so world-readability is essential. The only exception are the user specific files `/etc/fstab.d/$USER`, which only have to be readable by the $USER user account itself.

3.4.2 Invalid filenames

Filenames invalid under Win32 are not necessarily invalid under Cygwin. There are a few rules which apply to Windows filenames. Most notably, DOS device names like `AUX`, `COM1`, `LPT1` or `PRN` (to name a few) cannot be used as filename or extension in a native Win32 application. So filenames like `prn.txt` or `foo.aux` are invalid filenames for native Win32 applications.

This restriction doesn't apply to Cygwin applications. Cygwin can create and access files with such names just fine. Just don't try to use these files with native Win32 applications.

3.4.3 Forbidden characters in filenames

Some characters are disallowed in filenames on Windows filesystems. These forbidden characters are the ASCII control characters from ASCII value 1 to 31, plus the following characters which have a special meaning in the Win32 API:

```
"   *   :   <   >   ?   |   \
```

Cygwin can't fix this, but it has a method to workaround this restriction. All of the above characters, except for the backslash, are converted to special UNICODE characters in the range 0xf000 to 0xf0ff (the "Private use area") when creating or accessing files by adding 0xf000 to the forbidden characters' code points.

The backslash has to be exempt from this conversion, because Cygwin accepts Win32 filenames including backslashes as path separators on input. Converting backslashes using the above method would make this impossible.

Additionally Win32 filenames can't contain trailing dots and spaces for DOS backward compatibility. When trying to create files with trailing dots or spaces, all of them are removed before the file is created. This restriction only affects native Win32 applications. Cygwin applications can create and access files with trailing dots and spaces without problems.

An exception from this rule are some network filesystems (NetApp, NWFS) which choke on these filenames. They return with an error like "No such file or directory" when trying to create such files. Cygwin recognizes these filesystems and works around this problem by applying the same rule as for the other forbidden characters. Leading spaces and trailing dots and spaces will be converted to UNICODE characters in the private use area. This behaviour can be switched on explicitely for a filesystem or a directory tree by using the mount option `dos`.

3.4.4 Filenames with unusual (foreign) characters

Windows filesystems use Unicode encoded as UTF-16 to store filename information. If you don't use the UTF-8 character set (see Section 2.4) then there's a chance that a filename is using one or more characters which have no representation in the character set you're using.

Note
In the default "C" locale, Cygwin creates filenames using the UTF-8 charset. This will always result in some valid filename by default, but again might impose problems when switching to a non-"C" or non-"UTF-8" charset.

Note
To avoid this scenario altogether, always use UTF-8 as the character set.

If you don't want or can't use UTF-8 as character set for whatever reason, you will nevertheless be able to access the file. How does that work? When Cygwin converts the filename from UTF-16 to your character set, it recognizes characters which can't be converted. If that occurs, Cygwin replaces the non-convertible character with a special character sequence. The sequence starts with an ASCII CAN character (hex code 0x18, equivalent Control-X), followed by the UTF-8 representation of the character. The result is a filename containing some ugly looking characters. While it doesn't **look** nice, it **is** nice, because Cygwin knows how to convert this filename back to UTF-16. The filename will be converted using your usual character set. However, when Cygwin recognizes an ASCII CAN character, it skips over the ASCII CAN and handles the following bytes as a UTF-8 character. Thus, the filename is symmetrically converted back to UTF-16 and you can access the file.

Note
Please be aware that this method is not entirely foolproof. In some character set combinations it might not work for certain native characters.
Only by using the UTF-8 charset you can avoid this problem safely.

3.4.5 Case sensitive filenames

In the Win32 subsystem filenames are only case-preserved, but not case-sensitive. You can't access two files in the same directory which only differ by case, like `Abc` and `aBc`. While NTFS (and some remote filesystems) support case-sensitivity, the NT kernel does not support it by default. Rather, you have to tweak a registry setting and reboot. For that reason, case-sensitivity can not be supported by Cygwin, unless you change that registry value.

If you really want case-sensitivity in Cygwin, you can switch it on by setting the registry value

```
HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\kernel\obcaseinsensitive
```

to 0 and reboot the machine.

Note
When installing Microsoft's Services For Unix (SFU), you're asked if you want to use case-sensitive filenames. If you answer "yes" at this point, the installer will change the aforementioned registry value to 0, too. So, if you have SFU installed, there's some chance that the registry value is already set to case sensitivity.

After you set this registry value to 0, Cygwin will be case-sensitive by default on NTFS and NFS filesystems. However, there are limitations: while two **programs** `Abc.exe` and `aBc.exe` can be created and accessed like other files, starting applications is still case-insensitive due to Windows limitations and so the program you try to launch may not be the one actually started. Also, be aware that using two filenames which only differ by case might result in some weird interoperability issues with native Win32 applications. You're using case-sensitivity at your own risk. You have been warned!

Even if you use case-sensitivity, it might be feasible to switch to case-insensitivity for certain paths for better interoperability with native Win32 applications (even if it's just Windows Explorer). You can do this on a per-mount point base, by using the "posix=0" mount option in `/etc/fstab`, or your `/etc/fstab.d/$USER` file.

`/cygdrive` paths are case-insensitive by default. The reason is that the native Windows %PATH% environment variable is not always using the correct case for all paths in it. As a result, if you use case-sensitivity on the `/cygdrive` prefix, your shell might claim that it can't find Windows commands like **attrib** or **net**. To ease the pain, the `/cygdrive` path is case-insensitive by default and you have to use the "posix=1" setting explicitly in `/etc/fstab` or `/etc/fstab.d/$USER` to switch it to case-sensitivity, or you have to make sure that the native Win32 %PATH% environment variable is using the correct case for all paths throughout.

Note that mount points as well as device names and virtual paths like /proc are always case-sensitive! The only exception are the subdirectories and filenames under /proc/registry, /proc/registry32 and /proc/registry64. Registry access is always case-insensitive. Read on for more information.

3.4.6 Case sensitive directories

Windows 10 1803 introduced a new feature: NTFS directories can be marked as case-sensitive, independently of the `obcaseinsensit` registry key discussed in the previous section. This new per-directory case-sensitivity requires setting a flag in the NTFS filesystem header which is, unfortunately, undocumented. The result is that you have to activate `Windows Subsystem for Linux` (`WSL`), a feature available via `Programs and Features` -> `Turn Windows features on or off`. You only have to activate `WSL`, you don't have to install any actual Linux. After turning `WSL` on and performing the compulsory reboot, case-sensitive directories are activated.

Of course, there's a drawback. While these case-sensitive directories work like charm on the local machine, there are massive interoperability problems when trying to access these directories from remote machines at the time of writing this. We opened a bug report for that at Microsoft's WSL issue tracker, if you're interested in the details.

Note
If you want case-sensitivity and need interoperability with remote machines, better stick to switching the kernel to case-sensitivity as outlined in Section 3.4.5

With `WSL` activated and starting with Cygwin 3.0.0, Cygwin's **mkdir** system call automatically created all directories below the Cygwin installation directory as case-sensitive. With Cygwin 3.0.2, this feature had been disabled again for hopefully obvious reasons.

However, you can still use Cygwin's new chattr(1) tool with the `-C` option to control case-sensitivity of directories on NTFS filesystems.

Please keep in mind that switching *off* case-sensitivity on a directory has a condition attached to it: If the directory contains two files which only differ in case (e. g., `foo` and `FOO`), Windows refuses to convert the dir back to case-insensitive. First you have to fix the filename collision, i. e., you have to rename one of these files.

3.4.7 POSIX devices

While there is no need to create a POSIX `/dev` directory, the directory is automatically created as part of a Cygwin installation. It's existence is often a prerequisit to run certain applications which create symbolic links, fifos, or UNIX sockets in `/dev`. Also, the directories `/dev/shm` and `/dev/mqueue` are required to exist to use named POSIX semaphores, shared memory, and message queues, so a system without a real `/dev` directory is functionally crippled.

Apart from that, Cygwin automatically simulates POSIX devices internally. The `/dev` directory is automagically populated with existing POSIX devices by Cygwin in a way comparable with a udev based virtual `/dev` directory under Linux.

Cygwin supports the following character devices commonly found on POSIX systems:

```
/dev/null
/dev/zero
/dev/full
```

```
/dev/console  Pseudo device name for the current console window of a session.
    Cygwin's /dev/console is not quite comparable with the console
    device on UNIX machines.

/dev/cons0      Console sessions are numbered from  /dev/cons0 upwards.
/dev/cons1  Console device names are pseudo device names, only accessible
...   from processes within this very console session.  This is due
    to a restriction in Windows.

/dev/tty  The current controlling tty of a session.

/dev/ptmx Pseudo tty master device.

/dev/pty0 Pseudo ttys are numbered from /dev/pty0 upwards as they are
/dev/pty1 requested.
...

/dev/ttyS0  Serial communication devices.  ttyS0 == Win32 COM1,
/dev/ttyS1  ttyS1 == COM2, etc.
...

/dev/pipe
/dev/fifo

/dev/kmsg Kernel message pipe, for usage with sys logger services.

/dev/random Random number generator.
/dev/urandom

/dev/dsp  Default sound device of the system.
```

Cygwin also has several Windows-specific devices:

```
/dev/com1 The serial ports, starting with COM1 which is the same as ttyS0.
/dev/com2 Please use /dev/ttySx instead.
...

/dev/conin  Same as Windows CONIN$.
/dev/conout Same as Windows CONOUT$.
/dev/clipboard  The Windows clipboard, text only
/dev/windows  The Windows message queue.
```

Block devices are accessible by Cygwin processes using fixed POSIX device names. These POSIX device names are generated using a direct conversion from the POSIX namespace to the internal NT namespace. E.g. the first harddisk is the NT internal device \device\harddisk0\partition0 or the first partition on the third harddisk is \device\harddisk2\partition1. The first floppy in the system is \device\floppy0, the first CD-ROM is \device\cdrom0 and the first tape drive is \device\tape0.

The mapping from physical device to the name of the device in the internal NT namespace can be found in various places. For hard disks and CD/DVD drives, the Windows "Disk Management" utility (part of the "Computer Management" console) shows that the mapping of "Disk 0" is \device\harddisk0. "CD-ROM 2" is \device\cdrom2. Another place to find this mapping is the "Device Management" console. Disks have a "Location" number, tapes have a "Tape Symbolic Name", etc. Unfortunately, the places where this information is found is not very well-defined.

For external disks (USB-drives, CF-cards in a cardreader, etc) you can use Cygwin to show the mapping. `/proc/partitions` contains a list of raw drives known to Cygwin. The **df** command shows a list of drives and their respective sizes. If you match the information between `/proc/partitions` and the **df** output, you should be able to figure out which external drive corresponds to which raw disk device name.

Raw devices of partitions protected by BitLocker provide access to the *decrypted* NTFS image. If the partition is locked, read attempts fail with `Permission denied`. The corresponding block range from the raw device of the full disk provides access to the *encrypted* image as stored on the disk.

Note
Apart from tape devices which are not block devices and are by default accessed directly, accessing mass storage devices raw is something you should only do if you know what you're doing and know how to handle the information. **Writing** to a raw mass storage device you should only do if you **really** know what you're doing and are aware of the fact that any mistake can destroy important information, for the device, and for you. So, please, handle this ability with care.
Important: Windows may allow raw read **and write** access to partitions (for example `/dev/sda2`) even from unprivileged processes. This is usually the case for partitions on "removable" drives like USB flash drives or regular SATA/NVMe drives behind USB docking stations. If **chkdsk X:** works, raw access to the same partition is possible from the same user account. **You have been warned.**

Last but not least, the mapping from POSIX /dev namespace to internal NT namespace is as follows:

```
POSIX device name     Internal NT device name

/dev/st0        \device\tape0, rewind
/dev/nst0       \device\tape0, no-rewind
/dev/st1        \device\tape1
/dev/nst1       \device\tape1
...
/dev/st15
/dev/nst15

/dev/fd0        \device\floppy0
/dev/fd1        \device\floppy1
...
/dev/fd15

/dev/sr0        \device\cdrom0
/dev/sr1        \device\cdrom1
...
/dev/sr15

/dev/scd0       \device\cdrom0
/dev/scd1       \device\cdrom1
...
/dev/scd15

/dev/sda        \device\harddisk0\partition0  (whole disk)
/dev/sda1       \device\harddisk0\partition1  (first partition)
...
/dev/sda15        \device\harddisk0\partition15 (fifteenth partition)

/dev/sdb        \device\harddisk1\partition0
/dev/sdb1       \device\harddisk1\partition1

[up to]

/dev/sddx       \device\harddisk127\partition0
/dev/sddx1        \device\harddisk127\partition1
...
/dev/sddx15       \device\harddisk127\partition15
```

if you don't like these device names, feel free to create symbolic links as they are created on Linux systems for convenience:

```
ln -s /dev/sr0 /dev/cdrom
ln -s /dev/nst0 /dev/tape
...
```

3.4.8 The .exe extension

Win32 executable filenames end with `.exe` but the `.exe` need not be included in the command, so that traditional UNIX names can be used. However, for programs that end in `.bat` and `.com`, you cannot omit the extension.

As a side effect, the **ls filename** gives information about `filename.exe` if `filename.exe` exists and `filename` does not. In the same situation the function call `stat("filename",..)` gives information about `filename.exe`. The two files can be distinguished by examining their inodes, as demonstrated below.

```
bash$ ls *
a      a.exe     b.exe
bash$ ls -i a a.exe
445885548 a       435996602 a.exe
bash$ ls -i b b.exe
432961010 b       432961010 b.exe
```

If a shell script `myprog` and a program `myprog.exe` coexist in a directory, the shell script has precedence and is selected for execution of **myprog**. Note that this was quite the reverse up to Cygwin 1.5.19. It has been changed for consistency with the rest of Cygwin.

The **gcc** compiler produces an executable named `filename.exe` when asked to produce `filename`. This allows many makefiles written for UNIX systems to work well under Cygwin.

3.4.9 The /proc filesystem

Cygwin, like Linux and other similar operating systems, supports the `/proc` virtual filesystem. The files in this directory are representations of various aspects of your system, for example the command **`cat /proc/cpuinfo`** displays information such as what model and speed processor you have.

One unique aspect of the Cygwin `/proc` filesystem is `/proc/registry`, see next section.

The Cygwin `/proc` is not as complete as the one in Linux, but it provides significant capabilities. The `procps` package contains several utilities that use it.

3.4.9.1 proc

proc — process and system information pseudo-filesystem

Description

The `proc` filesystem is a pseudo-filesystem which provides an interface to Cygwin data structures. It is commonly mounted at `/proc`. Typically, it is mounted automatically by the system.

Overview

Underneath `/proc`, there are the following general groups of files and subdirectories:

`/proc/[pid]` subdirectories Each one of these subdirectories contains files and subdirectories exposing information about the process with the corresponding process id.

The `/proc/[pid]` subdirectories are visible when iterating through `/proc` with readdir(2) (and thus are visible when one uses ls(1) to view the contents of `/proc`).

`/proc/self` When a process accesses this magic symbolic link, it resolves to the process's own `/proc/[pid]` directory.

`/proc/[a-z]*` Various other files and subdirectories under `/proc` expose system-wide information.

All of the above are described in more detail below.

Files and directories

The following list provides details of many of the files and directories under the `/proc` hierarchy.

/proc/[pid] There is a numerical subdirectory for each running process; the subdirectory is named by the process id. Each `/proc/[pid]` subdirectory contains the pseudo-files and directories described below.

The files inside each `/proc/[pid]` directory are normally owned by the effective user and effective group id of the process.

/proc/[pid]/cmdline This read-only file holds the complete command line for the process, unless the process is a zombie. In the latter case, there is nothing in this file: that is, a read on this file will return 0 characters. The command-line arguments appear in this file as a set of strings followed by null bytes ('\0').

/proc/[pid]/ctty This read-only file holds the name of the console or control terminal device for the process, unless the process is detached from any terminal. In the latter case, there is only a newline in this file.

/proc/[pid]/cwd This is a symbolic link to the current working directory of the process. To find out the current working directory of process 20, for instance, you can do this:

```
$ cd /proc/20/cwd; /bin/pwd
```

Note that the *pwd* command is often a shell built-in, and might not work properly. In bash(1), you may use **pwd -P**.

/proc/[pid]/environ This read-only file contains the current environment that may have been changed by the currently executing program. The entries are separated by null bytes ('\0'), and there may be a null byte at the end. Thus, to print out the environment of process 1, you would do:

```
$ cat -A /proc/1/environ
```

If, after an execve(2), the process modifies its environment (e.g., by calling functions such as putenv(3) or modifying the environ(7) variable directly), this file will reflect those changes. That may not be the case on other systems such as Linux.

/proc/[pid]/exe This file is a symbolic link containing the actual pathname of the executed command. This symbolic link can be dereferenced normally; attempting to open it will open the executable. You can even type `/proc/[pid]/exe` to run another copy of the same executable that is being run by process *[pid]*. `/proc/[pid]/exe` is a pointer to the binary which was executed, and appears as a symbolic link.

/proc/[pid]/exename This read-only file contains the actual pathname of the executed command.

/proc/[pid]/fd/ This is a subdirectory containing one entry for each file which the process has open, named by its file descriptor, and which is a symbolic link to the actual file. Thus, 0 is standard input, 1 standard output, 2 standard error, and so on.

For file descriptors for pipes and sockets, the entries will be symbolic links whose content is the file type with the inode. A readlink(2) call on this file returns a string in the format: `type:[inode]`

For example, `socket:[2248868]` will be a socket and its inode is 2248868.

Programs that take a filename as a command-line argument, but don't take input from standard input if no argument is supplied, and programs that write to a file named as a command-line argument, but don't send their output to standard output if no argument is supplied, can nevertheless be made to use standard input or standard output by using `/proc/[pid]/fd` files as command-line arguments. For example, assuming that `-i` is the flag designating an input file and `-o` is the flag designating an output file:

```
$ foobar -i /proc/self/fd/0 -o /proc/self/fd/1 ...
```

and you have a working filter.

`/proc/self/fd/N` is approximately the same as `/dev/fd/N` in some Unix and Unix-like systems. Most Linux **makedev** scripts symbolically link `/dev/fd` to `/proc/self/fd`, in fact.

Most systems provide symbolic links `/dev/stdin`, `/dev/stdout`, and `/dev/stderr`, which respectively link to the files `0`, `1`, and `2` in `/proc/self/fd`. Thus the example command above could be written as:

```
$ foobar -i /dev/stdin -o /dev/stdout ...
```

Note that for file descriptors referring to inodes (pipes and sockets, see above), those inodes still have permission bits and ownership information distinct from those of the `/proc/[pid]/fd` entry, and that the owner may differ from the user and group ids of the process. An unprivileged process may lack permissions to open them, as in this example:

```
$ echo test | sudo -u nobody cat
test
$ echo test | sudo -u nobody cat /proc/self/fd/0
cat: /proc/self/fd/0: Permission denied
```

File descriptor 0 refers to the pipe created by the shell and owned by that shell's user, which is not `nobody`, so **cat** does not have permission to create a new file descriptor to read from that inode, even though it can still read from its existing file descriptor 0.

/proc/[pid]/gid This read-only file contains the primary group id for the process.

/proc/[pid]/maps A file containing the currently mapped memory regions and their access permissions. See mmap(2) for some further information about memory mappings.

The format of the file is:

```
address           perms offset   dev       inode                pathname

00010000-00020000 rw-s 00000000 0000:0000 0                    [win heap 1 default  ↩
    shared]
...
00080000-00082000 rw-p 00000000 0000:0000 0                    [win heap 0 default grow]
00082000-0009A000 ===p 00002000 0000:0000 0                    [win heap 0 default grow]
000A0000-000A1000 rw-p 00000000 0000:0000 0                    [win heap 2 grow]
000A1000-000BA000 ===p 00001000 0000:0000 0                    [win heap 2 grow]
000C0000-000D9000 rw-p 00000000 0000:0000 0                    [win heap 0 default grow]
000D9000-001C0000 ===p 00019000 0000:0000 0                    [win heap 0 default grow]
00200000-00377000 ===p 00000000 0000:0000 0
00377000-00378000 rw-p 00177000 0000:0000 0                    [peb]
00378000-0037A000 rw-p 00178000 0000:0000 0                    [teb (tid 8844)]
...
00400000-005F9000 ===p 00000000 0000:0000 0                    [stack (tid 8884)]
005F9000-005FC000 rw-g 001F9000 0000:0000 0                    [stack (tid 8884)]
005FC000-00600000 rw-p 001FC000 0000:0000 0                    [stack (tid 8884)]
00600000-006C7000 r--s 00000000 EE45:4341 281474976741117      /proc/cygdrive/c/Windows/ ↩
    System32/locale.nls
...
100400000-100401000 r--p 00000000 EE45:4341 281474978095037    /usr/bin/sh.exe
100401000-100413000 r-xp 00001000 EE45:4341 281474978095037    /usr/bin/sh.exe
100413000-100414000 rw-p 00013000 EE45:4341 281474978095037    /usr/bin/sh.exe
...
180010000-180020000 rw-s 00000000 0000:0000 0                  [procinfo]
180020000-180029000 rw-s 00000000 0000:0000 0                  [cygwin-user-shared]
180030000-18003C000 rw-s 00000000 0000:0000 0                  [cygwin-shared]
180040000-180041000 r--p 00000000 EE45:4341 2251799814294868    /usr/bin/cygwin1.dll
180041000-18022D000 r-xp 00001000 EE45:4341 2251799814294868    /usr/bin/cygwin1.dll
18022D000-180231000 rwxp 001ED000 EE45:4341 2251799814294868    /usr/bin/cygwin1.dll
180231000-18026A000 rw-p 001F1000 EE45:4341 2251799814294868    /usr/bin/cygwin1.dll
...
800000000-800090000 rw-p 00000000 0000:0000 0                  [heap]
800090000-820000000 ===p 00090000 0000:0000 0                  [heap]
7FF4FDEB0000-7FF4FDEB5000 r--s 00000000 0000:0000 0
7FF4FDEB5000-7FF4FDFB0000 ===s 00005000 0000:0000 0
7FF4FDFB0000-7FF5FDFD0000 ===p 00000000 0000:0000 0
...
```

```
7FFBEEAC0000-7FFBEEAC1000 r--p 00000000 EE45:4341 844424934724994   /proc/cygdrive/c/ ↩
    Windows/System32/kernel32.dll
7FFBEEAC1000-7FFBEEB36000 r-xp 00001000 EE45:4341 844424934724994   /proc/cygdrive/c/ ↩
    Windows/System32/kernel32.dll
7FFBEEB36000-7FFBEEB68000 r--p 00076000 EE45:4341 844424934724994   /proc/cygdrive/c/ ↩
    Windows/System32/kernel32.dll
7FFBEEB68000-7FFBEEB6A000 rw-p 000A8000 EE45:4341 844424934724994   /proc/cygdrive/c/ ↩
    Windows/System32/kernel32.dll
7FFBEEB6A000-7FFBEEB72000 r--p 000AA000 EE45:4341 844424934724994   /proc/cygdrive/c/ ↩
    Windows/System32/kernel32.dll
...
```

The `address` field is the address space in the process that the mapping occupies. The `perms` field is a set of permissions:

r read

w write

x execute

=== reserved

s shared

g guard

p private

The `offset` field is the offset into the file/whatever; `dev` is the device (major:minor); `inode` is the inode on that device. 0 indicates that no inode is associated with the memory region, as would be the case with BSS (uninitialized data).

The `pathname` field will usually be the file that is backing the mapping.

There are additional helpful pseudo-paths:

[cygwin-shared] Global shared Cygwin process information.

[cygwin-user-shared] Global shared Cygwin user information.

[peb] Windows Process Environment Block.

[procinfo] Cygwin process information.

[shared-user-data] Shared user information.

[heap] The process's heap.

[stack] The initial process's (also known as the main thread's) stack.

[stack (tid <tid>)] A thread's stack (where the `<tid>` is a thread id).

[teb (tid <tid>)] Windows Thread Environment Block (where `<tid>` is a thread id).

[win heap <n> default shared exec grow noserial debug] Windows extended heap (where `<n>` is a heap id) and the rest of the words are heap flags:

default default heap flags

shared shareable and mapped heap flags

exec executable heap flag

grow growable heap flag

noserial do not serialize heap flag

debug debugged heap flag

If the `pathname` field is blank, this is an anonymous mapping as obtained via mmap(2). There is no easy way to coordinate this back to a process's source, short of running it through gdb(1), strace(1), or similar.

`pathname` is shown unescaped except for newline characters, which are replaced with an octal escape sequence. As a result, it is not possible to determine whether the original `pathname` contained a newline character or the literal `\e012` character sequence.

If the mapping is file-backed and the file has been deleted, the string " `(deleted)`" is appended to the `pathname`. Note that this is ambiguous too.

/proc/[pid]/mountinfo This file contains information about mount points in the process's mount namespace (see mount_namesp
It supplies various information (e.g., propagation state, root of mount for bind mounts, identifier for each mount and its parent) that is missing from the (older) `/proc/[pid]/mounts` file, and fixes various other problems with that file (e.g., nonextensibility, failure to distinguish per-mount versus per-superblock options).

The file contains lines of the form:

```
36 35 98:0 /mnt1 /mnt2 rw,noatime master:1 - ext3 /dev/root rw,errors=continue
(1)(2)(3)   (4)   (5)      (6)      (?)   (7) (8)   (9)          (10)
```

The numbers in parentheses are labels for the descriptions below:

(1) mount id: a unique id for the mount (may be reused after umount(2)).

(2) parent id: the id of the parent mount (or of self for the root of this mount namespace's mount tree).

(3) *major*`:`*minor*: the value of `st_dev` for files on this filesystem (see stat(2)).

(4) root: the pathname of the directory in the filesystem which forms the root of this mount.

(5) mount point: the pathname of the mount point relative to the process's root directory.

(6) mount options: per-mount options (see mount(2)).

(?) optional fields: zero or more fields of the form "*tag*`[:`*value*`]`"; see below.

(7) separator: the end of the optional fields is marked by a single hyphen.

(8) filesystem type: the filesystem type in the form "*type*`[.`*subtype*`]`".

(9) mount source: filesystem-specific information or "`none`".

(10) super options: per-superblock options (see mount(2)).

/proc/[pid]/mounts This file lists all the filesystems currently mounted in the process's mount namespace (see mount_namespace
The format of this file is documented in fstab(5).

/proc/[pid]/pgid This read-only file contains the process group id for the process.

/proc/[pid]/ppid This read-only file contains the parent process id for the process.

/proc/[pid]/root UNIX and Linux support the idea of a per-process root of the filesystem, set by the chroot(2) system call. This file is a symbolic link that points to the process's root directory, and behaves in the same way as `exe`, and `fd/*`.

/proc/[pid]/sid This read-only file contains the session id for the process.

/proc/[pid]/stat Status information about the process. This is used by some implementations of ps(1).

The fields, in order, with their proper scanf(3) format specifiers, are listed below.

(1) *pid* %d The process id.

(2) *comm* %s The filename of the executable, in parentheses. This is visible whether or not the executable is swapped out.

(3) *state* %c One of the following characters, indicating process state:

- **R** Runnable
- **O** Running
- **S** Sleeping in an interruptible wait
- **D** Waiting in uninterruptible disk sleep
- **Z** Zombie
- **T** Stopped (on a signal) or trace stopped

(4) *ppid* %d The PID of the parent of this process.

(5) *pgrp* %d The process group id of the process.

(6) *session* %d The session id of the process.

(7) ***tty_nr*** **%d** The controlling terminal of the process. (The minor device number is contained in the combination of bits 31 to 20 and 7 to 0; the major device number is in bits 15 to 8.)

(8) ***tpgid*** **%d** The id of the foreground process group of the controlling terminal of the process.

(9) ***flags*** **%u** The kernel flags word of the process.

(10) ***minflt*** **%lu** The number of minor faults the process has made which have not required loading a memory page from disk.

(11) ***cminflt*** **%lu** The number of minor faults that the process's waited-for children have made.

(12) ***majflt*** **%lu** The number of major faults the process has made which have required loading a memory page from disk.

(13) ***cmajflt*** **%lu** The number of major faults that the process's waited-for children have made.

(14) ***utime*** **%lu** Amount of time that this process has been scheduled in user mode, measured in clock ticks (divide by `sysconf(_SC_CLK_TCK)`).

(15) ***stime*** **%lu** Amount of time that this process has been scheduled in kernel mode, measured in clock ticks (divide by `sysconf(_SC_CLK_TCK)`).

(16) ***cutime*** **%ld** Amount of time that this process's waited-for children have been scheduled in user mode, measured in clock ticks (divide by `sysconf(_SC_CLK_TCK)`). (See also times(2)).

(17) ***cstime*** **%ld** Amount of time that this process's waited-for children have been scheduled in kernel mode, measured in clock ticks (divide by `sysconf(_SC_CLK_TCK)`).

(18) ***priority*** **%ld** For processes running a real-time scheduling policy (*policy* below; see sched_setscheduler(2)), this is the negated scheduling priority, minus one; that is, a number in the range -2 to -100, corresponding to real-time priorities 1 to 99. For processes running under a non-real-time scheduling policy, this is the raw nice value (setpriority(2)) as represented in the kernel. The kernel stores nice values as numbers in the range 0 (high) to 39 (low), corresponding to the user-visible nice range of -20 to 19.

(19) ***nice*** **%ld** The nice value (see setpriority(2)), a value in the range 19 (low priority) to -20 (high priority).

(20) ***num_threads*** **%ld** Number of threads in this process. Currently shown as 0.

(21) ***itrealvalue*** **%ld** The time in jiffies before the next `SIGALRM` is sent to the process due to an interval timer. This field is no longer maintained, and is hard coded as 0.

(22) ***starttime*** **%llu** The time the process started after system boot. The value is expressed in clock ticks (divide by `sysconf(_SC_CLK_TCK)`).

(23) ***vsize*** **%lu** Virtual memory size in bytes.

(24) ***rss*** **%ld** Resident Set Size: number of pages the process has in real memory. This is just the pages which count toward text, data, or stack space. This does not include pages which have not been demand-loaded in, or which are swapped out.

(25) ***rsslim*** **%lu** Current soft limit in bytes on the rss of the process; see the description of `RLIMIT_RSS` in getrlimit(2).

`/proc/[pid]/statm` Provides information about memory usage, measured in pages. The columns are:

(1) size total program size (same as VmSize in `/proc/[pid]/status`)

(2) resident resident set size (same as VmRSS in `/proc/[pid]/status`)

(3) shared number of resident shared pages (i.e., backed by a file) (same as RssFile+RssShmem in `/proc/[pid]/status`)

(4) text text (code)

(5) lib library

(6) data data + stack

(7) dt dirty pages (always 0)

`/proc/[pid]/status` Provides much of the information in `/proc/[pid]/stat` and `/proc/[pid]/statm` in a format that's easier for humans to parse. Here's an example:

```
$ cat /proc/$$/status

Name:   bash
Umask:  0022
State:  S (sleeping)
Tgid:   17248
Pid:    17248
PPid:   17200
Uid:    1000    1000    1000    1000
Gid:    100     100     100     100
VmSize:   131168 kB
VmLck:         0 kB
VmRSS:     13484 kB
VmData:    10332 kB
VmStk:       136 kB
VmExe:       992 kB
VmLib:      2104 kB
SigPnd: 0000000000000000
SigBlk: 0000000000010000
SigIgn: 0000000000384004
```

The fields are as follows:

- *Name*: Command run by this process.
- *Umask*: Process umask, expressed in octal with a leading zero; see umask(2).
- *State*: Current state of the process. One of:

  R runnable
  O running
  S sleeping
  D disk sleep
  T stopped or tracing stop
  Z zombie
- *Tgid*: Thread group id (i.e., Process id).
- *Pid*: Thread id (see gettid(2)).
- *PPid*: PID of parent process.
- *Uid*, *Gid*: Real, effective, saved set, and filesystem UIDs (GIDs).
- *VmSize*: Virtual memory size.
- *VmLck*: Locked memory size (see mlock(2)).
- *VmRSS*: Resident set size.
- *VmData*, *VmStk*, *VmExe*: Size of data, stack, and text segments.
- *VmLib*: Shared library code size.
- *SigPnd*: Number of signals pending for process as a whole (see pthreads(7) and signal(7)).
- *SigBlk*, *SigIgn*: Masks indicating signals being blocked and ignored (see signal(7)).

/proc/[pid]/uid This read-only file contains the user id for the process.

/proc/[pid]/winexename This read-only file contains the Windows pathname of the executed command.

/proc/[pid]/winpid This read-only file contains the Windows process id for the process.

/proc/cpuinfo This is a collection of CPU and system architecture dependent items, for each supported architecture a different list. Two common entries are *processor* which gives CPU number and *bogomips*, a system constant that is calculated during kernel initialization. SMP machines have information for each CPU. The lscpu(1) command gathers its information from this file.

/proc/cygdrive This file is a symbolic link that points to the user's Windows mapped drive mount point, similar to *root*.

/proc/devices Text listing of major numbers and device groups. This can be used by **makedev** scripts for consistency with the system.

/proc/filesystems A text listing of the filesystems which are supported by Cygwin. (See also filesystems(5).) If a filesystem is marked with "nodev", this means that it does not require a block device to be mounted (e.g., virtual filesystem, network filesystem).

/proc/loadavg The first three fields in this file are load average figures giving the number of jobs in the run queue (state R) averaged over 1, 5, and 15 minutes. They are the same as the load average numbers given by uptime(1) and other programs. The fourth field consists of two numbers separated by a slash (/). The first of these is the number of currently runnable scheduling entities (processes, threads). The value after the slash is the number of scheduling entities that currently exist on the system.

/proc/meminfo This file reports statistics about memory usage on the system. It is used by free(1) to report the amount of free and used memory (both physical and swap) on the system as well as the shared memory and buffers used by the system. Each line of the file consists of a parameter name, followed by a colon, the value of the parameter, and an option unit of measurement (e.g., "kB"). The list below describes the parameter names and the format specifier required to read the field value. Some fields are displayed only if the system was configured with various options; those dependencies are noted in the list.

***MemTotal* %lu** Total usable RAM (i.e., physical RAM minus a few reserved bits and the system binary code).

***MemFree* %lu** The sum of *LowFree* + *HighFree*.

***HighTotal* %lu** Total amount of highmem.

***HighFree* %lu** Amount of free highmem.

***LowTotal* %lu** Total amount of lowmem. Lowmem is memory which can be used for everything that highmem can be used for, but it is also available for the system's use for its own data structures. Bad things happen when you're out of lowmem.

***LowFree* %lu** Amount of free lowmem.

***SwapTotal* %lu** Total amount of swap space available.

***SwapFree* %lu** Amount of swap space that is currently unused.

/proc/misc Text listing of minor device numbers and names of devices with major device number of the `misc` device group. This can be used by **makedev** scripts for consistency with the system.

/proc/mounts With the introduction of per-process mount namespaces, this file became a link to `/proc/self/mounts`, which lists the mount points of the process's own mount namespace. The format of this file is documented in fstab(5).

/proc/net This directory contains various files and subdirectories containing information about the networking layer. The files contain ASCII structures and are, therefore, readable with cat(1). However, the standard netstat(8) suite provides much cleaner access to these files.

/proc/net/if_inet6 This file contains information about IP V6 interface adapters, if used. Each line represents an IP V6 interface adapter.

```
fe800000000000002c393d3da6108636 12 40 20 80 {C6B5FBE5-A3AC-4DB0-A308-8EE94E1406A4}
fe8000000000000039da016f76bd92bc 13 40 20 20 {E06B8972-0918-41FC-851B-090C446C7D1C}
fe8000000000000050ba9cedf1fe1628 0b 40 20 20 {680ED6FD-DFAC-4398-AA85-FB33E17E38EA}
fe8000000000000030c5c6a0b30f109d 11 40 20 20 {B9E39F53-1659-4065-BDA5-F41162250E03}
20021840ac2c12343427e3b9ec6fa585 08 40 00 80 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c12342403e3b2c7a5a32f 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c1234284e8d0ecb4160cb 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c123468cb06ea72f1d678 08 80 00 80 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c12346cb59aca97c36e3b 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c123498af9881de1fb828 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c1234cd62a3d73a498611 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
20021840ac2c1234e410c873be09df93 08 80 00 20 {4083A7F8-99CF-4220-8715-6FDF268B002F}
```

```
fe80000000000003427e3b9ec6fa585 08 40 20 80 {4083A7F8-99CF-4220-8715-6FDF268B002F}
00000000000000000000000000000001 01 80 10 80 {2B5345AC-7502-11EA-AC73-806E6F6E6963}
         (1)   (2)(3)(4)(5)   (6)
```

The fields in each line are:

(1) The IP V6 address of the interface adapter.

(2) The IP V6 interface adapter index.

(3) The prefix length of the IP V6 interface address.

(4) The scope of the IP V6 interface address.

(5) The state of the IP V6 interface address.

(6) The DUID/GUID/UUID of the IP V6 interface adapter.

The last number exists only for compatibility reasons and is always 1.

/proc/partitions Contains the major and minor numbers of each partition as well as the number of 1024-byte blocks and the partition name.

/proc/registry Under Cygwin, this directory contains subdirectories for registry paths, keys, and subkeys, and files named for registry values which contain registry data, for the current process.

/proc/registry32 Under 64 bit Windows, this directory contains subdirectories for registry paths, keys, and subkeys, and files named for registry values which contain registry data, for 32 bit processes.

/proc/registry64 Under 64 bit Windows, this directory contains subdirectories for registry paths, keys, and subkeys, and files named for registry values which contain registry data, for 64 bit processes.

/proc/self This directory refers to the process accessing the `/proc` filesystem, and is identical to the `/proc` directory named by the process id of the same process.

/proc/stat system statistics. Varies with architecture. Common entries include:

cpu 10132153 0 3084719 46828483

cpu0 1393280 0 572056 13343292 The amount of time, measured in units of USER_HZ (1/100ths of a second on most architectures, use `sysconf(_SC_CLK_TCK)` to obtain the right value), that the system ("cpu" line) or the specific CPU ("cpu *N*" line) spent in various states:

(1) ***user*** Time spent in user mode.

(2) ***nice*** Time spent in user mode with low priority (nice).

(3) ***system*** Time spent in system mode.

(4) ***idle*** Time spent in the idle task.

page 5741 1808 The number of pages the system paged in and the number that were paged out (from disk).

swap 1 0 The number of swap pages that have been brought in and out.

intr 1462898 The number of interrupts serviced.

ctxt 115315 The number of context switches that the system underwent.

btime 769041601 boot time, in seconds since the Epoch, 1970-01-01 00:00:00 +0000 (UTC).

/proc/swaps Swap areas in use. See also swapon(8).

/proc/sys This directory contains a number of files and subdirectories linking to Windows objects, which can be read using these entries.

String values may be terminated by either '\0' or '\n'.

Integer and long values may be either in decimal or in hexadecimal notation (e.g. 0x3FFF). Multiple integer or long values may be separated by any of the following whitespace characters: ' ', '\t', or '\n'.

/proc/sysvipc Subdirectory containing the pseudo-files `msg`, `sem`and `shm`. These files list the System V Interprocess Communication (IPC) objects (respectively: message queues, semaphores, and shared memory) that currently exist on the system, providing similar information to that available via ipcs(1). These files are only available if the cygserver Cygwin service is running. These files have headers and are formatted (one IPC object per line) for easy understanding. svipc(7) provides further background on the information shown by these files.

/proc/uptime This file contains two numbers (values in seconds): the uptime of the system (including time spent in suspend) and the amount of time spent in the idle process.

/proc/version This string identifies the Cygwin version that is currently running. For example:

```
CYGWIN_NT-10.0-18363 version 3.1.7-340.x86_64 (corinna@calimero) (gcc version 9.3.0 ↩
    20200312 (Fedora Cygwin 9.3.0-1) (GCC) ) 2020-08-22 17:48 UTC
```

Notes

Many files contain strings (e.g., the environment and command line) that are in the internal format, with subfields terminated by null bytes ('\0'). When inspecting such files, you may find that the results are more readable if you use a command of the following form to display them:

```
$ cat -A file
```

This manual page is incomplete, possibly inaccurate, and is the kind of thing that needs to be updated very often.

See Also

cat(1), find(1), free(1), ps(1), pstree(1), tr(1), uptime(1), chroot(2), mmap(2), readlink(2), syslog(2), hier(7), arp(8), mount(8), netstat(8), route(8).

3.4.10 The /proc/registry filesystem

The `/proc/registry` filesystem provides read-only access to the Windows registry. It displays each `KEY` as a directory and each `VALUE` as a file. As anytime you deal with the Windows registry, use caution since changes may result in an unstable or broken system. There are additionally subdirectories called `/proc/registry32` and `/proc/registry64`. They are identical to `/proc/registry` on 32 bit host OSes. On 64 bit host OSes, `/proc/registry32` opens the 32 bit processes view on the registry, while `/proc/registry64` opens the 64 bit processes view.

Reserved characters ('/', '\', ':', and '%') or reserved names (`.` and `..`) are converted by percent-encoding:

```
bash$ regtool list -v '\HKEY_LOCAL_MACHINE\SYSTEM\MountedDevices'
...
\DosDevices\C: (REG_BINARY) = cf a8 97 e8 00 08 fe f7
...
bash$ cd /proc/registry/HKEY_LOCAL_MACHINE/SYSTEM
bash$ ls -l MountedDevices
...
-r--r----- 1 Admin SYSTEM  12 Dec 10 11:20 %5CDosDevices%5CC%3A
...
bash$ od -t x1 MountedDevices/%5CDosDevices%5CC%3A
0000000 cf a8 97 e8 00 08 fe f7 01 00 00 00
```

The unnamed (default) value of a key can be accessed using the filename `@`.

If a registry key contains a subkey and a value with the same name `foo`, Cygwin displays the subkey as `foo` and the value as `foo%val`.

3.4.11 The @pathnames

To circumvent the limitations on shell line length in the native Windows command shells, Cygwin programs, when invoked by non-Cygwin processes, expand their arguments starting with "@" in a special way. If a file `pathname` exists, the argument `@pathname` expands recursively to the content of `pathname`. Double quotes can be used inside the file to delimit strings containing blank space. In the following example compare the behaviors **/bin/echo** when run from bash and from the Windows command prompt.

Example 3.3 Using @pathname

```
bash$ /bin/echo 'This is "a long" line' > mylist
bash$ /bin/echo @mylist
@mylist
bash$ cmd
c:\> c:\cygwin\bin\echo @mylist
This is a     long line
```

3.5 The `CYGWIN` environment variable

3.5.1 Implemented options

The `CYGWIN` environment variable is used to configure many global settings for the Cygwin runtime system. It contains the options listed below, separated by blank characters. Many options can be turned off by prefixing with `no`.

- `(no)export` - If set, the final values of these settings are re-exported to the environment as `CYGWIN` again. Defaults to off.
- `error_start:Win32filepath` - if set, runs `Win32filepath` when cygwin encounters a fatal error, which can be useful for debugging. Defaults to not set.

  `Win32filepath` is typically set to **gdb** or **dumper**. If giving a path in `Win32filepath`, note that it is a Windows-style path and not a Cygwin path.

  The filename of the executing program and it's Windows process id are appended to the command as arguments.

  Note: This takes priority over writing core dump or .stackdump files, if enabled by `setrlimit(RLIMIT_CORE)` (e.g. via **ulimit -c**).

  Note: This has no effect if a debugger is already attached when the fatal error occurs.

  Note: The command invoked must either (i) attach to the errored process with `DebugActiveProcess()`, or (ii) forcibly terminate the errored process (with `TerminateProcess()` or similar), as otherwise the errored process will wait forever for a debugger to attach.
- `(no)glob[:ignorecase]` - if set, command line arguments containing UNIX-style file wildcard characters (brackets, braces, question mark, asterisk, escaped with \) are expanded into lists of files that match those wildcards. This is applicable only to programs run from non-Cygwin programs such as a CMD prompt. That means that this setting does not affect globbing operations for shells such as bash, sh, tcsh, zsh, etc. Default is set.

  This option also accepts an optional `[no]ignorecase` modifer. If supplied, wildcard matching is case insensitive. The default is `noignorecase`
- `(no)pipe_byte` - if set, Cygwin opens pipes in byte mode rather than message mode. This is the default starting with Cygwin 3.4.0.
- `proc_retry:n` - causes `fork()` and `exec*()` to retry n times when a child process fails due to certain windows-specific errors. These errors usually occur when processes are being started while a user is logging off.
- `(no)reset_com` - if set, serial ports are reset to 9600-8-N-1 with no flow control when used. This is done at open time and when handles are inherited. Defaults to set.

- `(no)wincmdln` - if set, the windows complete command line (truncated to ~32K) will be passed on any processes that it creates in addition to the normal UNIX argv list. Defaults to not set.
- `(no)winjitdebug` - if set, non-Cygwin executables started from a Cygwin process will have their error mode reset to the system default. That means, if they don't call SetErrorMode() explicitly, the OS will display error dialog boxes in the GUI if some fatal error occurs. Defaults to not set, so fatal errors in a non-Cygwin child process will just result in an error code be propagated back to the parent process.
- `winsymlinks:{lnk,native,nativestrict,sys}`
  - If set to just `winsymlinks` or `winsymlinks:lnk`, Cygwin creates symlinks as Windows shortcuts with a special header and the R/O attribute set.
  - If set to `winsymlinks:native` or `winsymlinks:nativestrict`, Cygwin creates symlinks as native Windows symlinks on filesystems and OS versions supporting them.

    The difference between `winsymlinks:native` and `winsymlinks:nativestrict` is this: If the filesystem supports native symlinks and Cygwin fails to create a native symlink for some reason, it will fall back to creating Cygwin default symlinks with `winsymlinks:native`, while with `winsymlinks:nativestrict` the `symlink(2)` system call will immediately fail.
  - If set to `winsymlinks:sys`, Cygwin creates symlinks as plain files with the `system` attribute, containing a magic cookie followed by the path to which the link points.

  Note that this setting has no effect where Cygwin knows that the filesystem only supports a creating symlinks in a specific way.

  For more information on symbolic links, see Section 3.1.6.
- `disable_pcon` - if set, pseudo console support in pty will be disabled. This is for programs which do not work properly under pty with pseudo console enabled. Defaults to not set.

3.5.2 Obsolete options

Certain CYGWIN options available in past releases have been removed over time for one reason or another. These obsolete options are listed below.

- `(no)binmode` - This option has been removed because all file opens default to binary mode, unless the open mode has been specified explicitly in the open(2) call.
- `(no)detect_bloda` - No case of a BLODA found by this option has been reported in years.
- `(no)dosfilewarning` - This option had been disabled for quite some time and nobody missed it.
- `check_case` - This option has been removed in favor of real case sensitivity and the per-mount option "posix=[0|1]". For more information, read the documentation in Section 3.1.2 and Section 3.4.5.
- `codepage:[ansi|oem]` - This option controlled which character set is used for file and console operations. Since Cygwin is now doing all character conversion by itself, depending on the application call to the `setlocale()` function, and in turn by the setting of the environment variables `$LANG`, `$LC_ALL`, or `$LC_CTYPE`, this setting became superfluous.
- `(no)envcache` - Originally, `envcache` controlled caching of environment variable conversion between Win32 and POSIX. The default setting works fine, the option was just useless.
- `forkchunk:[intval]` - This option allowed to influence the `fork()` function in the way the memory of the parent process gets copied to the child process. This functionality was only useful for Windows 95/98/Me.
- `(no)ntea` - This option has been removed since it only fakes security which is considered dangerous and useless. It also created an uncontrollably large file on FAT and was entirely useless on FAT32.
- `(no)ntsec` - This option has been removed in favor of the per-mount option "acl"/"noacl". For more information, read the documentation in Section 3.1.2.

- `(no)server` - Originally this option had to be enabled on the client side to use features only available when running **cygserver**. This option has been removed because Cygwin now always tries to contact cygserver if a function is called which requires cygserver being available. For more information, read the documentation in Section 3.7.
- `(no)smbntsec` - This option has been removed in favor of the per-mount option "acl"/"noacl". For more information, read the documentation in Section 3.1.2.
- `(no)strip_title` - Removed because setting the Window title can be controlled by the application via Escape sequences.
- `(no)title` - Removed because setting the Window title can be controlled by the application via Escape sequences.
- `(no)transparent_exe` - This option has been removed because the behaviour it switched on is now the standard behaviour in Cygwin.
- `(no)traverse` - This option has been removed because traverse checking is not quite correctly implemented by Microsoft and it's behaviour has been getting worse with each new OS version. This complicates its usage so the option has been removed for now.
- `(no)tty` - If set, Cygwin enabled extra support (i.e., termios) for UNIX-like ttys in the Windows console. This option has been removed because it can be easily replaced by using a terminal like **mintty**, and it does not work well with some Windows programs.
- `(no)upcaseenv` - This option could be used to convert all environment variables to uppercase. This was the default behavior in older releases of Cygwin. Since keeping the case of environment variables intact is POSIXly correct, Cygwin now does not change the case of environment variables, except for a restricted set to maintain minimal backward compatibility. The current list of always uppercased variables is:

```
COMMONPROGRAMFILES
COMSPEC
PATH
SYSTEMDRIVE
SYSTEMROOT
TEMP
TMP
WINDIR
```

3.6 POSIX accounts, permission, and security

This section discusses how the Windows security model is utilized in Cygwin to implement POSIX account information, POSIX-like permissions, and how the Windows authentication model is used to allow cygwin applications to switch users in a POSIX-like fashion.

The setting of POSIX-like file and directory permissions is controlled by the mount option `(no)acl` which is set to `acl` by default.

We start with a short overview. Note that this overview must be necessarily short. If you want to learn more about the Windows security model, see the Access Control article in MSDN documentation.

POSIX concepts and in particular the POSIX security model are not discussed here, but assumed to be understood by the reader. If you don't know the POSIX security model, search the web for beginner documentation.

3.6.1 Brief overview of Windows security

In the Windows security model, almost any "object" is securable. "Objects" are files, processes, threads, semaphores, etc.

Every object has a data structure attached, called a "security descriptor" (SD). The SD contains all information necessary to control who can access an object, and to determine what they are allowed to do to or with it. The SD of an object consists of five parts:

- Flags which control several aspects of this SD. This is not discussed here.
- The SID of the object owner.
- The SID of the object owner group.
- A list of "Access Control Entries" (ACE), called the "Discretionary Access Control List" (DACL).
- Another list of ACEs, called the "Security Access Control List" (SACL), which doesn't matter for our purpose. We ignore it here.

Every ACE contains a so-called "Security IDentifier" (SID) and other stuff which is explained a bit later. Let's talk about the SID first.

A SID is a unique identifier for users, groups, computers and Active Directory (AD) domains. SIDs are basically comparable to POSIX user ids (UIDs) and group ids (GIDs), but are more complicated because they are unique across multiple machines or domains. A SID is a structure of multiple numerical values. There's a convenient convention to type SIDs, as a string of numerical fields separated by hyphen characters. Here's an example:

SID of a machine "foo":

```
S-1-5-21-165875785-1005667432-441284377
```

SID of a user "johndoe" of the system "foo":

```
S-1-5-21-165875785-1005667432-441284377-1023
```

The first field is always "S", which is just a notational convention to show that this is a SID. The second field is the version number of the SID structure, So far there exists only one version of SIDs, so this field is always 1. The third and fourth fields represent the "authority" which can be thought of as a type or category of SIDs. There are a couple of builtin accounts and accounts with very special meaning which have certain well known values in these third and fourth fields. However, computer and domain SIDs always start with "S-1-5-21". The next three fields, all 32 bit values, represent the unique 96 bit identifier of the computer system. This is a hopefully unique value all over the world, but in practice it's sufficient if the computer SIDs are unique within a single Windows network.

As you can see in the above example, SIDs of users (and groups) are identical to the computer SID, except for an additional part, the so-called "relative identifier" (RID). So the SID of a user is always uniquely attached to the system on which the account has been generated.

It's a bit different in domains. The domain has its own SID, and that SID is identical to the SID of the first domain controller, on which the domain is created. Domain user SIDs look exactly like the computer user SIDs, the leading part is just the domain SID and the RID is created when the user is created.

Ok, consider you created a new domain "bar" on some new domain controller and you would like to create a domain account "johndoe":

SID of a domain "bar.local":

```
S-1-5-21-186985262-1144665072-740312968
```

SID of a user "johndoe" in the domain "bar.local":

```
S-1-5-21-186985262-1144665072-740312968-1207
```

So you now have two accounts called johndoe, one account created on the machine "foo", one created in the domain "bar.local". Both have different SIDs and not even the RID is the same. How do the systems know it's the same account? After all, the name is the same, right? The answer is, these accounts are **not** identical. All machines on the network will treat these SIDs as identifying two separate accounts. One is "FOO\johndoe", the other one is "BAR\johndoe" or "johndoe@bar.local". Different SID, different account. Full stop.

Starting with Cygwin 1.7.34, Cygwin uses an automatic, internal translation from Windows SID to POSIX UID/GID. This mechanism, which is the preferred method for the SID<=>UID/GID mapping, is described in detail in Section 3.6.2.

Prior to Cygwin 1.7.34, the last part of the SID, the so called "Relative IDentifier" (RID), was by default used as UID and/or GID when you created the `/etc/passwd` and `/etc/group` files using the **mkpasswd** and **mkgroup** tools. These tools as well

as reading accounts from `/etc/passwd` and `/etc/group` files is still present in recent versions of Cygwin, but you should switch to the aforementioned automatic translation, unless you have very specific needs. Again, see Section 3.6.2 for the details.

Do you still remember the SIDs with special meaning? In offical notation they are called "well-known SIDs". For example, POSIX has no GID for the group of "all users" or "world" or "others". The last three rwx bits in a unix-style permission value just represent the permissions for "everyone who is not the owner or is member of the owning group". Windows has a SID for these poor souls, the "Everyone" SID. Other well-known SIDs represent circumstances under which a process is running, rather than actual users or groups. Here are a few examples for well-known SIDs:

```
Everyone                        S-1-1-0    Simply everyone...
Batch                           S-1-5-3    Processes started via the task
             scheduler are member of this group.
Interactive     S-1-5-4    Only processes of users which are
             logged in via an interactive
             session are members here.
Authenticated Users             S-1-5-11   Users which have gone through
                                           the authentication process and
             survived.  Anonymously accessing
             users are not incuded here.
SYSTEM                          S-1-5-18   A special account which has all
             kinds of dangerous rights, sort of
             an uber-root account.
```

For a full list please refer to the MSDN document Well-known SIDs. The Cygwin package called "csih" provides a tool, /usr/lib/csih/getAccountName.exe, which can be used to print the (possibly localized) name for the various well-known SIDS.

Naturally, well-known SIDs are the same on each machine, so they are not unique to a machine or domain. They have the same meaning across the Windows network.

Additionally, there are a couple of well-known builtin groups, which have the same SID on every machine and which have certain user rights by default:

```
administrators                  S-1-5-32-544
users                           S-1-5-32-545
guests                          S-1-5-32-546
...
```

For instance, every account is usually member in the "Users" group. All administrator accounts are member of the "Administrators" group. That's all about it as far as single machines are involved. In a domain environment it's a bit more tricky. Since these SIDs are not unique to a machine, every domain user and every domain group can be a member of these well known groups. Consider the domain group "Domain Admins". This group is by default in the "Administrators" group. Let's assume the above computer called "foo" is a member machine of the domain "bar.local". If you stick the user "BAR\johndoe" into the group "Domain Admins", this guy will automatically be a member of the administrators group on "foo" when logging on to "foo". Neat, isn't it?

Back to ACE and ACL. POSIX is able to create three different permissions, the permissions for the owner, for the group and for the world. In contrast the Windows ACL has a potentially infinite number of members... as long as they fit into 64K. Every member is an ACE. ACE consist of three parts:

- The type of the ACE (allow ACE or deny ACE).
- Permission bits, 32 of them.
- The SID for which the permissions are allowed or denied.

The two (for us) important types of ACEs are the "access allowed ACE" and the "access denied ACE". As the names imply, the allow ACE tells the system to allow the given permissions to the SID, the deny ACE results in denying the specific permission bits.

The possible permissions on objects are more detailed than in POSIX. For example, the permission to delete an object is different from the permission to change object data, and even changing object data can be separated into different permission bits for different kind of data. But there's a problem with the definition of a "correct" ACL which disallows mapping of certain POSIX permissions cleanly. See Section 3.6.3.

POSIX is able to create only three different permissions? Not quite. Newer operating systems and file systems on POSIX systems also provide access control lists. Two different APIs exist for accessing these ACLs, the Solaris API and the POSIX API. Cygwin implements the original Solaris API to access Windows ACLs in a Unixy way. Online man pages for the Solaris ACL API can be found on http://docs.oracle.com. For an overview see acl(5).

3.6.2 Mapping Windows accounts to POSIX accounts

For as long as Cygwin has existed, it has stored user and group information in `/etc/passwd` and `/etc/group` files. Under the assumption that these files would never be too large, the first process in a process tree, as well as every execing process within the tree would parse them into structures in memory. Thus every Cygwin process would contain an expanded copy of the full information from `/etc/passwd` and `/etc/group`.

This approach has a few downsides. One of them is that the idea that these files will always be small, is flawed. Another one is that reading the entire file is most of the time entirely useless, since most processes only need information on their own user and the primary group. Last but not least, the passwd and group files have to be maintained separately from the already existing Windows user databases, the local SAM and Active Directory.

On the other hand, we have to have this mapping between Windows SIDs and POSIX uid/gid values, so we need a mechanism to convert SIDs to uid/gid values and vice versa.

Microsoft "Services for UNIX" (SFU) (deprecated since Windows 8/Server 2012) never used passwd/group files. Rather, SFU used a fixed, computational mapping between SIDs and POSIX uid/gid which even has Active Directory support. It allows us to generate uid/gid values from SIDs and vice versa. The mechanism is documented, albeit in a confusing way and spread over multiple MSDN articles.

Starting with Cygwin 1.7.34, Cygwin utilizes an approach inspired by the mapping method as implemented by SFU, with a few differences for backward compatibility and to handle some border cases differently.

3.6.2.1 Mapping Windows SIDs to POSIX uid/gid values

The following description assumes you're comfortable with the concept of Windows SIDs and RIDs. For a brief introduction, see Section 3.6.1.

Cygwin's mapping between SIDs and uid/gid values works in two ways.

- Read `/etc/passwd and/etc/group` files if they exist, just as in the olden days, mainly for backward compatibility.
- If no files are present, or if an entry is missing in the files, ask Windows.

At least, that's the default behaviour now. It will be configurable using a file `/etc/nsswitch.conf`, which is discussed in Section 3.6.2.4. Let's explore the default for now.

If the passwd or group files are present, they will be scanned on demand as soon as a mapping from SIDs to uid/gid or account names is required. The new mechanism will never read the entire file into memory, but only scan for the requested entry and cache this one in memory.

If no entry is found, or no passwd or group file was present, Cygwin will ask the OS.

Note

If the first process in a Cygwin process tree determines that no `/etc/passwd` or `/etc/group` file is present, no other process in the entire process tree will try to read the files later on. This is done for self-preservation. It's rather bad if the uid or gid of a user changes during the lifetime of a process tree.

For the same reason, if you delete the `/etc/passwd` or `/etc/group` file, this will be ignored. The passwd and group records read from the files will persist in memory until either a new `/etc/passwd` or `/etc/group` is created, or you exit all processes in the current process tree.

See the note in Section 3.6.2.4 for some comprehensive examples.

So if we've drawn a blank reading the files, we're going to ask the OS. First thing, we ask the local machine for the SID or the username. The OS functions LookupAccountSid and LookupAccountName are pretty intelligent. They have all the stuff built in to ask for any account of the local machine, the Active Directory domain of the machine, the Global Catalog of the forest of the domain, as well as any trusted domain of our forest for the information. One OS call and we're practically done...

Except, the calls only return the mapping between SID, account name and the account's domain. We don't have a mapping to POSIX uid/gid and we're missing information on the user's home dir and login shell.

Let's discuss the SID<=>uid/gid mapping first. Here's how it works.

- Well-known SIDs in the NT_AUTHORITY domain of the S-1-5-RID type, or aliases of the S-1-5-32-RID type are mapped to the uid/gid value RID. Examples:

```
"SYSTEM" S-1-5-18                    <=> uid/gid: 18
"Users"  S-1-5-32-545                <=> uid/gid: 545
```

- Other well-known SIDs in the NT_AUTHORITY domain (S-1-5-X-RID):

```
S-1-5-X-RID                          <=> uid/gid: 0x1000 * X + RID
```

  Example:

```
"NTLM Authentication" S-1-5-64-10    <=> uid/gid: 0x4000A == 262154
```

- Other well-known SIDs:

```
S-1-X-Y                              <=> uid/gid: 0x10000 + 0x100 * X + Y
```

  Example:

```
"LOCAL" S-1-2-0                      <=> uid/gid: 0x10200 == 66048
"Creator Group" S-1-3-1              <=> uid/gid: 0x10301 == 66305
```

- Logon SIDs: The LogonSid of the current user's session is converted to the fixed uid 0xfff == 4095 and named "CurrentSession". Any other LogonSid is converted to the fixed uid 0xffe == 4094 and named "OtherSession".
- Mandatory Labels:

```
S-1-16-RID                           <=> uid/gid: 0x60000 + RID
```

  Example:

```
"Medium Mandatory Level" S-1-16-8192 <=> uid/gid: 0x62000 == 401408
```

- Accounts from the local machine's user DB (SAM):

```
S-1-5-21-X-Y-Z-RID                   <=> uid/gid: 0x30000 + RID
```

  Example:

```
"Administrator" S-1-5-21-X-Y-Z-500   <=> uid/gid: 0x301f4 == 197108
```

- Accounts from the machine's primary domain:

```
S-1-5-21-X-Y-Z-RID                   <=> uid/gid: 0x100000 + RID
```

  Example:

```
"Domain Users" S-1-5-21-X-Y-Z-513    <=> uid/gid: 0x100201 == 1049089
```

- Accounts from a trusted domain of the machine's primary domain:

```
S-1-5-21-X-Y-Z-RID                   <=> uid/gid: trustPosixOffset(domain) + RID
```

`trustPosixOffset`? This needs a bit of explanation. This value exists in Windows domains already since before Active Directory days. What happens is this. If you create a domain trust between two domains, a trustedDomain entry will be added to both databases. It describes how *this* domain trusts the *other* domain. One attribute of a trust is a 32 bit value called `trustPosixOffset` For each new trust, `trustPosixOffset` will get some automatic value. In recent AD domain implementations, the first trusted domain will get `trustPosixOffset` set to 0x80000000. Following domains will get lower values. Unfortunately the domain admins are allowed to set the `trustPosixOffset` value for each trusted domain to some arbitrary 32 bit value, no matter what the other `trustPosixOffset` are set to, thus allowing any kind of collisions between the `trustPosixOffset` values of domains. That's not exactly helpful, but as the user of this value, we have to *trust* the domain admins to set `trustPosixOffset` to sensible values, or to keep it at the system chosen defaults.

So, for the first (or only) trusted domain of your domain, the automatic offset is 0x80000000. An example for a user of that trusted domain is

```
S-1-5-21-X-Y-Z-1234                    <=> uid/gid 0x800004d2 == 2147484882
```

There's one problem with this approach. Assuming you're running in the context of a local SAM user on a domain member machine. Local users don't have the right to fetch this kind of domain information from the DC, they'll get permission denied. In this case Cygwin will fake a sensible `trustPosixOffset` value.

Another problem is if the AD administrators chose an unreasonably small `trustPosixOffset` value. Anything below the hexadecimal value 0x100000 (the POSIX offset of the primary domain) is bound to produce collisions with system accounts as well as local accounts. The right thing to do in this case is to notify your administrator of the problem and to ask for moving the offset to a more reasonable value. However, to reduce the probability for collisions, Cygwin overrides this offset with a sensible fixed replacement offset.

- Local accounts from another machine in the network:

  There's no SID<=>uid/gid mapping implemented for this case. The problem is, there's no way to generate a bijective mapping. There's no central place which keeps an analogue of the `trustPosixOffset`, and there's the additional problem that the LookupAccountSid and LookupAccountName functions cannnot resolve the SIDs, unless they know the name of the machine this SID comes from. And even then it will probably suffer a `Permission denied` error when trying to ask the machine for its local account.

Now we have a semi-bijective mapping between SIDs and POSIX uid/gid values, but given that we have potentially users and groups in different domains having the same name, how do we uniquely distinguish between them by name? Well, we can do that by making their names unique in a per-machine way. Dependent on the domain membership of the account, and dependent of the machine being a domain member or not, the user and group names will be generated using a domain prefix and a separator character between domain and account name. The separator character is the plus sign, `+`.

- Well-known and builtin accounts will be named as in Windows:

  ```
  "SYSTEM", "LOCAL", "Medium Mandatory Level", ...
  ```

- If the machine is not a domain member machine, only local accounts can be resolved into names, so for ease of use, just the account names are used as Cygwin user/group names:

  ```
  "corinna", "bigfoot", "None", ...
  ```

- If the machine is a domain member machine, all accounts from the primary domain of the machine are mapped to Cygwin names without domain prefix:

  ```
  "corinna", "bigfoot", "Domain Users", ...
  ```

  while accounts from other domains are prepended by their domain:

  ```
  "DOMAIN1+corinna", "DOMAIN2+bigfoot", "DOMAIN3+Domain Users", ...
  ```

- Local machine accounts of a domain member machine get a Cygwin user name the same way as accounts from another domain: The local machine name gets prepended:

  ```
  "MYMACHINE+corinna", "MYMACHINE+bigfoot", "MYMACHINE+None", ...
  ```

- If LookupAccountSid fails, Cygwin checks the accounts against the known trusted domains. If the account is from one of the trusted domains, an artificial account name is created. It consists of the domain name, and a special name created from the account RID:

```
"MY_DOM+User(1234)", "MY_DOM+Group(5678)"
```

  Otherwise we know nothing about this SID, so it will be mapped to the fake accounts `Unknown+User`/`Unknown+Group` with uid/gid -1.

3.6.2.2 Caching account information

The information fetched from the Windows account database or the `/etc/passwd` and `/etc/group` files is cached by the process. The cached information is inherited by Cygwin child processes. A Cygwin process invoked from a Windows command, such as CMD.exe, will start a new Cygwin process tree and the caching starts from scratch (unless **cygserver** is running, but read on).

While usually working fine, this has some drawbacks. Consider a shell calling **id**. **id** fetches all group information from the current token and caches them. Unfortunately **id** doesn't start any child processes, so the information is lost as soon as **id** exits.

But there's another caching mechanism available. If **cygserver** is running it will provide passwd and group entry caching for all processes in every Cygwin process tree started after **cygserver**. So, if you start a Cygwin Terminal and **cygserver** is running at the time, **mintty**, the shell, and all child processes will use **cygserver** caching. If you start a Cygwin Terminal and **cygserver** is not running at the time, none of the processes started inside this terminal window will use **cygserver** caching.

The advantage of **cygserver** caching is that it's system-wide and, as long as **cygserver** is running, unforgetful. Every Cygwin process on the system will have the **cygserver** cache at its service. Additionally, all information requested from **cygserver** once, will be cached inside the process itself and, again, propagated to child processes.

If you automatically start Cygwin processes as Windows services at system startup, you may wish to consider starting **cygserver** first in order to take advantage of this system-wide caching. To assure that **cygserver** has started prior to starting **cygsshd** or other Cygwin services, you may wish to create service startup dependencies. **Cygserver** should probably wait for Windows TCPIP and AFD services before it starts, and then other Cygwin process should start after **cygserver**. Example Windows commands to accomplish this (after the services already exist) are shown below. You will need an administrative prompt to run the **sc config** commands.

```
# Delay Cygserver until TCPIP and AFD have started
# Note the (odd) required space character after "depend="

sc config cygserver depend= tcpip/afd

# Delay sshd until after Cygserver has started
# Again note the (odd) required space character after "depend="

sc config cygsshd depend= cygserver

# View the Cygserver service details

sc qc cygserver
```

Note that this **sc config** command *replaces* any existing dependencies. The above changes will not impact the running instance, only future instances.

```
# To remove all dependencies from the cygserver service

sc config cygserver depend= /
```

3.6.2.3 Cygwin user names, home dirs, login shells

Obviously, if you don't maintain `passwd` and `group` files, you need to have a way to maintain the other fields of a passwd entry as well. A couple of things come to mind:

- You want to use a Cygwin username different from your Windows username.

  Note
  This is only supported via `/etc/passwd`. A Cygwin username maintained in the Windows user databases would require very costly (read: slow) search operations.

- You want to change the primary group of a user. For AD accounts this is not supported. The primary group of a user is always the Windows primary group set in Active Directory and can't be changed. For SAM accounts, you can add the primary group to the SAM `description` field of the user. See Section 3.6.2.4.10 for more info.
- You want a home dir different from the default `/home/$USERNAME`.
- You want to specify a different login shell than `/bin/bash`.
- You want to add specific content to the pw_gecos field.

For simple needs you can create `/etc/passwd` and/or `/etc/group` files with entries for your account and tweak that.

For bigger installations, maintaining per-client files is rather troublesome. Also, no two environments are the same, so the needs are pretty different. Therefore Cygwin supports configuring how to fetch home directory, login shell, and gecos information in /etc/nsswitch.conf. See the next section for detailed information how to configure Cygwin's account handling.

3.6.2.4 The `/etc/nsswitch.conf` file

On Linux and some other UNIXy OSes, we have a file called /etc/nsswitch.conf. Among other things, it determines how passwd and group entries are generated. That's what Cygwin now provides as well.

The `/etc/nsswitch.conf` file is optional. If you don't have one, Cygwin uses sensible defaults.

Note
The `/etc/nsswitch.conf` file is read exactly once by the first process of a Cygwin process tree. If there was no `/etc/nsswitch.conf` file when this first process started, then no other process in the running Cygwin process tree will try to read the file.
If you create or change `/etc/nsswitch.conf`, you have to restart all Cygwin processes that need to see the change. If the process you want to see the change is a child of another process, you need to restart all of that process's parents, too.
For example, if you run **vim** inside the default Cygwin Terminal, **vim** is a child of your shell, which is a child of **mintty**. If you edit `/etc/nsswitch.conf` in that **vim** instance, your shell won't immediately see the change, nor will **vim** if you restart it from that same shell instance. This is because both are getting their nsswitch information from their ancestor, **mintty**. You have to start a fresh terminal window for the change to take effect.
By contrast, if you leave that Cygwin Terminal window open after making the change to `/etc/nsswitch.conf`, then restart a Cygwin service like **cron**, **cron** will see the change, because it is not a child of **mintty** or any other Cygwin process. (Technically, it is a child of **cygrunsrv**, but that instance also restarts when you restart the service.)
The reason we point all this out is that the requirements for restarting things are not quite as stringent as when you replace `cygwin1.dll`. If you have three process trees, you have three independent copies of the nsswitch information. If you start a fresh process tree, it will see the changes. As long as any process in an existing process tree remains running, all processes in that tree will continue to use the old information.

So, what settings can we perform with `/etc/nsswitch.conf`? Let's start with an example `/etc/nsswitch.conf` file set up to all default values:

```
# /etc/nsswitch.conf
passwd: files db
group:  files db
db_enum:  cache builtin
db_home:  /home/%U
db_shell: /bin/bash
db_gecos: <empty>
```

3.6.2.4.1 The `/etc/nsswitch.conf` syntax

The first line, starting with a hash # is a comment. The hash character starts a comment, just as in shell scripts. Everything up to the end of the line is ignored. So this:

```
foo:  bar # baz
```

means, set "foo" to value "bar", ignore everything after the hash.

The other lines define the available settings. The first word up to a colon is a keyword. Note that the colon *must* follow immediately after the keyword. This is a valid line:

```
foo: bar
```

This is not valid:

```
foo  :  bar
```

Apart from this restriction, the remainder of the line can have as many spaces and TABs as you like.

When the same keyword occurs multiple times, the last one wins, as if the previous ones were ignored.

3.6.2.4.2 The `passwd:` and `group:` settings

The two lines starting with the keywords `passwd:` and `group:` define where Cygwin gets its passwd and group information from. `files` means, fetch the information from the corresponding file in the /etc directory. `db` means, fetch the information from the Windows account databases, the SAM for local accounts, Active Directory for domain account. Examples:

```
passwd: files
```

Read passwd entries only from /etc/passwd.

```
group: db
```

Read group entries only from SAM/AD.

```
group: files # db
```

Read group entries only from `/etc/group` (`db` is only a comment).

```
passwd: files db
```

Read passwd entries from `/etc/passwd`. If a user account isn't found, try to find it in SAM or AD. This is the default for both, passwd and group information.

```
group: db files
```

This is a valid entry, but the order will be ignored by Cygwin. If both settings, `files` and `db` are specified, Cygwin will always try the files first, then the db.

`passwd:` and `group:` are the two basic settings defining where to get the account information from. The following settings starting with `db_` define certain aspects of the Windows account database search and how to generate `passwd` and `group` information from the database.

3.6.2.4.3 The `db_enum:` setting

`db_enum:` defines the depth of a database search, if an application calls one of the enumeration functions getpwent or getgrent. The problem with these functions is, they neither allow to define how many entries will be enumerated when calling them in a loop, nor do they allow to add some filter criteria. They were designed back in the days, when only `/etc/passwd` and `/etc/group` files existed and the number of user accounts on a typical UNIX system was seldomly a three-digit number.

These days, with user and group databases sometimes going in the six-digit range, they are a potential burden. For that reason, Cygwin does not enumerate all user or group accounts by default, but rather just a very small list, consisting only of the accounts cached in memory by the current process, as well as a handful of predefined builtin accounts.

`db_enum:` allows to specify the accounts to enumerate in a fine-grained manner. It takes a list of sources as argument:

```
db_enum:  source1 source2 ...
```

The recognized sources are the following:

`none` No output from `getpwent`/`getgrent` at all.

`all` The opposite. Enumerates accounts from all known sources, including all trusted domains.

`cache` Enumerate all accounts currently cached in memory.

`builtin` Enumerate the predefined builtin accounts for backward compatibility. These are five passwd accounts (SYSTEM, LocalService, NetworkService, Administrators, TrustedInstaller) and two group accounts (SYSTEM and TrustedInstaller).

`files` Enumerate the accounts from `/etc/passwd` or `/etc/group`.

`local` Enumerate all accounts from the local SAM.

`primary` Enumerate all accounts from the primary domain.

`alltrusted` Enumerate all accounts from all trusted domains.

`some.domain` Enumerate all accounts from the trusted domain some.domain. The trusted domain can be given as Netbios flat name (MY_DOMAIN) or as dns domain name (my_domain.corp). In contrast to the aforementioned fixed source keywords, distinct domain names are caseinsensitive. Only domains which are actually trusted domains are enumerated. Unknown domains are simply ignored.

Please note that `getpwent`/`getgrent` do *not* test if an account was already listed from another source, so an account can easily show up twice or three times. Such a test would be rather tricky, nor does the Linux implementation perform such test. Here are a few examples for `/etc/nsswitch.conf`:

```
db_enum: none
```

No output from `getpwent`/`getgrent` at all. The first call to the function immediately returns a NULL pointer.

```
db_enum: cache files
```

Enumerate all accounts cached by the current process, plus all entries from either the /etc/passwd or /etc/group file.

```
db_enum: cache local primary
```

Enumerate all accounts cached by the current process, all accounts from the SAM of the local machine, and all accounts from the primary domain of the machine.

```
db_enum: local primary alltrusted
```

Enumerate the accounts from the machine's SAM, from the primary domain of the machine, and from all trusted domains.

```
db_enum: primary domain1.corp sub.domain.corp domain2.net
```

Enumerate the accounts from the primary domain and from the domains domain1.corp, sub.domain.corp and domain2.net.

```
db_enum: all
```

Enumerate everything and the kitchen sink.

3.6.2.4.4 Settings defining how to create the `passwd` entry

`/etc/nsswitch.conf` supports three settings to configure where to get the pw_dir, pw_shell, and pw_gecos content of a `passwd` entry from:

```
db_home: schema...      # Define how to fetch the pw_dir entry.
db_shell: schema...     # Define how to fetch the pw_shell entry.
db_gecos: schema...     # Define how to fetch the pw_gecos entry.
```

"schema..." is a list of up to four space-separated schemata:

```
db_FOO: schema1 schema2 ...
```

When generating a passwd entry, Cygwin tries the schemata in order. If the first schema returns an empty string, it skips to the second, and so on. Schemata only supported on AD are silently skipped for SAM accounts and on non-AD machines.

Five schemata are predefined, two schemata are variable. The predefined schemata are the following:

`windows` Utilizes typical Windows settings. Supported for AD and SAM accounts.

`cygwin` Utilizes the cygwinUser AD schema extension. This schema extension is available via a schema extension file `/usr/share/cygwin/cygwin.ldif`. See Section 3.6.2.4.8 for more information.

`unix` Utilizes the posixAccount schema attributes per RFC 2307. The posixAccount schema is available by default in Windows Server, but typically only utilized when installing the Active Directory "Server for NIS" feature (which is deprecated since Server 2012 R2). See also Section 3.6.2.4.9.

`desc` Utilizes XML-style attributes in the description attribute. Supported for AD and SAM accounts. See Section 3.6.2.4.10 for a more detailed description.

`env` Utilizes the user's environment. This schema is only supported for setting the home directory yet. See Section 3.6.2.4.5 for the description.

The variable schemata are as follows. Note that the leading characters (`@` and `/`) are an integral part of the definition.

`@ad_attribute` `ad_attribute` is any arbitrary AD attribute name which should (ideally) be available in the User class or in any attached auxiliary class. It's always treated as a single string argument. Only the first string of a multi-string attributes will be read.

`/path` An arbitrary string, typically a path. The leading slash is required. Given that a single, fixed path for all users only makes marginal sense, the /path schema supports wildcards. A wildcard is a per-cent (`%`) character, followed by another character giving the meaning. The supported wildcard characters are:

- **`%u`** The Cygwin username (that's lowercase `u`).
- **`%U`** The Windows username (that's uppercase `U`).
- **`%D`** Windows domain in NetBIOS style.
- **`%H`** Windows home directory in POSIX style. Note that, for the `db_home:` setting, this only makes sense right after the preceeding slash, as in

  ```
  db_home:  /%H/cygwin
  ```

- **`%_`** Since space and TAB characters are used to separate the schemata, a space in the filename has to be given as `%_` (that's an underscore).
- **`%%`** A per-cent character.

Any other `%X` expression is treated as if the character `X` has been given alone.

The exact meaning of a schema depends on the setting it's used for. The following sections explain the settings in detail.

3.6.2.4.5 The `db_home:` setting

The `db_home:` setting defines how Cygwin fetches the user's home directory, or, more precise, the content of the `pw_dir` member of the user's passwd entry. The following list describes the meaning of each schema when used with `db_home:`

`windows` The user's home directory is set to the same directory which is used as Windows home directory. This is the `homeDirectory` AD attribute. For SAM accounts, this is equivalent to the "Home folder" setting in SAM. If both attributes are unset, Cygwin falls back to the user's local profile directory, typically something along the lines of `C:\Users\$USERNAME`. Of course, the Windows directory is converted to POSIX-style by Cygwin.

`cygwin` AD only: The user's home directory is set to the POSIX path given in the `cygwinHome` attribute from the `cygwinUser` auxiliary class. See also Section 3.6.2.4.8.

`unix` AD only: The user's home directory is set to the POSIX path given in the `unixHomeDirectory` attribute from the `posixAccount` auxiliary class. See also Section 3.6.2.4.9.

`desc` The user's home directory is set to the POSIX path given in the home="..." XML-alike setting in the user's `description` attribute in SAM or AD. See Section 3.6.2.4.10 for a detailed description.

`env` Derives the home directory of the current user from the environment variable `HOME` (falling back to `HOMEDRIVE\HOMEPATH` and `USERPROFILE`, in that order). This is faster than the `windows` schema at the expense of determining only the current user's home directory correctly. This schema is skipped for any other account.

`@ad_attribute` AD only: The user's home directory is set to the path given in the `ad_attribute` attribute. The path can be given as Windows or POSIX path.

`/path` The user's home directory is set to the given POSIX path. Remember the wildcards described in Section 3.6.2.4.4.

Fallback If none of the schemes given for `db_home:` define a non-empty directory, the user's home directory is set to `/home/$USERNAME`.

`db_home:` defines no default schemata. If this setting is not present in `/etc/nsswitch.conf`, the aforementioned fallback takes over, which is equivalent to a `/etc/nsswitch.conf` settting of

```
db_home: /home/%U
```

3.6.2.4.6 The `db_shell:` setting

The `db_shell:` setting defines how Cygwin fetches the user's login shell, the content of the `pw_shell` member of the user's passwd entry. The following list describes the meaning of each schema when used with `db_shell:`

`windows` The `windows` schema is ignored for now. The logical choice would be CMD, but that introduces some problems, for instance the fact that CMD has no concept of running as `login shell`. This may change in future.

`cygwin` AD only: The user's home directory is set to the POSIX path given in the `cygwinShell` attribute from the `cygwinUser` auxiliary class. See also Section 3.6.2.4.8.

`unix` AD only: The user's login shell is set to the POSIX path given in the `loginShell` attribute from the `posixAccount` auxiliary class. See also Section 3.6.2.4.9.

`desc` The user's login shell is set to the POSIX path given in the shell="..." XML-alike setting in the user's `description` attribute in SAM or AD. See Section 3.6.2.4.10 for a detailed description.

`@ad_attribute` AD only: The user's login shell is set to the path given in the `ad_attribute` attribute. The path can be given as Windows or POSIX path.

`/path` The user's login shell is set to the given POSIX path. Albeit not being as important here, the wildcards described in Section 3.6.2.4.4 are also available for specifying a login shell path.

Fallback If none of the schemes given for `db_shell:` define a non-empty pathname, the user's login shell is set to `/bin/bash`.

`db_shell:` defines no default schemata. If this setting is not present in `/etc/nsswitch.conf`, the aforementioned fallback takes over, which is equivalent to a `/etc/nsswitch.conf` settting of

```
db_shell: /bin/bash
```

3.6.2.4.7 The `db_gecos:` setting

The `db_gecos:` setting defines how to fetch additional content for the `pw_gecos` member of the user's passwd entry. There's always a fixed, Cygwin-specific part in the `pw_gecos` field for identifying the account. However, an administrator might want to add informative content like, for instance, the user's full name. That's what the `db_gecos:` setting is for. The following list describes the meaning of each schema when used with `db_gecos:`

`windows` Add the AD `displayName` attribute or, for SAM accounts, the "Full name" entry to the `pw_gecos` field.

`cygwin` AD only: The content of the `cygwinGecos` attribute from the `cygwinUser` auxiliary class is added to `pw_gecos`. See also Section 3.6.2.4.8.

`unix` AD only: The content of the `gecos` attribute from the `posixAccount` auxiliary class is added to `pw_gecos`. See also Section 3.6.2.4.9.

`desc` The content of the gecos="..." XML-alike setting in the user's `description` attribute in SAM or AD is added to `pw_gecos`. See Section 3.6.2.4.10 for a detailed description.

`@ad_attribute` AD only: The content of the `ad_attribute` attribute is added to `pw_gecos`.

`/path` The string following the slash is added to `pw_gecos`. Here, the wildcards described in Section 3.6.2.4.4 may come in handy.

Fallback If none of the schemes given for `db_gecos:` define a non-empty string, nothing is added to `pw_gecos`.

`db_gecos:` defines no default schemata.

3.6.2.4.8 The `cygwin` schema

The `cygwin` schema is based on a Cygwin-specific Active Directory schema extension. Using this schema extension allows to maintain Cygwin-specific settings entirely within AD, without colliding with any other schema.

The cygwin schema extension is available in a default Cygwin installation in the file `/usr/share/cygwin/cygwin.ldif`. To install the schema extension, you have to be schema admin, and you have to run the **ldifde** command on the schema master. The installation itself is rather simple. Assuming you're schema admin and running a shell with administrative privileges:

```
$ cd /usr/share/cygwin
$ ldifde -i -f cygwin.ldif -k -c "CN=schema,CN=Configuration,DC=X" #schemaNamingContext
```

Afterwards, the auxiliary class `cygwinUser` is attached to the class `User`, and the auxiliary class `cygwinGroup` is attached to the class `Group`. The new attributes can be immediately edited using **ADSI Edit**.

At the time of writing the following attributes are utilized by Cygwin:

: `cygwinHome`, *:* Used as Cygwin home directory with `db_home:` `cygwin`. See Section 3.6.2.4.5.
: `cygwinShell`, *:* Used as Cygwin login shell with `db_shell:` `cygwin`. See Section 3.6.2.4.6.
: `cygwinGecos`, *:* Content will be added to the pw_gecos field with `db_gecos:` `cygwin`. See Section 3.6.2.4.7.

3.6.2.4.9 The `unix` schema

The `unix` schema utilizes the `posixAccount` attribute extension. This is one of two schema extensions which are connected to AD accounts, available by default. They are usually **not set**, unless used by the Active Directory `Server for NIS` feature (deprecated since Server 2012 R2). Two schemata are interesting for Cygwin, `posixAccount`, connected to user accounts, and `posixGroup`, connected to group accounts. Both follow the description of RFC 2307, an Approach for Using LDAP as a Network Information Service. The user attributes utilized by Cygwin are:

: `unixHomeDirectory`, *:* Used as Cygwin home directory with `db_home: unix`. See Section 3.6.2.4.5.
: `loginShell`, *:* Used as Cygwin login shell with `db_shell: unix`. See Section 3.6.2.4.6.
: `gecos`, *:* Content will be added to the pw_gecos field with `db_gecos: unix`. See Section 3.6.2.4.7.
: `uidNumber`, *:* See Section 3.6.2.5 and Section 3.6.2.6.

The group attributes utilized by Cygwin are:

: `gidNumber`, *:* See Section 3.6.2.5 and Section 3.6.2.6.

Apart from power shell scripting or inventing new CLI tools, these attributes can be changed using the `Attribute Editor` tab in the user properties dialog of the `Active Directory Users and Computers` MMC snap-in. Alternatively, if the `Server for NIS` administration feature has been installed, there will be a `UNIX Attributes` tab which contains the required fields, except for the gecos field. Last resort is **ADSI Edit**.

3.6.2.4.10 The `desc` schema

When using user accounts from the local account database, the SAM, there are only a very limited number of settings available. In contrast to Active Directory there's no way to add fields to a user's entry. You have to make do with the fields available. The method to utilize the `description` field has been mainly introduced for those accounts, usually the only ones a home user has. However, for symmetry, and because there may be a reason to use this in an AD environment, this schema is also supported for AD users.

Note
The presentation of local user account settings on Windows is confusing, to say the least. The `description` field is not visible at all in the user settings available via the `User Accounts` control settings. And while it's called `Description` in the `Local Users and Groups` MMC snap-in (available, for instance, via the `Computer Management` GUI), in the command line tool **net user** the same field is called `comment`. The latter is especially confusing for AD admins, because the `comment` attribute in AD is called `usercomment` on the command line. Confused? Never mind, you're not the only one...

Fortunately you can utilize the `description` field even if you're running a "home edition" of Windows, by using the command line. The **net user** command allows to set all values in the SAM, even if the GUI is crippled.

A Cygwin SAM comment entry looks like this:

```
<cygwin key="value" key="value" [...] />
```

The supported keys are:

: `home="value"`, *:* Sets the Cygwin home dir to value.
: `shell="value"`, *:* Sets the Cygwin login shell to value.
: `gecos="value"`, *:* Adds the string value to the user's gecos field.

The next two settings are only supported for SAM accounts.

: `group="value"`, *:* Sets the Cygwin primary group of the account to value, provided that the user *is* already a member of that group. This allows to override the default `None` primary group for local accounts. One nice idea here is, for instance, group="Users".
: `unix="value"`, *:* Sets the NFS/Samba uid of the user to the decimal value. See Section 3.6.2.5 and Section 3.6.2.6.

The <cygwin .../> string can start at any point in the comment, but you have to follow the rules:

- It starts with "<cygwin " and ends with "/>".

- The "cygwin" string and the key names have to be lowercase.
- No spaces between key and "value", just the equal sign.
- The value must be placed within double quotes and it must not contain a double quote itself. The double quotes are required for the decimal values as well!

Note
There's also a length restriction imposed by Windows. The `description` entry has a maximum length of 1023 characters.

CMD example:

```
net user corinna /comment:"<cygwin home=\"/home/foo\"/>"
```

Bash example (use single quotes):

```
net user corinna /comment:'<cygwin home="/home/foo"/>'
```

For changing group comments, use the `net localgroup' command. The supported key/value pair for SAM groups are:

: `unix="value"`, *:* Sets the NFS/Samba gid of the group to the decimal value. See Section 3.6.2.5 and Section 3.6.2.6.

3.6.2.5 NFS account mapping

Microsoft's NFS client does not map the uid/gid values on the NFS shares to SIDs. There's no such thing as a (fake) security descriptor returned to the application. Rather, via an undocumented API an application can fetch RFC 1813 compatible NFSv3 stat information from the share. This is what Cygwin is using to show stat information for files on NFS shares.

The problem is, while all other information in this stat record, like timestamps, file size etc., can be used by Cygwin, Cygwin had no way to map the values of the st_uid and st_gid members to a Windows SID for a long time. So it just faked the file owner info and claimed that it's you.

However, SFU has, over time, developed multiple methods to map UNIX uid/gid values on NFS shares to Windows SIDs. You'll find the full documentation of the mapping methods in NFS Identity Mapping in Windows Server 2012

Cygwin now utilizes the RFC 2307 mapping for this purpose. This is most of the time provided by an AD domain, but it could also be a standalone LDAP mapping server. Per RFC 2307, the uid is in the attribute `uidNumber`. For groups, the gid is in the `gidNumber` attribute. See Section 3.6.2.4.9.

When Cygwin stat()s files on an NFS share, it asks the mapping server via LDAP in two different ways, depending on the role of the mapping server.

- If the server is an AD domain controller, it asks for an account with `uidNumber` attribute == `st_uid` field of the stat record returned by NFS. If an account matches, AD returns the Windows SID, so we have an immediate mapping from UNIX uid to a Windows SID, if the user account has a valid `uidNumber` attribute. For groups, the method is the same, just that Cygwin asks for a group with `gidNumber` attribute == `st_gid` field of the stat record.
- If the server is a standalone LDAP mapping server Cygwin asks for the same `uidNumber`/`gidNumber` attributes, but it can't expect that the LDAP server knows anything about Windows SIDs. Rather, the mapping server returns the account name. Cygwin then asks the DC for an account with this name, and if that succeeds, we have a mapping between UNIX uid/gid and Windows SIDs.

The mapping will be cached for the lifetime of the process, and inherited by child processes.

3.6.2.6 Samba account mapping

A fully set up Samba file server with domain integration is running winbindd to map Windows SIDs to artificially created UNIX uids and gids, and this mapping is transparent within the domain, so Cygwin doesn't have to do anything special.

However, setting up winbindd isn't for everybody, and it fails to map Windows accounts to already existing UNIX users or groups. In contrast to NFS, Samba returns security descriptors, but unmapped UNIX accounts get special SIDs:

- A UNIX user account with uid X is mapped to the Windows SID S-1-22-1-X.
- A UNIX group account with gid X is mapped to SID S-1-22-2-X.

As you can see, even though we have SIDs, they just reflect the actual uid/gid values on the UNIX box in the RID value. It's only marginally different from the NFS method, so why not just use the same method as for NFS?

That's what Cygwin will do. If it encounters a S-1-22-x-y SID, it will perform the same RFC 2307 mapping as for NFS shares.

For home users without any Windows domain or LDAP server per RFC 2307, but with a Linux machine running Samba, just add this information to your SAM account. Assuming the uid of your Linux user account is 505 and the gid of your primary group is, say, 100, just add the values to your SAM user and group accounts. The following example assumes you didn't already add something else to the comment field.

To your user's SAM comment (remember: called `Description` in the GUI), add:

```
<cygwin group="Users" unix="505"/>
```

To the `Users` group SAM comment add:

```
<cygwin unix="100"/>
```

This should be sufficient to work on your Samba share and to see all files owned by your Linux user account as your files.

3.6.3 File permissions

On NTFS and if the `noacl` mount option is not specified for a mount point, Cygwin sets file permissions as on POSIX systems. Basically this is done by defining a Security Descriptor with the matching owner and group SIDs, and a DACL which contains ACEs for the owner, the group and for "Everyone", which represents what POSIX calls "others".

There's just one problem when trying to map the POSIX permission model onto the Windows permission model.

There's a leak in the definition of a "correct" ACL which disallows a certain POSIX permission setting. The official documentation explains in short the following:

- The requested permissions are checked against all ACEs of the user as well as all groups the user is member of. The permissions given in these user and groups access allowed ACEs are accumulated and the resulting set is the set of permissions of that user given for that object.
- The order of ACEs is important. The system reads them in sequence until either any single requested permission is denied or all requested permissions are granted. Reading stops when this condition is met. Later ACEs are not taken into account.
- All access denied ACEs **should** precede any access allowed ACE. ACLs following this rule are called "canonical".

Note that the last rule is a preference or a definition of correctness. It's not an absolute requirement. All Windows kernels will correctly deal with the ACL regardless of the order of allow and deny ACEs. The second rule is not modified to get the ACEs in the preferred order.

Unfortunately, the security tab in the file properties dialog of the Windows Explorer will pop up a warning stating "The permissions on ... are incorrectly ordered, which may cause some entries to be ineffective." Pressing the Cancel button of the properties dialog fortunately leaves the sort order unchanged, but pressing OK will cause Explorer to canonicalize the order of the ACEs, thereby invalidating POSIX compatibility.

Canonical ACLs are unable to reflect each possible combination of POSIX permissions. Example:

```
rw-r-xrw-
```

Ok, so here's the first try to create a matching ACL, assuming the Windows permissions only have three bits, as their POSIX counterpart:

```
UserAllow:   110
GroupAllow:  101
OthersAllow: 110
```

Hmm, because of the accumulation of allow rights the user may execute because the group may execute.

Second try:

```
UserDeny:    001
GroupAllow:  101
OthersAllow: 110
```

Now the user may read and write but not execute. Better? No! Unfortunately the group may write now because others may write.

Third try:

```
UserDeny:    001
GroupDeny:   010
GroupAllow:  001
OthersAllow: 110
```

Now the group may not write as intended but unfortunately the user may not write anymore, either. How should this problem be solved? According to the canonical order a UserAllow has to follow the GroupDeny but it's easy to see that this can never be solved that way.

The only chance:

```
UserDeny:    001
UserAllow:   010
GroupDeny:   010
GroupAllow:  001
OthersAllow: 110
```

Again: This works on all supported versions of Windows. Only the GUIs aren't able (or willing) to deal with that order.

3.6.4 Switching the user context

Windows users have been accustomed to the "Switch User" feature, which switches the entire desktop to another user while leaving the original user's desktop "suspended". Another Windows feature is the "Run as..." context menu entry, which allows you to start an application using another user account when right-clicking on applications and shortcuts.

On POSIX systems, this operation can be performed by processes running under the privileged user accounts (usually the "root" user account) on a per-process basis. This is called "switching the user context" for that process, and is performed using the POSIX **setuid** and **seteuid** system calls.

While this sort of feature is available on Windows as well, Windows does not support the concept of these calls in a simple fashion. Switching the user context in Windows is generally a tricky process with lots of "behind the scenes" magic involved.

Windows uses so-called `access tokens' to identify a user and its permissions. Usually the access token is created at logon time and then it's attached to the starting process. Every new process within a session inherits the access token from its parent process. Every thread can get its own access token, which allows, for instance, to define threads with restricted permissions.

3.6.4.1 Switching the user context with password authentication

To switch the user context, the process has to request such an access token for the new user. This is typically done by calling the Win32 API function **LogonUser** with the user name and the user's cleartext password as arguments. If the user exists and the password was specified correctly, the access token is returned and either used in **ImpersonateLoggedOnUser** to change the user context of the current thread, or in **CreateProcessAsUser** to change the user context of a spawned child process.

Later versions of Windows define new functions in this context and there are also functions to manipulate existing access tokens (usually only to restrict them). Windows Vista also adds subtokens which are attached to other access tokens which plays an important role in the UAC (User Access Control) facility of Vista and later. However, none of these extensions to the original concept are important for this documentation.

Back to this logon with password, how can this be used to implement **set(e)uid**? Well, it requires modification of the calling application. Two Cygwin functions have been introduced to support porting **setuid** applications which only require login with passwords. You only give Cygwin the right access token and then you can call **seteuid** or **setuid** as usual in POSIX applications. Porting such a **setuid** application is illustrated by a short example:

```
/* First include all needed cygwin stuff. */
#ifdef __CYGWIN__
#include <windows.h>
#include <sys/cygwin.h>
#endif

[...]

  struct passwd *user_pwd_entry = getpwnam (username);
  char *cleartext_password = getpass ("Password:");

[...]

#ifdef __CYGWIN__
  /* Patch the typical password test. */
  {
    HANDLE token;

    /* Try to get the access token from Windows. */
    token = cygwin_logon_user (user_pwd_entry, cleartext_password);
    if (token == INVALID_HANDLE_VALUE)
       error_exit;
    /* Inform Cygwin about the new impersonation token. */
    cygwin_set_impersonation_token (token);
    /* Cygwin is now able, to switch to that user context by setuid or seteuid calls. */
  }
#else
    /* Use standard method on non-Cygwin systems. */
    hashed_password = crypt (cleartext_password, salt);
    if (!user_pwd_entry ||
        strcmp (hashed_password, user_pwd_entry->pw_passwd))
      error_exit;
#endif /* CYGWIN */

[...]

  /* Everything else remains the same! */

  setegid (user_pwd_entry->pw_gid);
  seteuid (user_pwd_entry->pw_uid);
  execl ("/bin/sh", ...);
```

3.6.4.2 Switching the user context without password, Method 1: Kerberos/MsV1_0 S4U authentication

An unfortunate aspect of the implementation of **set(e)uid** is the fact that the calling process requires the password of the user to switch to. Applications such as **sshd** wishing to switch the user context after a successful public key authentication, or the **cron** application which, again, wants to switch the user without any authentication are stuck here. But there are other ways to get new user tokens.

Starting with Cygwin 3.0, Cygwin tries to create a token by using `Windows S4U authentication` by default. For a quick description, see this blog posting. Cygwin versions prior to 3.0 tried to creat a user token from scratch using an officially undocumented function **NtCreateToken** which is now disabled.

So we just start the services which have to switch the user context (**cygsshd**, **inetd**, **cron**, ...) as Windows services under the SYSTEM (or LocalSystem in the GUI) account and everything just works. Unfortunately that's too simple. Using `S4U` has a drawback.

Annoyingly, you don't have the usual comfortable access to network shares. The reason is that the token has been created without knowing the password. The password are your credentials necessary for network access. Thus, if you logon with a password, the password is stored hidden as "token credentials" within the access token and used as default logon to access network resources. Since these credentials are missing from the token created with `S4U` or **NtCreateToken**, you only can access network shares from the new user's process tree by using explicit authentication, on the command line for instance:

```
bash$ net use '\\server\share' /user:DOMAIN\my_user my_users_password
```

Note that, on some systems, you can't even define a drive letter to access the share, and under some circumstances the drive letter you choose collides with a drive letter already used in another session. Therefore it's better to get used to accessing these shares using the UNC path as in

```
bash$ grep foo //server/share/foofile
```

3.6.4.3 Switching the user context without password, Method 2: With password

Not being able to access network shares without having to specify a cleartext password on the command line or in a script is a harsh problem for automated logons for testing purposes and similar stuff.

Fortunately there is a solution, but it has its own drawbacks. But, first things first, how does it work? The title of this section says it all. Instead of trying to logon without password, we just logon with password. The password gets stored two-way encrypted in a hidden, obfuscated area of the registry, the LSA private registry area. This part of the registry contains, for instance, the passwords of the Windows services which run under some non-default user account.

So what we do is to utilize this registry area for the purpose of **set(e)uid**. The Cygwin command **passwd -R** allows a user to specify his/her password for storage in this registry area. When this user tries to login using ssh with public key authentication, Cygwin's **set(e)uid** examines the LSA private registry area and searches for a Cygwin specific key which contains the password. If it finds it, it calls **LogonUser** under the hood, using this password. If that works, **LogonUser** returns an access token with all credentials necessary for network access.

For good measure, and since this way to implement **set(e)uid** is not only used by Cygwin but also by Microsoft's SFU (Services for Unix), we also look for a key stored by SFU (using the SFU command **regpwd**) and use that if it's available.

We got it. A full access token with its own logon session, with all network credentials. Hmm, that's heaven...

Back on earth, what about the drawbacks?

First, adding a password to the LSA private registry area requires administrative access. So calling **passwd -R** as a normal user will fail! Cygwin provides a workaround for this. If **cygserver** is started as a service running under the SYSTEM account (which is the default way to run **cygserver**) you can use **passwd -R** as normal, non-privileged user as well.

Second, as aforementioned, the password is two-way encrypted in a hidden, obfuscated registry area. Only SYSTEM has access to this area for listing purposes, so, even as an administrator, you can't examine this area with regedit. Right? No. Every administrator can start regedit as SYSTEM user, the Internet is your friend here.

Additionally, if an administrator knows under which name the private key is stored (which is well-known since the algorithms used to create the Cygwin and SFU keys are no secret), every administrator can access the password of all keys stored this way in the registry.

Conclusion: If your system is used exclusively by you, and if you're also the only administrator of your system, and if your system is adequately locked down to prevent malicious access, you can safely use this method. If your machine is part of a network which has dedicated administrators, and you're not one of these administrators, but you (think you) can trust your administrators, you can probably safely use this method.

In all other cases, don't use this method. You have been warned.

3.6.4.4 Switching the user context, how does it all fit together?

Now we learned about three different ways to switch the user context using the **set(e)uid** system call, but how does **set(e)uid** really work? Which method does it use now?

The answer is, all three of them. So here's a brief overview what **set(e)uid** does under the hood:

- When **set(e)uid** is called, it tests if the user context had been switched by an earlier call already, and if the new user account is the privileged user account under which the process had been started originally. If so, it just switches to the original access token of the process it had been started with.
- Next, it tests if an access token has been stored by an earlier call to **cygwin_set_impersonation_token**. If so, it tests if that token matches the requested user account. If so, the stored token is used for the user context switch.

  If not, there's no predefined token which can just be used for the user context switch, so we have to create a new token. The order is as follows.
- Check if the user has stored the logon password in the LSA private registry area, either under a Cygwin key, or under a SFU key. If so, use this to call **LogonUser**. If this succeeds, we use the resulting token for the user context switch.
- Otherwise, use the default `S4U` authentication to create a token.
- Older systems, like WOW64 under Windows 7 64 bit, don't support `S4U` authentication for local machine accounts. On these systems Cygwin falls back to an old and otherwise deprecated method to create a user token from scratch. The underlying system call is undocumented and has an unfortunate requirement: We have to create a special account with dangerous permissions to perform this action. Therefore this is only enabled on affected systems.
- If all of the above fails, our process has insufficient privileges to switch the user context at all, so **set(e)uid** fails and returns -1, setting errno to EPERM.

3.7 Cygserver

3.7.1 What is Cygserver?

Cygserver is a program which is designed to run as a background service. It provides Cygwin applications with services which require security arbitration or which need to persist while no other cygwin application is running.

The implemented services so far are:

- XSI IPC Message Queues.
- XSI IPC Semaphores.
- XSI IPC Shared Memory.
- Allows non-privileged users to store obfuscated passwords in the registry to be used by **setuid** and **seteuid** calls to create user tokens with network credentials. This service is used by **passwd -R**. Using the stored passwords in **set(e)uid** does not require running Cygserver. For details, see Section 3.6.4.

3.7.2 Cygserver command line options

Options to Cygserver take the normal UNIX-style `-X' or `--longoption' form. Nearly all options have a counterpart in the configuration file (see below) so setting them on the command line isn't really necessary. Command line options override settings from the Cygserver configuration file.

The one-character options are prepended by a single dash, the long variants are prepended with two dashes. Arguments to options are marked in angle brackets below. These are not part of the actual syntax but are used only to denote the arguments. Note that all arguments are required. Cygserver has no options with optional arguments.

The recognized options are:

- `-f, --config-file <file>`

  Use <file> as configuration file instead of the default configuration line. The default configuration file is /etc/cygserver.conf. The --help and --version options will print the default configuration pathname.

  This option has no counterpart in the configuration file, for obvious reasons.

- `-c, --cleanup-threads <num>`

  Number of threads started to perform cleanup tasks. Default is 2. Configuration file option: kern.srv.cleanup_threads

- `-r, --request-threads <num>`

  Number of threads started to serve application requests. Default is 10. The -c and -r options can be used to play with Cygserver's performance under heavy load conditions or on slow machines. Configuration file option: kern.srv.request_threads

- `-d, --debug`

  Log debug messages to stderr. These will clutter your stderr output with a lot of information, typically only useful to developers.

- `-e, --stderr`

  Force logging to stderr. This is the default if stderr is connected to a tty. Otherwise, the default is logging to the system log. By using the -e, -E, -y, -Y options (or the appropriate settings in the configuration file), you can explicitly set the logging output as you like, even to both, stderr and syslog. Configuration file option: kern.log.stderr

- `-E, --no-stderr`

  Don't log to stderr. Configuration file option: kern.log.stderr

- `-y, --syslog`

  Force logging to the system log. This is the default, if stderr is not connected to a tty, e. g. redirected to a file. Configuration file option: kern.log.syslog

- `-Y, --no-syslog`

  Don't log to syslog. Configuration file option: kern.log.syslog

- `-l, --log-level <level>`

  Set the verbosity level of the logging output. Valid values are between 1 and 7. The default level is 6, which is relatively chatty. If you set it to 1, you will get only messages which are printed under severe conditions, which will result in stopping Cygserver itself. Configuration file option: kern.log.level

- `-m, --no-sharedmem`

  Don't start XSI IPC Shared Memory support. If you don't need XSI IPC Shared Memory support, you can switch it off here. Configuration file option: kern.srv.sharedmem

- `-q, --no-msgqueues`

  Don't start XSI IPC Message Queues. Configuration file option: kern.srv.msgqueues

- `-s, --no-semaphores`

  Don't start XSI IPC Semaphores. Configuration file option: kern.srv.semaphores

- `-S, --shutdown`

  Shutdown a running daemon and exit. Other methods are sending a SIGHUP to the Cygserver PID or, if running as service, calling `net stop cygserver' or `cygrunsrv -E cygserver'.

- `-h, --help`

  Output usage information and exit.

- `-V, --version`

  Output version information and exit.

3.7.3 How to install Cygserver

Cygserver is part of the base **cygwin** package. Therefore, whenever Cygwin is installed, so is Cygserver.

You may want to install Cygserver as a service. See Section 3.7.4.

3.7.4 How to start Cygserver

Before you run Cygserver for the first time, you should run the /usr/bin/cygserver-config script once. It creates the default configuration file and, upon request, installs Cygserver as service. The script only performs a default install, with no further options given to Cygserver when running as service. Due to the wide configurability by changing the configuration file, that's typically not necessary.

You should always run Cygserver as a service under LocalSystem account. This is the way it is installed for you by the /usr/bin/cygserver-config script.

3.7.5 The Cygserver configuration file

Cygserver has many options, which allow you to customize the server to your needs. Customization is accomplished by editing the configuration file, which is by default /etc/cygserver.conf. This file is only read once, at startup of Cygserver. There's no option to re-read the file at runtime by, say, sending a signal to Cygserver.

The configuration file determines how Cygserver operates. There are options which set the number of threads running in parallel, options for setting how and what to log and options to set various maximum values for the IPC services.

The default configuration file delivered with Cygserver is installed to /etc/defaults/etc. The /usr/bin/cygserver-config script copies it to /etc, giving you the option to overwrite an already existing file or to leave it alone. Therefore, the /etc file is safe to be changed by you, since it will not be overwritten by a later update installation.

The default configuration file contains many comments which describe everything needed to understand the settings. A comment at the start of the file describes the syntax rules for the file. The default options are shown in the file but are commented out.

It is generally a good idea to uncomment only options which you intend to change from the default values. Since reading the options file on Cygserver startup doesn't take much time, it's also considered good practice to keep all other comments in the file. This keeps you from searching for clues in other sources.

3.8 Cygwin Utilities

Cygwin comes with a number of command-line utilities that are used to manage the UNIX emulation portion of the Cygwin environment. While many of these reflect their UNIX counterparts, each was written specifically for Cygwin. You may use the long or short option names interchangeably; for example, `--help` and `-h` function identically. All of the Cygwin command-line utilities support the `--help` and `--version` options.

3.8.1 chattr

chattr — Change file attributes

Synopsis

`chattr` [-RVf] [+ | - | =*MODE*...] [*FILE*...]

`chattr` -H | -v

Options

```
-R, --recursive     recursively apply the changes to directories and
                    their contents
-V, --verbose       Be verbose during operation
-f, --force         suppress error messages
-H, --help          this help text
-v, --version       display the program version
```

Description

The **chattr** program allows to change file attributes, namely DOS attributes, as well as making files sparse, encrypt or compress them on FS level, or setting directories' case sensitivity.

The format of 'mode' is {+-=}[acCehnprsStu]

The operator '+' causes the selected attributes to be added to the existing attributes of the files; '-' causes them to be removed; and '=' causes them to be the only attributes that the files have. A single '=' causes all attributes to be removed.

Supported attributes:

```
'r', 'Readonly':      file is read-only
'h', 'Hidden':        file or directory is hidden
's', 'System':        file or directory that the operating system uses
'a', 'Archive':       file or directory has the archive marker set
't', 'Temporary':     file is being used for temporary storage
'S', 'Sparse':        file is sparse
'c', 'Compressed':    file or directory is compressed
'n', 'Notindexed':    file or directory is not to be indexed by the
    content indexing service
'e', 'Encrypted':     file is encrypted
'p', 'Pinned':        file is pinned
'u', 'Unpinned':      file is unpinned
'C', 'Casesensitive': directory is handled case sensitive
```

Case-sensitive directories

Case-sensitive directories are supported starting with Windows 10 1803. They are only supported on local NTFS filesystems.

The system-wide availability of case-sensitive directories depends on the setting of the registry value of type DWORD called HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\FileSystem\NtfsEnableDirCaseSensitivity. The value 0 disables case-sensitive directories. The value 1 enables case-sensitive directories. The value 3 enables case-sensitive directories, too, with the additional requirement that a directory can only be set to case-sensitive if it's empty. No other value is supported.

Removing case-sensitivity on a directory requires that the directory does not contain files only differing by case.

Trying to access a case-sensitive directory on a remote NTFS leads to all kinds of weird errors and is therefore *not* recommended.

3.8.2 cygcheck

cygcheck — List system information, check installed packages, or query package database

Synopsis

`cygcheck` [-v] [-h] *`PROGRAM`*

`cygcheck` -c [-d] [-n] [*`PACKAGE`*]

`cygcheck` -s [-r] [-v] [-h]

`cygcheck` -k

`cygcheck` -e [--requires] [--build-reqs] *`PATTERN`*...

`cygcheck` -i [--inst] [--curr] [--prev] [--test] [--deps] [--build-deps] *`PATTERN`*...

`cygcheck` -f *`FILE`*...

`cygcheck` -l [*`PACKAGE`*...]

`cygcheck` -p *`REGEXP`*

`cygcheck` --delete-orphaned-installation-keys

`cygcheck` -h | -V

Options

```
At least one command option or a PROGRAM is required, as shown above.

  PROGRAM              list library (DLL) dependencies of PROGRAM
  -c, --check-setup    show installed version of PACKAGE and verify integrity
                       (or for all installed packages if none specified)
  -d, --dump-only      do not verify packages (with -c)
  -n, --names-only     just list package names (implies -c -d)
  -s, --sysinfo        produce diagnostic system information (implies -c -d)
  -r, --registry       also scan registry for Cygwin settings (with -s)
  -k, --keycheck       perform a keyboard check session (must be run from a
                       plain console only, not from a pty/rxvt/xterm)
  -e, --search-package list all available packages matching PATTERN
                       PATTERN is a glob pattern with * and ? as wildcard chars
      search selection specifiers (multiple allowed):
      --requires       list packages depending on packages matching PATTERN
      --build-reqs     list packages depending on packages matching PATTERN
                       when building these packages
                       only the most recent available releases are checked
                       to collect requirements info
  -i, --info-package   print full info on packages matching PATTERN, installed
```

```
                        and available releases
                        PATTERN is a glob pattern with * and ? as wildcard chars
      info selection specifiers (multiple allowed):
      --inst            only print info on installed package release
      --curr            only print info on most recent available release
      --prev            only print info on older, still available releases
      --test            only print info on test releases
      --deps            additionally print package dependencies
      --build-deps      additionally print package build dependencies
  -f, --find-package    find the package to which FILE belongs
  -l, --list-package    list contents of PACKAGE (or all packages if none given)
  -p, --package-query   search for REGEXP in the entire cygwin.com package
                        repository (requires internet connectivity)
  --delete-orphaned-installation-keys
                        Delete installation keys of old, now unused
                        installations from the registry.  Requires the right
                        to change the registry.
  -v, --verbose         produce more verbose output
  -h, --help            annotate output with explanatory comments when given
                        with another command, otherwise print this help
  -V, --version         print the version of cygcheck and exit

Notes:
  -c, -f, and -l only report on packages that are currently installed.
  -i and -e report on available packages, too.  To search for files within
  uninstalled Cygwin packages, use -p.  The -p REGEXP matches package names,
  descriptions, and names of files/paths within all packages.
```

Description

The **cygcheck** program is a diagnostic utility for dealing with Cygwin programs. If you are familiar with **dpkg** or **rpm**, **cygcheck** is similar in many ways. (The major difference is that **setup** handles installing and uninstalling packages; see Section 2.1 for more information.)

The `-c` option checks the version and status of installed Cygwin packages. If you specify one or more package names, **cygcheck** will limit its output to those packages, or with no arguments it lists all packages. A package will be marked `Incomplete` if files originally installed are no longer present. The best thing to do in that situation is reinstall the package with **setup**. To see which files are missing, use the `-v` option. If you do not need to know the status of each package and want **cygcheck** to run faster, add the `-d` option and **cygcheck** will only output the name and version for each package. Add the `-n` option to output only the names of packages.

If you list one or more programs on the command line, **cygcheck** will diagnose the runtime environment of that program or programs, providing the names of DLL files on which the program depends. If you specify the `-s` option, **cygcheck** will give general system information. If you list one or more programs on the command line and specify `-s`, **cygcheck** will report on both.

The `-e` option allows to seach for available packages in the Cygwin distribution. `PATTERN` is a glob pattern, using * and ? as wildcard characters, just as in filename patterns. `PATTERN` is searched for in the package name and the summary of a package. The `--requires` and `--build-reqs` options allow to search for packages which have a certain dependency, either at runtime or at build time.

The `-i` option prints a lot of information available for installed packages, as well as for available packages in the Cygwin distribution. `PATTERN` is a glob pattern, using * and ? as wildcard characters, just as in filename patterns. `PATTERN` is compared against the package name as well as against the combined package name and version. With additional info selectors, `--inst`, `--curr`, `--prev`, and `--test`, allow to specify that only information in terms of installed, current latest available, older available, as well as test packages respectively, is requested. The `--deps` and `--build-deps` options allow to print additional dependency information.

Example 3.4 Example **cygcheck** -e/-i usage

```
$ cygcheck -e grep
grep : search for regular expression matches in text files
grep-debuginfo : Debug info for grep
grepmail : search mailboxes for mail matching an expression
pdfgrep : Command-line utility for searching text in PDFs
pdfgrep-debuginfo : Debug info for pdfgrep
sgrep : Search indexed text regions like SGML,XML and HTML files

$ cygcheck -i --curr --deps grep
Latest available package:
-------------------------

Name         : grep
Version      : 3.8
Release      : 2
Architecture: x86_64
Size         : 401340 (392 K)
Source       : grep-3.8-2-src.tar.xz
Dependencies: bash, cygwin, libintl8, libpcre2_8_0
Summary      : search for regular expression matches in text files
Description :
GNU grep searches one or more input files for lines containing a
match to a specified pattern. By default, grep outputs the matching lines.
The GNU implementation includes several useful extensions over POSIX.
```

Note that `-e` and `-i` options fetch info from a distribution db file. This file will be downloading on demand and refreshed if it's older than 24 hours.

The `-f` option helps you to track down which package a file came from, and `-l` lists all files in a package. For example, to find out about `/usr/bin/less` and its package:

Example 3.5 Example **cygcheck** -f/-l usage

```
$ cygcheck -f /usr/bin/less
less-381-1

$ cygcheck -l less
/usr/bin/less.exe
/usr/bin/lessecho.exe
/usr/bin/lesskey.exe
/usr/man/man1/less.1
/usr/man/man1/lesskey.1
```

The `-h` option prints additional helpful messages in the report, at the beginning of each section. It also adds table column headings. While this is useful information, it also adds some to the size of the report, so if you want a compact report or if you know what everything is already, just leave this out.

The `-v` option causes the output to be more verbose. What this means is that additional information will be reported which is usually not interesting, such as the internal version numbers of DLLs, additional information about recursive DLL usage, and if a file in one directory in the PATH also occurs in other directories on the PATH.

The `-r` option causes **cygcheck** to search your registry for information that is relevant to Cygwin programs. These registry entries are the ones that have "Cygwin" in the name. If you are paranoid about privacy, you may remove information from this report, but please keep in mind that doing so makes it harder to diagnose your problems.

In contrast to the other options that search the packages that are installed on your local system, the `-p` option can be used to search the entire official Cygwin package repository. It takes as argument a Perl-compatible regular expression which is used to match package names, package descriptions, and path/filenames of the contents of packages. This feature requires an active internet connection, since it must query the `cygwin.com` web site. In fact, it is equivalent to the search that is available on the Cygwin package listing page.

For example, perhaps you are getting an error because you are missing a certain DLL and you want to know which package includes that file:

Example 3.6 Searching all packages for a file

```
$ cygcheck -p 'cygintl-2\.dll'
Found 1 matches for 'cygintl-2\.dll'.

libintl2-0.12.1-3         GNU Internationalization runtime library

$ cygcheck -p 'libexpat.*\.a'
Found 2 matches for 'libexpat.*\.a'.

expat-1.95.7-1            XML parser library written in C
expat-1.95.8-1            XML parser library written in C

$ cygcheck -p '/ls\.exe'
Found 2 matches for '/ls\.exe'.

coreutils-5.2.1-5         GNU core utilities (includes fileutils, sh-utils and textutils)
coreutils-5.3.0-6         GNU core utilities (includes fileutils, sh-utils and textutils)
```

Note that this option takes a regular expression, not a glob or wildcard. This means that you need to use `.*` if you want something similar to the wildcard `*` commonly used in filename globbing. Similarly, to match the period character you should use `\.` since the `.` character in a regexp is a metacharacter that will match any character. Also be aware that the characters such as `\` and `*` are shell metacharacters, so they must be either escaped or quoted, as in the example above.

The third example above illustrates that if you want to match a whole filename, you should include the `/` path seperator. In the given example this ensures that filenames that happen to end in `ls.exe` such as `ncftpls.exe` are not shown. Note that this use does not mean "look for packages with `ls` in the root directory," since the `/` can match anywhere in the path. It's just there to anchor the match so that it matches a full filename.

By default the matching is case-sensitive. To get a case insensitive match, begin your regexp with `(?i)` which is a PCRE-specific feature. For complete documentation on Perl-compatible regular expression syntax and options, read the **perlre** manpage, or one of many websites such as `perldoc.com` that document the Perl language.

The **cygcheck** program should be used to send information about your system for troubleshooting when requested. When asked to run this command save the output so that you can email it, for example:

```
$ cygcheck -s -v -r -h > cygcheck_output.txt
```

Each Cygwin DLL stores its path and installation key in the registry. This allows troubleshooting of problems which could be a result of having multiple concurrent Cygwin installations. However, if you're experimenting a lot with different Cygwin installation paths, your registry could accumulate a lot of old Cygwin installation entries for which the installation doesn't exist anymore. To get rid of these orphaned registry entries, use the **cygcheck --delete-orphaned-installation-keys** command.

3.8.3 cygpath

cygpath — Convert Unix and Windows format paths, or output system path information

Synopsis

`cygpath` -d | -m | -u | -w | -t *TYPE* [-f *FILE*] [-i] [*CONVERSION_OPTION*...] *NAME*...

`cygpath` [-c *HANDLE*]

`cygpath` [-A] -D | -H | -O | -P | -S | -W | -F *ID*

`cygpath` -h | -V

Options

```
Output type options:

  -d, --dos             print DOS (short) form of NAMEs (C:\PROGRA~1\)
  -m, --mixed           like --windows, but with regular slashes (C:/WINNT)
  -M, --mode            report on mode of file (currently binmode or textmode)
  -u, --unix            (default) print Unix form of NAMEs (/cygdrive/c/winnt)
  -w, --windows         print Windows form of NAMEs (C:\WINNT)
  -t, --type TYPE       print TYPE form: 'dos', 'mixed', 'unix', or 'windows'

Path conversion options:

  -a, --absolute        output absolute path
  -l, --long-name       print Windows long form of NAMEs (with -w, -m only,
                        don't mix with -r and -s)
  -r, --root-local      print Windows path with root-local path prefix (\\?\,
                        with -w only)
  -p, --path            NAME is a PATH list (i.e., '/bin:/usr/bin')
  -U, --proc-cygdrive   Emit /proc/cygdrive path instead of cygdrive prefix
                        when converting Windows path to UNIX path.
  -s, --short-name      print DOS (short) form of NAMEs (with -w, -m only,
                        don't mix with -l and -r)
  -C, --codepage CP     print DOS, Windows, or mixed pathname in Windows
                        codepage CP.  CP can be a numeric codepage identifier,
                        or one of the reserved words ANSI, OEM, or UTF8.
                        If this option is missing, cygpath defaults to the
                        character set defined by the current locale.

System information:

  -A, --allusers        use 'All Users' instead of current user for -D, -P
  -D, --desktop         output 'Desktop' directory and exit
  -H, --homeroot        output 'Profiles' directory (home root) and exit
  -O, --mydocs          output 'My Documents' directory and exit
  -P, --smprograms      output Start Menu 'Programs' directory and exit
  -S, --sysdir          output system directory and exit
  -W, --windir          output 'Windows' directory and exit
  -F, --folder ID       output special folder with numeric ID and exit

Other options:

  -f, --file FILE       read FILE for input; use - to read from STDIN
  -o, --option          read options from FILE as well (for use with --file)
  -c, --close HANDLE    close HANDLE (for use in captured process)
  -i, --ignore          ignore missing argument
  -h, --help            output usage information and exit
  -V, --version         output version information and exit
```

Description

The **cygpath** program is a utility that converts Windows native filenames to Cygwin POSIX-style pathnames and vice versa. It can be used when a Cygwin program needs to pass a file name to a native Windows program, or expects to get a file name from a native Windows program. Alternatively, **cygpath** can output information about the location of important system directories in either format.

The `-u` and `-w` options indicate whether you want a conversion to UNIX (POSIX) format (`-u`) or to Windows format (`-w`). Use the `-d` to get DOS-style 8.3 file and path names. The `-m` option will output Windows-style format but with forward slashes instead of backslashes. This option is especially useful in shell scripts, which use backslashes as an escape character.

In combination with the `-w` and `-m` options, you can use the `-l` and `-s` options to use normal (long) or DOS-style 8.3 (short) form. The `-d` option is identical to `-w` and `-s` together.

Note that short DOS-style 8.3 names are not always available. The generation of additional 8.3 filenames is the responsibility of the underlying filesystem. Modern Windows OS allows to switch off 8.3 filename generation and some filesystems never generate 8.3 names. In these cases, using the `-s` option may fail or may be ignored.

In combination with the `-w` option, you can use the `-r` option to generate root-local paths with leading \\?\ prefix. This is especially useful if your path contains path components invalid in DOS paths, for instance file or directory names with trailing dot.

Note that the root-local path prefix is automatically prepended for paths exceeding a length of MAX_PATH (260) bytes.

The `-C` option allows to specify a Windows codepage to print DOS and Windows paths created with one of the `-d`, `-m`, or `-w` options. The default is to use the character set of the current locale defined by one of the internationalization environment variables `LC_ALL`, `LC_CTYPE`, or `LANG`, see Section 2.4. This is sometimes not sufficient for interaction with native Windows tools, which might expect native, non-ASCII characters in a specific Windows codepage. Console tools, for instance, might expect pathnames in the current OEM codepage, while graphical tools like Windows Explorer might expect pathnames in the current ANSI codepage.

The `-U` option allows to use cygpath to create unambiguous Unix paths pointing outside the Cygwin tree andf thus having no explicit POSIX path. Those paths usually use the cygdrive prefix. However, the cygdrive prefix can be changed by the user, so symbolic links created using the cygdrive prefix are not foolproof. With `-U` cygpath will generate such paths prepended by the virtual `/proc/cygdrive` symbolic link, which will never change, so the created path is safe against changing the cygdrive prefix.

The `-C` option takes a single parameter:

- `ANSI`, to specify the current ANSI codepage
- `OEM`, to specify the current OEM (console) codepage
- `UTF8`, to specify UTF-8.
- A numerical, decimal codepage number, for instance 936 for GBK, 28593 for ISO-8859-3, etc. A full list of supported codepages is listed on the Microsoft MSDN page Code Page Identifiers. A codepage of 0 is the same as if the `-C` hasn't been specified at all.

The `-p` option means that you want to convert a path-style string rather than a single filename. For example, the PATH environment variable is semicolon-delimited in Windows, but colon-delimited in UNIX. By giving `-p` you are instructing **cygpath** to convert between these formats.

The `-i` option supresses the print out of the usage message if no filename argument was given. It can be used in make file rules converting variables that may be omitted to a proper format. Note that **cygpath** output may contain spaces (C:\Program Files) so should be enclosed in quotes.

Example 3.7 Example **cygpath** usage

```
#!/bin/sh
if [ "${1}" = "" ];
  then
    XPATH=".";
  else
    XPATH="$(cygpath -C ANSI -w "${1}")";
fi
explorer $XPATH &
```

The capital options `-D`, `-H`, `-P`, `-S`, and `-W` output directories used by Windows that are not the same on all systems, for example `-S` might output C:\WINNT\system32 or C:\Windows\System32. The `-H` shows the Windows profiles directory that can be used as root of home. The `-A` option forces use of the "All Users" directories instead of the current user for the `-D`, `-O` and `-P` options. The `-F` outputs other special folders specified by their internal numeric code (decimal or 0x-prefixed hex). For valid codes and

symbolic names, see the CSIDL_* definitions in the include file /usr/include/w32api/shlobj.h from package w32api. The current valid range of codes for folders is 0 (Desktop) to 59 (CDBurn area). By default the output is in UNIX (POSIX) format; use the `-w` or `-d` options to get other formats.

3.8.4 dumper

dumper — Dump core from WIN32PID to FILENAME.core

Synopsis

`dumper` [-n] [-d] [-q] *`FILENAME WIN32PID`*

`dumper` -h | -V

Options

```
-n, --nokill   don't terminate the dumped process
-d, --verbose  be verbose while dumping
-h, --help     output help information and exit
-q, --quiet    be quiet while dumping (default)
-V, --version  output version information and exit
```

Description

The **dumper** utility can be used to create a core dump of running Windows process. This core dump can be later loaded into **gdb** and analyzed.

If the core file size limit is set to unlimited (e.g. **ulimit -c unlimited**) and an `error_start` executable hasn't been configured in the `CYGWIN` environment variable, Cygwin will automatically run **dumper** when a fatal error occurs.

dumper can be also be started from the command line to create a core dump of any running process.

For historical reasons, unless the `-n` option is given, after the core dump is created and when the **dumper** exits, the target process is also terminated.

To save space in the core dump, **dumper** doesn't write those portions of the target process's memory space that were loaded from executable and dll files and are unchanged (e.g. program code). Instead, **dumper** saves paths to the files which contain that data. When a core dump is loaded into gdb, it uses these paths to load the appropriate files. That means that if you create a core dump on one machine and try to debug it on another, you'll need to place identical copies of the executable and dlls in the same directories as on the machine where the core dump was created.

Notes

A Cygwin "core dump file" is an ELF file containing the mutable parts of the process memory and special note sections which capture the process, thread and loaded module context needed to recreate the process image in a debugger.

3.8.5 getconf

getconf — Get configuration values

Synopsis

`getconf` [-v *`specification`*] *`variable_name`* [*`pathname`*]

`getconf` -a [*`pathname`*]

`getconf` -h | -V

Options

```
  -v specification     Indicate specific version for which configuration
                       values shall be fetched.
  -a, --all            Print all known configuration values

Other options:

  -h, --help           This text
  -V, --version        Print program version and exit
```

Description

The **getconf** utility prints the value of the configuration variable specified by `variable_name`. If no `pathname` is given, **getconf** serves as a wrapper for the `confstr` and `sysconf` functions, supporting the symbolic constants defined in the `limits.h` and `unistd.h` headers, without their respective `_CS_` or `_SC_` prefixes.

If `pathname` is given, **getconf** prints the value of the configuration variable for the specified pathname. In this form, **getconf** serves as a wrapper for the `pathconf` function, supporting the symbolic constants defined in the `unistd.h` header, without the `_PC_` prefix.

If you specify the `-v` option, the parameter denotes a specification for which the value of the configuration variable should be printed. Note that the only specifications supported by Cygwin are `POSIX_V7_ILP32_OFFBIG` and the legacy `POSIX_V6_ILP32_O` and `XBS5_ILP32_OFFBIG` equivalents.

Use the `-a` option to print a list of all available configuration variables for the system, or given `pathname`, and their values.

3.8.6 getfacl

getfacl — Display file and directory access control lists (ACLs)

Synopsis

`getfacl` [-adceEn] *`FILE`*...

`getfacl` -h | -V

Options

```
  -a, --access        display the file access control list only
  -d, --default       display the default access control list only
  -c, --omit-header   do not display the comment header
  -e, --all-effective print all effective rights
  -E, --no-effective  print no effective rights
  -n, --numeric       print numeric user/group identifiers
  -V, --version       print version and exit
  -h, --help          this help text

When multiple files are specified on the command line, a blank
line separates the ACLs for each file.
```

Description

For each argument that is a regular file, special file or directory, **getfacl** displays the owner, the group, and the ACL. For directories **getfacl** displays additionally the default ACL. With no options specified, **getfacl** displays the filename, the owner, the group, the setuid (s), setgid (s), and sticky (t) bits if available, and both the ACL and the default ACL, if it exists. For more information on Cygwin and Windows ACLs, see Section 3.6 in the Cygwin User's Guide. The format for ACL output is as follows:

```
    # file: filename
    # owner: name or uid
    # group: name or uid
    # flags: sst
    user::perm
    user:name or uid:perm
    group::perm
    group:name or gid:perm
    mask:perm
    other:perm
    default:user::perm
    default:user:name or uid:perm
    default:group::perm
    default:group:name or gid:perm
    default:mask:perm
    default:other:perm
```

3.8.7 gmondump

gmondump — Display formatted contents of profile data files

Synopsis

`gmondump` [-v] [FILENAME...]

`gmondump` -h | -V

Options

```
  -h, --help             Display usage information and exit
  -v, --verbose          Display more file details (toggle: default false)
  -V, --version          Display version information and exit
```

Description

The **gmondump** utility displays the contents of one or more profile data files. Such files usually have names starting with "gmon.out" and are created by a profiling program such as **profiler** or **ssp**. Compiling your gcc/g++ programs with option `-pg` also works.

By default, summary information is shown. You can use the option `-v` to get more detailed displays.

Note that **gmondump** just displays the raw data; one would usually use **gprof** to display the data in a useful form incorporating symbolic info such as function names and source line numbers.

Here is an example of **gmondump** operation:

```
$ gmondump gmon.out.21900.zstd.exe
file gmon.out.21900.zstd.exe, gmon version 0x51879, sample rate 100
  address range 0x100401000..0x1004cc668
  numbuckets 208282, hitbuckets 1199, hitcount 12124, numrawarcs 0
```

3.8.8 kill

kill — Send signals to processes

Synopsis

`kill` [-f] [-signal] [-s *`signal`*] *`pid`*...

`kill` -l *`signal`* | -L

`kill` -h | -V

Options

```
-f, --force     force, using win32 interface if necessary
-l, --list      print a list of signal names
-L, --table     print a formatted table of signal names
-s, --signal    send signal (use kill --list for a list)
-W, --winpid    specified pids are windows PIDs, not Cygwin PIDs
                (use with extreme caution!)
-h, --help      output usage information and exit
-V, --version   output version information and exit
```

Description

The **kill** program allows you to send arbitrary signals to other Cygwin programs. The usual purpose is to end a running program from some other window when ^C won't work, but you can also send program-specified signals such as SIGUSR1 to trigger actions within the program, like enabling debugging or re-opening log files. Each program defines the signals they understand.

You may need to specify the full path to use **kill** from within some shells, including **bash**, the default Cygwin shell. This is because **bash** defines a **kill** builtin function; see the **bash** man page under *BUILTIN COMMANDS* for more information. To make sure you are using the Cygwin version, try

```
$ /bin/kill --version
```

which should give the Cygwin **kill** version number and copyright information.

The `-f` option uses Windows functions to terminate processes forcefully. Use `-f` to terminate native Windows processes not started by Cygwin processes. `-f` can also be useful to terminate Cygwin processes not answering to SIGKILL.

Unless you specific the `-W` option, the "pid" values used by **kill** are the Cygwin pids, not the Windows pids. To get a list of running programs and their Cygwin pids, use the Cygwin **ps** program. **ps -W** will display *all* windows pids.

The **kill -l** option prints the name of the given signal, or a list of all signal names if no signal is given.

The **kill -L** option is similar to `-l`, but it will print signal names and their corresponding numbers.

To send a specific signal, use the `-signN` option, either with a signal number or a signal name (minus the "SIG" part), as shown in these examples:

Example 3.8 Using the kill command

```
$ kill 123
$ kill -1 123
$ kill -HUP 123
$ kill -f 123
```

Here is a list of available signals, their numbers, and some commentary on them, from the file `<sys/signal.h>`, which should be considered the official source of this information.

```
SIGHUP       1    hangup
SIGINT       2    interrupt
SIGQUIT      3    quit
SIGILL       4    illegal instruction (not reset when caught)
SIGTRAP      5    trace trap (not reset when caught)
SIGABRT      6    used by abort
SIGIOT       6    another name for SIGABRT
SIGEMT       7    EMT instruction
SIGFPE       8    floating point exception
SIGKILL      9    kill (cannot be caught or ignored)
SIGBUS      10    bus error
SIGSEGV     11    segmentation violation
SIGSYS      12    bad argument to system call
SIGPIPE     13    write on a pipe with no one to read it
SIGALRM     14    alarm clock
SIGTERM     15    software termination signal from kill
SIGURG      16    urgent condition on IO channel
SIGSTOP     17    sendable stop signal not from tty
SIGTSTP     18    stop signal from tty
SIGCONT     19    continue a stopped process
SIGCHLD     20    to parent on child stop or exit
SIGCLD      20    System V name for SIGCHLD
SIGTTIN     21    to readers pgrp upon background tty read
SIGTTOU     22    like TTIN for output if (tp->t_local&LTOSTOP)
SIGIO       23    input/output possible
SIGPOLL     23    System V name for SIGIO
SIGXCPU     24    exceeded CPU time limit
SIGXFSZ     25    exceeded file size limit
SIGVTALRM   26    virtual time alarm
SIGPROF     27    profiling time alarm
SIGWINCH    28    window changed
SIGLOST     29    resource lost (eg, record-lock lost)
SIGPWR      29    power failure
SIGUSR1     30    user defined signal 1
SIGUSR2     31    user defined signal 2
```

3.8.9 ldd

ldd — Print shared library dependencies

Synopsis

`ldd` [-ruv] *FILE*...

`ldd` -h | -V

Options

```
  -h, --help              print this help and exit
  -V, --version           print version information and exit
  -r, --function-relocs   process data and function relocations
                          (currently unimplemented)
  -u, --unused            print unused direct dependencies
                          (currently unimplemented)
  -v, --verbose           print all information
                          (currently unimplemented)
```

Description

ldd prints the shared libraries (DLLs) loaded when running an executable or DLL.

Security

ldd invokes the Windows loader on the file specified, then uses the Windows debugging interface to report DLLs loaded, and (for executables) to attempt to stop execution before the entrypoint. Thus, you should never use ldd on an untrusted file.

3.8.10 locale

locale — Get locale-specific information

Synopsis

`locale` [-amvhV]

`locale` [-ck] *NAME*

`locale` [-iusfnU]

`locale` -h | -V

Options

```
System information:

  -a, --all-locales    List all available supported locales
  -m, --charmaps       List all available character maps
  -v, --verbose        More verbose output

Modify output format:

  -c, --category-name  List information about given category NAME
  -k, --keyword-name   Print information about given keyword NAME

Default locale information:

  -i, --input          Print current input locale
  -u, --user           Print locale of user's default UI language
  -s, --system         Print locale of system default UI language
  -f, --format         Print locale of user's regional format settings
                       (time, numeric & monetary)
  -n, --no-unicode     Print system default locale for non-Unicode programs
  -U, --utf            Attach \".UTF-8\" to the result

Other options:

  -h, --help           This text
  -V, --version        Print program version and exit
```

Description

locale without parameters prints information about the current locale environment settings.

The `-i`, `-u`, `-s`, `-f`, and `-n` options can be used to request the various Windows locale settings. The purpose is to use this command in scripts to set the POSIX locale variables.

The `-i` option prints the current input language. This is called the "Input language" and basically equivalent to the current keyboard layout setting.

The `-u` option prints the current user's Windows UI locale to stdout. In Windows this setting is called the "Display Language".

The `-s` option prints the systems default instead.

The `-f` option prints the user's setting for time, date, number and currency. That's equivalent to the setting in the "Formats" or "Regional Options" tab in the "Region and Language" or "Regional and Language Options" dialog.

The `-n` option prints the system's default language used for applications which don't support Unicode.

With the `-U` option **locale** appends the string ".UTF-8" to enforce using UTF-8. Using UTF-8 as codeset is recommended.

Usage example:

```
bash$ export LANG=$(locale -uU)
bash$ echo $LANG
en_US.UTF-8
bash$ export LC_TIME=$(locale -fU)
bash$ echo $LC_TIME
de_DE.UTF-8
```

The `-a` option is helpful to learn which locales are supported by your Windows machine. It prints all available locales and the allowed modifiers. Example:

```
bash$ locale -a
C
C.utf8
POSIX
af_ZA
af_ZA.utf8
am_ET
am_ET.utf8
...
be_BY
be_BY.utf8
be_BY@latin
...
ca_ES
ca_ES.utf8
ca_ES@euro
catalan
...
```

The `-v` option prints more detailed information about each available locale. Example:

```
bash$ locale -av
locale: af_ZA           archive: /cygdrive/c/Windows/system32/kernel32.dll
----------------------------------------------------------------------------
 language | Afrikaans
territory | South Africa
  codeset | ISO-8859-1

locale: af_ZA.utf8      archive: /cygdrive/c/Windows/system32/kernel32.dll
----------------------------------------------------------------------------
 language | Afrikaans
territory | South Africa
  codeset | UTF-8

...

locale: ca_ES@euro      archive: /cygdrive/c/Windows/system32/kernel32.dll
----------------------------------------------------------------------------
```

```
 language | Catalan
territory | Spain
  codeset | ISO-8859-15

locale: catalan         archive: /usr/share/locale/locale.alias
-------------------------------------------------------------------------------
 language | Catalan
territory | Spain
  codeset | ISO-8859-1

...
```

The `-m` option prints the names of the available charmaps supported by Cygwin to stdout.

Otherwise, if arguments are given, **locale** prints the values assigned to these arguments. Arguments can be names of locale categories (for instance: LC_CTYPE, LC_MONETARY), or names of keywords supported in the locale categories (for instance: thousands_sep, charmap). The `-c` option prints additionally the name of the category. The `-k` option prints additionally the name of the keyword. Example:

```
bash$ locale -ck LC_MESSAGES
LC_MESSAGES
yesexpr="^[yY]"
noexpr="^[nN]"
yesstr="yes"
nostr="no"
messages-codeset="UTF-8"
bash$ locale noexpr
^[nN]
```

3.8.11 lsattr

lsattr — List file attributes

Synopsis

`lsattr` [-Radln] [*FILE*...]

`lsattr` -h | -V

Options

```
  -R, --recursive     recursively list attributes of directories and their
                      contents
  -V, --version       display the program version
  -a, --all           list all files in directories, including files that
                      start with '.'
  -d, --directory     list directories like other files, rather than listing
                      their contents.
  -l, --long          print options using long names instead of single
                      character abbreviations
  -n, --no-headers    don't print directory headers when recursing
  -h, --help          this help text
```

Description

The **lsattr** program allows to list file attributes, namely DOS attributes, file sparseness, FS level encryption and compression state, as well as directories' case sensitivity setting.

Supported attributes:

```
  'r', 'Readonly':      file is read-only, directory is system-marked
  'h', 'Hidden':        file or directory is hidden
  's', 'System':        file or directory that the operating system uses
  'a', 'Archive':       file or directory has the archive marker set
  't', 'Temporary':     file is being used for temporary storage
  'S', 'Sparse':        file is sparse
  'r', 'Reparse':       file or directory that has a reparse point
  'c', 'Compressed':    file or directory is compressed
  'o', 'Offline':       the data of a file is moved to offline storage
  'n', 'Notindexed':    file or directory is not to be indexed by the
                        content indexing service
  'e', 'Encrypted':     file is encrypted
  'p', 'Pinned':        file is pinned
  'u', 'Unpinned':      file is unpinned
  'C', 'Casesensitive': directory is handled case sensitive
                        (Windows 10 1803 or later, local NTFS only,
                         WSL must be installed)
```

3.8.12 minidumper

minidumper — Write minidump from WIN32PID to FILENAME.dmp

Synopsis

`minidumper` [-d] [-n] [-q] [-t *TYPE*] *FILENAME WIN32PID*

`minidumper` -h | -V

Options

```
-t, --type     minidump type flags
-n, --nokill   don't terminate the dumped process
-d, --verbose  be verbose while dumping
-h, --help     output help information and exit
-q, --quiet    be quiet while dumping (default)
-V, --version  output version information and exit
```

Description

The **minidumper** utility can be used to create a minidump of a running Windows process. This minidump can be later analysed using breakpad or Windows debugging tools.

minidumper can be used with cygwin's Just-In-Time debugging facility by adding `error_start=minidumper` to the `CYGWIN` environment variable. If `CYGWIN` is set this way, then **minidumper** will be started whenever a program encounters a fatal exception.

minidumper can also be started from the command line to create a minidump of any running process. For compatibility with **dumper** the target process is terminated after dumping unless the `-n` option is given.

3.8.13 mkgroup

mkgroup — Write /etc/group-like output to stdout

Synopsis

`mkgroup` [-l | -L [*MACHINE*]] [-d [*DOMAIN*]] [-c] [-S *CHAR*] [-o *OFFSET*] [-g *GROUPNAME*] [-b] [-U *GROUPLIST*]

`mkgroup` -h | -V

Options

```
   -l,--local [machine]    Print local group accounts of \"machine\",
                           from local machine if no machine specified.
                           Automatically adding machine prefix for local
                           machine depends on settings in /etc/nsswitch.conf.
   -L,--Local [machine]    Ditto, but generate groupname with machine prefix.
   -d,--domain [domain]    Print domain groups,
                           from current domain if no domain specified.
   -c,--current            Print current group.
   -S,--separator char     For -L use character char as domain\\group
                           separator in groupname instead of default '+'.
   -o,--id-offset offset   Change the default offset (0x10000) added to gids
   -g,--group groupname    Only return information for the specified group.
                           One of -l, -d must be specified, too.
   -b,--no-builtin         Don't print BUILTIN groups.
   -U,--unix grouplist     Print UNIX groups when using -l on a UNIX Samba
                           server.  Grouplist is a comma-separated list of
                           groupnames or gid ranges (root,-25,50-100).
                           Enumerating large ranges can take a long time!
   -h,--help               Print this message.
   -v,--version            Print version information and exit.

Default is to print local groups on stand-alone machines, plus domain
groups on domain controllers and domain member machines.
```

Description

Don't use this command to generate a local /etc/group file, unless you really need one. See the Cygwin User's Guide for more information.

The **mkgroup** program can be used to create a local `/etc/group` file. Cygwin doesn't need this file, because it reads group information from the Windows account databases, but you can add an `/etc/group` file for instance, if your machine is often disconnected from its domain controller.

Note that this information is static, in contrast to the information automatically gathered by Cygwin from the Windows account databases. If you change the group information on your system, you'll need to regenerate the group file for it to have the new information.

By default, the information generated by **mkgroup** is equivalent to the information generated by Cygwin itself. The `-d` and `-l`/`-L` options allow you to specify where the information comes from, some domain, or the local SAM of a machine. Note that you can only enumerate accounts from trusted domains. Any non-trusted domain will be ignored. Access-restrictions of your current account apply. The `-l`/`-L` when used with a machine name, tries to contact that machine to enumerate local groups of other machines, typically outside of domains. This scenario cannot be covered by Cygwin's account automatism. If you want to use the `-L` option, but you don't like the default domain/group separator from `/etc/nsswitch.conf`, you can specify another separator using the `-S` option, for instance:

Example 3.9 Setting up group entry for current user with different domain/group separator

```
$ mkgroup -L server1 -S= > /etc/group
```

For very simple needs, an entry for the current user's group can be created by using the option `-c`.

The `-o` option allows for (unlikely) special cases with multiple machines where the GIDs might match otherwise. The `-g` option only prints the information for one group. The `-U` option allows you to enumerate the standard UNIX groups on a Samba machine. It's used together with `-l samba-server` or `-L samba-server`. The normal UNIX groups are usually not enumerated, but they can show up as a group in **ls -l** output.

3.8.14 mkpasswd

mkpasswd — Write /etc/passwd-like output to stdout

Synopsis

`mkpasswd` [-l | -L [*MACHINE*]] [-d [*DOMAIN*]] [-c] [-S *CHAR*] [-o *OFFSET*] [-u *USERNAME*] [-b] [-U *USERLIST*]

`mkpassword` -h | -V

Options

```
   -l,--local [machine]    Print local user accounts of \"machine\",
                           from local machine if no machine specified.
                           Automatically adding machine prefix for local
                           machine depends on settings in /etc/nsswitch.conf.
   -L,--Local [machine]    Ditto, but generate username with machine prefix.
   -d,--domain [domain]    Print domain accounts,
                           from current domain if no domain specified.
   -c,--current            Print current user.
   -S,--separator char     For -L use character char as domain\\user
                           separator in username instead of the default '+'.
   -o,--id-offset offset   Change the default offset (0x10000) added to uids
                           of foreign local machine accounts.  Use with -l/-L.
   -u,--username username  Only return information for the specified user.
                           One of -l, -d must be specified, too
   -b,--no-builtin         Don't print BUILTIN users.
   -p,--path-to-home path  Use specified path instead of user account home dir
                           or /home prefix.
   -U,--unix userlist      Print UNIX users when using -l on a UNIX Samba
                           server.  Userlist is a comma-separated list of
                           usernames or uid ranges (root,-25,50-100).
                           Enumerating large ranges can take a long time!
   -h,--help               Displays this message.
   -V,--version            Version information and exit.

Default is to print local accounts on stand-alone machines, domain accounts
on domain controllers and domain member machines.
```

Description

Don't use this command to generate a local /etc/passwd file, unless you really need one. See the Cygwin User's Guide for more information.

The **mkpasswd** program can be used to create a `/etc/passwd` file. Cygwin doesn't need this file, because it reads user information from the Windows account databases, but you can add an `/etc/passwd` file, for instance if your machine is often disconnected from its domain controller.

Note that this information is static, in contrast to the information automatically gathered by Cygwin from the Windows account databases. If you change the user information on your system, you'll need to regenerate the passwd file for it to have the new information.

By default, the information generated by **mkpasswd** is equivalent to the information generated by Cygwin itself. The `-d` and `-l/-L` options allow you to specify where the information comes from, some domain, or the local SAM of a machine. Note that you can only enumerate accounts from trusted domains. Any non-trusted domain will be ignored. Access-restrictions of your current account apply. The `-l/-L` when used with a machine name, tries to contact that machine to enumerate local groups of other machines, typically outside of domains. This scenario cannot be covered by Cygwin's account automatism. If you want to use the `-L` option, but you don't like the default domain/group separator from `/etc/nsswitch.conf`, you can specify another separator using the `-S` option, analog to **mkgroup**.

For very simple needs, an entry for the current user can be created by using the option `-c`.

The `-o` option allows for special cases (such as multiple domains) where the UIDs might match otherwise. The `-p` option causes **mkpasswd** to use the specified prefix instead of the account home dir or `/home/` . For example, this command:

Example 3.10 Using an alternate home root

```
$ mkpasswd -l -p "$(cygpath -H)" > /etc/passwd
```

would put local users' home directories in the Windows 'Profiles' directory. The `-u` option creates just an entry for the specified user. The `-U` option allows you to enumerate the standard UNIX users on a Samba machine. It's used together with `-l samba-server` or `-L samba-server`. The normal UNIX users are usually not enumerated, but they can show up as file owners in **ls -l** output.

3.8.15 mount

mount — Display information about mounted filesystems, or mount a filesystem

Synopsis

`mount` [-f] [-o *MOUNT_OPTION,...*] *WIN32PATHPOSIXPATH*

`mount` -a

`mount` *POSIXPATH*

`mount` [-m]

`mount` -c *POSIXPATH* | -p

`mount` -h | -V

Options

```
  -a, --all                     mount all filesystems mentioned in fstab
  -c, --change-cygdrive-prefix  change the cygdrive path prefix to <posixpath>
  -f, --force                   force mount, don't warn about missing mount
                                point directories
  -h, --help                    output usage information and exit
  -m, --mount-entries           write fstab entries to replicate mount points
                                and cygdrive prefixes
  -o, --options X[,X...]        specify mount options
  -p, --show-cygdrive-prefix    show user and/or system cygdrive path prefix
  -V, --version                 output version information and exit
```

Description

The **mount** program is used to map your drives and shares onto Cygwin's simulated POSIX directory tree, much like as is done by mount commands on typical UNIX systems. However, in contrast to mount points given in `/etc/fstab`, mount points created or changed with **mount** are not persistent. They disappear immediately after the last process of the current user exited. Please see Section 3.1.2 for more information on the concepts behind the Cygwin POSIX file system and strategies for using mounts. To remove mounts temporarily, use **umount**

Using mount

If you just type **mount** with no parameters, it will display the current mount table for you.

Example 3.11 Displaying the current set of mount points

```
$ mount
C:/cygwin/bin on /usr/bin type ntfs (binary)
C:/cygwin/lib on /usr/lib type ntfs (binary)
C:/cygwin on / type ntfs (binary)
C: on /mnt/c type ntfs (binary,user,noumount)
D: on /mnt/d type fat (binary,user,noumount)
```

In this example, c:/cygwin is the POSIX root and the D drive is mapped to `/mnt/d`. Note that in this case, the root mount is a system-wide mount point that is visible to all users running Cygwin programs, whereas the `/mnt/d` mount is only visible to the current user.

The **mount** utility is also the mechanism for adding new mounts to the mount table in memory. The following example demonstrates how to mount the directory `//pollux/home/joe/data` to `/data` for the duration of the current session.

Example 3.12 Adding mount points

```
$ ls /data
ls: /data: No such file or directory
$ mount //pollux/home/joe/data /data
mount: warning - /data does not exist!
$ mount
//pollux/home/joe/data on /data type smbfs (binary)
C:/cygwin/bin on /usr/bin type ntfs (binary)
C:/cygwin/lib on /usr/lib type ntfs (binary)
C:/cygwin on / type ntfs (binary)
C: on /c type ntfs (binary,user,noumount)
D: on /d type fat (binary,user,noumount)
```

A given POSIX path may only exist once in the mount table. Attempts to replace the mount will fail with a busy error. The `-f` (force) option causes the old mount to be silently replaced with the new one, provided the old mount point was a user mount point. It's not valid to replace system-wide mount points. Additionally, the `-f` option will silence warnings about the non-existence of directories at the Win32 path location.

The `-o` option is the method via which various options about the mount point may be recorded. The following options are available (note that most of the options are duplicates of other mount flags):

```
  acl         - Use the filesystem's access control lists (ACLs) to
                implement real POSIX permissions (default).
  binary      - Files default to binary mode (default).
  bind        - Allows to remount part of the file hierarchy somewhere else.
                Different from other mount calls, the first argument
                specifies an absolute POSIX path, rather than a Win32 path.
                This POSIX path is remounted to the POSIX path specified as
                the second parameter.  The conversion to a Win32 path is done
                within Cygwin immediately at the time of the call.  Note that
                symlinks are ignored while performing this path conversion.
```

```
  cygexec    - Treat all files below mount point as cygwin executables.
  dos        - Always convert leading spaces and trailing dots and spaces to
               characters in the UNICODE private use area.  This allows to use
               broken filesystems which only allow DOS filenames, even if they
               are not recognized as such by Cygwin.
  exec       - Treat all files below mount point as executable.
  ihash      - Always fake inode numbers rather than using the ones returned
               by the filesystem.  This allows to use broken filesystems which
               don't return unambiguous inode numbers, even if they are not
               recognized as such by Cygwin.
  noacl      - Ignore ACLs and fake POSIX permissions.
  nosuid     - No suid files are allowed (currently unimplemented)
  notexec    - Treat all files below mount point as not executable.
  override   - Override immutable mount points.
  posix=0    - Switch off case sensitivity for paths under this mount point.
  posix=1    - Switch on case sensitivity for paths under this mount point
               (default).
  sparse     - Switch on support for sparse files.  This option only makes
               sense on NTFS and then only if you really need sparse files.
         This flag is always silently enabled on SSD drives.
  text       - Files default to CRLF text mode line endings.
```

For a more complete description of the mount options and the `/etc/fstab` file, see Section 3.1.2.

Note that all mount points added with **mount** are user mount points. System mount points can only be specified in the `/etc/fstab` file.

If you added mount points to `/etc/fstab` or your `/etc/fstab.d/<username>` file, you can add these mount points to your current user session using the `-a`/`--all` option, or by specifing the posix path alone on the command line. As an example, consider you added a mount point with the POSIX path `/my/mount`. You can add this mount point with either one of the following two commands to your current user session.

```
$ mount /my/mount
$ mount -a
```

The first command just adds the `/my/mount` mount point to your current session, the **mount -a** adds all new mount points to your user session.

If you change a mount point to point to another native path, or if you changed the flags of a mount point, you have to **umount** the mount point first, before you can add it again. Please note that all such added mount points are added as user mount points, and that the rule that system mount points can't be removed or replaced in a running session still applies.

To bind a POSIX path to another POSIX path, use the `bind` mount flag.

```
$ mount -o bind /var /usr/var
```

This command makes the file hirarchy under `/var` additionally available under `/usr/var`.

The `-m` option causes the **mount** utility to output the current mount table in a series of fstab entries. You can save this output as a backup when experimenting with the mount table. Copy the output to `/etc/fstab` to restore the old state. It also makes moving your settings to a different machine much easier.

Cygdrive mount points

Whenever Cygwin cannot use any of the existing mounts to convert from a particular Win32 path to a POSIX one, Cygwin will, instead, convert to a POSIX path using a default mount point: `/cygdrive`. For example, if Cygwin accesses `z:\foo` and the z drive is not currently in the mount table, then `z:\` will be accessible as `/cygdrive/z`. The **mount** utility can be used to change this default automount prefix through the use of the "--change-cygdrive-prefix" option. In the following example, we will set the automount prefix to `/mnt`:

Example 3.13 Changing the default prefix

```
$ mount --change-cygdrive-prefix /mnt
```

Note that the cygdrive prefix can be set both per-user and system-wide, and that as with all mounts, a user-specific mount takes precedence over the system-wide setting. The **mount** utility creates system-wide mounts by default if you do not specify a type. You can always see the user and system cygdrive prefixes with the `-p` option. Using the `--options` flag with `--change-cygdrive-prefix` makes all new automounted filesystems default to this set of options. For instance (using the short form of the command line flags)

Example 3.14 Changing the default prefix with specific mount options

```
$ mount -c /mnt -o binary,noacl
```

Limitations

Limitations: there is a hard-coded limit of 64 mount points. Also, although you can mount to pathnames that do not start with "/", there is no way to make use of such mount points.

Normally the POSIX mount point in Cygwin is an existing empty directory, as in standard UNIX. If this is the case, or if there is a place-holder for the mount point (such as a file, a symbolic link pointing anywhere, or a non-empty directory), you will get the expected behavior. Files present in a mount point directory before the mount become invisible to Cygwin programs.

It is sometimes desirable to mount to a non-existent directory, for example to avoid cluttering the root directory with names such as `a`, `b`, `c` pointing to disks. Although **mount** will give you a warning, most everything will work properly when you refer to the mount point explicitly. Some strange effects can occur however. For example if your current working directory is `/dir`, say, and `/dir/mtpt` is a mount point, then `mtpt` will not show up in an **ls** or **echo *** command and **find .** will not find `mtpt`.

3.8.16 newgrp

newgrp — change to a new primary group

Synopsis

`newgrp` [-l] [*`group`*] [*`command`* [*`args`*...]]

Description

newgrp starts a new shell environment under a new primary group.

If the `-l` flag is given as first argument, the user's environment will be reinitialized as though the user had logged in, otherwise the current environment, including current working directory, remains unchanged. For Linux compatibility, the flag - is allowed as well.

newgrp changes the current primary group to the named group, or to the default group listed in /etc/passwd if no group name is given. The user's standard shell is started, called as login shell if the `-l` or - flag has been specified.

The group argument can be specified as group name from the group database or a non-negative numeric group ID.

If a group has been given as argument, a command and its arguments can be specified on the command line. Note that this usage is Cygwin-only and incompatible with POSIX and Linux.

The new primary group must be either the old primary group, or it must be part of the supplementary group list. Setting the primary group to an arbitrary group is not allowed in Windows.

See also

id(1), **login**(1).

3.8.17 passwd

passwd — Change password or password attributes

Synopsis

`passwd` -S | [-l | -u] [-c | -C] [-e | -E] [-p | -P] [-d *SERVER*] [*USER*]

`passwd` -R

`passwd` -i *NUM* | -n *MINDAYS* | -x *MAXDAYS* | -L *LEN*

`passwd` -h | -V

Options

```
User operations:
  -l, --lock               lock USER's account.
  -u, --unlock             unlock USER's account.
  -c, --cannot-change      USER can't change password.
  -C, --can-change         USER can change password.
  -e, --never-expires      USER's password never expires.
  -E, --expires            USER's password expires according to system's
                           password aging rule.
  -p, --pwd-not-required   no password required for USER.
  -P, --pwd-required       password is required for USER.
  -R, --reg-store-pwd      enter password to store it in the registry for
                           later usage by services to be able to switch
                           to this user context with network credentials.

System operations:
  -i, --inactive NUM       set NUM of days before inactive accounts are disabled
                           (inactive accounts are those with expired passwords).
  -n, --minage MINDAYS     set system minimum password age to MINDAYS days.
  -x, --maxage MAXDAYS     set system maximum password age to MAXDAYS days.
  -L, --length LEN         set system minimum password length to LEN.

Other options:
  -d, --logonserver SERVER connect to SERVER (e.g. domain controller).
                           Usually not required.
  -S, --status             display password status for USER (locked, expired,
                           etc.) plus global system password settings.
  -h, --help               output usage information and exit.
  -V, --version            output version information and exit.

If no option is given, change USER's password.  If no user name is given,
operate on current user.  System operations must not be mixed with user
operations.  Don't specify a USER when triggering a system operation.

Don't specify a user or any other option together with the -R option.
Non-Admin users can only store their password if cygserver is running.
Note that storing even obfuscated passwords in the registry is not overly
secure.  Use this feature only if the machine is adequately locked down.
Don't use this feature if you don't need network access within a remote
session.  You can delete your stored password by using 'passwd -R' and
specifying an empty password.
```

Description

passwd changes passwords for user accounts. A normal user may only change the password for their own account, but administrators may change passwords on any account. **passwd** also changes account information, such as password expiry dates and intervals.

For password changes, the user is first prompted for their old password, if one is present. This password is then encrypted and compared against the stored password. The user has only one chance to enter the correct password. The administrators are permitted to bypass this step so that forgotten passwords may be changed.

The user is then prompted for a replacement password. **passwd** will prompt twice for this replacement and compare the second entry against the first. Both entries are required to match in order for the password to be changed.

After the password has been entered, password aging information is checked to see if the user is permitted to change their password at this time. If not, **passwd** refuses to change the password and exits.

To get current password status information, use the `-S` option. Administrators can use **passwd** to perform several account maintenance functions (users may perform some of these functions on their own accounts). Accounts may be locked with the `-l` flag and unlocked with the `-u` flag. Similarly, `-c` disables a user's ability to change passwords, and `-C` allows a user to change passwords. For password expiry, the `-e` option disables expiration, while the `-E` option causes the password to expire according to the system's normal aging rules. Use `-p` to disable the password requirement for a user, or `-P` to require a password.

Administrators can also use **passwd** to change system-wide password expiry and length requirements with the `-i`, `-n`, `-x`, and `-L` options. The `-i` option is used to disable an account after the password has been expired for a number of days. After a user account has had an expired password for *NUM* days, the user may no longer sign on to the account. The `-n` option is used to set the minimum number of days before a password may be changed. The user will not be permitted to change the password until *MINDAYS* days have elapsed. The `-x` option is used to set the maximum number of days a password remains valid. After *MAXDAYS* days, the password is required to be changed. Allowed values for the above options are 0 to 999. The `-L` option sets the minimum length of allowed passwords for users who don't belong to the administrators group to *LEN* characters. Allowed values for the minimum password length are 0 to 14. In any of the above cases, a value of 0 means `no restrictions'.

All operations affecting the current user are by default run against the logon server of the current user (taken from the environment variable `LOGONSERVER`. When password or account information of other users should be changed, the logon server is evaluated automatically. In rare cases, it might be necessary to switch to another domain controller to perform the action. In this case, use the `-d` option to specify the machine to run the command against. Note that the current user must have account operator permissions to perform user account changes in a domain.

Users can use the **passwd -R** to enter a password which then gets stored in a special area of the registry on the local system, which is also used by Windows to store passwords of accounts running Windows services. When a privileged Cygwin application calls the **set{e}uid(user_id)** system call, Cygwin checks if a password for that user has been stored in this registry area. If so, it uses this password to switch to this user account using that password. This allows you to logon through, for instance, **ssh** with public key authentication and get a full qualified user token with all credentials for network access. However, the method has some drawbacks security-wise. This is explained in more detail in Section 3.6.

Please note that storing passwords in that registry area is a privileged operation which only administrative accounts are allowed to do. Administrators can enter the password for other user accounts into the registry by specifying the username on the commandline. If normal, non-admin users should be allowed to enter their passwords using **passwd -R**, it's required to run **cygserver** as a service under the LocalSystem account before running **passwd -R**. This only affects storing passwords. Using passwords in privileged processes does not require **cygserver** to run.

Limitations: Users may not be able to change their password on some systems.

3.8.18 pldd

pldd — List dynamic shared objects loaded into a process

Synopsis

`pldd` *`PID`*

`pldd` -? | --usage | -V

Options

```
  -?, --help                Give this help list
      --usage               Give a short usage message
  -V, --version             Print program version
```

Description

pldd prints the shared libraries (DLLs) loaded by the process with the given PID.

3.8.19 profiler

profiler — Sampling profiler of Cygwin programs with their DLLs

Synopsis

`profiler` [-defw] [-o *FILENAME*] [-s *N*] *PROGRAM ARG*... | -p *PID*

`profiler` -h | -V

Options

```
  -d, --debug             Display debugging messages (toggle: default false)
  -e, --events            Display Windows DEBUG_EVENTS (toggle: default false)
  -f, --fork-profile      Profiles child processes (toggle: default false)
  -h, --help              Display usage information and exit
  -o, --output=FILENAME   Write output to file FILENAME rather than stdout
  -p, --pid=N             Attach to running program with Cygwin pid N
                          ...                     or with Windows pid -N
  -s, --sample-rate=N     Set IP sampling rate to N Hz (default 100)
  -v, --verbose           Display more status messages (toggle: default false)
  -V, --version           Display version information and exit
  -w, --new-window        Launch given command in a new window
```

Description

The **profiler** utility executes a given program and any children of that program, collecting the location of the CPU instruction pointer (IP) many times per second. (It is optional to collect this info from child processes.) This info gives a profile of the program's execution, showing where the most time is being spent. This profiling technique is called "IP sampling".

A novel feature of **profiler** is that time spent in DLLs loaded with or by your program is profiled too. You use **gprof** to process and display the resulting profile information. In this fashion you can determine whether your own code, the Cygwin DLL, or another DLL has "hot spots" that might benefit from tuning.

(See also **ssp**, another profiler that operates in a different fashion: stepping by instruction. This can provide a different view on your program's operation.)

Here is an example of **profiler** operation:

```
$ profiler du -khs .
22G     .
97 samples across 83 buckets written to gmon.out.5908.cygwin1.dll
4 samples across 4 buckets written to gmon.out.5908.KernelBase.dll
1 sample across 1 bucket written to gmon.out.5908.kernel32.dll
7318 samples across 42 buckets written to gmon.out.5908.ntdll.dll
5 samples across 4 buckets written to gmon.out.5908.du.exe
```

3.8.20 ps

ps — Report process status

Synopsis

`ps` [-aeflsW] [-u *UID*] [-p *PID*]

`ps` -h | -V

Options

```
 -a, --all       show processes of all users
 -e, --everyone  show processes of all users
 -f, --full      show process uids, ppids and command line
 -h, --help      output usage information and exit
 -l, --long      show process uids, ppids, pgids, winpids
 -p, --process   show information for specified PID
 -s, --summary   show process summary
 -u, --user      list processes owned by UID
 -V, --version   output version information and exit
 -W, --windows   show windows as well as cygwin processes
With no options, ps outputs the long format by default
```

Description

The **ps** program gives the status of all the Cygwin processes running on the system (ps = "process status"). Due to the limitations of simulating a POSIX environment under Windows, there is little information to give.

The PID column is the process ID you need to give to the **kill** command. The PPID is the parent process ID, and PGID is the process group ID. The WINPID column is the process ID displayed by NT's Task Manager program. The TTY column gives which pseudo-terminal a process is running on, or a `'?'` for services. The UID column shows which user owns each process. STIME is the time the process was started, and COMMAND gives the name of the program running. Listings may also have a status flag in column zero; `S` means stopped or suspended (in other words, in the background), `I` means waiting for input or interactive (foreground), and `O` means waiting to output.

By default, **ps** will only show processes owned by the current user. With either the `-a` or `-e` option, all user's processes (and system processes) are listed. There are historical UNIX reasons for the synonomous options, which are functionally identical. The `-f` option outputs a "full" listing with usernames for UIDs and the command line of the process, rather than just the full path to the executable. The `-l` option is the default display mode, showing a "long" listing with all the above columns. The other display option is `-s`, which outputs a shorter listing of just PID, TTY, STIME, and COMMAND. The `-u` option allows you to show only processes owned by a specific user. The `-p` option allows you to show information for only the process with the specified PID. The `-W` option causes **ps** show non-Cygwin Windows processes as well as Cygwin processes. The WINPID is also the PID, and they can be killed with the Cygwin **kill** command's `-f` option.

3.8.21 regtool

regtool — View or edit the Windows registry

Synopsis

`regtool` [-qvwW] add|check|get|list|remove|unset|load|unload|save *KEY* [*PATH* | *DATA*]

`regtool` add *KEY\SUBKEY*

`regtool` check *KEY*

`regtool` [-bnx] get *KEY*

`regtool` [-klp] list *KEY*

`regtool` remove *KEY*

`regtool` [-bDeimnQsf] set *KEY\VALUE* [*DATA*...]

`regtool` [-f] unset *KEY\VALUE*

`regtool` load *KEY\SUBKEY PATH*

`regtool` unload *KEY\SUBKEY*

`regtool` save *KEY\SUBKEY PATH*

`regtool` [-f] restore *KEY/SUBKEY PATH*

`regtool` -h | -V

Options

```
Actions:

 add KEY\SUBKEY             add new SUBKEY
 check KEY                  exit 0 if KEY exists, 1 if not
 get KEY\VALUE              prints VALUE to stdout
 list KEY                   list SUBKEYs and VALUEs
 remove KEY                 remove KEY
 set KEY\VALUE [data ...]   set VALUE
 unset KEY\VALUE            removes VALUE from KEY
 load KEY\SUBKEY PATH       load hive from PATH into new SUBKEY
 unload KEY\SUBKEY          unload hive and remove SUBKEY
 save KEY\SUBKEY PATH       save SUBKEY into new file PATH
 restore KEY\SUBKEY PATH    restore SUBKEY from file PATH

Options for 'list' Action:

 -k, --keys           print only KEYs
 -l, --list           print only VALUEs
 -p, --postfix        like ls -p, appends '\' postfix to KEY names

Options for 'get' Action:

 -b, --binary         print REG_BINARY data as hex bytes
 -n, --none           print data as stream of bytes as stored in registry
 -x, --hex            print numerical data as hex numbers

Options for 'set' Action:

 -b, --binary         set type to REG_BINARY (hex args or '-')
 -D, --dword-be       set type to REG_DWORD_BIG_ENDIAN
 -e, --expand-string  set type to REG_EXPAND_SZ
 -i, --integer        set type to REG_DWORD
 -m, --multi-string   set type to REG_MULTI_SZ
 -n, --none           set type to REG_NONE
 -Q, --qword          set type to REG_QWORD
 -s, --string         set type to REG_SZ

Options for 'set' and 'unset' Actions:

 -K<c>, --key-separator[=]<c>  set key separator to <c> instead of '\'

Options for 'restore' action:
```

```
 -f, --force    restore even if open handles exist at or beneath the location
                in the registry hierarchy to which KEY\SUBKEY points

Other Options:

 -h, --help     output usage information and exit
 -q, --quiet    no error output, just nonzero return if KEY/VALUE missing
 -v, --verbose  verbose output, including VALUE contents when applicable
 -w, --wow64    access 64 bit registry view (ignored on 32 bit Windows)
 -W, --wow32    access 32 bit registry view (ignored on 32 bit Windows)
 -V, --version  output version information and exit

KEY is in the format [host]\prefix\KEY\KEY\VALUE, where host is optional
remote host in either \\hostname or hostname: format and prefix is any of:
  root     HKCR  HKEY_CLASSES_ROOT (local only)
  config   HKCC  HKEY_CURRENT_CONFIG (local only)
  user     HKCU  HKEY_CURRENT_USER (local only)
  machine  HKLM  HKEY_LOCAL_MACHINE
  users    HKU   HKEY_USERS

You can use forward slash ('/') as a separator instead of backslash, in
that case backslash is treated as an escape character.
You can also supply the registry path prefix /proc/registry{,32,64}/ to
use path completion.
Example:
  regtool list '/HKLM/SOFTWARE/Classes/MIME/Database/Content Type/audio\\/wav'
```

Description

The **regtool** program allows shell scripts to access and modify the Windows registry. Note that modifying the Windows registry is dangerous, and carelessness here can result in an unusable system. Be careful.

The `-v` option means "verbose". For most commands, this causes additional or lengthier messages to be printed. Conversely, the `-q` option supresses error messages, so you can use the exit status of the program to detect if a key exists or not (for example).

The `-w` option allows you to access the 64 bit view of the registry. Several subkeys exist in a 32 bit and a 64 bit version when running on Windows 64. Since Cygwin is running in 32 bit mode, it only has access to the 32 bit view of these registry keys. When using the `-w` switch, the 64 bit view is used and **regtool** can access the entire registry. This option is simply ignored when running on 32 bit Windows versions.

The `-W` option allows you to access the 32 bit view on the registry. The purpose of this option is mainly for symmetry. It permits creation of OS agnostic scripts which would also work in a hypothetical 64 bit version of Cygwin.

You must provide **regtool** with an *action* following options (if any). Currently, the action must be `add`, `set`, `check`, `get`, `list`, `remove`, `set`, or `unset`.

The `add` action adds a new key. The `check` action checks to see if a key exists (the exit code of the program is zero if it does, nonzero if it does not). The `get` action gets the value of a key, and prints it (and nothing else) to stdout. Note: if the value doesn't exist, an error message is printed and the program returns a non-zero exit code. If you give `-q`, it doesn't print the message but does return the non-zero exit code.

The `list` action lists the subkeys and values belonging to the given key. With `list`, the `-k` option instructs **regtool** to print only KEYs, and the `-l` option to print only VALUEs. The `-p` option postfixes a `'/'` to each KEY, but leave VALUEs with no postfix. The `remove` action removes a key. Note that you may need to remove everything in the key before you may remove it, but don't rely on this stopping you from accidentally removing too much.

The `get` action prints a value within a key. With the `-b` option, data is printed as hex bytes. `-n` allows to print the data as a typeless stream of bytes. Integer values (REG_DWORD, REG_QWORD) are usually printed as decimal values. The `-x` option allows to print the numbers as hexadecimal values.

The `set` action sets a value within a key. `-b` means it's binary data (REG_BINARY). The binary values are specified as hex bytes in the argument list. If the argument is `'-'`, binary data is read from stdin instead. `-d` or `-i` means the value is a 32 bit integer value (REG_DWORD). `-D` means the value is a 32 bit integer value in Big Endian representation (REG_DWORD_BIG_ENDIAN). `-Q` means the value is a 64 bit integer value (REG_QWORD). `-s` means the value is a string (REG_SZ). `-e` means it's an expanding string (REG_EXPAND_SZ) that contains embedded environment variables. `-m` means it's a multi-string (REG_MULTI_SZ). If you don't specify one of these, **regtool** tries to guess the type based on the value you give. If it looks like a number, it's a DWORD, unless it's value doesn't fit into 32 bit, in which case it's a QWORD. If it starts with a percent, it's an expanding string. If you give multiple values, it's a multi-string. Else, it's a regular string.

The `unset` action removes a value from a key.

The `load` action adds a new subkey and loads the contents of a registry hive into it. The parent key must be HKEY_LOCAL_MACHINE or HKEY_USERS. The `unload` action unloads the file and removes the subkey.

The `save` action saves a subkey into a registry file. Ideally you append the suffix `.reg` to the file so it gets automatically recognized as registry file by **Windows Explorer**.

The `restore` action restores a registry subkey from a file saved via the aforementioned `save` action.

By default, the last "\" or "/" is assumed to be the separator between the key and the value. You can use the `-K` option to provide an alternate key/value separator character.

3.8.22 setfacl

setfacl — Modify file and directory access control lists (ACLs)

Synopsis

`setfacl` [-n] -f *ACL_FILE* | -s *acl_entries* *FILE*...

`setfacl` [-n] -bk | -x *acl_entries* [-m *acl_entries*] *FILE*...

`setfacl` -h | -V

Options

```
  -b, --remove-all       remove all extended ACL entries
  -x, --delete           delete one or more specified ACL entries
  -f, --set-file         set ACL entries for FILE to ACL entries read
                         from ACL_FILE
  -k, --remove-default   remove all default ACL entries
  -m, --modify           modify one or more specified ACL entries
  -n, --no-mask          don't recalculate the effective rights mask
      --mask             do recalculate the effective rights mask
  -s, --set              set specified ACL entries on FILE
  -V, --version          print version and exit
  -h, --help             this help text

At least one of (-b, -x, -f, -k, -m, -s) must be specified
```

Description

For each file given as parameter, **setfacl** will either replace its complete ACL (`-s`, `-f`), or it will add, modify, or delete ACL entries. For more information on Cygwin and Windows ACLs, see Section 3.6 in the Cygwin User's Guide.

Acl_entries are one or more comma-separated ACL entries from the following list:

```
u[ser]::perm
u[ser]:uid:perm
g[roup]::perm
g[roup]:gid:perm
m[ask]::perm
o[ther]::perm
```

Default entries are like the above with the additional default identifier. For example:

```
d[efault]:u[ser]:uid:perm
```

perm is either a 3-char permissions string in the form "rwx" with the character '-' for no permission or it is the octal representation of the permissions, a value from 0 (equivalent to "---") to 7 ("rwx"). *uid* is a user name or a numerical uid. *gid* is a group name or a numerical gid.

The following options are supported:

`-b,--remove-all` Remove all extended ACL entries. The base ACL entries of the owner, group and others are retained. This option can be combined with the `-k,--remove-default` option to delete all non-standard POSIX permissions.

`-x,--delete` Delete one or more specified entries from the file's ACL. The owner, group and others entries must not be deleted. Acl_entries to be deleted should be specified without permissions, as in the following list:

```
u[ser]:uid[:]
g[roup]:gid[:]
m[ask][:]
d[efault]:u[ser][:uid]
d[efault]:g[roup][:gid]
d[efault]:m[ask][:]
d[efault]:o[ther][:]
```

`-f,--set-file` Take the Acl_entries from ACL_FILE one per line. Whitespace characters are ignored, and the character "#" may be used to start a comment. The special filename "-" indicates reading from stdin. Note that you can use this with **getfacl** and **setfacl** to copy ACLs from one file to another:

```
$ getfacl source_file | setfacl -f - target_file
```

Required entries are: one user entry for the owner of the file, one group entry for the group of the file, and one other entry.

If additional user and group entries are given: a mask entry for the file group class of the file, and no duplicate user or group entries with the same uid/gid.

If it is a directory: one default user entry for the owner of the file, one default group entry for the group of the file, one default mask entry for the file group class, and one default other entry.

`-k,--remove-default` Remove all default ACL entries. If no default ACL entries exist, no warnings are issued. This option can be combined with the `-b,--remove-all` option to delete all non-standard POSIX permissions.

`-m,--modify` Add or modify one or more specified ACL entries. Acl_entries is a comma-separated list of entries from the same list as above.

`-n,--no-mask` Valid in conjunction with -m. Do not recalculate the effective rights mask. The default behavior of setfacl is to recalculate the ACL mask entry, unless a mask entry was explicitly given. The mask entry is set to the union of all permissions of the owning group, and all named user and group entries. (These are exactly the entries affected by the mask entry).

`--mask` Valid in conjunction with -m. Do recalculate the effective rights mask, even if an ACL mask entry was explicitly given. (See the -n option.)

`-s,--set` Like `-f`, but set the file's ACL with Acl_entries specified in a comma-separated list on the command line.

While the `-x` and `-m` options may be used in the same command, the `-f` and `-s` options may be used only exclusively.

Directories may contain default ACL entries. Files created in a directory that contains default ACL entries will have permissions according to the combination of the current umask, the explicit permissions requested and the default ACL entries.

3.8.23 setmetamode

setmetamode — Get or set keyboard meta mode

Synopsis

`setmetamode` [metabit | escprefix]

`setmetamode` -h | -V

Options

```
  Without argument, it shows the current meta key mode.

  metabit|meta|bit     The meta key sets the top bit of the character.
  escprefix|esc|prefix The meta key sends an escape prefix.

Other options:

  -h, --help           This text
  -V, --version        Print program version and exit
```

Description

setmetamode can be used to determine and set the key code sent by the meta (aka `Alt`) key.

3.8.24 ssp

ssp — The Single Step Profiler

Synopsis

`ssp` [-cdelstv] *`low_pc high_pc command`*...

`ssp` -h | -V

Options

```
 -c, --console-trace  trace every EIP value to the console. *Lots* slower.
 -d, --disable        disable single-stepping by default; use
                      OutputDebugString ("ssp on") to enable stepping
 -e, --enable         enable single-stepping by default; use
                      OutputDebugString ("ssp off") to disable stepping
 -h, --help           output usage information and exit
 -l, --dll            enable dll profiling.  A chart of relative DLL usage
                      is produced after the run.
 -s, --sub-threads    trace sub-threads too.  Dangerous if you have
                      race conditions.
 -t, --trace-eip      trace every EIP value to a file TRACE.SSP.  This
                      gets big *fast*.
 -v, --verbose        output verbose messages about debug events.
 -V, --version        output version information and exit

Example: ssp 0x401000 0x403000 hello.exe
```

Description

The SSP is a program that uses the Win32 debug API to run a program one ASM instruction at a time. It records the location of each instruction used, how many times that instruction is used, and all function calls. The results are saved in a format that is usable by the profiling program **gprof**, although **gprof** will claim the values are seconds, they really are instruction counts. More on that later.

(See also **profiler**, another profiler that operates in a different fashion: IP sampling. This can provide a different view on your program's operation.)

Because the SSP was originally designed to profile the Cygwin DLL, it does not automatically select a block of code to report statistics on. You must specify the range of memory addresses to keep track of manually, but it's not hard to figure out what to specify. Use the "objdump" program to determine the bounds of the target's ".text" section. Let's say we're profiling cygwin1.dll. Make sure you've built it with debug symbols (else **gprof** won't run) and run objdump like this:

```
$ objdump -h cygwin1.dll
```

It will print a report like this:

```
cygwin1.dll:     file format pei-i386

Sections:
Idx Name          Size      VMA       LMA       File off  Algn
  0 .text         0007ea00  61001000  61001000  00000400  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, CODE, DATA
  1 .data         00008000  61080000  61080000  0007ee00  2**2
                  CONTENTS, ALLOC, LOAD, DATA
  . . .
```

The only information we're concerned with are the VMA of the .text section and the VMA of the section after it (sections are usually contiguous; you can also add the Size to the VMA to get the end address). In this case, the VMA is 0x61001000 and the ending address is either 0x61080000 (start of .data method) or 0x6107fa00 (VMA+Size method).

There are two basic ways to use SSP - either profiling a whole program, or selectively profiling parts of the program.

To profile a whole program, just run **ssp** without options. By default, it will step the whole program. Here's a simple example, using the numbers above:

```
$ ssp 0x61001000 0x61080000 hello.exe
```

This will step the whole program. It will take at least 8 minutes on a PII/300 (yes, really). When it's done, it will create a file called "gmon.out". You can turn this data file into a readable report with **gprof**:

```
$ gprof -b cygwin1.dll
```

The "-b" means 'skip the help pages'. You can omit this until you're familiar with the report layout. The **gprof** documentation explains a lot about this report, but **ssp** changes a few things. For example, the first part of the report reports the amount of time spent in each function, like this:

```
Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls  ms/call  ms/call  name
 10.02    231.22    72.43       46  1574.57  1574.57  strcspn
  7.95    288.70    57.48      130   442.15   442.15  strncasematch
```

The "seconds" columns are really CPU opcodes, 1/100 second per opcode. So, "231.22" above means 23,122 opcodes. The ms/call values are 10x too big; 1574.57 means 157.457 opcodes per call. Similar adjustments need to be made for the "self" and "children" columns in the second part of the report.

OK, so now we've got a huge report that took a long time to generate, and we've identified a spot we want to work on optimizing. Let's say it's the time() function. We can use SSP to selectively profile this function by using OutputDebugString() to control SSP from within the program. Here's a sample program:

```
#include <windows.h>
main()
{
  time_t t;
  OutputDebugString("ssp on");
  time(&t);
  OutputDebugString("ssp off");
}
```

Then, add the `-d` option to ssp to default to *disabling* profiling. The program will run at full speed until the first OutputDebugString, then step until the second. You can then use **gprof** (as usual) to see the performance profile for just that portion of the program's execution.

There are many options to ssp. Since step-profiling makes your program run about 1,000 times slower than normal, it's best to understand all the options so that you can narrow down the parts of your program you need to single-step.

`-v` - verbose. This prints messages about threads starting and stopping, OutputDebugString calls, DLLs loading, etc.

`-t` and `-c` - tracing. With `-t`, *every* step's address is written to the file "trace.ssp". This can be used to help debug functions, since it can trace multiple threads. Clever use of scripts can match addresses with disassembled opcodes if needed. Warning: creates *huge* files, very quickly. `-c` prints each address to the console, useful for debugging key chunks of assembler. Use `addr2line -C -f -s -e foo.exe < trace.ssp > lines.ssp` and then `perl cvttrace` to convert to symbolic traces.

`-s` - subthreads. Usually, you only need to trace the main thread, but sometimes you need to trace all threads, so this enables that. It's also needed when you want to profile a function that only a subthread calls. However, using OutputDebugString automatically enables profiling on the thread that called it, not the main thread.

`-l` - dll profiling. Generates a pretty table of how much time was spent in each dll the program used. No sense optimizing a function in your program if most of the time is spent in the DLL. I usually use the `-v`, `-s`, and `-l` options:

```
$ ssp -v -s -l -d 0x61001000 0x61080000 hello.exe
```

3.8.25 strace

strace — Trace system calls and signals

Synopsis

`strace` [-defnqtuw] [-b *SIZE*] [-m *MASK*] [-o *FILENAME*] [-f *PERIOD*] *command-line* | [-T] -p *pid*

`strace` -h | -V

Options

```
-b, --buffer-size=SIZE       set size of output file buffer
-d, --no-delta               don't display the delta-t microsecond timestamp
-e, --events                 log all Windows DEBUG_EVENTS (toggle - default true)
-f, --trace-children         trace child processes (toggle - default true)
-h, --help                   output usage information and exit
-m, --mask=MASK              set message filter mask
-n, --crack-error-numbers    output descriptive text instead of error
                             numbers for Windows errors
-o, --output=FILENAME        set output file to FILENAME
-p, --pid=n                  attach to executing program with cygwin pid n
-q, --quiet                  toggle "quiet" flag.  Defaults to on if "-p",
                             off otherwise.
-S, --flush-period=PERIOD    flush buffered strace output every PERIOD secs
```

```
  -t, --timestamp             use an absolute hh:mm:ss timestamp insted of
                              the default microsecond timestamp.  Implies -d
  -T, --toggle                toggle tracing in a process already being
                              traced. Requires -p <pid>
  -u, --usecs                 toggle printing of microseconds timestamp
  -V, --version               output version information and exit
  -w, --new-window            spawn program under test in a new window

    MASK can be any combination of the following mnemonics and/or hex values
    (0x is optional).  Combine masks with '+' or ',' like so:

                     --mask=wm+system,malloc+0x00800

    Mnemonic Hex     Corresponding Def  Description
    ============================================================================
    all      0x000001 (_STRACE_ALL)      All strace messages.
    flush    0x000002 (_STRACE_FLUSH)    Flush output buffer after each message.
    inherit  0x000004 (_STRACE_INHERIT)  Children inherit mask from parent.
    uhoh     0x000008 (_STRACE_UHOH)     Unusual or weird phenomenon.
    syscall  0x000010 (_STRACE_SYSCALL)  System calls.
    startup  0x000020 (_STRACE_STARTUP)  argc/envp printout at startup.
    debug    0x000040 (_STRACE_DEBUG)    Info to help debugging.
    paranoid 0x000080 (_STRACE_PARANOID) Paranoid info.
    termios  0x000100 (_STRACE_TERMIOS)  Info for debugging termios stuff.
    select   0x000200 (_STRACE_SELECT)   Info on ugly select internals.
    wm       0x000400 (_STRACE_WM)       Trace Windows msgs (enable _strace_wm).
    sigp     0x000800 (_STRACE_SIGP)     Trace signal and process handling.
    minimal  0x001000 (_STRACE_MINIMAL)  Very minimal strace output.
    pthread  0x002000 (_STRACE_PTHREAD)  Pthread calls.
    exitdump 0x004000 (_STRACE_EXITDUMP) Dump strace cache on exit.
    system   0x008000 (_STRACE_SYSTEM)   Serious error; goes to console and log.
    nomutex  0x010000 (_STRACE_NOMUTEX)  Don't use mutex for synchronization.
    malloc   0x020000 (_STRACE_MALLOC)   Trace malloc calls.
    thread   0x040000 (_STRACE_THREAD)   Thread-locking calls.
    special  0x100000 (_STRACE_SPECIAL)  Special debugging printfs for
                                         non-checked-in code
```

Description

The **strace** program executes a program, and optionally the children of the program, reporting any Cygwin DLL output from the program(s) to stdout, or to a file with the `-o` option. With the `-w` option, you can start an strace session in a new window, for example:

```
$ strace -o tracing_output -w sh -c 'while true; do echo "tracing..."; done' &
```

This is particularly useful for **strace** sessions that take a long time to complete.

Note that **strace** is a standalone Windows program and so does not rely on the Cygwin DLL itself (you can verify this with **cygcheck**). As a result it does not understand symlinks. This program is mainly useful for debugging the Cygwin DLL itself.

3.8.26 tzset

tzset — Print POSIX-compatible timezone ID from current Windows timezone setting

Synopsis

`tzset` [-h | -V]

Options

```
Options:
  -h, --help                output usage information and exit.
  -V, --version             output version information and exit.
```

Description

Use tzset to set your TZ variable. In POSIX-compatible shells like bash, dash, mksh, or zsh:

```
export TZ=$(tzset)
```

In csh-compatible shells like tcsh:

```
setenv TZ `tzset`
```

The **tzset** tool reads the current timezone from Windows and generates a POSIX-compatible timezone information for the TZ environment variable from that information. That's all there is to it. For the way how to use it, see the above usage information.

3.8.27 umount

umount — Unmount filesystems

Synopsis

`umount` *POSIXPATH*

`umount` -U

`umount` -h | -V

Options

```
  -h, --help                    output usage information and exit
  -U, --remove-user-mounts      remove all user mounts
  -V, --version                 output version information and exit
```

Description

The **umount** program removes mounts from the mount table in the current session. If you specify a POSIX path that corresponds to a current mount point, **umount** will remove it from the current mount table. Note that you can only remove user mount points. The `-U` flag may be used to specify removing all user mount points from the current user session.

See Section 3.1.2 for more information on the mount table.

3.9 Using Cygwin effectively with Windows

Cygwin is not a full operating system, and so must rely on Windows for accomplishing some tasks. For example, Cygwin provides a POSIX view of the Windows filesystem, but does not provide filesystem drivers of its own. Therefore part of using Cygwin effectively is learning to use Windows effectively. Many Windows utilities provide a good way to interact with Cygwin's predominately command-line environment. For example, **ipconfig.exe** provides information about network configuration, and **net.exe** views and configures network file and printer resources. Most of these tools support the `/?` switch to display usage information.

Unfortunately, no standard set of tools included with all versions of Windows exists. Generally, the younger the Windows version, the more complete are the on-board tools. Additionally, many independent sites such as download.com, simtel.net, and Microsoft's own Sysinternals provide quite useful command-line utilities, as far as they are not already provided by Cygwin. A few Windows tools, such as **find.exe**, **link.exe** and **sort.exe**, may conflict with the Cygwin versions make sure that you use the full path (**/usr/bin/find**) or that your Cygwin `bin` directory comes first in your `PATH`.

3.9.1 Pathnames

Windows programs do not understand POSIX pathnames, so any arguments that reference the filesystem must be in Windows (or DOS) format or translated. Cygwin provides the **cygpath** utility for converting between Windows and POSIX paths. A complete description of its options and examples of its usage are in cygpath(1), including a shell script for starting Windows Explorer in any directory. The same format works for most Windows programs, for example

```
notepad.exe "$(cygpath -aw "Desktop/Phone Numbers.txt")"
```

A few programs require a Windows-style, semicolon-delimited path list, which **cygpath** can translate from a POSIX path with the `-p` option. For example, a Java compilation from **bash** might look like this:

```
javac -cp "$(cygpath -pw "$CLASSPATH")" hello.java
```

Since using quoting and subshells is somewhat awkward, it is often preferable to use **cygpath** in shell scripts.

3.9.2 Cygwin and Windows Networking

Many popular Cygwin packages, such as `ncftp`, `lynx`, and `wget`, require a network connection. Since Cygwin relies on Windows for connectivity, if one of these tools is not working as expected you may need to troubleshoot using Windows tools. The first test is to see if you can reach the URL's host with **ping.exe**, one of the few utilities included with every Windows version since Windows 95. If you chose to install the `inetutils` package, you may have both Windows and Cygwin versions of utilities such as **ftp** and **telnet**. If you are having problems using one of these programs, see if the alternate one works as expected.

There are a variety of other programs available for specific situations. If your system does not have an always-on network connection, you may be interested in **rasdial.exe** for automating dialup connections. Users who frequently change their network configuration can script these changes with **netsh.exe**. For proxy users, the open source NTLM Authorization Proxy Server or the no-charge Hummingbird SOCKS Proxy may allow you to use Cygwin network programs in your environment.

3.9.3 Creating shortcuts

By default, Cygwin does not create symlinks as .lnk files, but there's an option to do that, see Section 3.5. These symlink .lnk files are compatible with Windows-created .lnk files, but they are still different. They do not include much of the information that is available in a standard Microsoft shortcut, such as the working directory, an icon, etc. The `cygutils` package includes a **mkshortcut** utility for creating standard native Microsoft .lnk files from the command line.

But here's the problem. If Cygwin handled these native shortcuts like any other symlink, you could not archive Microsoft .lnk files into **tar** archives and keep all the information in them. After unpacking, these shortcuts would have lost all the extra information and would be no different than standard Cygwin symlinks. Therefore these two types of links are treated differently. Unfortunately, this means that the usual Unix way of creating and using symlinks does not work with native Windows shortcuts.

3.9.4 Printing

There are several options for printing from Cygwin, including the **lpr** found in `cygutils-extra` (not to be confused with the native Windows **lpr.exe**). The easiest way to use `cygutils-extra`'s **lpr** is to specify a default device name in the `PRINTER` environment variable. You may also specify a device on the command line with the `-d` or `-P` options, which will override the environment variable setting.

A device name may be a UNC path (`\\server_name\printer_name`), a reserved DOS device name (`prn`, `lpt1`), or a local port name that is mapped to a printer share. Note that forward slashes may be used in a UNC path (`//server_name/printer_na` which is helpful when using **lpr** from a shell that uses the backslash as an escape character.

lpr sends raw data to the printer; no formatting is done. Many, but not all, printers accept plain text as input. If your printer supports PostScript, packages such as `a2ps` and `enscript` can prepare text files for printing. The `ghostscript` package also provides some translation from PostScript to various native printer languages. Additionally, a native Windows application for printing PostScript, **gsprint**, is available from the Ghostscript website.

Chapter 4

Programming with Cygwin

4.1 Using GCC with Cygwin

4.1.1 Standard Usage

Use gcc to compile, just like under UNIX. Refer to the GCC User's Guide for information on standard usage and options. Here's a simple example:

Example 4.1 Building Hello World with GCC

```
bash$ gcc hello.c -o hello.exe
bash$ hello.exe
Hello, World

bash$
```

4.1.2 Building applications for 64 bit Cygwin

The 64 bit Cygwin toolchain uses the Microsoft x64 calling convention by default, so you can create applications using the Win32 API just as with the 32 bit Cygwin toolchain.

There's just one important difference. The 64 bit Cygwin compilers use a different data model than the Mingw and Microsoft compilers. For reference, see the Wikipedia entry on 64-bit computing.

While the Mingw and Microsoft compilers use the `LLP64` data model, Cygwin compilers use the `LP64` data model, just like Linux. This affects the size of the type `long`. In the `LLP64` model preferred by Microsoft, `sizeof(long)` is 4. This applies for the related Win32 types like `LONG`, `ULONG`, `DWORD`, etc., too.

In the `LP64` model used by Cygwin, `sizeof(long)` is 8, just like the size of pointers or the types `size_t/ssize_t`. This simplifies porting Linux applications to 64 bit Cygwin, but it requires due diligence when calling Windows functions taking LONG, ULONG, DWORD, or any other equivalent type. This is especially important in conjunction with pointers.

Here's an example. The Win32 function `ReadFile` returns the number of read bytes via a pointer to a DWORD variable:

```
BOOL WINAPI ReadFile (HANDLE, PVOID, DWORD, PDWORD, LPOVERLAPPED);
```

Note that the forth parameter is a pointer to a DWORD, thus it's a pointer to a 4 byte type, on 32 as well as on 64 bit Windows. Now we write our own `my_read` function using ReadFile:

Example 4.2 64bit-programming, Using ReadFile, 1st try

```
ssize_t
my_read (int fd, void *buffer, size_t bytes_to_read)
{
  HANDLE fh = _get_osfhandle (fd);
  ssize_t bytes_read;

  if (ReadFile (fh, buffer, bytes_to_read, (PDWORD) &bytes_read, NULL))
    return bytes_read;
  set_errno_from_get_last_error ();
  return -1;
}
```

While this example code works fine on 32 bit Windows, it has in fact a bad bug. The assumption that the size of ssize_t is the same as the size of DWORD is wrong for 64 bit. In fact, since `sizeof(ssize_t)` is 8, `ReadFile` will write the number of read bytes into the lower 4 bytes of the variable `bytes_read`, while the upper 4 bytes will contain an undefined value. `my_read` will very likely return the wrong number of read bytes to the caller.

Here's the fixed version of `my_read`:

Example 4.3 64bit-programming, Using ReadFile, 2nd try

```
ssize_t
my_read (int fd, void *buffer, size_t bytes_to_read)
{
  HANDLE fh = _get_osfhandle (fd);
  DWORD bytes_read;

  if (ReadFile (fh, buffer, bytes_to_read, &bytes_read, NULL))
    return (ssize_t) bytes_read;
  set_errno_from_get_last_error ();
  return -1;
}
```

4.1.3 GUI Mode Applications

Cygwin comes with an X server, so usually you should compile your GUI applications as X applications to allow better interoperability with other Cygwin GUI applications.

Other than that, Cygwin allows you to build programs with full access to the standard Windows API, including the GUI functions as defined in any Microsoft or off-the-shelf publication.

The build process is similar to any other build process. The only difference is that you use **gcc -mwindows** to link your program into a GUI application instead of a command-line application. Here's an example Makefile:

```
myapp.exe : myapp.o myapp.res
  gcc -mwindows myapp.o myapp.res -o $@

myapp.res : myapp.rc resource.h
  windres $< -O coff -o $@
```

Note the use of `windres` to compile the Windows resources into a COFF-format `.res` file. That will include all the bitmaps, icons, and other resources you need, into one handy object file. For more information on `windres`, consult the Binutils manual.

4.2 Debugging Cygwin Programs

When your program doesn't work right, it usually has a "bug" in it, meaning there's something wrong with the program itself that is causing unexpected results or crashes. Diagnosing these bugs and fixing them is made easy by special tools called *debuggers*. In the case of Cygwin, the debugger is GDB, which stands for "GNU DeBugger". This tool lets you run your program in a controlled environment where you can investigate the state of your program while it is running or after it crashes. Crashing programs sometimes create "core" files. In Cygwin these are regular text files that cannot be used directly by GDB.

Before you can debug your program, you need to prepare your program for debugging. What you need to do is add `-g` to all the other flags you use when compiling your sources to objects.

Example 4.4 Compiling with -g

```
bash$ gcc -g -O2 -c myapp.c
bash$ gcc -g myapp.c -o myapp
```

What this does is add extra information to the objects (they get much bigger too) that tell the debugger about line numbers, variable names, and other useful things. These extra symbols and debugging information give your program enough information about the original sources so that the debugger can make debugging much easier for you.

To invoke GDB, simply type **gdb myapp.exe** at the command prompt. It will display some text telling you about itself, then `(gdb)` will appear to prompt you to enter commands. Whenever you see this prompt, it means that gdb is waiting for you to type in a command, like **run** or **help**. Oh `:-)` type **help** to get help on the commands you can type in, or read the [**?**] for a complete description of GDB and how to use it.

If your program crashes and you're trying to figure out why it crashed, the best thing to do is type **run** and let your program run. After it crashes, you can type **where** to find out where it crashed, or **info locals** to see the values of all the local variables. There's also a **print** that lets you look at individual variables or what pointers point to.

If your program is doing something unexpected, you can use the **break** command to tell gdb to stop your program when it gets to a specific function or line number:

Example 4.5 "break" in gdb

```
(gdb) break my_function
(gdb) break 47
```

Now, when you type **run** your program will stop at that "breakpoint" and you can use the other gdb commands to look at the state of your program at that point, modify variables, and **step** through your program's statements one at a time.

Note that you may specify additional arguments to the **run** command to provide command-line arguments to your program. These two cases are the same as far as your program is concerned:

Example 4.6 Debugging with command line arguments

```
bash$ myprog -t foo --queue 47

bash$ gdb myprog
(gdb) run -t foo --queue 47
```

4.3 Building and Using DLLs

DLLs are Dynamic Link Libraries, which means that they're linked into your program at run time instead of build time. There are three parts to a DLL:

- the exports
- the code and data

- the import library

The code and data are the parts you write - functions, variables, etc. All these are merged together, like if you were building one big object files, and put into the dll. They are not put into your .exe at all.

The exports is a list of functions and variables that the dll makes available to other programs. Think of this as the list of "public" symbols, the rest being hidden. [1] This list can be in a module definition (.def) file, which you can write by hand with a text editor, but it's also possible to have it generated automatically from the functions and variables in your code, by annotating the declarations with `__attribute__ ((dllexport))`. [2]

The import library is a regular UNIX-like `.a` library, but it only contains the tiny bit of information ("a stub") needed to tell the OS how your program interacts with ("imports") the dll. This information is linked into your `.exe`.

Refer to the section of the ld manual discussing Win32 PE specifics for more details.

4.3.1 Building DLLs

This page gives only a few simple examples of gcc's DLL-building capabilities. To begin an exploration of the many additional options, see the gcc documentation and website, currently at http://gcc.gnu.org/

Let's go through a simple example of how to build a dll. For this example, we'll use a single file `myprog.c` for the program (`myprog.exe`) and a single file `mydll.c` for the contents of the dll (`mydll.dll`).

Say you want to build this minimal function in `mydll.c`:

```
#include <stdio.h>

int
hello()
{
  printf ("Hello World!\n");
}
```

First compile `mydll.c` to the object `mydll.o`:

```
gcc -c mydll.c
```

Then, tell gcc that it is building a shared library:

```
gcc -shared -o mydll.dll mydll.o -Wl,--out-implib libmydll.a
```

That's it! You now have the dll (`mydll.dll`) and the import library (`libmydll.a`). [3]

To finish up the example, you can now link to the dll with a simple program, `myprog.c`:

```
int
main ()
{
  hello ();
}
```

Then link to your dll with a command like:

```
gcc -o myprog myprog.c -L./ -lmydll
```

Try it out:

[1] Note that `ld`'s default behaviour is to export all global symbols, if there otherwise wouldn't be any exported symbols (i.e. because you haven't specified a def file or made any export annotations). (See `--export-all-symbols` in the `ld` man page for more details.)

[2] If you're making these annotations on the declarations in a header which is also installed to be included by users of your library, you probably want to use macros to do the right thing and increase portability. See this example for details.

[3] In fact, `--out-implib` is optional in this simple example, because `ld` can automatically generate import stubs when told to link directly to a .dll. (See `--enable-auto-import` in the `ld` man page for more details.)

```
$ ./myprog
Hello World!
```

However, if you are building a dll for installation, you will probably want to use a more complex syntax:

```
gcc -shared -o cyg${module}.dll \
    -Wl,--out-implib=lib${module}.dll.a \
    -Wl,--whole-archive ${objs_libs} -Wl,--no-whole-archive \
    ${dependency_libs}
```

- The name of your library is `${module}`, prefixed with `cyg` for the DLL and `lib` for the import library. Cygwin DLLs use the `cyg` prefix to differentiate them from native-Windows MinGW DLLs.
- `${objs_libs}` are all your object files, bundled together in static libs or single object files
- `${dependency_libs}` are static or import libs you need to link against, e.g **`'-lpng -lz -L/usr/local/special -lmyspeciallib'`** .

When the import library is installed into `/usr/lib`, it can be linked to with just `-l${module}`. The dll itself is installed into `/usr/bin` so it can be found on `PATH` by the loader when a linked .exe is run.

4.3.2 dlltool

Historically, the process for building a dll with `gcc` and `binutils` wasn't so simple, and the `dlltool` tool was used:

- To create the exports section of the dll, from the module definition file or by scanning object files.
- To generate the import library.

(See the `dlltool` man page for more details.)

4.3.3 Linking Against Foreign DLLs

If you have an existing DLL already, you need to build a Cygwin-compatible import library. If you have the source to compile the DLL, see Section 4.3.1 for details on having `gcc` build one for you. If you do not have the source or a supplied working import library, you can get most of the way by creating a .def file with these commands (you might need to do this in `bash` for the quoting to work correctly):

```
echo EXPORTS > foo.def
nm foo.dll | grep ' T _' | sed 's/.* T _//' >> foo.def
```

Note that this will only work if the DLL is not stripped. Otherwise you will get an error message: "No symbols in foo.dll".

Once you have the `.def` file, you can create an import library from it like this:

```
dlltool --def foo.def --dllname foo.dll --output-lib foo.a
```

4.4 Defining Windows Resources

`windres` reads a Windows resource file (`*.rc`) and converts it to a res or coff file. The syntax and semantics of the input file are the same as for any other resource compiler, so please refer to any publication describing the Windows resource format for details. Also, the `windres` program itself is fully documented in the Binutils manual. Here's an example of using it in a project:

```
myapp.exe : myapp.o myapp.res
  gcc -mwindows myapp.o myapp.res -o $@

myapp.res : myapp.rc resource.h
  windres $< -O coff -o $@
```

What follows is a quick-reference to the syntax `windres` supports.

```
id ACCELERATORS suboptions
BEG
"^C" 12
"Q" 12
65 12
65 12 , VIRTKEY ASCII NOINVERT SHIFT CONTROL ALT
65 12 , VIRTKEY, ASCII, NOINVERT, SHIFT, CONTROL, ALT
(12 is an acc_id)
END

SHIFT, CONTROL, ALT require VIRTKEY


id BITMAP memflags "filename"
memflags defaults to MOVEABLE


id CURSOR memflags "filename"
memflags defaults to MOVEABLE,DISCARDABLE


id DIALOG memflags exstyle x,y,width,height styles BEG controls END
id DIALOGEX memflags exstyle x,y,width,height styles BEG controls END
id DIALOGEX memflags exstyle x,y,width,height,helpid styles BEG controls END

memflags defaults to MOVEABLE
exstyle may be EXSTYLE=number
styles: CAPTION "string"
  CLASS id
  STYLE  FOO | NOT FOO | (12)
  EXSTYLE number
  FONT number, "name"
  FONT number, "name",weight,italic
  MENU id
  CHARACTERISTICS number
  LANGUAGE number,number
  VERSIONK number
controls:
  AUTO3STATE params
  AUTOCHECKBOX params
  AUTORADIOBUTTON params
  BEDIT params
  CHECKBOX params
  COMBOBOX params
  CONTROL ["name",] id, class, style, x,y,w,h [,exstyle] [data]
  CONTROL ["name",] id, class, style, x,y,w,h, exstyle, helpid [data]
  CTEXT params
  DEFPUSHBUTTON params
  EDITTEXT params
  GROUPBOX params
```

```
  HEDIT params
  ICON ["name",] id, x,y [data]
  ICON ["name",] id, x,y,w,h, style, exstyle [data]
  ICON ["name",] id, x,y,w,h, style, exstyle, helpid [data]
  IEDIT params
  LISTBOX params
  LTEXT params
  PUSHBOX params
  PUSHBUTTON params
  RADIOBUTTON params
  RTEXT params
  SCROLLBAR params
  STATE3 params
  USERBUTTON "string", id, x,y,w,h, style, exstyle
params:
  ["name",] id, x, y, w, h, [data]
  ["name",] id, x, y, w, h, style [,exstyle] [data]
  ["name",] id, x, y, w, h, style, exstyle, helpid [data]

[data] is optional BEG (string|number) [,(string|number)] (etc) END


id FONT memflags "filename"
memflags defaults to MOVEABLE|DISCARDABLE

id ICON memflags "filename"
memflags defaults to MOVEABLE|DISCARDABLE

LANGUAGE num,num

id MENU options BEG items END
items:
  "string", id, flags
  SEPARATOR
  POPUP "string" flags BEG menuitems END
flags:
  CHECKED
  GRAYED
  HELP
  INACTIVE
  MENUBARBREAK
  MENUBREAK

id MENUEX suboptions BEG items END
items:
  MENUITEM "string"
  MENUITEM "string", id
  MENUITEM "string", id, type [,state]
  POPUP "string" BEG items END
  POPUP "string", id BEG items END
  POPUP "string", id, type BEG items END
  POPUP "string", id, type, state [,helpid] BEG items END

id MESSAGETABLE memflags "filename"
memflags defaults to MOVEABLE

id RCDATA suboptions BEG (string|number) [,(string|number)] (etc) END

STRINGTABLE suboptions BEG strings END
strings:
  id "string"
  id, "string"
```

```
(User data)
id id suboptions BEG (string|number) [,(string|number)] (etc) END

id VERSIONINFO stuffs BEG verblocks END
stuffs: FILEVERSION num,num,num,num
  PRODUCTVERSION num,num,num,num
  FILEFLAGSMASK num
  FILEOS num
  FILETYPE num
  FILESUBTYPE num
verblocks:
  BLOCK "StringFileInfo" BEG BLOCK BEG vervals END END
  BLOCK "VarFileInfo" BEG BLOCK BEG vertrans END END
vervals: VALUE "foo","bar"
vertrans: VALUE num,num



suboptions:
  memflags
  CHARACTERISTICS num
  LANGUAGE num,num
  VERSIONK num

memflags are MOVEABLE/FIXED PURE/IMPURE PRELOAD/LOADONCALL DISCARDABLE
```

4.5 Profiling Cygwin Programs

4.5.1 Introduction

Profiling is a way to analyze your program to find out where it is spending its time. You might need to do this if it seems your program is taking more time to do its job than you think it should. It is always preferable to profile your program than to just guess where the time is being spent; even expert programmers are known to guess badly at this.

In Cygwin, you enable profiling with a compiler flag and you display the resulting profiling data with gprof. Read on to find out how.

To enable profiling of your program, first compile it with an additional gcc flag: **-pg**. That flag should be used when compiling every source file of the program. If your program has a Makefile, you would add the flag to all gcc compilation commands or to the CFLAGS= setting. A manual compilation that enables profiling looks like this:

```
bash$ gcc -pg -g -o myapp myapp.c
```

The **-pg** flag causes gcc to do two additional things as it compiles your program. First, a small bit of code is added to the beginning of each function that records its address and the address it was called from at run time. gprof uses this data to generate a call graph. Second, gcc arranges to have a special "front end" added to the beginning of your program. The front end starts a recurring timer and every time the timer fires, 100 times per second, the currently executing address is saved. gprof uses this data to generate a "flat profile" showing where your program is spending its time.

After compiling your program (and linking it, if you do that as a separate step), you are ready to profile it. Just run it as you normally would. If there are specific code paths you want to profile, take the actions that would exercise those code paths. When your program exits, you will have an additional file in the current directory: gmon.out. That file contains the profiling data gprof processes and displays.

gprof has many flags to control its operation. The [**?**] details everything gprof can do. We will only use a few of gprof's flags here. You launch gprof as follows:

```
bash$ gprof [flags] appname [datafile]...
```

If you don't specify any flags, gprof operates as if you gave it flags **-p -q** which means: generate a flat profile with descriptive text and generate a call graph with more descriptive text. In the examples below we will give specific flags to gprof to demonstrate specific displays. We'll also use flag **-b** which means: be brief, i.e. don't display the descriptive text. You can also specify a trailing list of one or more profiling data files. If you don't, gprof assumes gmon.out is the only file to process and display.

4.5.2 Examples

Example 4.7 Flat profile

```
bash$ gprof -b -p myapp
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 25.11     13.34    13.34        1    13.34    13.34  func0
 25.00     26.62    13.28        1    13.28    13.28  func1
 25.00     39.90    13.28        1    13.28    13.28  func3
 24.89     53.12    13.22        1    13.22    13.22  func2
```

Example 4.8 Call graph

```
bash$ gprof -b -q myapp
                        Call graph


granularity: each sample hit covers 4 byte(s) for 0.02% of 53.12 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00   53.12                 main [1]
               13.34    0.00       1/1           func0 [2]
               13.28    0.00       1/1           func1 [3]
               13.28    0.00       1/1           func3 [4]
               13.22    0.00       1/1           func2 [5]
-----------------------------------------------
               13.34    0.00       1/1           main [1]
[2]     25.1   13.34    0.00       1         func0 [2]
-----------------------------------------------
               13.28    0.00       1/1           main [1]
[3]     25.0   13.28    0.00       1         func1 [3]
-----------------------------------------------
               13.28    0.00       1/1           main [1]
[4]     25.0   13.28    0.00       1         func3 [4]
-----------------------------------------------
               13.22    0.00       1/1           main [1]
[5]     24.9   13.22    0.00       1         func2 [5]
-----------------------------------------------


Index by function name

   [2] func0                   [5] func2
   [3] func1                   [4] func3
```

Example 4.9 Source line profile

```
bash$ gprof -b -l myapp
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 25.11     13.34    13.34        1    13.34    13.34  func0 (myapp.c:9 @ 1004010e0)
 25.00     26.62    13.28        1    13.28    13.28  func1 (myapp.c:10 @ 10040111a)
 25.00     39.90    13.28        1    13.28    13.28  func3 (myapp.c:12 @ 10040118e)
 24.89     53.12    13.22        1    13.22    13.22  func2 (myapp.c:11 @ 100401154)


                     Call graph


granularity: each sample hit covers 4 byte(s) for 0.02% of 53.12 seconds

index % time    self  children    called     name
               13.34    0.00       1/1           main (myapp.c:26 @ 10040123c) [1]
[2]     25.1   13.34    0.00       1         func0 (myapp.c:9 @ 1004010e0) [2]
-----------------------------------------------
               13.28    0.00       1/1           main (myapp.c:26 @ 10040123c) [1]
[3]     25.0   13.28    0.00       1         func1 (myapp.c:10 @ 10040111a) [3]
-----------------------------------------------
               13.28    0.00       1/1           main (myapp.c:28 @ 100401246) [5]
[4]     25.0   13.28    0.00       1         func3 (myapp.c:12 @ 10040118e) [4]
-----------------------------------------------
               13.22    0.00       1/1           main (myapp.c:27 @ 100401241) [7]
[6]     24.9   13.22    0.00       1         func2 (myapp.c:11 @ 100401154) [6]
-----------------------------------------------


Index by function name

   [2] func0 (myapp.c:9 @ 1004010e0) [6] func2 (myapp.c:11 @ 100401154)
   [3] func1 (myapp.c:10 @ 10040111a) [4] func3 (myapp.c:12 @ 10040118e)
```

4.5.3 Special situations

4.5.3.1 Profiling multi-threaded programs

Multi-threaded programs are profiled just like single-threaded programs. There is no mechanism to turn profiling on or off for specific threads. gprof combines the data for all threads when generating its displays.

4.5.3.2 Profiling programs that fork

Programs that fork, i.e., use the fork() system call with or without using exec() afterwards, require special care. Since there is only one gmon.out file, profiling data from the parent process might get overwritten by the child process, or vice-versa, after a fork(). You can avoid this by setting the environment variable GMON_OUT_PREFIX before running your program. If the variable is non-empty, its contents will be used as a prefix to name the profiling data files. Here's an example:

```
bash$ export GMON_OUT_PREFIX=myapp.out
bash$ ./myapp -fork
bash$ ls myapp.out*
```

```
myapp.out.2728  myapp.out.3224

bash$ gprof -bp myapp myapp.out.2728
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 50.25     30.28    30.28        2    15.14    15.14  func3
 24.99     45.34    15.06        1    15.06    15.06  func1
 24.76     60.26    14.92        1    14.92    14.92  func2

bash$ gprof -bp myapp myapp.out.3224
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 49.25     29.36    29.36        2    14.68    14.68  func3
 25.43     44.52    15.16        1    15.16    15.16  func1
 25.33     59.62    15.10        1    15.10    15.10  func2

bash$ gprof -bp myapp myapp.out*
Flat profile:

Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 49.75     59.64    59.64        4    14.91    14.91  func3
 25.21     89.86    30.22        2    15.11    15.11  func1
 25.04    119.88    30.02        2    15.01    15.01  func2
```

As the last gprof command above shows, gprof can combine the data from a selection of profiling data files to generate its displays. Just list the names of those files at the end of the gprof command; you can use a wildcard here. NOTE: If you update your program, remember to remove stale profiling data files before profiling your program again. If you aren't careful about this, gprof could combine data from your most recent version with stale data from prior versions, possibly giving misleading displays.

4.5.3.3 Getting better profiling resolution

To get better resolution (i.e., more data points) when profiling your program, try running it multiple times with the environment variable GMON_OUT_PREFIX set, as described in the previous situation. There will be multiple profiling data files generated and you can have gprof combine the data from all of them into one display.

4.5.3.4 Profiling programs with their libraries

At the time of this writing Cygwin's profiling support only allows for one range of addresses per program. It is hard-wired to be the range covering the .text segment of your program, which is where your code resides. If you build your program with static libraries (e.g., libfoo.a), the code from those libraries is linked into your program's .text segment so will be included when profiling. But dynamic libraries (e.g., libfoo.dll) reside in other address ranges and code within them won't be included.

4.5.3.5 Profiling Cygwin itself

Due to the issue mentioned in the previous situation and other issues, at the time of this writing there is no support for profiling Cygwin itself.