

Monotone

A distributed version control system

Graydon Hoare and others

This manual is for the “monotone” distributed version control system. This edition documents version 0.39.

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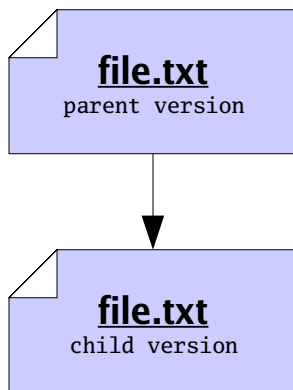
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1 Concepts

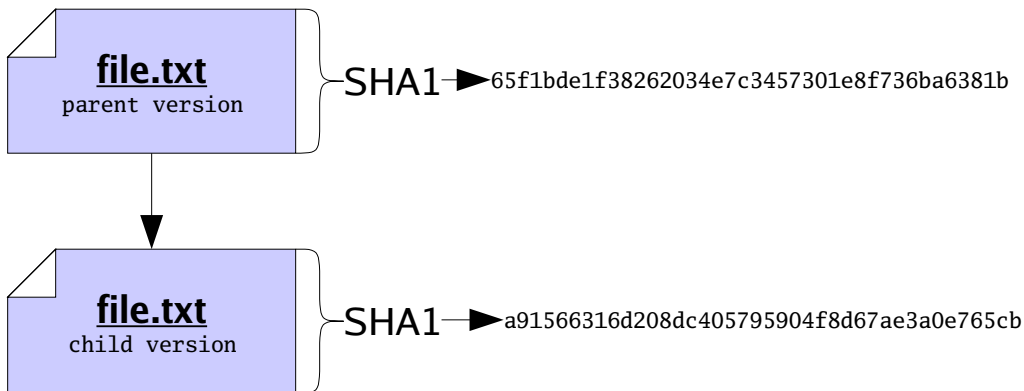
This chapter should familiarize you with the concepts, terminology, and behavior described in the remainder of the user manual. Please take a moment to read it, as later sections will assume familiarity with these terms.

1.1 Versions of files

Suppose you wish to modify a file ‘file.txt’ on your computer. You begin with one *version* of the file, load it into an editor, make some changes, and save the file again. Doing so produces a new *version* of the file. We will say that the older version of the file was a *parent*, and the new version is a *child*, and that you have performed an *edit* between the parent and the child. We may draw the relationship between parent and child using a graph, where the arrow in the graph indicates the direction of the edit, from parent to child.



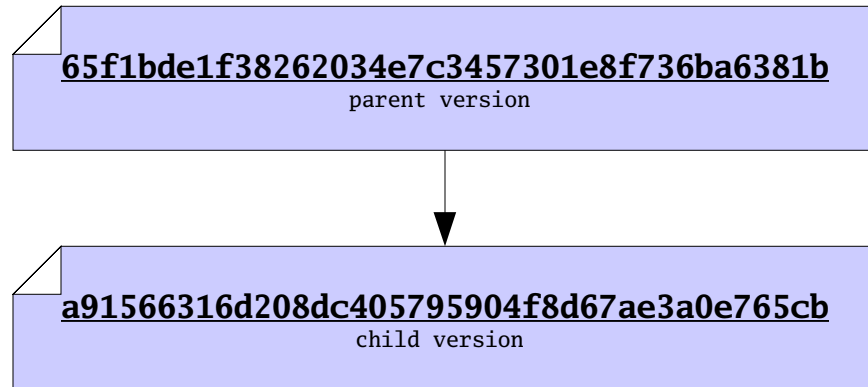
We may want to identify the parent and the child precisely, for sake of reference. To do so, we will compute a *cryptographic hash function*, called SHA1, of each version. The details of this function are beyond the scope of this document; in summary, the SHA1 function takes a version of a file and produces a short string of 20 bytes, which we will use to uniquely identify the version¹. Now our graph does not refer to some “abstract” parent and child, but rather to the exact edit we performed between a specific parent and a specific child.



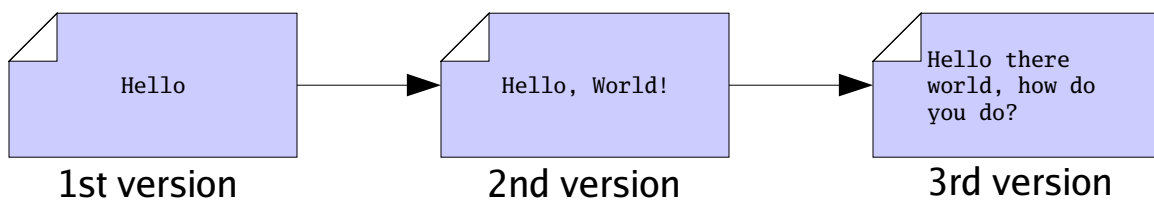
When dealing with versions of files, we will dispense with writing out “file names”, and identify versions *purely* by their SHA1 value, which we will also refer to as their *file ID*. Using IDs alone will often help us accommodate the fact that people often wish to call files

¹ We say SHA1 values are “unique” here, when in fact there is a small probability of two different versions having the same SHA1 value. This probability is very small, so we discount it.

by different names. So now our graph of parent and child is just a relationship between two versions, only identified by ID.

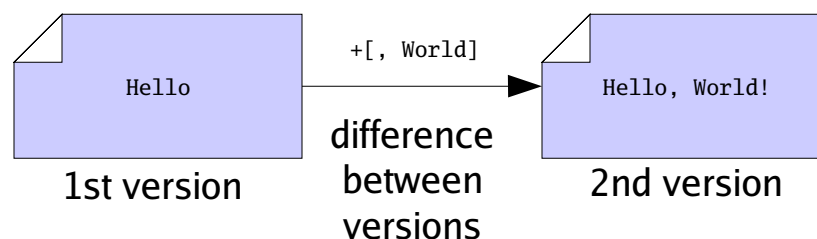


Version control systems, such as monotone, are principally concerned with the storage and management of *multiple* versions of some files. One way to store multiple versions of a file is, literally, to save a separate *complete* copy of the file, every time you make a change. When necessary, monotone will save complete copies of your files, compressed with the `zlib` compression format.



Often we find that successive versions of a file are very similar to one another, so storing multiple complete copies is a waste of space. In these cases, rather than store *complete* copies of each version of a file, we store a compact description of only the *changes* which are made between versions. Such a description of changes is called a *delta*.

Storing deltas between files is, practically speaking, as good as storing complete versions of files. It lets you undo changes from a new version, by applying the delta backwards, and lets your friends change their old version of the file into the new version, by applying the delta forwards. Deltas are usually smaller than full files, so when possible monotone stores deltas, using a modified `xdelta` format. The details of this format are beyond the scope of this document.



1.2 Versions of trees

After you have made many different files, you may wish to capture a “snapshot” of the versions of all the files in a particular collection. Since files are typically collected into *trees* in a file system, we say that you want to capture a *version of your tree*. Doing so will permit you to undo changes to multiple files at once, or send your friend a *set* of changes to many files at once.

To make a snapshot of a tree, we begin by writing a special file called a *manifest*. In fact, monotone will write this file for us, but we could write it ourselves too. It is just a plain text file, in a structured but human-readable format used by several parts of monotone. Each file entry of a manifest binds a specific name, as a full path from the root of the workspace, to a specific file ID, as the hash of its content. In this way, the manifest collects together the snapshot of the file names and contents you have at this point in time; other snapshots with other manifests can use different names for the same file, or different contents for the same name.

Other entries in the manifest format name directories or store file attrs, which we will cover later.



manifest

```
format_version "1"

dir ""

dir "fs"

  file "fs/readdir.c"
  content [f2e5719b975e319c2371c98ed2c7231313fac9b5]

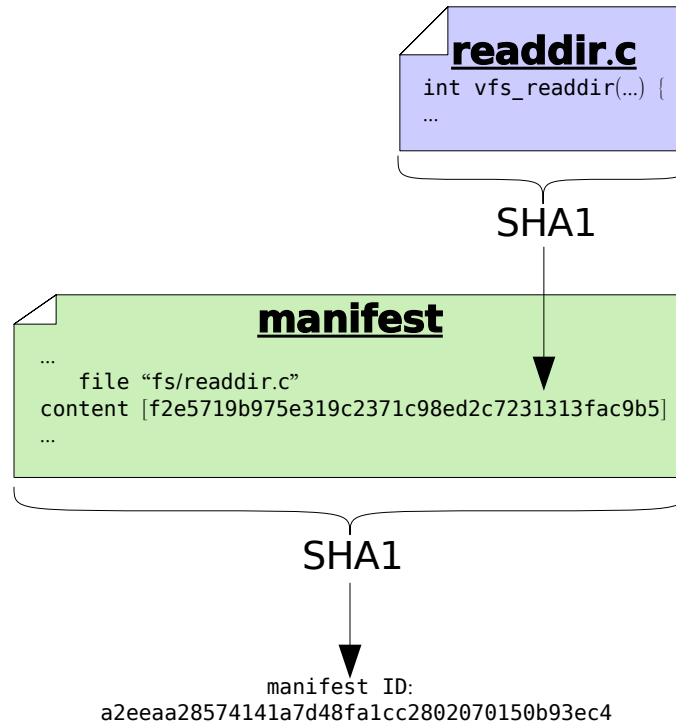
  file "fs/read_write.c"
  content [81f0c9a0df254bc8d51bb785713a9f6d0b020b22]

  file "fs/pipe.c"
  content [943851e7da46014cb07473b90d55dd5145f24de0]

  file "fs/inode.c"
  content [8ddcfcc568f33db6205316d072825d2e5c123275]
```

Now we note that a manifest is itself a file. Therefore a manifest can serve as input to the SHA1 function, and thus every manifest has an ID of its own. By calculating the SHA1 value of a manifest, we capture the *state of our tree* in a single *manifest ID*. In other words, the ID of the manifest essentially captures all the IDs and file names of every file in our

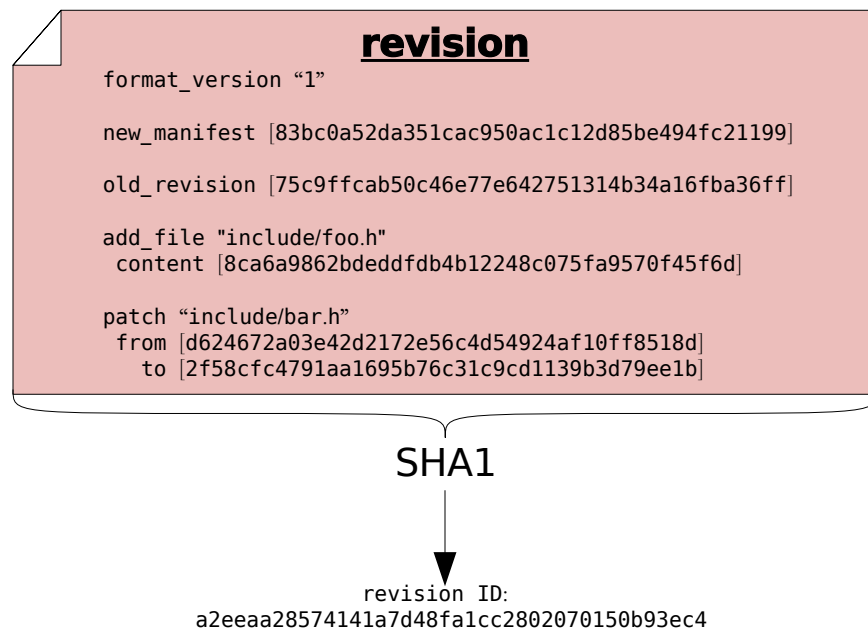
tree, combined. So we may treat manifests and their IDs as *snapshots* of a tree of files, though lacking the actual contents of the files themselves.



As with versions of files, we may decide to store manifests in their entirety, or else we may store only a compact description of changes which occur between different versions of manifests. As with files, when possible monotone stores compact descriptions of changes between manifests; when necessary it stores complete versions of manifests.

1.3 Historical records

Suppose you sit down to edit some files. Before you start working, you may record a manifest of the files, for reference sake. When you finish working, you may record another manifest. These “before and after” snapshots of the tree of files you worked on can serve as historical records of the set of changes, or *changeset*, that you made. In order to capture a “complete” view of history – both the changes made and the state of your file tree on either side of those changes – monotone builds a special composite file called a *revision* each time you make changes. Like manifests, revisions are ordinary text files which can be passed through the SHA1 function and thus assigned a *revision ID*.



The content of a revision includes one or more changesets. These changesets make reference to file IDs, to describe how the tree changed. The revision also contains manifest IDs, as another way of describing the tree “before and after” the changeset — storing this information in two forms allows monotone to detect any bugs or corrupted data before they can enter your history. Finally and crucially, revisions also make reference to *other revision IDs*. This fact – that revisions include the IDs of other revisions – causes the set of revisions to join together into a historical *chain of events*, somewhat like a “linked list”. Each revision in the chain has a unique ID, which includes *by reference* all the revisions preceding it. Even if you undo a changeset, and return to a previously-visited manifest ID

during the course of your edits, each revision will incorporate the ID of its predecessor, thus forming a new unique ID for each point in history.



1.4 Certificates

Often, you will wish to make a *statement* about a revision, such as stating the reason that you made some changes, or stating the time at which you made the changes, or stating that the revision passes a test suite. Statements such as these can be thought of, generally, as a bundle of information with three parts:

- an *ID*, indicating which revision you are making a statement about
- a *name* indicating the type of statement you are making, such as “changelog”, “date” or “testresult”
- a *value* indicating the remaining detail of the statement, such as “fixed a bug”, “March 9th” or “1”

For example, if you want to say that a particular revision was composed on April 4, 2003, you might make a statement like this:

statement

revision ID: a2eeaa28574141a7d48fa1cc2802070150b93ec4
statement name: "date"
statement value: "2003-04-04T07:39:51"

In an ideal world, these are all the parts of a statement we would need in order to go about our work. In the real world, however, there are sometimes malicious people who would make false or misleading statements; so we need a way to verify that a particular person made a particular statement about a revision. We therefore will add two more pieces of information to our bundle:

- a *key* which identifies the person making a statement
- a *signature* — just a large number with particular properties — certifying the fact that the person made the statement

When these 2 items accompany a statement, we call the total bundle of 5 items a *certificate*, or *cert*. A cert makes a statement in a secure fashion. The security of the signature in a cert is derived from the RSA cryptography system, the details of which are beyond the scope of this document.

certificate

revision ID: a2eeaa28574141a7d48fa1cc2802070150b93ec4
statement name: "date"
statement value: "2003-04-04T07:39:51"
signed by key: "jrh@example.com"
signature: "a02380def....0983fe90"

Monotone uses certs extensively. Any “extra” information which needs to be stored, transmitted or retrieved — above and beyond files, manifests, and revisions — is kept in the form of certs. This includes change logs, time and date records, branch membership,

authorship, test results, and more. When monotone makes a decision about storing, transmitting, or extracting files, manifests, or revisions, the decision is often based on certs it has seen, and the trustworthiness you assign to those certs.

The RSA cryptography system — and therefore monotone itself — requires that you exchange special “public” numbers with your friends, before they will trust certificates signed by you. These numbers are called *public keys*. Giving someone your public key does not give them the power to *impersonate* you, only to verify signatures made by you. Exchanging public keys should be done over a trusted medium, in person, or via a trusted third party. Advanced secure key exchange techniques are beyond the scope of this document.

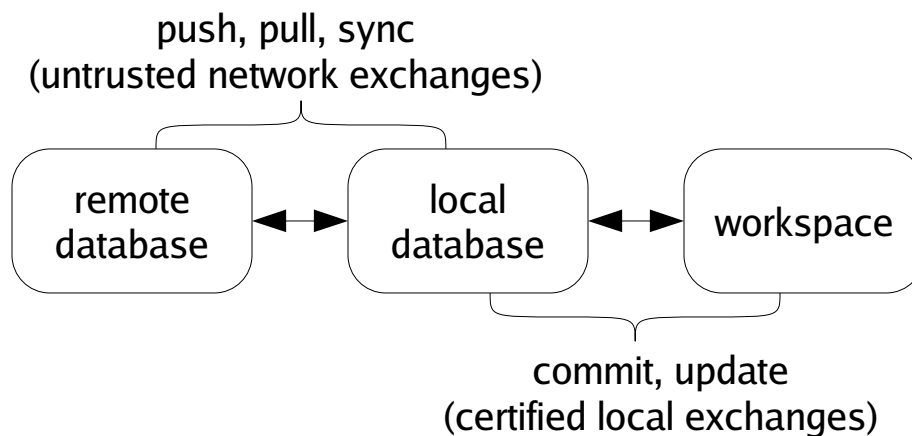
1.5 Storage and workflow

Monotone moves information in and out of four different types of storage:

- a *keystore* in your home directory
- a *workspace* in the local file system
- a *local database* in the local file system
- a *remote database* elsewhere on the internet

The *keystore* is a directory `‘.monotone/keys’` in your home directory which contains copies of all your private keys. Each key is stored in a file whose name is the key identifier with some characters converted to underscores. When you use a key to sign a cert, the public half of that key is copied into your local database along with the cert.

All information passes *through* your local database, en route to some other destination. For example, when changes are made in a workspace, you may save those changes to your database, and later you may synchronize your database with someone else’s. Monotone will not move information directly between a workspace and a remote database, or between workspaces. Your local database is always the “switching point” for communication.

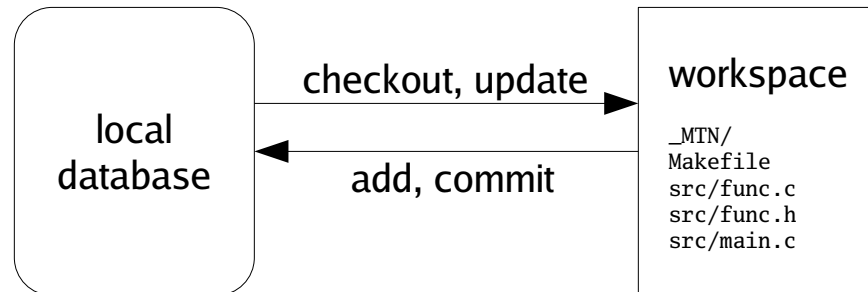


A *workspace* is a tree of files in your file system, arranged according to the list of file paths and IDs in a particular manifest. A special directory called `‘_MTN’` exists in the root of any workspace. Monotone keeps some special files in the `‘_MTN’` directory, in order to track changes you make to your workspace. If you ever want to know if a directory is a monotone workspace, just look for this `‘_MTN’` directory.

Aside from the special `‘_MTN’` directory, a workspace is just a normal tree of files. You can directly edit the files in a workspace using a plain text editor or other program; monotone will automatically notice when you make any changes. If you wish to add files, remove files, or move files within your workspace, you must tell monotone explicitly what you are doing, as these actions cannot be deduced.

If you do not yet have a workspace, you can *check out* a workspace from a database, or construct one from scratch and *add* it into a database. As you work, you will occasionally *commit* changes you have made in a workspace to a database, and *update* a workspace

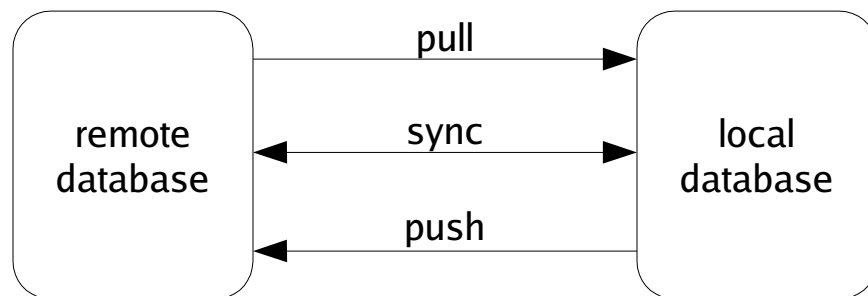
to receive changes that have arrived in a database. Committing and updating take place purely between a database and a workspace; the network is not involved.



A *database* is a single, regular file. You can copy or back it up using standard methods. Typically you keep a database in your home directory. Databases are portable between different machine types. You can have multiple databases and divide your work between them, or keep everything in a single database if you prefer. You can dump portions of your database out as text, and read them back into other databases, or send them to your friends. Underneath, databases are accessed using a standard, robust data manager, which makes using even very large databases efficient. In dire emergencies, you can directly examine and manipulate a database using a simple SQL interface.

A database contains many files, manifests, revisions, and certificates, some of which are not immediately of interest, some of which may be unwanted or even false. It is a collection of information received from network servers, workspaces, and other databases. You can inspect and modify your databases without affecting your workspaces, and vice-versa.

Monotone knows how to exchange information in your database with other remote databases, using an interactive protocol called *netsync*. It supports three modes of exchange: pushing, pulling, and synchronizing. A *pull* operation copies data from a remote database to your local database. A *push* operation copies data from your local database to a remote database. A *sync* operation copies data both directions. In each case, only the data missing from the destination is copied. The *netsync* protocol calculates the data to send “on the fly” by exchanging partial hash values of each database.



In general, work flow with monotone involves 3 distinct stages:

- When you *commit* changes from your workspace to your database, your database stores the changes but does not communicate with the network. Your commits happen immediately, without consulting any other party, and do not require network connectivity.

- When you are ready to *exchange* work with someone else, you can push, pull, or sync with other databases on the network. When you talk to other servers on the network, your database may change, but your workspace will not. In fact, you do not need a workspace at all when exchanging work.
- When you *update* your workspace, some (but not all) of the changes which your database received from the network are applied to your workspace. The network is not consulted during updates.

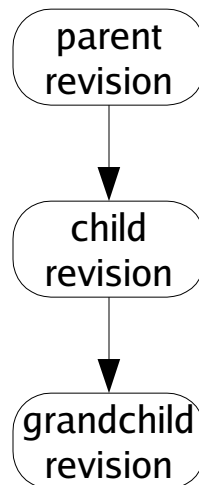
The last stage of workflow is worth clarifying: monotone does *not* blindly apply all changes it receives from a remote database to your workspace. Doing so would be very dangerous, because remote databases are not always trustworthy systems. Rather, monotone evaluates the certificates it has received along with the changes, and decides which particular changes are safe and desirable to apply to your workspace.

You can always adjust the criteria monotone uses to judge the trustworthiness and desirability of changes in your database. But keep in mind that it always uses *some* criteria; receiving changes from a remote server is a *different* activity than applying changes to a workspace. Sometimes you may receive changes which monotone judges to be untrusted or bad; such changes may stay in your database but will *not* be applied to your workspace.

Remote databases, in other words, are just untrusted “buckets” of data, which you can trade with promiscuously. There is no trust implied in communication.

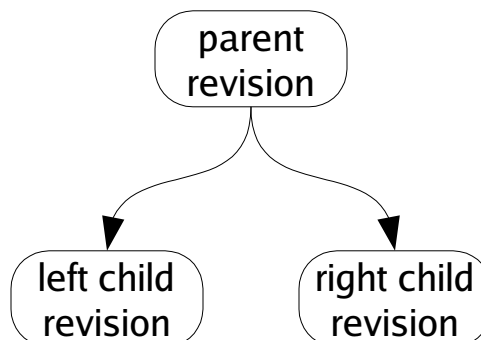
1.6 Forks and merges

So far we have been talking about revisions as though each logically follows exactly one revision before it, in a simple sequence of revisions.



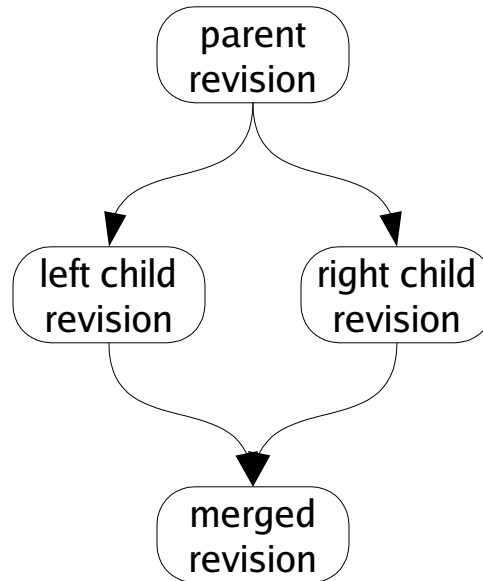
This is a rosy picture, but sometimes it does not work out this way. Sometimes when you make new revisions, other people are *simultaneously* making new revisions as well, and their revisions might be derived from the same parent as yours, or contain different changesets. Without loss of generality, we will assume simultaneous edits only happen two-at-a-time; in fact many more edits may happen at once but our reasoning will be the same.

We call this situation of simultaneous edits a *fork*, and will refer to the two children of a fork as the *left child* and *right child*. In a large collection of revisions with many people editing files, especially on many different computers spread all around the world, forks are a common occurrence.



If we analyze the changes in each child revision, we will often find that the changeset between the parent and the left child are unrelated to the changeset between the parent and

the right child. When this happens, we can usually *merge* the fork, producing a common grandchild revision which contains both changesets.



1.7 Branches

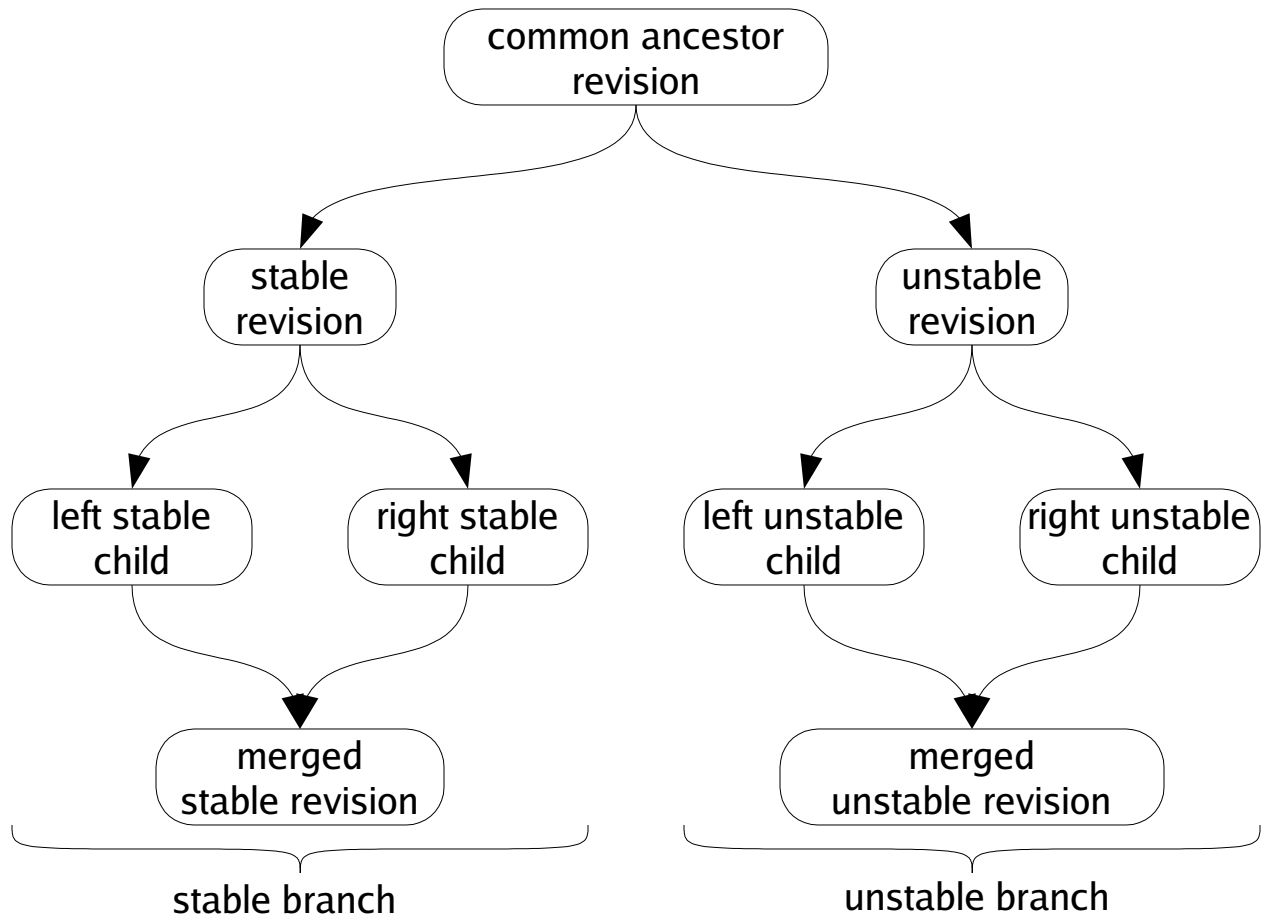
Sometimes, people intentionally produce forks which are *not supposed to be merged*; perhaps they have agreed to work independently for a time, or wish to change their files in ways which are not logically compatible with each other. When someone produces a fork which is supposed to last for a while (or perhaps permanently) we say that the fork has produced a new *branch*. Branches tell monotone which revisions you would like to merge, and which you would like to keep separate.

You can see all the available branches using `mtn list branches`.

Branches are indicated with certs. The cert name **branch** is reserved for use by monotone, for the purpose of identifying the revisions which are members of a branch. A **branch** cert has a symbolic “branch name” as its value. When we refer to “a branch”, we mean all revisions with a common branch name in their **branch** certs.

For example, suppose you are working on a program called “wobbler”. You might develop many revisions of wobbler and then decide to split your revisions into a “stable branch” and an “unstable branch”, to help organize your work. In this case, you might call the new branches “wobbler-stable” and “wobbler-unstable”. From then on, all revisions in the stable branch would get a cert with name **branch** and value **wobbler-stable**; all revisions in the unstable branch would get a cert with name **branch** and value **wobbler-unstable**. When a **wobbler-stable** revision forks, the children of the fork will be merged. When a **wobbler-unstable** revision forks, the children of the fork will be merged. However, the

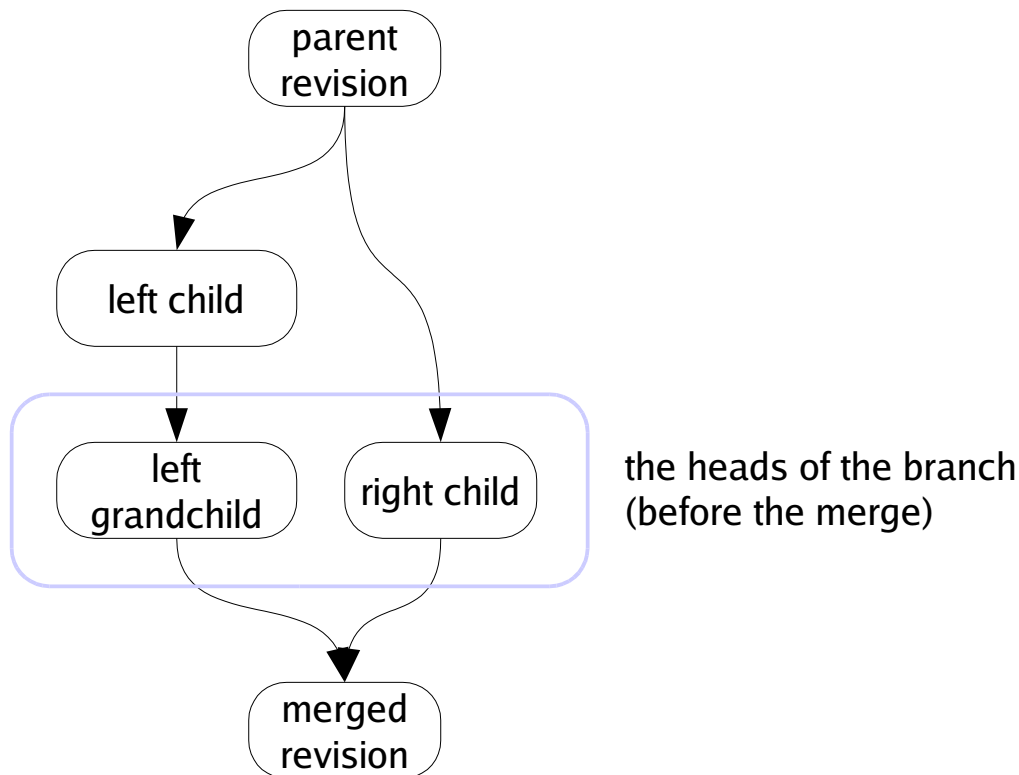
wobbler-stable and wobbler-unstable branches will not be merged together, despite having a common ancestor.



For each branch, the set of revisions with *no children* is called the *heads* of the branch. Monotone can automatically locate, and attempt to merge, the heads of a branch. If it fails to automatically merge the heads, it may ask you for assistance or else fail cleanly, leaving the branch alone.

For example, if a fork's left child has a child of its own (a "left grandchild"), monotone will merge the fork's right child with the left grandchild, since those revisions are the heads

of the branch. It will not merge the left child with the right child, because the left child is not a member of the heads.



When there is only one revision in the heads of a branch, we say that *the heads are merged*, or more generally that *the branch is merged*, since the heads is the logical set of candidates for any merging activity. If there are two or more revisions in the heads of a branch, and you ask to merge the branch, monotone will merge them two-at-a-time until there is only one.

1.7.1 Branch Names

The branch names used in the above section are fine for an example, but they would be bad to use in a real project. The reason is, monotone branch names must be *globally* unique, over all branches in the world. Otherwise, bad things can happen. Fortunately, we have a handy source of globally unique names — the DNS system.

When naming a branch, always prepend the reversed, fully qualified, domain name of a host that you control or are otherwise authorized to use. For example, monotone development happens on the branch `net.venge.monotone`, because `venge.net` belongs to monotone's primary author. The idea is that this way, you can coordinate with other people using a host to make sure there are no conflicts — in the example, monotone's primary author can be certain that no-one else using `venge.net` will start up a different program named `monotone`. If you work for Yoyodyne, Inc. (owners of `yoyodyne.com`), then all your branch names should look like `com.yoyodyne.something`.

What the *something* part looks like is up to you, but usually the first part is the project name (the `monotone` in `net.venge.monotone`), and then possibly more stuff after

that to describe a particular branch. For example, monotone's win32 support was initially developed on the branch `net.venge.monotone.win32`.

(For more information, see [Section 3.12 \[Naming Conventions\]](#), page 65.)

2 Tutorial

This chapter illustrates the basic uses of monotone by means of an example, fictional software project.

2.1 Issues

Before we walk through the tutorial, there are two minor issues to address: standard options and revision selectors.

2.1.1 Standard Options

Before operating monotone, two important command-line options should be explained.

- Most commands operate on a *database*, which is selected with the ‘`--db`’ option.
- Many commands operate on a subset of the database, called a *branch*, which is selected with the ‘`--branch`’ option.

Monotone will cache the settings for these options in your workspace, so ordinarily once you have checked out a project, you will not need to specify them again. We will therefore only mention these arguments in the first example.

2.1.2 Revision Selectors

Many commands require you to supply 40-character SHA1 values as arguments, which identify revisions. These “revision IDs” are tedious to type, so monotone permits you to supply “revision selectors” rather than complete revision IDs. Selectors are a more “human friendly” way of specifying revisions by combining certificate values into unique identifiers. This “selector” mechanism can be used anywhere a revision ID would normally be used. For details on selector syntax, see [Section 3.2 \[Selectors\]](#), page 47.

We are now ready to explore our fictional project.

2.2 The Fictional Project

Our fictional project involves 3 programmers cooperating to write firmware for a robot, the JuiceBot 7, which dispenses fruit juice. The programmers are named Jim, Abe and Beth.

- Jim lives in Japan, and owns JuiceBot Inc. You will know when we're talking about Jim, because everything he does involves the letter "j".
- Abe lives in Australia and writes code related to apple juice. You will know when we're talking about Abe, because everything he does involves the letter "a".
- Beth lives in Brazil and writes code related to banana juice. You will know when we're talking about Beth, because everything she does involves the letter "b".

In our example the programmers work privately on laptops, and are usually *disconnected* from the network. They share no storage system. Thus when each programmer enters a command, it affects only his or her own computer, unless otherwise stated.

In the following, our fictional project team will work through several version control tasks. Some tasks must be done by each member of our example team; other tasks involve only one member.

2.3 Creating a Database

The first step Jim, Abe and Beth each need to perform is to create a new database. This is done with the `mtn db init` command, providing a `--db` option to specify the location of the new database. Each programmer creates their own database, which will reside in their home directory and store all the revisions, files and manifests they work on. Monotone requires this step as an explicit command, to prevent spurious creation of databases when an invalid `--db` option is given.

In real life, most people prefer to keep one database for each project they work on. If we followed that convention here in the tutorial, though, then all the databases would be called `juicebot.mtn`, and that would make things more confusing to read. So instead, we'll have them each name their database after themselves.

Thus Jim issues the command:

```
$ mtn db init --db=~/.jim.mtn
```

Abe issues the command:

```
$ mtn db init --db=~/.abe.mtn
```

And Beth issues the command:

```
$ mtn db init --db=~/.beth.mtn
```

2.4 Generating Keys

Now Jim, Abe and Beth must each generate an RSA key pair for themselves. This step requires choosing a key identifier. Typical key identifiers are similar to email addresses, possibly modified with some prefix or suffix to distinguish multiple keys held by the same owner. Our example programmers will use their email addresses at the fictional “juicebot.co.jp” domain name. When we ask for a key to be generated, monotone will ask us for a passphrase. This phrase is used to encrypt the key when storing it on disk, as a security measure.

Jim does the following:

```
$ mtn genkey jim@juicebot.co.jp
mtn: generating key-pair 'jim@juicebot.co.jp'
enter passphrase for key ID [jim@juicebot.co.jp] : <Jim enters his passphrase>
confirm passphrase for key ID [jim@juicebot.co.jp]: <Jim confirms his passphrase>
mtn: storing key-pair 'jim@juicebot.co.jp' in /home/jim/.monotone/keys
```

Abe does something similar:

```
$ mtn genkey abe@juicebot.co.jp
mtn: generating key-pair 'abe@juicebot.co.jp'
enter passphrase for key ID [abe@juicebot.co.jp] : <Abe enters his passphrase>
confirm passphrase for key ID [abe@juicebot.co.jp]: <Abe confirms his passphrase>
mtn: storing key-pair 'abe@juicebot.co.jp' in /home/abe/.monotone/keys
```

as does Beth:

```
$ mtn genkey beth@juicebot.co.jp
mtn: generating key-pair 'beth@juicebot.co.jp'
enter passphrase for key ID [beth@juicebot.co.jp] : <Beth enters her passphrase>
confirm passphrase for key ID [beth@juicebot.co.jp]: <Beth confirms her passphrase>
mtn: storing key-pair 'beth@juicebot.co.jp' in /home/beth/.monotone/keys
```

Each programmer has now generated a key pair and placed it in their keystore. Each can list the keys in their keystore, to ensure the correct key was generated. For example, Jim might see this:

```
$ mtn list keys

[public keys]
9e9e9ef1d515ad58bfaa5cf282b4a872d8fda00c jim@juicebot.co.jp  (*)
(*) - only in /home/jim/.monotone/keys/

[private keys]
771ace046c27770a99e5fddfa99c9247260b5401 jim@juicebot.co.jp
```

The hexadecimal string printed out before each key name is a *fingerprint* of the key, and can be used to verify that the key you have stored under a given name is the one you intended to store. Monotone will never permit one keystore to store two keys with the same name or the same fingerprint.

This output shows one private and one public key stored under the name `jim@juicebot.co.jp`, so it indicates that Jim’s key-pair has been successfully generated and stored. On subsequent commands, Jim will need to re-enter his passphrase in order to perform security-sensitive tasks.

Pretty soon Jim gets annoyed when he has to enter his passphrase every time he invokes `mtn` (and, more importantly, it simplifies the tutorial text to skip the passphrase prompts)

so he decides to use *ssh-agent* to store his key. He does this by using the `ssh_agent_export` command to export his key into a format that *ssh-agent* can understand and adding it with `ssh-add`.

```
$ mtn ssh_agent_export ~/.ssh/id_monotone
enter passphrase for key ID [user@example.com]:
enter new passphrase for key ID [user@example.com]:
confirm passphrase for key ID [user@example.com]:
$ chmod 600 ~/.ssh/id_monotone
```

From now on, Jim just needs to add his key to *ssh-agent* when he logs in and he will not need to enter his passphrase every time he uses *monotone*.

```
$ ssh-agent /bin/bash
$ ssh-add ~/.ssh/id_monotone
Enter passphrase for /home/user/.ssh/id_monotone:
Identity added: /home/user/.ssh/id_monotone (/home/user/.ssh/id_monotone)
$ mtn ci -m"Changed foo to bar"
$ mtn push
```

The following procedure is deprecated and not suggested for general use as it is very insecure.

Jim isn't very worried about security so he decides to store his passphrase in his 'monotonerc' file. He does this by writing a *hook function* which returns the passphrase:

```
$ mkdir ~/.monotone
$ cat >>~/.monotone/monotonerc
function get_passphrase(keypair_id)
    return "jimsekret"
end
^D
```

Now whenever *monotone* needs his passphrase, it will call this function instead of prompting him to type it. Note that we are appending the new hook to the (possibly existing) file. We do this to avoid losing other changes by mistake; therefore, be sure to check that no other `get_passphrase` function appears in the configuration file.

Abe and Beth do the same, with their secret passphrases.

2.5 Starting a New Project

Before he can begin work on the project, Jim needs to create a *workspace* — a directory whose contents monotone will keep track of. Often, one works on projects that someone else has started, and creates workspaces with the **checkout** command, which you’ll learn about later. Jim is starting a new project, though, so he does something a little bit different. He uses the **mtn setup** command to create a new workspace.

This command creates the named directory (if it doesn’t already exist), and creates the ‘_MTN’ directory within it. The ‘_MTN’ directory is how monotone recognizes that a directory is a workspace, and monotone stores some bookkeeping files within it. For instance, command line values for the ‘--db’, ‘--branch’ or ‘--key’ options to the **setup** command will be cached in a file called ‘_MTN/options’, so you don’t have to keep passing them to monotone all the time.

He chooses `jp.co.juicebot.jb7` as a branch name. (See [Section 3.12 \[Naming Conventions\]](#), [page 65](#) for more information about appropriate branch names.) Jim then creates his workspace:

```
/home/jim$ mtn --db=jim.mtn --branch=jp.co.juicebot.jb7 setup juice
/home/jim$ cd juice
/home/jim/juice$
```

Notice that Jim has changed his current directory to his newly created workspace. For the rest of this example we will assume that everyone issues all further monotone commands from their workspace directories.

2.6 Adding Files

Next Jim decides to add some files to the project. He writes up a file containing the prototypes for the JuiceBot 7:

```
$ mkdir include
$ cat >include/jb.h
/* Standard JuiceBot hw interface */

#define FLOW_JUICE 0x1
#define POLL_JUICE 0x2
int spoutctl(int port, int cmd, void *x);

/* JuiceBot 7 API */

#define APPLE_SPOUT 0x7e
#define BANANA_SPOUT 0x7f
void dispense_apple_juice ();
void dispense_banana_juice ();
^D
```

Then adds a couple skeleton source files which he wants Abe and Beth to fill in:

```
$ mkdir src
$ cat >src/apple.c
#include "jb.h"

void
dispense_apple_juice()
{
    /* Fill this in please, Abe. */
}
^D
$ cat >src/banana.c
#include "jb.h"

void
dispense_banana_juice()
{
    /* Fill this in please, Beth. */
}
^D
```

Now Jim tells monotone to add these files to its record of his workspace. He specifies one filename and one directory; monotone recursively scans the directory and adds all its files.

```
$ mtn add include/jb.h src
mtn: adding include/jb.h to workspace manifest
mtn: adding src/apple.c to workspace manifest
mtn: adding src/banana.c to workspace manifest
```

This command produces a record of Jim's intentions in a special file called `'_MTN/revision'`, stored in the workspace. The file is plain text:

```
$ cat _MTN/revision

format_version "1"

new_manifest [2098eddb833046174de28172a813150a6cbda7b]

old_revision []

add_file "include/jb.h"
  content [3b12b2d0b31439bd50976633db1895cff8b19da0]

add_file "src/apple.c"
  content [2650ffc660dd00a08b659b883b65a060cac7e560]

add_file "src/banana.c"
  content [e8f147e5b4d5667f3228b7bba1c5c1e639f5db9f]
```

You will never have to look at this file, but it is nice to know that it is there.

Jim then gets up from his machine to get a coffee. When he returns he has forgotten what he was doing. He asks monotone:

```
$ mtn status
Current branch: jp.co.juicebot.jb7
Changes against parent :
  added   include/jb.h
  added   src/apple.c
  added   src/banana.c
```

The output of this command tells Jim that his edits, so far, constitute only the addition of some files.

Jim wants to see the actual details of the files he added, however, so he runs a command which prints out the status *and* a GNU “unified diff” of the patches involved in the changeset:

```

$ mtn diff
#
# old_revision []
#
# add_file "include/jb.h"
# content [3b12b2d0b31439bd50976633db1895cff8b19da0]
#
# add_file "src/apple.c"
# content [2650ffc660dd00a08b659b883b65a060cac7e560]
#
# add_file "src/banana.c"
# content [e8f147e5b4d5667f3228b7bba1c5c1e639f5db9f]
#
=====
--- include/jb.h
+++ include/jb.h 3b12b2d0b31439bd50976633db1895cff8b19da0
@ -0,0 +1,13 @
+/* Standard JuiceBot hw interface */
+
+#define FLOW_JUICE 0x1
+#define POLL_JUICE 0x2
+#define SET_INTR 0x3
+int spoutctl(int port, int cmd, void *x);
+
+/* JuiceBot 7 API */
+
+#define APPLE_SPOUT 0x7e
+#define BANANA_SPOUT 0x7f
+void dispense_apple_juice ();
+void dispense_banana_juice ();
=====
--- src/apple.c
+++ src/apple.c 2650ffc660dd00a08b659b883b65a060cac7e560
@ -0,0 +1,7 @
+#include "jb.h"
+
+void
+dispense_apple_juice()
+{
+ /* Fill this in please, Abe. */
+}
=====
--- src/banana.c
+++ src/banana.c e8f147e5b4d5667f3228b7bba1c5c1e639f5db9f
@ -0,0 +1,7 @
+#include "jb.h"
+
+void
+dispense_banana_juice()
+{
+ /* Fill this in please, Beth. */
+}

```

2.7 Committing Work

Satisfied with the work he's done, Jim wants to save his changes. He then commits his workspace, which causes monotone to process the `'_MTN/revision'` file and record the file contents, manifest, and revision into the database. Since he provided a branch name when he ran `setup`, monotone will use this as the default branch name when he commits.

```
$ mtn commit --message="initial checkin of project"
mtn: beginning commit on branch 'jp.co.juicebot.jb7'
mtn: committed revision 2e24d49a48adf9acf3a1b6391a080008cbef9c21
```

When monotone committed Jim's revision, it updated `'_MTN/revision'` to record the workspace's new base revision ID. Jim can use this revision ID in the future, as an argument to the `checkout` command, if he wishes to return to this revision:

```
$ mtn automate get_base_revision_id
2e24d49a48adf9acf3a1b6391a080008cbef9c21
```

Monotone also generated a number of certificates attached to the new revision, and made sure that the database contained a copy of Jim's public key. These certs store metadata about the commit. Jim can ask monotone for a list of certs on this revision.

```
$ mtn ls certs 2e24d49a48adf9acf3a1b6391a080008cbef9c21
-----
Key   : jim@juicebot.co.jp
Sig   : ok
Name  : branch
Value : jp.co.juicebot.jb7
-----
Key   : jim@juicebot.co.jp
Sig   : ok
Name  : date
Value : 2004-10-26T02:53:08
-----
Key   : jim@juicebot.co.jp
Sig   : ok
Name  : author
Value : jim@juicebot.co.jp
-----
Key   : jim@juicebot.co.jp
Sig   : ok
Name  : changelog
Value : initial checkin of project
```

The output of this command has a block for each cert found. Each block has 4 significant pieces of information. The first indicates the signer of the cert, in this case `jim@juicebot.co.jp`. The second indicates whether this cert is “ok”, meaning whether the RSA signature provided is correct for the cert data. The third is the cert name, and the fourth is the cert value. This list shows us that monotone has confirmed that, according to `jim@juicebot.co.jp`, the revision `2e24d49a48adf9acf3a1b6391a080008cbef9c21` is a member of the branch `jp.co.juicebot.jb7`, written by `jim@juicebot.co.jp`, with the given date and changelog.

It is important to keep in mind that revisions are not “in” or “out” of a branch in any global sense, nor are any of these cert values *true* or *false* in any global sense. Each cert indicates that *some person* – in this case Jim – would like to associate a revision with some value; it is up to you to decide if you want to accept that association.

Jim can now check the status of his branch using the “heads” command, which lists all the head revisions in the branch:

```
$ mtn heads  
branch 'jp.co.juicebot.jb7' is currently merged:  
2e24d49a48adf9acf3a1b6391a080008cbef9c21 jim@juicebot.co.jp 2004-10-26T02:53:08
```

The output of this command tells us that there is only one current “head” revision in the branch `jp.co.juicebot.jb7`, and it is the revision Jim just committed. A head revision is one without any descendants. Since Jim has not committed any changes to this revision yet, it has no descendants.

2.8 Basic Network Service

Jim now decides he will make his base revision available to his employees. To do this, he arranges for Abe and Beth to synchronise their databases with his, over the network. There are two pre-requisites for this: first, he has to get a copy of each of their public keys; then, he has to tell monotone that the holders of those keys are permitted to access his database. Finally, with these pre-requisites in place, he needs to tell monotone to provide network access to his database.

First, Abe exports his public key:

```
$ mtn --db=~/.abe.mtn pubkey abe@juicebot.co.jp >~/abe.pubkey
```

His public key is just a plain block of ASCII text:

```
$ cat ~/abe.pubkey
[pubkey abe@juicebot.co.jp]
MIGdMA0GCSqGSIb3DQEBAQUAA4GLADCBhwKBgQCbaVff9SF78FiB/1nUdmjbU/TtPyQqe/fW
CDg7hSg1yY/hWgC1XE9FI0bHtjPMIx1kB0ig09AkCT7tBXM9z6iGWxTBhSR7D/qsJQGPorOD
D07xovIHthMbZZ9FnyvB/BCyiibdWgGT0Gtq940KdvCRNuT59e5v9L4pBkvajb+IzQIBEQ==
[end]
```

Beth also exports her public key:

```
$ mtn --db=~/.beth.mtn pubkey beth@juicebot.co.jp >~/beth.pubkey
```

Then Abe and Beth both send their keys to Jim. The keys are not secret, but the team members must be relatively certain that they are exchanging keys with the person they intend to trust, and not some malicious person pretending to be a team member. Key exchange may involve sending keys over an encrypted medium, or meeting in person to exchange physical copies, or any number of techniques. All that matters, ultimately, is that Jim receives both Abe's and Beth's key in a way that he can be sure of.

So eventually, after key exchange, Jim has the public key files in his home directory. He tells monotone to read the associated key packets into his database:

```
$ cat ~/abe.pubkey ~/beth.pubkey | mtn --db=~/.jim.mtn read
mtn: read 2 packets
```

Now Jim's monotone is able to identify Beth and Abe, and he is ready to give them permission to access his database. He does this by editing a pair of small files in his '~/.monotone' directory:

```
$ cat >>~/monotone/read-permissions
pattern "*"
allow "abe@juicebot.co.jp"
allow "beth@juicebot.co.jp"
^D

$ cat >>~/monotone/write-permissions
abe@juicebot.co.jp
beth@juicebot.co.jp
^D
```

These files are read by the default monotone hooks that will decide whether remote monotone users will be allowed access to Jim's database, identified by the named keys.

Jim then makes sure that his TCP port 4691 is open to incoming connections, adjusting his firewall settings as necessary, and runs the monotone **serve** command:

```
$ mtn --db=jim.mtn serve
```

This command starts monotone listening on all network interfaces of his laptop on the default port 4691, serving everything in his database.

2.9 Synchronising Databases

With Jim's server preparations done, now Abe is ready to fetch Jim's code. To do this he issues the monotone `sync` command:

```
$ mtn --db=abe.mtn sync jim-laptop.juicebot.co.jp "jp.co.juicebot.jb7*"
mtn: setting default server to jim-laptop.juicebot.co.jp
mtn: setting default branch include pattern to 'jp.co.juicebot.jb7*'
mtn: setting default branch exclude pattern to ''
mtn: connecting to jim-laptop.juicebot.co.jp
mtn: first time connecting to server jim-laptop.juicebot.co.jp:4691
mtn: I'll assume it's really them, but you might want to double-check
mtn: their key's fingerprint: 9e9e9ef1d515ad58bfaa5cf282b4a872d8fda00c
mtn: warning: saving public key for jim@juicebot.co.jp to database
mtn: finding items to synchronize:
mtn: bytes in | bytes out | revs in | revs out | revs written
mtn:      2587 |      1025 |      1 |      0 |      1
mtn: successful exchange with jim-laptop.juicebot.co.jp
```

Abe now has, in his database, a copy of everything Jim put in the branch. Therefore Abe can disconnect from the expensive network connection he's on and work locally for a while. Remember that, in monotone, work is done between workspaces in the filesystem and the local database; network connectivity is necessary only when that work is to be shared with others.

As we follow the juicebot team through the next several steps, we'll see them run the `sync` command again with Jim, and work will flow both ways. The first time you `sync` a new database, monotone remembers the server and branch patterns you use, and makes them the default for future operations.

At the end of each exchange, information about all changes in the branch known to each database have been sent to the other party - including the work of the third team member that had previously been exchanged. As well as allowing each team member to learn about the others' work, this also means that each party's laptop contains a *backup* of the others' work too.

Jim, Abe and Beth will continue working like this while they're getting started, and we'll revisit the issue of network service with them a little later as the project grows.

2.10 Making Changes

Abe decides to do some work on his part of the code. He has a copy of Jim's database contents, but cannot edit any of that data yet. He begins his editing by checking out the head of the `jp.co.juicebot.jb7` branch into a workspace, so he can edit it:

```
$ mtn --db=abe.mtn --branch=jp.co.juicebot.jb7 checkout .
```

Monotone unpacks the set of files in the head revision's manifest directly into Abe's current directory. (If he had specified something other than `'.'` at the end, monotone would have created that directory and unpacked the files into it.) Abe then opens up one of the files, `'src/apple.c'`, and edits it:

```
$ vi src/apple.c
<Abe writes some apple-juice dispensing code>
```

The file `'src/apple.c'` has now been *changed*. Abe gets up to answer a phone call, and when he returns to his work he has forgotten what he changed. He can ask monotone for details:

```
$ mtn diff
#
# old_revision [2e24d49a48adf9acf3a1b6391a080008cbef9c21]
#
# patch "src/apple.c"
#   from [2650ffc660dd00a08b659b883b65a060cac7e560]
#     to [e2c418703c863eabe70f9bde988765406f885fd0]
#
=====
--- src/apple.c 2650ffc660dd00a08b659b883b65a060cac7e560
+++ src/apple.c e2c418703c863eabe70f9bde988765406f885fd0
@ -1,7 +1,10 @
#include "jb.h"

void
dispense_apple_juice()
{
- /* Fill this in please, Abe. */
+ spoutctl(APPLE_SPOUT, FLOW_JUICE, 1);
+ while (spoutctl(APPLE_SPOUT, POLL_JUICE, 1) == 0)
+   usleep (1000);
+ spoutctl(APPLE_SPOUT, FLOW_JUICE, 0);
}
```

Satisfied with his day's work, Abe decides to commit.

```
$ mtn commit
mtn: beginning commit on branch 'jp.co.juicebot.jb7'
```

Abe neglected to provide a `'--message'` option specifying the change log on the command line and the file `'_MTN/log'` is empty because he did not document his changes there. Monotone therefore invokes an external "log message editor" — typically an editor like `vi` — with an explanation of the changes being committed and the opportunity to enter a log message.

```

polling implementation of src/apple.c
MTN:
MTN: -----
MTN: Enter Log. Lines beginning with 'MTN:' are removed automatically
MTN:
MTN: format_version "1"
MTN:
MTN: new_manifest [b33cb337dccf21d6673f462d677a6010b60699d1]
MTN:
MTN: old_revision [2e24d49a48adf9acf3a1b6391a080008cbef9c21]
MTN:
MTN: patch "src/apple.c"
MTN: from [2650ffc660dd00a08b659b883b65a060cac7e560]
MTN: to [e2c418703c863eabe70f9bde988765406f885fd0]
MTN:
MTN: -----
MTN:

```

Abe enters a single line above the explanatory message, saying “polling implementation of src/apple.c”. He then saves the file and quits the editor. Monotone deletes all the lines beginning with “MTN:” and leaves only Abe’s short message. Returning to the shell, Abe’s commit completes:

```

mtn: committed revision 70dec4b31a8227a629c0e364495286c5c75f979

```

Abe then sends his new revision back to Jim:

```

$ mtn sync
mtn: connecting to jim-laptop.juicebot.co.jp
mtn: finding items to synchronize:
mtn:   certs |   keys | revisions
mtn:     8 |     2 |         2
mtn: bytes in | bytes out | revs in | revs out | revs written
mtn:   615 |   2822 |     0 |     1 |         0
mtn: successful exchange with jim-laptop.juicebot.co.jp

```

Beth does a similar sequence. First she syncs her database with Jim’s:

```

$ mtn --db=beth.mtn sync jim-laptop.juicebot.co.jp "jp.co.juicebot.jb7*"
mtn: setting default server to jim-laptop.juicebot.co.jp
mtn: setting default branch include pattern to 'jp.co.juicebot.jb7*'
mtn: setting default branch exclude pattern to ''
mtn: connecting to jim-laptop.juicebot.co.jp
mtn: first time connecting to server jim-laptop.juicebot.co.jp:4691
mtn: I'll assume it's really them, but you might want to double-check
mtn: their key's fingerprint: 9e9e9ef1d515ad58bfaa5cf282b4a872d8fda00c
mtn: warning: saving public key for jim@juicebot.co.jp to database
mtn: finding items to synchronize:
mtn: bytes in | bytes out | revs in | revs out | revs written
mtn:   4601 |   1239 |     2 |     0 |         1
mtn: verifying new revisions (this may take a while)
mtn: bytes in | bytes out | revs in | revs out | revs written
mtn:   4601 |   1285 |     2 |     0 |         2
mtn: successful exchange with jim-laptop.juicebot.co.jp

```

She checks out a copy of the tree from her database:

```

$ mtn --db=beth.mtn --branch=jp.co.juicebot.jb7 checkout .

```

She edits the file ‘src/banana.c’:

```

$ vi src/banana.c
<Beth writes some banana-juice dispensing code>

```

and logs her changes in ‘_MTN/log’ right away so she does not forget what she has done like Abe.

```
$ vi _MTN/log
* src/banana.c: Added polling implementation
```

Later, she commits her work. Monotone again invokes an external editor for her to edit her log message, but this time it fills in the messages she’s written so far, and she simply checks them over one last time before finishing her commit:

```
$ mtn commit
mtn: beginning commit on branch 'jp.co.juicebot.jb7'
mtn: committed revision 80ef9c9d251d39074d37e72abf4897e0bbae1cfb
```

And she syncs with Jim again:

```
$ mtn sync
mtn: connecting to jim-laptop.juicebot.co.jp
mtn: finding items to synchronize:
mtn:   certs |   keys | revisions
mtn:    12 |    3 |    3
mtn: bytes in | bytes out | revs in | revs out | revs written
mtn:    709 |    2879 |    0 |    1 |    0
mtn: successful exchange with jim-laptop.juicebot.co.jp
```

2.11 Dealing with a Fork

Careful readers will note that, in the previous section, the JuiceBot company’s work was perfectly serialized:

1. Jim did some work
2. Abe synced with Jim
3. Abe did some work
4. Abe synced with Jim
5. Beth synced with Jim
6. Beth did some work
7. Beth synced with Jim

The result of this ordering is that Jim’s work entirely preceded Abe’s work, which entirely preceded Beth’s work. Moreover, each worker was fully informed of the “up-stream” worker’s actions, and produced purely derivative, “down-stream” work:

1. Jim made revision 2e24d...
2. Abe changed revision 2e24d... into revision 70dec...
3. Beth derived revision 70dec... into revision 80ef9...

This is a simple, but sadly unrealistic, ordering of events. In real companies or work groups, people often work in parallel, *diverging* from commonly known revisions and *merging* their work together, sometime after each unit of work is complete.

Monotone supports this diverge/merge style of operation naturally; any time two revisions diverge from a common parent revision, we say that the revision graph has a *fork* in it. Forks can happen at any time, and require no coordination between workers. In fact any interleaving of the previous events would work equally well; with one exception: if forks were produced, someone would eventually have to run the `merge` command, and possibly resolve any conflicts in the fork.

To illustrate this, we return to our workers Beth and Abe. Suppose Jim sends out an email saying that the current polling juice dispensers use too much CPU time, and must be rewritten to use the JuiceBot’s interrupt system. Beth wakes up first and begins working immediately, basing her work off the revision 80ef9... which is currently in her workspace:

```
$ vi src/banana.c
<Beth changes her banana-juice dispenser to use interrupts>
```

Beth finishes and examines her changes:

```
$ mtn diff
#
# old_revision [80ef9c9d251d39074d37e72abf4897e0bbae1cfb]
#
# patch "src/banana.c"
# from [7381d6b3adfdaf16dc0fdb05e0f2d1873e3132a]
# to [5e6622cf5c8805bcbd50921ce7db86dad40f2ec6]
#
=====
--- src/banana.c 7381d6b3adfdaf16dc0fdb05e0f2d1873e3132a
+++ src/banana.c 5e6622cf5c8805bcbd50921ce7db86dad40f2ec6
@ -1,10 +1,15 @
#include "jb.h"

+static void
+shut_off_banana()
+{
+  spoutctl(BANANA_SPOUT, SET_INTR, 0);
+  spoutctl(BANANA_SPOUT, FLOW_JUICE, 0);
+}
+
+void
-dispense_banana_juice()
+dispense_banana_juice()
+{
+  spoutctl(BANANA_SPOUT, SET_INTR, &shut_off_banana);
+  spoutctl(BANANA_SPOUT, FLOW_JUICE, 1);
+  while (spoutctl(BANANA_SPOUT, POLL_JUICE, 1) == 0)
+    usleep (1000);
+  spoutctl(BANANA_SPOUT, FLOW_JUICE, 0);
+}
```

She commits her work:

```
$ mtn commit --message="interrupt implementation of src/banana.c"
mtn: beginning commit on branch 'jp.co.juicebot.jb7'
mtn: committed revision 8b41b5399a564494993063287a737d26ede3dee4
```

And she syncs with Jim:

```
$ mtn sync
```

Unfortunately, before Beth managed to sync with Jim, Abe had woken up and implemented a similar interrupt-based apple juice dispenser, but his workspace is 70dec..., which is still “upstream” of Beth’s.

```
$ vi apple.c
<Abe changes his apple-juice dispenser to use interrupts>
```

Thus when Abe commits, he unknowingly creates a fork:

```
$ mtn commit --message="interrupt implementation of src/apple.c"
```

Abe does not see the fork yet; Abe has not actually seen *any* of Beth’s work yet, because he has not synchronized with Jim. Since he has new work to contribute, however, he now syncs:

```
$ mtn sync
```

Now Jim and Abe will be aware of the fork. Jim sees it when he sits down at his desk and asks monotone for the current set of heads of the branch:


```
$ mtn heads
mtn: branch 'jp.co.juicebot.jb7' is currently unmerged:
39969614e5a14316c7ffefc588771f491c709152 abe@juicebot.co.jp 2004-10-26T02:53:16
8b41b5399a564494993063287a737d26ede3dee4 beth@juicebot.co.jp 2004-10-26T02:53:15
```

Clearly there are two heads to the branch: it contains an un-merged fork. Beth will not yet know about the fork, but in this case it doesn't matter: anyone can merge the fork, and since there are no conflicts Jim does so himself:

```
$ mtn merge
mtn: starting with revision 1 / 2
mtn: merging with revision 2 / 2
mtn: [source] 39969614e5a14316c7ffefc588771f491c709152
mtn: [source] 8b41b5399a564494993063287a737d26ede3dee4
mtn: common ancestor 70dec4b31a8227a629c0e364495286c5c75f979 abe@juicebot.co.jp 2004-10-26T02:50:01 found
mtn: trying 3-way merge
mtn: [merged] da499b9d9465a0e003a4c6b2909102ef98bf4e6d
mtn: your workspaces have not been updated
```

The output of this command shows Jim that two heads were found, combined via a 3-way merge with their ancestor, and saved to a new revision. This happened automatically, because the changes between the common ancestor and heads did not conflict. If there had been a conflict, monotone would have invoked an external merging tool to help resolve it.

After merging, the branch has a single head again, and Jim updates his workspace.

```
$ mtn update
mtn: selected update target da499b9d9465a0e003a4c6b2909102ef98bf4e6d
mtn: updating src/apple.c to f088e24beb43ab1468d7243e36ce214a559bdc96
mtn: updating src/banana.c to 5e6622cf5c8805bcd50921ce7db86dad40f2ec6
mtn: updated to base revision da499b9d9465a0e003a4c6b2909102ef98bf4e6d
```

The update command selected an update target — in this case the newly merged head — and performed an in-memory merge between Jim's workspace and the chosen target. The result was then written to Jim's workspace. If Jim's workspace had any uncommitted changes in it, they would have been merged with the update in exactly the same manner as the merge of multiple committed heads.

Monotone makes very little distinction between a “pre-commit” merge (an update) and a “post-commit” merge. Both sorts of merge use the exact same algorithm. The major difference concerns the recoverability of the pre-merge state: if you commit your work first, and merge after committing, then even if the merge somehow fails (due to difficulty in a manual merge step, for instance), your committed state is still safe. If you update, on the other hand, you are requesting that monotone directly modify your workspace, and while monotone will try hard not to break anything, this process is inherently more open to error. It is therefore recommended that you commit your work *first*, before merging.

If you have previously used another version control system, this may at first seem surprising; there are some systems where you are *required* to update, and risk the above problems, before you can commit. Monotone, however, was designed with this problem in mind, and thus *always* allows you to commit before merging. A good rule of thumb is to only use **update** in workspaces with no local modifications, or when you actually want to work against a different base revision (perhaps because finishing your change turns out to require some fixes made in another revision, or because you discover that you have accidentally started working against a revision that contains unrelated bugs, and need to back out to a working revision for testing).

2.12 Branching and Merging

So by now you're familiar with making changes, sharing them with other people, and integrating your changes with their changes. Sometimes, though, you may want to make some changes, and *not* integrate them with other people's — or at least not right away. One way to do this would be to simply never run `mtn merge`; but it would quickly become confusing to try and keep track of which changes were in which revisions. This is where *branches* are useful.

Continuing our example, suppose that Jim is so impressed by Beth's work on banana juice support that he assigns her to work on the JuiceBot 7's surprise new feature: muffins. In the mean time, Abe will continue working on the JuiceBot's basic juice-related functions.

The changes required to support muffins are somewhat complicated, and Beth is worried that her work might destabilize the program, and interfere with Abe's work. In fact, she isn't even sure her first attempt will turn out to be the right approach; she might work on it for a while and then decide it was a bad idea, and should be discarded. For all these reasons, she decides that she will work on a branch, and then once she is satisfied with the new code, she will merge back onto the mainline.

She decides that since main development is in branch `jp.co.juicebot.jb7`, she will use branch `jp.co.juicebot.jb7.muffins`. So, she makes the first few edits to the new muffins code, and commits it on a new branch by simply passing '`--branch`' to commit:

```
$ mtn commit --branch=jp.co.juicebot.jb7.muffins --message='autobake framework'
mtn: beginning commit on branch 'jp.co.juicebot.jb7.muffins'
mtn: committed revision d33caefd61823ecbb605c39ffb84705dec449857
```

That's all there is to it — there is now a `jp.co.juicebot.jb7.muffins` branch, with her initial checkin on it. She can make further checkins from the same workspace, and they will automatically go to the muffins branch; if anyone else wants to help her work on muffins, they can check out that branch as usual.

Of course, while Beth is working on the new muffins code, Abe is still making fixes to the main line. Occasionally, Beth wants to integrate his latest work into the muffins branch, so that her version doesn't fall too far behind. She does this by using the `propagate` command:

```
$ mtn propagate jp.co.juicebot.jb7 jp.co.juicebot.jb7.muffins
mtn: propagating jp.co.juicebot.jb7 -> jp.co.juicebot.jb7.muffins
mtn: [source] da003f115752ac6e4750b89aaca9dbba178ac80c
mtn: [target] d0e5c93bb61e5fd25a0dadf41426f209b73f40af
mtn: common ancestor 853b8c7ac5689181d4b958504adfb5d07fd959ab jim@juicebot.co.jp 2004-10-26T:12:44:23 found
mtn: trying 3-way merge
mtn: [merged] 89585b3c5e51a5a75f5d1a05dda859c5b7dde52f
```

The `propagate` merges all of the new changes on one branch onto another.

When the muffins code is eventually stable and ready to be integrated into the main line of development, she simply propagates the other way:

```
$ mtn propagate jp.co.juicebot.jb7.muffins jp.co.juicebot.jb7
mtn: propagating jp.co.juicebot.jb7.muffins -> jp.co.juicebot.jb7
mtn: [source] 4e48e2c9a3d2ca8a708cb0cc545700544efb5021
mtn: [target] bd29b2bfd07644ab370f50e0d68f26dcfd3bb4af
mtn: common ancestor 652b1035343281a0d2a5de79919f9a31a30c9028 jim@juicebot.co.jp 2004-10-26T:15:25:05 found
mtn: [merged] 03f7495b51cc70b76872ed019d19dee1b73e89b6
```

Monotone always records the full history of all merges, and is designed to handle an arbitrarily complicated graph of changes. You can make a branch, then branch off from that branch, propagate changes between arbitrary branches, and so on; monotone will track all of it, and do something sensible for each merge. Of course, it is still probably a good idea to come up with some organization of branches and a plan for which should be merged to which other ones. Monotone may keep track of graphs of arbitrary complexity — but you will have more trouble. Whatever arrangement of branches you come up with, though, monotone should be able to handle it.

If you are unsure of the name of a branch, you can list all branches using the `ls branches` command. This is very useful, but if you create a lot of branches then the list can become very long and unwieldy. To help this monotone has the `suspend` command which partially hides revisions/branches you are no longer using. Further commits on hidden branches will automatically unhide the branches.

For example, if Beth is now finished with the muffins branch, she can stop it from cluttering the list of branches by suspending the last revision in that branch:

```
$ mtn ls branches
jp.co.juicebot.jb7
jp.co.juicebot.jb7.muffins
$ mtn heads
mtn: branch 'jp.co.juicebot.jb7.muffins' is currently merged:
4e48e2c9a3d2ca8a708cb0cc545700544efb5021 beth@juicebot.co.jp 2007-07-08T02:17:37
$ mtn suspend 4e48e2c9a3d2ca8a708cb0cc545700544efb5021
$ mtn ls branches
jp.co.juicebot.jb7
```

2.13 Network Service Revisited

Up until now, Jim has been using his laptop and database as a sort of “central server” for the company; Abe and Beth have been syncing with Jim, and learning of each other’s work via Jim’s database. This has worked fine while the product has been in early development; Jim has good network connectivity in Japan, and has been staying home concentrating on programming. He has been able to leave his laptop connected and running all the time, while his employees in different time-zones work and sync their databases. This is now starting to change, and two problems are starting to cause occasional difficulties.

- First, Jim is finding that he has to spend more of his time travelling, demonstrating the new juicebot features to customers; thus his laptop is spending more time disconnected from the network, or connected at dynamic addresses where it’s not convenient for Abe and Beth to find him and sync.

This doesn’t prevent them doing any work, but it does have some uncomfortable consequences: they’re more likely to have to manually merge conflicting changes when they finally sync up and discover they’ve both come up with slightly different fixes for the same bug in the meantime, and they’re more exposed to loss of work if one of them suffers a disk failure before they’ve had a chance to sync that work with another database.

- Second, because Jim has been using the one database file both for his own local work, and for serving to the others in the team, he occasionally finds that the monotone serve process (busy syncing with Abe or Beth) has a lock on the database, while he’s trying to do local work like updates or commits.

The level of project activity is picking up, and there are more and more changes to be synced in the narrower window of time while Jim is connected. He finds he sometimes needs to take down the server process to do this local work, further exacerbating the first problem.

The juicebot team are resourceful, and by now quite used to working independently. While Jim has been away travelling, Abe and Beth have come up with their own solution to the first problem: they’ll run servers from their databases, setting them up just like Jim did previously. That way, if Jim’s database is offline, either Beth or Abe can run the `serve` command and provide access for the other to `sync` with. Beth also has the idea to create a second database for the `serve` process, and to `sync` her development database with that server locally, avoiding locking contention between multiple monotone processes on the one database file.

When Jim reappears, the next person to `sync` with him will often pass him information about both employees’ work that they’ve sync’ed with each other in the meantime, just as he used to do. In fact, Jim now finds it more convenient to initiate the sync with one of the other servers when he has a spare moment and dynamic connectivity from a hotel room or airport. Changes will flow between servers automatically as clients access them and trade with one another.

This gets them by for a while, but there are still occasional inconveniences. Abe and Beth live in very different time-zones, and don’t always have reliable network connectivity, so sometimes Jim finds that neither of them is online to sync with when he has the chance. Jim now also has several customers interested in beta-testing the new code, and following changes as the bugs and issues they report are addressed.

Jim decides it's time for a permanent server they can all sync with; this way, everyone always knows where to go to get the latest changes, and people can push their changes out without first calling their friends and making sure that they have their servers running.

Jim has rented some web server space on a service provider's shared system for the JuiceBot Inc. public website, `www.juicebot.co.jp`; he thinks this server will be a good place to host the central monotone server too. He sets up a new monotone database on the server, generates a new key specially for the server (so he doesn't have to expose his own development private key on the shared system), and loads in the team-members' keys:

```
$ mtn --db=server.mtn db init
$ mtn genkey monotone-server@www.juicebot.co.jp
mtn: generating key-pair 'monotone-server@www.juicebot.co.jp'
enter passphrase for key ID [monotone-server@www.juicebot.co.jp] : <Jim enters a new passphrase>
confirm passphrase for key ID [monotone-server@www.juicebot.co.jp]: <Jim confirms the passphrase>
mtn: storing key-pair 'monotone-server@www.juicebot.co.jp' in /home/jim/.monotone/keys
$ cat abe.pubkey beth.pubkey jim.pubkey | mtn --db=server.mtn read
mtn: read 3 packets
```

For the team members, he sets up the permissions files on the server much like before — except that of course he needs to also grant his `jim@juicebot.co.jp` key permission to access the new server. For the beta-testers, Jim wants to allow them read-only access just to the main JuiceBot 7 development line, but not to any of the sub-branches where other experimental development is going on. He adds some lines at the top of the `'~/monotone/read-permissions'` on the server, above the broader permissions given to team-members. See the [Chapter 6 \[Hook Reference\]](#), page 143 for `get_netsync_read_permitted` for more details; the resulting file looks like this:

```
comment "Provide beta-testers with specific read-only access"
pattern "jp.co.juicebot.jb7"
allow "beta1@juicebot.co.jp"
allow "beta2@juicebot.co.jp"
continue "true"

comment "Fall-through, and allow staff access to all branches"
pattern "*"
allow "abe@juicebot.co.jp"
allow "beth@juicebot.co.jp"
allow "jim@juicebot.co.jp"
```

Jim could log in and start the monotone process manually from his shell account on the server, perhaps under a program like `screen` to let it stay running while he's away. This would be one way of giving it the server-key's passphrase each startup, but he wants to make sure that the server is up all the time; if the host reboots while he's travelling and the monotone server is down until he next logs in, things aren't much better than before. For the server to start automatically each time, he'll need to use the `get_passphrase` hook in the server's `'monotonerc'` file again.

Because he's running on a shared server, Jim needs to be a little more restrictive about which interfaces and addresses his new server process will listen on. He should only accept connections at the address used for his website, because some of the provider's other customers might also want to publish their own monotone projects on this host. Jim uses the `'--bind=address:port'` argument like so:

```
$ mtn --db=server.mtn --bind=www.juicebot.co.jp serve
```

This will start monotone listening on the default port (4691), but only on the IP address associated with `www.juicebot.co.jp`. Jim can do this because his hosting provider has given him a dedicated IP address for his website. If the hosting provider offered only a single shared IP address belonging to the server, each customer could bind a different port number on that address.

While he's first testing the setup, Jim uses `--bind=localhost:1234`. This causes the monotone process to listen only to port 1234 on the loopback interface 127.0.0.1, which is not accessible from the network, so Jim doesn't expose an open port to the rest of the world until he's satisfied with the permissions configuration. You can cause monotone to listen on all interfaces on port 1234 by leaving out the address part like `--bind=:1234`.

When he's satisfied the server is set up correctly, Jim does an initial `sync` with the new database, filling it with all the revision history currently on his laptop. While Jim has been busy setting up the server, Abe and Beth have kept working; the server will catch up with their latest changes when they next `sync`, too.

All of the team members now want to `sync` with the new monotone server by default. Previously, they had been syncing with Jim's laptop by default, even if they occasionally specified another team-member's server on the command line when Jim was away, because monotone had remembered the first server and branch patterns used in database [Section 3.9 \[Vars\]](#), page 60. These vars can be seen as follows:

```
$ mtn list vars
database: default-exclude-pattern
database: default-include-pattern jp.co.juicebot.jb7*
database: default-server jim-laptop.juicebot.co.jp
known-servers: jim-laptop.juicebot.co.jp 9e9e9ef1d515ad58bfaa5cf282b4a872d8fda00c
known-servers: abe-laptop.juicebot.co.jp a2bb16a183247af4133621f7f5aefb21a9d13855
known-servers: www.juicebot.co.jp 120a99ch93b4f174432c13d3e3e9f2234aa92612
```

The team members can reset their local database vars accordingly:

```
$ mtn set database default-server www.juicebot.co.jp
```

With their new server, the juicebot team have gained the convenience of a readily available common point of reference for syncs. However, they also know that this is there only as a convenience, and doesn't prevent them working as they did before:

- The team members can still `sync` with each other if needed.
Hopefully, their new server won't ever be down, but sometimes they might be working together while away from ready network access — fixing up the last few issues and finalising presentation materials while travelling to a sales conference, for example. The server will learn of these changes on the next `sync`.
- The team members continue to discover multiple heads and changes that need merging, as before. Each team member can merge the heads, and will produce the same revision id if they merge to the same result.

They now develop a new habit out of courtesy, though — they try not to leave multiple heads and unmerged changes on the server, at least not for long. This saves them from repeating work, and also helps prevent confusion for the beta-testers. When each team member is ready to `sync`, they develop the habit of doing a `pull` from the server first. If new revisions were received from the server, they first `merge` their new revisions with the head(s) from the server, and finally `sync` to publish their merged changes as one. If the last `sync` happens to pull in new revisions again from the server, it means someone

else has deposited new work at the same time, and another `merge` and `sync` would probably be polite.

- Jim knows he doesn't have to keep a special backup of the new server's contents; if the server should fail, all the contents of its database can be found amongst the other team members (especially because no commits are done on the server itself).

He does, however, take a copy of the server's private key, so he can restore that if necessary.

- In fact, Jim realises that he can now commit a copy of the web site's current contents into monotone on a new branch, `jp.co.juicebot.www`, and keep a backup of that content too.

Now he can use monotone to work on the website offline, and let other team members add and edit the content; he can also preview changes locally before updating the production content. He keeps a workspace checkout of this content in the webroot on the server, and runs a monotone `update` in there when he wants to bring the public web site up to date. Later, he'll think about using monotone's [Section 3.8 \[Quality Assurance\]](#), [page 59](#) mechanisms and Event Notification [Section 6.1 \[Hooks\]](#), [page 144](#), so that the web server can update itself automatically when appropriate new revisions are received.

- Jim also knows that even if someone should break into the shared hosting server and tamper with the database, they won't be able to inject malicious code into the project, because all revisions are signed by the team members, and he has set his [\[Trust Evaluation Hooks\]](#), [page 152](#) so he doesn't trust the server key for signing revisions.

In monotone, the important trust consideration is on the *signed content*, rather than on the *replication path* by which that content arrived in your database.

3 Advanced Uses

This chapter covers slightly less common aspects of using monotone. Some users of monotone will find these helpful, though possibly not all. We assume that you have read through the taxonomy and tutorial, and possibly spent some time playing with the program to familiarize yourself with its operation.

3.1 Other Transports

Monotone’s database synchronization system is based on a protocol called `netsync`. By default, monotone transports this protocol over a plain TCP connection, but this is not the only transport monotone can use. It can also transport `netsync` through SSH, or any program which can provide a full-duplex connection over `stdio`.

When a monotone client initiates a push, pull, or sync operation, it parses the first command-line argument as a URI and calls a Lua hook to convert that URI into a *connection command*. If the Lua hook returns a connection command, monotone spawns the command locally and speaks `netsync` over a pipe connected to the command’s standard I/O handles.

If the Lua hook does not return a connection command, monotone attempts to parse the command-line argument as a TCP address – a hostname with an optional port number – connects a TCP socket the host and port, and speaks `netsync` over the socket.

By default, monotone understands two URI schemes:

1. SSH URIs, of the form `ssh://[user@]hostname[:port]/path/to/db.mtn`, to synchronize between private databases on hosts accessible only through SSH. (These paths are absolute; to refer to a path relative to a home directory, use `ssh://host-part/~relative/path.mtn` or `ssh://host-part/~user/relative/path.mtn`.)
2. File URIs, of the form `file:/path/to/db.mtn`, to synchronize between local databases.

In the case of SSH URIs, the `ssh` program must be in your command execution path, either `$PATH` on Unix-like systems or `%PATH%` on Windows systems. Monotone will execute `ssh` as a subprocess, running `mtn serve` on the other end of the SSH connection. You will need `mtn` to be in the command execution path of the remote shell environment.

In the case of File URIs, `mtn` is run locally, so must be in your command execution path.

In both cases, the database specified in the URI needs to exist already, and will be locked for the duration of the synchronization operation. Therefore, it must also be writable, even when monotone isn’t going to modify it, as it is the case for `pull`. Also note that monotone’s default transport authentication is *disabled* over these transports, to reduce the complexity of configuration and eliminate redundant protocol cost.

Additional URI schemes can be supported by customization of the Lua hooks `get_netsync_connect_command` and `use_transport_auth`. For details on these hooks, see [\[Netsync Transport Hooks\]](#), page 149.

3.2 Selectors

Revisions can be specified on the monotone command line, precisely, by entering the entire 40-character hexadecimal SHA1 code. This can be cumbersome, so monotone also allows a more general syntax called “selectors” which is less precise but more “human friendly”. Any command which expects a precise revision ID can also accept a selector in its place; in fact a revision ID is just a special type of selector which is very precise.

Simple examples

Some selector examples are helpful in clarifying the idea:

`a432` Revision IDs beginning with the string `a432`

`graydon@pobox.com/2004-04`

Revisions written by `graydon@pobox.com` in April 2004.

`"jrh@example.org/2 weeks ago"`

Revisions written by `jrh@example.org` 2 weeks ago.

`graydon/net.venge.monotone.win32/yesterday`

Revisions in the `net.venge.monotone.win32` branch, written by `graydon`, yesterday.

A moment’s examination reveals that these specifications are “fuzzy” and indeed may return multiple values, or may be ambiguous. When ambiguity arises, monotone will inform you that more detail is required, and list various possibilities. The precise specification of selectors follows.

Selectors in detail

A selector is a combination of a selector type, which is a single ASCII character, followed by a `:` character and a selector string. All selectors strings except for selector type `c` are just values. The value is matched against identifiers or certs, depending on its type, in an attempt to match a single revision. Selectors are matched as prefixes. The current set of selection types are:

Generic cert selector

Uses selector type `c`. The selector string has the syntax *name* or *name=value*. The former syntax will select any revision that has a cert with that name, regardless of value; the latter will match any revision that has a cert with that name and value. Values to match for can have shell wildcards. For example, `c:tag` matches all revisions that have a tag, and `c:tag=monotone-0.25` will match the revision tagged `monotone-0.25`. (See also the `t` selector below.)

Author selection

Uses selector type `a`. For example, `a:graydon` matches `author` certs where the cert value contains `graydon`.

Branch selection

Uses selector type `b`. For example, `b:net.venge.monotone` matches `branch` certs where the cert value is `net.venge.monotone`. Values to match for can have shell wildcards. If you give a bare `b`: monotone will require you to be in a workspace, and will use the branch value recorded in your `._MTN/options` file.

Heads selection

Uses selector type **h**. For example, **h:net.venge.monotone** matches **branch** certs where the cert value is **net.venge.monotone** and the associated revision is a head revision on that branch. Values to match for can have shell wildcards like the branch selector. If you give a bare **h:** monotone will require you to be in a workspace, and use the branch recorded in your `._MTN/options` file.

Date selection

Uses selector type **d**. For example, **d:2004-04** matches **date** certs where the cert value begins with **2004-04**. This selector also accepts expanded date syntax (see below).

"Earlier or equal than" selection

Uses selector type **e**. For example, **e:2004-04-25** matches **date** certs where the cert value is less or equal than **2004-04-25T00:00:00**. If the time component is unspecified, monotone will assume **00:00:00**. This selector also accepts expanded date syntax (see below)

"Later than" selection

Uses selector type **l**. For example, **l:2004-04-25** matches **date** certs where the cert value is strictly greater than **2004-04-25T00:00:00**. If the time component is unspecified, monotone will assume **00:00:00**. This selector also accepts expanded date syntax (see below)

Identifier selection

Uses selector type **i**. For example, **i:0f3a** matches revision IDs which begin with **0f3a**.

Parent selection

Uses selector type **p**. For example, **p:0f3a** matches the revision IDs which are the parent of the revision ID which begins with **0f3a**.

Tag selection

Uses selector type **t**. For example, **t:monotone-0.11** matches **tag** certs where the cert value begins with **monotone-0.11**. Values to match for can have shell wildcards.

Further selector types may be added in the future.

Composite selectors

Selectors may be combined with the `/` character. The combination acts as database intersection (or logical **and**). For example, the selector **a:graydon/d:2004-04** can be used to select a revision which has an **author** cert beginning with **graydon** *as well as* a **date** cert beginning with **2004-04**. The `/` character can be escaped using the `\` character if necessary.

Selector expansion

Before selectors are passed to the database, they are expanded using a Lua hook: **expand_selector**. The default definition of this hook attempts to guess a number of common forms for selection, allowing you to omit selector types in many cases. For example, the hook guesses that the typeless selector **jr@example.org** is an author selector, due to its

syntactic form, so modifies it to read `a:jrh@example.org`. This hook will generally assign a selector type to values which “look like” partial hex strings, email addresses, branch names, or date specifications. For the complete source code of the hook, see [Chapter 6 \[Hook Reference\]](#), page 143.

Expanding dates

All date-related selectors (`d`, `e`, `l`) support an English-like syntax similar to CVS. This syntax is expanded to the numeric format by a Lua hook: `expand_date`. The allowed date formats are:

- `now` Expands to the current date and time.
- `today` Expands to today’s date. `e` and `l` selectors assume time 00:00:00
- `yesterday` Expands to yesterday’s date. `e` and `l` selectors assume time 00:00:00
- `<number> {minute|hour} <ago>`
 Expands to today date and time, minus the specified **number** of minutes|hours.
- `<number> {day|week|month|year} <ago>`
 Expands to today date, minus the specified **number** of days|weeks|months|years. `e` and `l` selectors assume time 00:00:00
- `<year>-<month>[-day[Thour:minute:second]]`
 Expands to the supplied year/month. The day and time component are optional. If missing, `e` and `l` selectors assume the first day of month and time 00:00:00. The time component, if supplied, must be complete to the second.

For the complete source code of the hook, see [Chapter 6 \[Hook Reference\]](#), page 143.

Typeless selection

If, after expansion, a selector still has no type, it is matched as a special “unknown” selector type, which will match either a tag, an author, or a branch. This costs slightly more database access, but often permits simple selection using an author’s login name and a date. For example, the selector `graydon/net.venge.monotone.win32/yesterday` would pass through the selector `graydon` as an unknown selector; so long as there are no branches or tags beginning with the string `graydon` this is just as effective as specifying `a:graydon`.

3.3 Restrictions

Several monotone commands accept optional *pathname...* arguments in order to establish a “restriction”. Restrictions are used to limit the files and directories these commands examine for changes when comparing the workspace to the revision it is based on. Restricting a command to a specified set of files or directories simply ignores changes to files or directories not included by the restriction.

The following commands all support restrictions using optional *pathname...* arguments:

- `status`
- `diff`
- `revert`
- `commit`
- `list known`
- `list unknown`
- `list ignored`
- `list missing`
- `list changed`

Including either the old or new name of a renamed file or directory will cause both names to be included in a restriction. If in doubt, the `status` command can be used to “test” a set of pathnames to ensure that the expected files are included or excluded by a restriction.

Commands which support restrictions also support the ‘`--depth=n`’ option, where *n* specifies the maximum number of directories to descend. For example, *n*=0 disables recursion, *n*=1 means descend at most one directory, and so on.

The `update` command does not allow for updates to a restricted set of files, which may be slightly different than other version control systems. Partial updates don’t really make sense in monotone, as they would leave the workspace based on a revision that doesn’t exist in the database, starting an entirely new line of development.

Subdirectory restrictions

The restrictions facility also allows commands to operate from within a subdirectory of the workspace. By default, the *entire workspace* is always examined for changes. However, specifying an explicit `".` pathname to a command will restrict it to the current subdirectory. Note that this is quite different from other version control systems and may seem somewhat surprising.

The expectation is that requiring a single `".` to restrict to the current subdirectory should be simple to use. While the alternative, defaulting to restricting to the current subdirectory, would require a somewhat complicated `../..` sequence to remove the restriction and operate on the whole tree.

This default was chosen because monotone versions whole project trees and generally expects to commit all changes in the workspace as a single atomic unit. Other version control systems often version individual files or directories and may not support atomic commits at all.

When working from within a subdirectory of the workspace all paths specified to monotone commands must be relative to the current subdirectory.

Finding a workspace

Monotone only stores a single ‘_MTN’ directory at the root of a workspace. Because of this, a search is done to find the ‘_MTN’ directory in case a command is executed from within a subdirectory of a workspace. Before a command is executed, the search for a workspace directory is done by traversing parent directories until an ‘_MTN’ directory is found or the filesystem root is reached. Upon finding an ‘_MTN’ directory, the ‘_MTN/options’ file is read for default options. The ‘--root’ option may be used to stop the search early, before reaching the root of the physical filesystem.

Many monotone commands don’t require a workspace and will simply proceed with no default options if no ‘_MTN’ directory is found. However, some monotone commands do require a workspace and will fail if no ‘_MTN’ directory can be found.

The `checkout`, `clone` and `setup` commands create a *new workspace* and initialize a new ‘_MTN/options’ file based on their current option settings.

3.4 Scripting

People often want to write programs that call monotone — for example, to create a graphical interface to monotone’s functionality, or to automate some task. For most programs, if you want to do this sort of thing, you just call the command line interface, and do some sort of parsing of the output. Monotone’s output, however, is designed for humans: it’s localized, it tries to prompt the user with helpful information depending on their request, if it detects that something unusual is happening it may give different output in an attempt to make this clear to the user, and so on. As a result, it is not particularly suitable for programs to parse.

Rather than trying to design output to work for both humans and computers, and serving neither audience well, we elected to create a separate interface to make programmatically extracting information from monotone easier. The command line interface has a command **automate**; this command has subcommands that print various sorts of information on standard output, in simple, consistent, and easily parseable form.

For details of this interface, see [Section 5.9 \[Automation\]](#), page 102.

3.5 Inodeprints

Fairly often, in order to accomplish its job, monotone has to look at your workspace and figure out what has been changed in it since your last commit. Commands that do this include **status**, **diff**, **update**, **commit**, and others. There are two different techniques it can use to do this. The default, which is sufficient for most projects, is to simply read every file in the workspace, compute their SHA1 hash, and compare them to the hashes monotone has stored. This is very safe and reliable, and turns out to be fast enough for most projects. However, on very large projects, ones whose source trees are many megabytes in size, it can become unacceptably slow.

The other technique, known as *inodeprints*, is designed for this situation. When running in inodeprints mode, monotone does not read the whole workspace; rather, it keeps a cache of interesting information about each file (its size, its last modification time, and so on), and skips reading any file for which these values have not changed. This is inherently somewhat less safe, and, as mentioned above, unnecessary for most projects, so it is disabled by default.

If you do determine that it is necessary to use inodeprints with your project, it is simple to enable them. Simply run **mtn refresh_inodeprints**; this will enable inodeprints mode and generate an initial cache. If you ever wish to turn them off again, simply delete the file ‘**_MTN/inodeprints**’. You can at any time delete or truncate the ‘**_MTN/inodeprints**’ file; monotone uses it only as a cache and will continue to operate correctly.

Normally, instead of enabling this up on a per-workspace basis, you will want to simply define the **use_inodeprints** hook to return **true**; this will automatically enable inodeprints mode in any new workspaces you create. See [Chapter 6 \[Hook Reference\]](#), page 143 for details.

3.6 Merge Conflicts

Several different types of conflicts may be encountered when merging two revisions using the database merge commands `merge`, `explicit_merge`, `propagate` and `merge_into_dir` or when using the workspace merge commands `update`, `pluck` and `merge_into_workspace`. The `show_conflicts` command can be used to list conflicts between database revisions which would be encountered by the database merge commands. Unfortunately, this command can't yet list conflicts between a database revision and the current workspace revision which would be encountered by the workspace merge commands.

3.6.1 Conflict Types

Monotone versions both files and directories explicitly and it tracks individual file and directory identity from birth to death so that name changes throughout the full life-cycle can be tracked exactly. Partly because of these qualities, monotone also notices several types of conflicts that other version control systems may not.

The two most common conflicts are described first, then all other possible conflicts.

File Content Conflict

This type of conflict is generally the one encountered most commonly and represents conflicting changes made to lines of text within two versions of a single file.

Monotone does not generally use CVS style conflict markers for content conflicts. Instead it makes the content of both conflicting files and the content of their common ancestor available for use with your favorite merge tool. See the `merge3` hook for more information.

Alternatively, rather than using a merge tool it is possible to make further changes to one or both of the conflicting file versions so that they will merge cleanly. This can also be a very helpful strategy if the merge conflicts are due to sections of text in the file being moved from one location to another. Rather than struggling to merge such conflicting changes with a merge tool, similar rearrangements can be made to one of the conflicting files before redoing the merge.

Duplicate Name Conflict

A duplicate name conflict occurs when two distinct files or directories have been given the same name in the two merge parents. This can occur when each of the merge parents adds a new file or directory with the conflicting name, or when one parent adds a new file or directory with the conflicting name and the other renames an existing file or directory to the conflicting name, or when both parents rename an existing file or directory to the conflicting name.

In earlier versions of monotone (before version 0.39) this type of conflict was referred to as a *rename target conflict* although it doesn't necessarily have anything to do with renames.

There are two main situations in which duplicate name conflicts occur:

- Two people both realize a new file should be added, and commit it. In this case, the files have the right name and the right contents, but monotone reports a conflict because they were added separately.
- Two people each decide to add new files with different content, and accidentally pick the same name.

These conflicts are reported when someone tries to merge the two revisions containing the new files.

Same file

For the first case, the conflict is resolved by **dropping** one file. The contents should be manually merged first, in case they are slightly different. Typically, a user will have one of the files in their current workspace; the other can be retrieved via `automate get_file_of`; the revision id is shown in the merge error message. The process can be confusing; here's a detailed example.

Suppose Beth and Abe each commit a new file `'checkout.sh'`. When Beth attempts to merge the two heads, she gets a message like:

```
mtn: 2 heads on branch 'testbranch'
mtn: [left] ae94e6677b8e31692c67d98744dccf5fa9ccffe5
mtn: [right] dfdf50b19fb971f502671b0cfa6d15d69a0d04bb
mtn: conflict: duplicate name 'checkout.sh'
mtn: added as a new file on the left
mtn: added as a new file on the right
mtn: error: merge failed due to unresolved conflicts
```

The file labeled **right** is the file in Beth's workspace. To retrieve a copy of Abe's file, Beth executes:

```
mtn automate get_file_of checkout.sh \
--revision=ae94e6677b8e31692c67d98744dccf5fa9ccffe5 \
> checkout.sh-merge
```

Now Beth manually merges (using her favorite merge tool) `'checkout.sh'` and `'checkout.sh-merge'`, leaving the results in `'checkout.sh-merge'` (*not* in her copy).

Then Beth drops her copy, and commits that change:

```
mtn drop checkout.sh
mtn commit --message "resolving conflicting 'checkout.sh'"
```

Now Beth can merge the two heads, and update her workspace:

```
mtn merge
mtn update
```

This leaves a copy of Abe's original `'checkout.sh'`. Beth overwrites it with her merged version, and commits again:

```
rm checkout.sh
mv checkout.sh-merge checkout.sh
mtn commit --message "resolving conflicting 'checkout.sh' - done"
```

When Abe later syncs and updates, he will get the merged version.

Different files

The second case, where two different files accidentally have the same name, is resolved by renaming one or both of them.

Suppose Beth and Abe each start working on different thermostat models (say Honeywell and Westinghouse), but they both name the file `'thermostat'`. When Beth attempts to merge, she will get the same error message as in the first case. When she retrieves Abe's file, she will see that they should be different files. So she renames her file, merges, and updates:

```
mtn rename thermostat thermostat-honeywell
mtn merge
mtn update
```

Now she has her file in ‘`thermostat-honeywell`’, and Abe’s in ‘`thermostat`’. She may rename Abe’s file to ‘`thermostat-westinghouse`’, or ask Abe to do that.

If a project has a good file naming convention, this second case should be rare.

Missing Root Conflict

Monotone’s merge strategy is sometimes referred to as *die-die-die* merge, with reference to the fact that when a file or directory is deleted there is no means of resurrecting it. Merging the deletion of a file or directory will *always* result in that file or directory being deleted.

A missing root conflict occurs when some directory has been moved to the root directory in one of the merge parents and has been deleted in the other merge parent. Because of die-die-die merge the result will not contain the directory that has been moved to the root.

Missing root conflicts should be very rare because it is unlikely that a project’s root directory will change. It is even more unlikely that a project’s root directory will be changed to some other directory in one merge parent and that this directory will also be deleted in the other merge parent. Even still, a missing root directory conflict can be easily resolved by moving another directory to the root in the merge parent where the root directory was previously changed. Because of die-die-die merge, no change to resolve the conflict can be made to the merge parent that deleted the directory which was moved to the root in the other merge parent.

See the `pivot_root` command for more information on moving another directory to the project root.

Invalid Name Conflict

Monotone reserves the name ‘`_MTN`’ in a workspace root directory for internal use and treats this name as *illegal* for a versioned file or directory in the project root. This name is *legal* for a versioned file or directory as long as it is not in the project root directory.

An invalid name conflict occurs when some directory is moved to the project root in one of the merge parents and a file or directory that exists in this new root directory is renamed to ‘`_MTN`’ or a new file or directory is added with the name ‘`_MTN`’ to this directory in the other merge parent.

Invalid name conflicts should be very rare because it is unlikely that a project’s root directory will change. It is even more unlikely that a project’s root directory will change and the new root directory will contain a file or directory named ‘`_MTN`’. Even still, an invalid name conflict can be easily resolved in several different ways. A different root directory can be chosen, the offending ‘`_MTN`’ file or directory can be renamed or deleted, or it can be moved to some other subdirectory in the project.

See the `pivot_root` command for more information on moving another directory to the project root.

Directory Loop Conflict

A directory loop conflict occurs when one directory is moved under a second in one of the merge parents and the second directory is moved under the first in the other merge parent.

Directory loop conflicts should be rare but can be easily resolved by moving one of the conflicting directories out from under the other.

Orphaned Node Conflict

An orphaned node conflict occurs when a directory and all of its contents are deleted in one of the merge parents and further files or directories are added to this deleted directory, or renamed into it, in the other merge parent.

Orphaned node conflicts do happen occasionally but can be easily resolved by renaming the orphaned files or directories out of the directory that has been deleted and into another directory that exists in both merge parents, or that has been added in the revision containing the orphaned files or directories.

Multiple Name Conflict

A multiple name conflict occurs when a single file or directory has been renamed to two different names in the two merge parents. Monotone does not allow this and requires that each file and directory has exactly one unique name.

Multiple name conflicts do happen occasionally but can be easily resolved by renaming the conflicting file or directory in one or both of the merge parents so that both agree on the name.

In earlier versions of monotone (those before version 0.39) this type of conflict was referred to as a *name conflict*.

Attribute Conflict

An attribute conflict occurs when a versioned attribute on a file or directory is set to two different values by the two merge parents or if one of the merge parents changes the attribute's value and the other deletes the attribute entirely.

Attribute conflicts may happen occasionally but can be easily resolved by ensuring that the attribute is set to the same value or is deleted in both of the merge parents. Attributes are *not* merged using the die-die-die rules and may be resurrected by simply setting their values.

3.6.2 Conflict Resolution

Resolving the different types of conflicts is accomplished by checking out one of the conflicting revisions, making changes as described above, committing these changes as a new revision and then running the merge again using this new revision as one of the merge parents. This process can be repeated as necessary to get two revisions into a state where they will merge cleanly, or with a minimum of file content conflicts.

3.7 Workspace Collisions

Sometimes when you work on a project, several people make similar changes in parallel. When these changes occur in an existing file that is known to both sides, monotone can merge the edits when the two revisions meet (possibly after getting help to resolve content conflicts). Other kinds of changes cannot be merged so readily, especially ones that involve files in your workspace that are not tracked by monotone.

Workspace collisions can happen for many reasons; some examples include:

- You have a file in your workspace that is unknown to monotone (you have not **added** it). Someone else has **added** and **committed** a different file with the same name. If you try to **update** your workspace to their revision, the added file in the incoming revision will collide with your file over use of the name.
- There is a directory which contains both versioned and unversioned files (perhaps versioned sources, and unversioned object files built from the sources). Someone else **commits** a revision that **drops** the versioned files *and* the containing directory. If you try to **update** to this revision, your directory will still contain the untracked files, and therefore cannot be deleted.
- You have an unversioned file in your workspace, and you're trying to **update** to a revision that **adds** a directory with the same name.

These examples describe collisions on **update**; the same kinds of things can happen with other commands that can bring changes into your workspace, such as **checkout** or **pluck** too.

Monotone is careful to avoid hitting such collisions. Before changing the workspace, it will try and detect the possibility of collisions, and the command will fail, warning you about the names that collide. The file content in the database is safe and can be recovered at any time, so monotone is conservative and will refuse to destroy the information in your workspace contents.

However, monotone cannot detect all kinds of failures and collisions in your workspace. For example:

- On some systems with case-insensitive and/or internationalised filesystems, names that look distinct to monotone may in fact be considered the same by the underlying platform.
- If some other program is creating files in the workspace at the same time as monotone, the colliding file might be created after the collision check at the start.
- Other kinds of unpredictable system errors, like permissions problems or disk full conditions, might cause failures when monotone is rearranging the workspace content.

These are all hopefully very rare occurrences. If such a filesystem error *does* cause a failure part-way during a workspace alteration, monotone will stop immediately rather than risk potentially doing further damage, and your workspace may be left in an incomplete state. If this happens, you will need to resolve the issue and clean up the workspace manually. If you need to do so, understanding how monotone manipulates the workspace is helpful.

When monotone applies renaming changes to the workspace, each file is first *detached* from the workspace under its old name, then *attached* under the new name. This is done

by moving it to the ‘_MTN/**detached**’ directory. Newly added files are created here before being moved into place, too. While inside ‘_MTN/**detached**’, the file or directory is named as a simple integer (these numbers come from monotone’s internal identification of the node). If the detached node is a directory, the directory is moved with all of its contents (including unversioned files); this can help identify which directory has been detached.

If a previous workspace alteration failed part-way, the ‘_MTN/**detached**’ directory will still exist, and monotone will refuse to attempt another alteration while the workspace is in this inconsistent state. This also acts as a lock against multiple monotone processes performing workspace alterations (but not other programs).

The best way to avoid a messy recovery from such a failure is simply to ensure that you always **commit** before trying to **update** (or **pluck**, etc) other changes from the database into your workspace. This ensures that your current workspace contents are safely stored, and can be retrieved later (such as with **revert**).

3.8 Quality Assurance

Monotone was constructed to serve both as a version control tool and as a quality assurance tool. The quality assurance features permit users to ignore, or “filter out”, versions which do not meet their criteria for quality. This section describes the way monotone represents and reasons about quality information.

Monotone often views the collection of revisions as a directed graph, in which revisions are the nodes and changes between revisions are the edges. We call this the *revision graph*. The revision graph has a number of important subgraphs, many of which overlap. For example, each branch is a subgraph of the revision graph, containing only the nodes carrying a particular **branch** cert.

Many of monotone’s operations involve searching the revision graph for the ancestors or descendants of a particular revision, or extracting the “heads” of a subgraph, which is the subgraph’s set of nodes with no descendants. For example, when you run the **update** command, monotone searches the subgraph consisting of descendants of the base revision of the current workspace, trying to locate a unique head to update the base revision to.

Monotone’s quality assurance mechanisms are mostly based on restricting the subgraph each command operates on. There are two methods used to restrict the subgraph:

- By restricting the set of trusted **branch** certificates, you can require that specific code reviewers have approved of each edge in the subgraph you focus on.
- By restricting the set of trusted **testresult** certificates, you can require that the *end-points* of an update operation have a certificate asserting that the revision in question passed a certain test, or testsuite.

The evaluation of trust is done on a cert-by-cert basis by calling a set of Lua hooks: `get_revision_cert_trust`, `get_manifest_cert_trust` and `get_file_cert_trust`. These hooks are only called when a cert has at least one good signature from a known key, and are passed *all* the keys which have signed the cert, as well as the cert’s ID, name and value. The hook can then evaluate the set of signers, as a group, and decide whether to grant or deny trust to the assertion made by the cert.

The evaluation of testresults is controlled by the `accept_testresult_change` hook. This hook is called when selecting update candidates, and is passed a pair of tables describing the **testresult** certs present on the source and proposed destination of an update. Only if the change in test results are deemed “acceptable” does monotone actually select an update target to merge into your workspace.

For details on these hooks, see the [Chapter 6 \[Hook Reference\]](#), page 143.

3.9 Vars

Every monotone database has a set of *vars* associated with it. Vars are simple configuration variables that monotone refers to in some circumstances; they are used for configuration that monotone needs to be able to modify itself, and that should be per-database (rather than per-user or per-workspace, both of which are supported by ‘`monotonerc`’ scripts). Vars are local to a database, and never transferred by netsync.

A var is a *name = value* pairing inside a *domain*. Domains define what the vars inside it are used for; for instance, one domain might contain database-global settings, and particular vars inside it would define things like that database’s default netsync server. Another domain might contain key fingerprints for servers that monotone has interacted with in the past, to detect man-in-the-middle attacks; the vars inside this domain would map server names to their fingerprints.

You can set vars with the `set` command, delete them with the `unset` command, and see them with the `ls vars` command. See the documentation for these specific commands for more details.

Existing vars

There are several pre-defined domains that monotone knows about:

database Contains database-global configuration information. Defined names are:

default-exclude-pattern

The default branch exclusion glob pattern for netsync operations to use. Automatically set by first use of netsync, and by any netsync that uses the ‘`--set-default`’ option.

default-include-pattern

The default branch glob pattern for netsync operations to use. Automatically set by first use of netsync, and by any netsync that uses the ‘`--set-default`’ option.

default-server

The default server for netsync operations to use. Automatically set by first use of netsync, and by any netsync that uses the ‘`--set-default`’ option.

known-servers

Contains key hashes for servers that we have netsynced with in the past. Analogous to `ssh`’s ‘`known_hosts`’ file, this is needed to detect man-in-the-middle attacks. Automatically set the first time you netsync with any given server. If that server’s key later changes, monotone will notice, and refuse to connect until you have run `mtn unset known-servers server-name`.

3.10 Reserved Files

A monotone workspace consists of control files and non-control files. Each type of file can be versioned or non-versioned. These classifications lead to four groups of files:

- versioned control files
- non-versioned control files
- versioned non-control files
- non-versioned non-control files

Control files contain special content formatted for use by monotone. Versioned files are recorded in a monotone database and have their state tracked as they are modified.

If a control file is versioned, it is considered *part of* the state of the workspace, and will be recorded as a manifest entry. If a control file is not versioned, it is used to *manage* the state of the workspace, but it not considered an intrinsic part of it.

Most files you manage with monotone will be versioned non-control files. For example, if you keep source code or documents in a monotone database, they are versioned non-control files. Non-versioned, non-control files in your workspace are generally temporary or junk files, such as backups made by editors or object files made by compilers. Such files are ignored by monotone.

Identifying control files

Control files are identified by their names. Non-control files can have any name *except* the names reserved for control files. The names of control files follow a regular pattern:

Versioned control files

Any file name beginning with `‘.mtn-’`

Non-versioned control files

Any file in the directory `‘_MTN/’`

The general intention is that versioned control files are things that you may want to edit directly. In comparison, you should never have to edit non-versioned control files directly; monotone should do that for you whenever it is appropriate. However, both are documented here, just in case a situation arises where you need to go “under the hood”.

Existing control files

The following control files are currently used. More control files may be added in the future, but they will follow the patterns given above.

`‘.mtn-ignore’`

Contains a list of regular expression patterns, one per line. If it exists, any file with a name matching one of these patterns is ignored. See [Section 7.5 \[Regexps\]](#), page 187, for the syntax of these regular expressions.

`‘_MTN/wanted-testresults’`

Contains a list of testresult key names, one per line. If it exists, update will only select revisions that do not have regressions according to the given testresult keys.

`‘_MTN/revision’`

Contains the identity of the “base” revision of the workspace, and a list of additions, deletions, and renames which have occurred in the current workspace, relative to that version.

Every workspace has a base revision, which is the revision that was originally checked out to create that workspace. When the workspace is committed, the base revision is considered to be the ancestor of the committed revision.

`‘_MTN/options’`

Contains “sticky” command-line options such as `‘--db’` or `‘--branch’`, such that you do not need to enter them repeatedly after checking out a particular workspace.

`‘_MTN/log’`

Contains log messages to append to the “changelog” cert upon commit. The user may add content to this file while they work. Upon a successful commit monotone will empty the file making it ready for the next edit/commit cycle.

`‘_MTN/inodeprints’`

If this file exists, monotone considers the directory to be in [Section 3.5 \[Inodeprints\]](#), [page 52](#) mode, and uses this file to cache the inodeprints.

`‘_MTN/debug’`

If monotone detects a bug in itself or crashes, then before exiting it dumps a log of its recent activity to this file, to aid in debugging.

3.11 Reserved Certs

Every certificate has a name. Some names have meaning which is built in to monotone, others may be used for customization by a particular user, site, or community. If you wish to define custom certificates, you should prefix such certificate names with **x-**. For example, if you want to make a certificate describing the existence of security vulnerabilities in a revision, you might wish to create a certificate called **x-vulnerability**. Monotone reserves all names which do not begin with **x-** for possible internal use. If an **x-** certificate becomes widely used, monotone will likely adopt it as a reserved cert name and standardize its semantics.

Most reserved certificate names have no meaning yet; some do. Usually monotone is also responsible for *generating* many of these certs as part of normal operation, such as during a **commit**. Others will be added explicitly via other commands, like **tag** or **approve**.

As well as carrying other information, certs (and combinations of certs) are useful for identifying revisions with [Section 3.2 \[Selectors\]](#), [page 47](#); in particular, this is the primary purpose of the **tag** cert.

The pre-defined, reserved certificate names are:

| | |
|------------------|--|
| author | This cert's value is the name of a person who committed the revision the cert is attached to. The cert is generated when you commit a revision. It is displayed by the log command. |
| branch | This cert's value is the name of a branch. A branch cert associates a revision with a branch. The revision is said to be "in the branch" named by the cert. The cert is generated when you commit a revision, either directly with the commit command or indirectly with the merge or propagate commands. The branch certs are read and directly interpreted by <i>many</i> monotone commands, and play a fundamental role in organizing work in any monotone database. |
| changelog | This cert's value is the change log message you provide when you commit a revision. It is displayed by the log command. |
| comment | This cert's value is an additional comment, usually provided after committing, about a revision. Certs with the name comment will be shown together with changelog certs by the log command. |
| date | This cert's value is an ISO date string indicating the time at which a revision was committed. It is displayed by the log command, and may be used as an additional heuristic or selection criterion in other commands in the future. |
| suspend | This cert's value is the name of a branch (see the branch cert). This cert is generated by the suspend command. A suspended revision is removed from the list of head revisions of a branch in most cases. A branch with all its heads suspended will not appear in the list of branches. Suspended revisions can still have children, and those children are in no way affected by the suspend cert on their parent. |
| tag | This cert's value is a symbolic name given to a revision, which may be used as a way of selecting the revision by name for later commands like checkout , log or diff . |

testresult

This cert's value is interpreted as a boolean string, either 0 or 1. It is generated by the **testresult** command and represents the results of running a particular test on the underlying revision. Typically you will make a separate signing key for each test you intend to run on revisions. This cert influences the **update** algorithm.

3.12 Naming Conventions

Some names in monotone are private to your work, such as filenames. Other names are potentially visible outside your project, such as RSA key identifiers or branch names. It is possible that if you choose such names carelessly, you will choose a name which someone else in the world is using, and subsequently you may cause confusion when your work and theirs is received simultaneously by some third party.

We therefore recommend two naming conventions:

- For RSA keys, use the name of an active email address you own. This will minimize conflicts, and also serves as a mnemonic to associate your personal *identity* with signatures made with your key. For example, monotone’s primary author uses the key identifier `graydon@pobox.com`.
- For branch names, select any name you like but prefix it with the “inverted domain name” of a DNS domain you control or are otherwise authorized to use. This behavior mimics the package naming convention in the java programming language. For example, monotone itself is developed within the `net.venge.monotone` branch, because the author owns the DNS domain `venge.net`.

3.13 File Attributes

Monotone contains a support for storing *persistent attributes* on files and directories, generally known as *attrs* for short. An attr associates a simple name/value pair with a file or directory, and is stored in the manifest. Attrs are first-class versioned data; they can be changed in a workspace, and those changes will be saved when the workspace is committed. The merger knows how to intelligently merge attrs.

The attribute mechanism was originally motivated by the fact that some people like to store executable programs in version control systems, and would like the programs to remain executable when they check out a workspace. For example, the `configure` shell script commonly shipped with many programs should be executable. Similarly, some people would like to store devices, symbolic links, read-only files, and all manner of extra attributes of a file, not directly related to a file's data content.

Monotone comes with support for some attrs built-in; for instance, if an executable file is given to `mtn add`, then it will automatically mark the new file with a `mtn:execute` attr, and when the file is checked out later, the executable bit will be set automatically. (Of course, if it is checked out on Windows, which does not support the executable bit, then the executable bit will not be set. However, monotone will still know that the attr is set, and Windows users can view and modify the attr like anyone else.)

Attrs in the current workspace can be seen and modified using the `mtn attr` command; see [Section 5.2 \[Workspace\]](#), page 81. Attrs can also be found by examining any manifest directly.

You can tell monotone to automatically take actions based on these attributes by defining hooks; see the `attr_functions` entry in [Chapter 6 \[Hook Reference\]](#), page 143. Every time your workspace is written to, monotone will run the corresponding hooks registered for each attr in your workspace. This way, you can extend the vocabulary of attrs understood by monotone simply by writing new hooks.

You can make up your own attrs for anything you find useful; the mechanism is fully general. (If you make up some particularly useful ones, we may even be interested in adding support to monotone proper.) We only ask that if you do use custom attrs, you use some prefix for them besides `mtn:`; attrs beginning with `mtn:` are reserved for monotone's own use.

3.14 Merging

Monotone has two merging modes, controlled by the `manual_merge` attribute. By default all files are merged in automatic mode, unless the `manual_merge` attribute for that file is present and `true`. In automatic mode files are merged without user intervention, using monotone's internal three-way merging algorithm. Only if there are conflicts or an ancestor is not available monotone switches to manual mode, essentially escalating the merging to the user. When working in manual mode, monotone invokes the `merge3` hook to start an user defined external merge tool. If the tool terminates without writing the merged file, monotone aborts the merging, reverting any changes made. By redefining the aforementioned hooks the user can not only choose a preferred merge tool, but even select different programs for different file types. For example, gimp for .png files, OpenOffice.org for .doc, and so on. Starting with monotone 0.20, the `manual_merge` attribute is automatically set at add time for all “binary” files, i.e. all files for which the `binary_file` hook returns true. Currently, this means all files with extension gif, jpeg, png, bz2, gz and zip, plus files containing at least one of the following bytes:

```
0x00 thru 0x06
0x0E thru 0x1a
0x1c thru 0x1f
```

The attribute could also be manually forced or removed using the appropriate monotone commands. Remember that monotone switches to manual merging even if only one of the files to be merged has the `manual_merge` attribute set.

3.15 Migrating and Dumping

While the state of your database is logically captured in terms of a packet stream, it is sometimes necessary or desirable (especially while monotone is still in active development) to modify the SQL table layout or storage parameters of your version database, or to make backup copies of your database in plain text. These issues are not properly addressed by generating packet streams: instead, you must use *migration* or *dumping* commands.

The `mtn db migrate` command is used to alter the SQL schema of a database. The schema of a monotone database is identified by a special hash of its generating SQL, which is stored in the database's auxiliary tables. Each version of monotone knows which schema version it is able to work with, and it will refuse to operate on databases with different schemas. When you run the `migrate` command, monotone looks in an internal list of SQL logic which can be used to perform in-place upgrades. It applies entries from this list, in order, attempting to change the database it *has* into the database it *wants*. Each step of this migration is checked to ensure no errors occurred and the resulting schema hashes to the intended value. The migration is attempted inside a transaction, so if it fails — for example if the result of migration hashes to an unexpected value — the migration is aborted.

If more drastic changes to the underlying database are made, such as changing the page size of SQLite, or if you simply want to keep a plain text version of your database on hand, the `mtn db dump` command can produce a plain ASCII SQL statement which generates the state of your database. This dump can later be reloaded using the `mtn db load` command.

Note that when reloading a dumped database, the schema of the dumped database is *included* in the dump, so you should not try to `init` your database before a `load`.

3.16 Importing from CVS

Monotone is capable of reading CVS files directly and importing them into a database. This feature is still somewhat immature, but moderately large “real world” CVS trees on the order of 1GB have successfully been imported.

Note however that the machine requirements for CVS trees of this size are not trivial: it can take several hours on a modern system to reconstruct the history of such a tree and calculate the millions of cryptographic certificates involved. We recommend experimenting with smaller trees first, to get a feel for the import process.

We will assume certain values for this example which will differ in your case:

- Your domain name, `example.net` in this example.
- Your key name, `import@example.net` in this example.
- Your project name, `wobbler` in this example.
- Your database name, ‘`test.mtn`’ in this example.
- Your CVS repository path, ‘`/usr/local/cvsroot`’ in this example.
- The CVS module name for your project, `wobbler` in this example.

Accounting for these differences at your site, the following is an example procedure for importing a CVS repository “from scratch”, and checking the resulting head version of the import out into a workspace:

```
$ mtn --db=test.mtn db init
$ mtn --db=test.mtn genkey import@example.net
$ mtn --db=test.mtn --branch=net.example.wobbler cvs_import /usr/local/cvsroot/wobbler
$ mtn --db=test.mtn --branch=net.example.wobbler checkout wobbler-checkout
```

3.17 Using packets

Suppose you made changes to your database, and want to send those changes to someone else but for some reason you cannot use netsync. Or maybe you want to extract and inject individual revisions automatically via an external program. In this case, you can convert the information into packets. Packets are a convenient way to represent revisions and other database contents as plain text with wrapped lines – just what you need if you want to send them in the body of an email.

This is a tutorial on how to transfer single revisions between databases by dumping them from one database to a text file and then reading the dump into a second database.

We will create two databases, A and B, then create a few revisions in A, and transfer part of them to B.

First we initialize the databases:

```
$ mtn -d A db init
$ mtn -d B db init
```

Now set up a branch in A:

```
$ mtn -d A setup -b test test
```

And let's put some revisions in that branch:

```
$ cd test/
$ cat > file
xyz
^D
$ mtn add file
$ mtn ci -m "One"      You may need to select a key and type a passphrase here
$ cat > file2
file 2 getting in
^D
$ cat > file
ERASE
^D
$ mtn add file2
$ mtn ci -m "Two"
$ cat > file
THIRD
^D
$ mtn ci -m "Three"
```

OK, that's enough. Let's see what we have:

```
$ cd ..
$ mtn -d A automate select i: | mtn -d A automate toposort -
a423db0ad651c74e41ab2529eca6f17513ccf714
d14e89582ad9030e1eb62f563c8721be02ca0b65
151f1fb125f19ebe11eb8bfe3a5798fcbea4e736
```

Three revisions! Let's transfer the first one to the database B. First we get the meta-information on that revision:

```
$ mtn -d A automate get_revision a423db0ad651c74e41ab2529eca6f17513ccf714
format_version "1"

new_manifest [b6dbdbbe0e7f41e44d9b72f9fe29b1f1a4f47f18]

old_revision []

add_dir ""

add_file "file"
content [8714e0ef31edb00e33683f575274379955b3526c]
```

OK, one file was added in this revision. We'll transfer it. Now, *ORDER MATTERS!* We should transfer:

1. The file data (fdata) and file deltas (fdeltas), if any
2. The release data (rdata)
3. The certs

In that order. This is because certs make reference to release data, and release data makes reference to file data and file deltas.

```
mtn -d A automate packet_for_fdata 8714e0ef31edb00e33683f575274379955b3526c > PACKETS
mtn -d A automate packet_for_rdata a423db0ad651c74e41ab2529eca6f17513ccf714 >> PACKETS
mtn -d A automate packets_for_certs a423db0ad651c74e41ab2529eca6f17513ccf714 >> PACKETS
mtn -d B read < PACKETS
```

This revision (a423db0ad651c74e41ab2529eca6f17513ccf714) was already sent to database B. You may want to check the PACKETS file to see what the packets look like.

Now let's transfer one more revision:

```
mtn -d A automate get_revision d14e89582ad9030e1eb62f563c8721be02ca0b65
format_version "1"

new_manifest [48a03530005d46ed9c31c8f83ad96c4fa22b8b28]

old_revision [a423db0ad651c74e41ab2529eca6f17513ccf714]

add_file "file2"
content [d2178687226560032947c1deacb39d16a16ea5c6]

patch "file"
from [8714e0ef31edb00e33683f575274379955b3526c]
to [8b52d96d4fab6c1e56d6364b0a2673f4111b228e]
```

From what we see, in this revision we have one new file and one patch, so we do the same we did before for them:

```
mtn -d A automate packet_for_fdata d2178687226560032947c1deacb39d16a16ea5c6 > PACKETS2
mtn -d A automate packet_for_fdelta 8714e0ef31edb00e33683f575274379955b3526c 8b52d96d4fab6c1e56d6364b0a26 >> PACKETS2
mtn -d A automate packet_for_rdata d14e89582ad9030e1eb62f563c8721be02ca0b65 >> PACKETS2
mtn -d A automate packets_for_certs d14e89582ad9030e1eb62f563c8721be02ca0b65 >> PACKETS2
mtn -d B read < PACKETS2
```

Fine. The two revisions should be in the second database now. Let's take a look at what's in each database:

```
$ mtn -d A automate select i: | mtn -d A automate toposort -
a423db0ad651c74e41ab2529eca6f17513ccf714
d14e89582ad9030e1eb62f563c8721be02ca0b65
151f1fb125f19ebe11eb8bfe3a5798fcbea4e736
```

```
$ mtn -d B automate select i: | mtn -d B automate toposort -
a423db0ad651c74e41ab2529eca6f17513ccf714
d14e89582ad9030e1eb62f563c8721be02ca0b65
```

Good! B has the two first revisions (as expected), and A has all three. However, a checkout of that branch on B will not work, because the certificate signatures cannot be verified. We need to transfer the signatures too (suppose the key used had the ID "johndoe@domain.com"):

```
mtn -d A pubkey johndoe@domain.com > KEY_PACKETS
mtn -d B read < KEY_PACKETS
```

Done.

```
$ mtn -d B co -b test test-B
$ ls test-B
file2 _MTN x
$ more test-B/file2
file 2 getting in
```

And that's it! The revisions were successfully transferred.

4 CVS Phrasebook

This chapter translates common CVS commands into monotone commands. It is an easy alternative to reading through the complete command reference.

Checking Out a Tree

```
$ CVSROOT=:pserver:cvcs.foo.com/wobbler $ mtn pull www.foo.com com.foo.wobbler*
$ cvs -d $CVSROOT checkout -r 1.2      $ mtn checkout --revision=fe37 wobbler
```

The CVS command contacts a network server, retrieves a revision, and stores it in your workspace. There are two cosmetic differences with the monotone command: remote databases are specified by hostnames and globs, and revisions are denoted by SHA1 values (or selectors).

There is also one deep difference: pulling revisions into your database is a separate step from checking out a single revision; after you have pulled from a network server, your database will contain *several* revisions, possibly the entire history of a project. Checking out is a separate step, after communication, which only copies a particular revision out of your database and into a named directory.

Committing Changes

```
$ cvs commit -m "log message"          $ mtn commit --message="log message"
$ mtn push www.foo.com com.foo.wobbler*
```

As with other networking commands, the communication step with monotone is explicit: committing changes only saves them to the local database. A separate command, **push**, sends the changes to a remote database.

Undoing Changes

```
$ cvs update -C file                   $ mtn revert file
```

Unlike CVS, monotone includes a separate **revert** command for undoing local changes and restoring the workspace to the original contents of the base revision. Because this can be dangerous, **revert** insists on an explicit argument to name the files or directories to be reverted; use the current directory `"."` at the top of the workspace to revert everything. The **revert** command is also used to restore deleted files (with a convenient `'--missing'` option for naming these files).

In CVS, you would need to use **update** to restore missing or changed files, and you might get back a newer version of the file than you started with. In monotone, **revert** always takes you back to where you started, and the **update** command is only used to move the workspace to a different (usually newer) base revision.

Incorporating New Changes

```
$ cvs update -d                       $ mtn pull www.foo.com com.foo.wobbler*
$ mtn merge
$ mtn update
```

This command, like other networking commands, involves a separate communication step with monotone. The extra command, **merge**, ensures that the branch you are working on has a unique head. You can omit the **merge** step if you only want **update** to examine descendants of your base revision, and ignore other heads on your branch.

Tagging Revisions

```
$ cvs tag FOO_TAG .                $ mtn tag h: FOO_TAG
```

With CVS, tags are placed on individual files, and the closest thing to identifying a consistent repository-wide revision is a set of files with the same tag. In monotone, all changes are part of a repository-wide revision, and some of those revisions may be tagged. Monotone has no partial tags that apply only to a subset of files.

Moving Workspace to Another Revision

```
$ cvs update -r FOO_TAG -d          $ mtn update -r 830ac1a5f033825ab364f911608ec294fe37f7bc
$ mtn update -r t:FOO_TAG
```

With a revision parameter, the **update** command operates similarly in monotone and CVS. One difference is that a subsequent **commit** will be based off the chosen revision in monotone, while a **commit** in the CVS case is not possible without going back to the branch head again. This version of **update** can thus be very useful if, for example, you discover that the tree you are working against is somehow broken — you can **update** to an older non-broken version, and continue to work normally while waiting for the tree to be fixed.

Viewing Differences

```
$ cvs diff                          $ mtn diff

$ cvs diff -r 1.2 -r 1.4 myfile     $ mtn diff -r 3e7db -r 278df myfile
```

Monotone's **diff** command is modeled on that of CVS, so the main features are the same: **diff** alone prints the differences between your workspace and its base revision, whereas **diff** accompanied by two revision numbers prints the difference between those two revisions. The major difference between CVS and monotone here is that monotone's revision numbers are *revision IDs*, rather than file IDs. If one leaves off the file argument, then **diff** can print the difference between two entire trees.

Showing Workspace Status

```
$ cvs status                        $ mtn status
```

This command operates similarly in monotone and CVS. The only major difference is that monotone's **status** command always gives a status of the whole tree, and outputs a more compact summary than CVS.

Adding Directories and Files to Workspace

```
$ cvs add dir                                $ mtn add dir/subdir/file.txt
$ cvs add dir/subdir
$ cvs add dir/subdir/file.txt
```

Monotone does not explicitly store directories, so adding a file only involves adding the file's complete path, including any directories. Directories are created as needed, and empty directories are ignored.

Removing Directories and Files from Workspace

```
$ rm file.txt                                $ mtn drop file.txt
$ cvs remove file.txt
```

Monotone does not require that you erase a file from the workspace before you drop it. Dropping a file both removes its entry in the manifest of the current revision and removes it from the filesystem.

Viewing History

```
$ cvs log [file]                             $ mtn log [file]
```

Unlike CVS log, monotone log can also be used without a workspace; but in this case you must pass a ‘--from’ revision argument to tell monotone where to start displaying the log from.

Importing a New Project

```
$ cvs import wobbler vendor start
$ mtn --db=/path/to/database.mtn -
  -branch=com.foo.wobbler setup .
$ mtn add .
$ mtn commit
```

The `setup` command turns an ordinary directory into a monotone workspace. After that, you can add your files and commit them as usual.

Initializing a Repository

```
$ cvs init -d /path/to/repository    $ mtn db init --db=/path/to/database.mtn
```

Monotone's “repository” is a single-file database, which is created and initialized by this command. This file is only ever used by you, and does not need to be in any special location, or readable by other users.

5 Command Reference

Monotone has a large number of commands. To help navigate through them all, commands are grouped into logical categories.

5.1 Tree

```
mtn cat path
```

```
mtn cat --revision=id path
```

Write the contents of a specific file *path* to standard output.

Without a ‘`--revision`’ argument, the command outputs the contents of *path* as found in the current revision. This requires the command be executed from within a workspace.

With an explicit ‘`--revision`’ argument, the command outputs contents of *path* at that revision.

```
mtn checkout --revision=id directory
```

```
mtn co --revision=id directory
```

```
mtn --branch=branchname checkout directory
```

```
mtn --branch=branchname co directory
```

These commands copy a revision *id* out of your database, recording the chosen revision (the *base revision*) in the file ‘*directory*/_MTN/revision’. These commands then copy every file version listed in the revision’s manifest to paths under *directory*. For example, if the revision’s manifest contains these entries:

```
dir ""

    file "Makefile"
    content [84e2c30a2571bd627918deee1e6613d34e64a29e]

    file "include/hello.h"
    content [c61af2e67eb9b81e46357bb3c409a9a53a7cdfc6]

    file "src/hello.c"
    content [97dfc6fd4f486df95868d85b4b81197014ae2a84]
```

Then the following files are created:

```
directory/
directory/Makefile
directory/include/hello.h
directory/src/hello.c
```

If you wish to `checkout` in the current directory, you can supply the special name ‘.’ (a single period) for *directory*. When running `checkout` into an existing directory, it is sometimes possible for [Section 3.7 \[Workspace Collisions\]](#), [page 57](#) to occur.

If no *id* is provided, as in the latter two commands, you *must* provide a *branchname*; monotone will attempt to infer *id* as the unique head of *branchname* if it exists.

```
mtn clone --branch=branchname address directory
```

The clone command is a helper command that performs the roles of a number of other commands all at once. Firstly, it constructs a new database. It then populates this database by pulling any data in the branch *branchname* from the remote database, *address*. Finally, it copies the files out of the newly created database into a local directory, just as `checkout` would. The created database is placed in the new workspace as ‘*directory*/_MTN/mtn.db’.

mtn disapprove *id*

This command records a disapproval of the changes between *id*'s ancestor and *id*. It does this by committing the *inverse* changes as a new revision descending from *id*. The new revision will show up as a new head and thus a subsequent **merge** will incorporate the inverse of the disapproved changes in the other head(s).

Conceptually, **disapproves** contract is that **disapprove**(A) gives a revision B such that whenever B is merged with a descendant D of A the merge will result in what D “would have looked like” if A had never happened.

Note that as a consequence of this contract the **disapprove** command only works if *id* has exactly one ancestor, since it hasn't been worked out how to generate such a descendant in the multi-ancestor case.

mtn heads --branch=*branchname*

This command lists the “heads” of *branchname*.

The “heads” of a branch is the set of revisions which are members of the branch, but which have no descendants. These revisions are generally the “newest” revisions committed by you or your colleagues, at least in terms of ancestry. The heads of a branch may not be the newest revisions, in terms of time, but synchronization of computer clocks is not reliable, so monotone usually ignores time.

mtn merge [--branch=*branchname*]

This command merges the “heads” of *branchname*, if there are multiple heads, and commits the results to the database, marking the resulting merged revision as a member of *branchname*. The merged revision will contain each of the head revision IDs as ancestors.

Merging is performed by repeated pairwise merges: two heads are selected, then their least common ancestor is located in the ancestry graph and these 3 revisions are provided to the built-in 3-way merge algorithm. The process then repeats for each additional head, using the result of each previous merge as an input to the next.

mtn propagate *sourcebranch destbranch*

This command takes a unique head from *sourcebranch* and merges it with a unique head of *destbranch*, using the least common ancestor of the two heads for a 3-way merge. The resulting revision is committed to *destbranch*. If either *sourcebranch* or *destbranch* has multiple heads, **propagate** aborts, doing nothing.

The purpose of **propagate** is to copy all the changes on *sourcebranch*, since the last **propagate**, to *destbranch*. This command supports the idea of making separate branches for medium-length development activities, such as maintenance branches for stable software releases, trivial bug fix branches, public contribution branches, or branches devoted to the development of a single module within a larger project.

mtn explicit_merge *id id destbranch*

This command merges exactly the two *ids* you give it, and places the result in branch *destbranch*. It is useful when you need more control over the merging

process than `propagate` or `merge` give you. For instance, if you have a branch with three heads, and you only want to merge two of them, you can use this command. Or if you have a branch with two heads, and you want to propagate one of them to another branch, again, you can use this command.

```
mtn merge_into_dir sourcebranch destbranch dir
```

This command takes a unique head from *sourcebranch* and merges it into a unique head of *destbranch*, as a directory. The resulting revision is committed to *destbranch*. If either *sourcebranch* or *destbranch* has multiple heads, `merge_into_dir` aborts, doing nothing.

The purpose of `merge_into_dir` is to permit a project to contain another project in such a way that `propagate` can be used to keep the contained project up-to-date. It is meant to replace the use of nested checkouts in many circumstances.

Note that `merge_into_dir` *does not* permit changes made to the contained project in *destbranch* to be propagated back to *sourcebranch*. Attempting this would lead to *sourcebranch* containing both projects nested as in *destbranch* instead of only the project originally in *sourcebranch*, which is almost certainly not what would be intended.

```
mtn import --branch=branch [--message=message] [--dry-run] dir
```

```
mtn import --revision=revision [--message=message] [--dry-run] dir
```

This command imports the contents of the given directory and commits it to the head of the given branch or as a child of the given revision (and consequently into the branch that revision resides in).

If the given branch doesn't exist, it is created automatically. If the branch already exists, any missing files are dropped and any unknown files are added before committing.

If `--dry-run` is given, no commit is done.

5.2 Workspace

`mtn setup [directory]`

This command prepares *directory* as a monotone workspace, by creating and populating the ‘_MTN’ directory with basic information. This information must include at least the branch and the database to be used, both of which will be placed in the ‘_MTN/options’ file.

This can be used with an empty directory to start a new blank project, or within an existing directory full of files, prior to using `mtn commit`. If no directory is specified, the current directory is used.

`mtn add pathname...`

`mtn add --unknown`

This command places “add” entries for the paths specified in *pathname...* in the workspace’s “work list”. The work list of your workspace is stored in ‘_MTN/revision’, and is a list of explicit pathname changes you wish to commit at some future time, such as addition, removal or renaming of files.

As a convenience, the ‘--unknown’ option can be used; this option will cause all of the files listed by `mtn list unknown` to be added.

While this command places an “add” entry on your work list, it does not immediately affect your database. When you `commit` your workspace, monotone will use the work list to build a new revision, which it will then commit to the database. The new revision will have any added entries inserted in its manifest.

`mtn [--no-respect-ignore] mkdir directory...`

This command creates a directory in the filesystem relative to your current location and adds it to your workspace’s “work list”. The changes are not reflected in your database until such time as you perform a commit. If you use the ‘--no-respect-ignore’ flag, entries in `.mtn-ignore` will not be honored.

`mtn [--bookkeep-only] drop pathname...`

`mtn drop --missing`

This command places “drop” entries for the paths specified in *pathname...* in the workspace’s “work list” and deletes the file from the workspace. The work list of your workspace is stored in ‘_MTN/revision’, and is a list of explicit pathname changes you wish to commit at some future time, such as addition, removal, or renaming of files. This command also removes any attributes on *pathname*; see [Section 3.13 \[File Attributes\]](#), page 66 for more details. If you use the ‘--missing’ flag it will add drop entries for any paths that monotone is tracking for which you have already removed the files from the filesystem, in addition to all those specified in *pathname...*

While this command places a “drop” entry on your work list, it does not immediately affect your database. When you `commit` your workspace, monotone will use the work list to build a new revision, which it will then commit to the database. The new revision will have any dropped entries removed from its manifest.

There are situations in which `drop` will tell monotone to remove the file from the revision at commit time, but where it will *not* to remove the file from the

workspace immediately. One is if the ‘--bookkeep-only’ option is supplied. Another is if a file has un-committed changes or if a directory is not empty.

```
mtn [--bookkeep-only] rename src dst
mtn [--bookkeep-only] mv src dst
mtn [--bookkeep-only] rename src1 ... dst/
mtn [--bookkeep-only] mv src1 ... dst/
```

This command places “rename” entries for the paths specified in *src* and *dst* in the workspace’s “work list”. The second form renames a number of source paths to the given destination. The work list of your workspace is stored in ‘_MTN/revision’, and is a list of explicit pathname changes you wish to commit at some future time, such as addition, removal, or renaming of files. This command also moves any attributes on *src* to *dst*; see [Section 3.13 \[File Attributes\]](#), [page 66](#) for more details, and, unless the ‘--bookkeep-only’ option is supplied, it will rename the files immediately in the filesystem. In the case where *dst* must be a directory (multiple *src* items), exists physically in the filesystem as a directory or is specified as a directory by convention (a trailing /), it will be automatically added to the workspace if it is not already versioned.

```
mtn commit
mtn ci
mtn commit --message=logmsg [--message=logmsg...]
mtn ci --message=logmsg [--message=logmsg...]
mtn commit --message-file=logfile
mtn ci --message-file=logfile
mtn commit pathname...
mtn ci pathname...
mtn commit --message=logmsg [--message=logmsg...] pathname...
mtn ci --message=logmsg [--message=logmsg...] pathname...
mtn commit --message-file=logfile pathname...
mtn ci --message-file=logfile pathname...
```

This command looks at your workspace, decides which files have changed, and saves the changes to your database. It does this by loading the revision named in ‘_MTN/revision’, locating the base manifest for your workspace, applying any pathname changes described in ‘_MTN/revision’, and then comparing the updated base manifest to the files it finds in your workspace, to determine which files have been edited.

For each edited file, a delta is copied into the database. Then the newly constructed manifest is recorded (as a delta) and finally the new revision. Once all these objects are recorded in you database, `commit` updates ‘_MTN/revision’ to indicate that the base revision is now the newly created revision, and that there are no pathname changes to apply.

Specifying pathnames to `commit` restricts the set of changes that are visible and results in only a partial commit of the workspace. Changes to files not included in the specified set of pathnames will be ignored and will remain in the workspace until they are included in a future commit. With a partial commit, only the relevant entries in ‘_MTN/revision’ will be removed and other entries will remain for future commits.

From within a subdirectory of the workspace the `commit` command will, by default, include *all changes* in the workspace. Specifying only the pathname `"."` will restrict `commit` to files changed within the current subdirectory of the workspace.

The `--message` and `--message-file` options are mutually exclusive. Both provide a *logmsg* describing the commit. `--message-file` actually specifies the name of the file containing the log message, while `--message` provides it directly.

Multiple `--message` options may be provided on the command line. The log message will be formed by concatenating the `--message` options provided, with each one starting at the beginning of a new line.

The `_MTN/log` file can be edited by the user during their daily work to record the changes made to the workspace. When running the `commit` command without a *logmsg* supplied, the contents of the `_MTN/log` file will be read and passed to the Lua hook `edit_comment` as a second parameter named *user_log_content*. The log message will be prepended with a 'magic' string that must be removed to confirm the commit. This allows the user to easily cancel a commit, without emptying the entire log message. If the commit is successful, the `_MTN/log` file is cleared of all content making it ready for another edit/commit cycle.

If a `--branch` option is specified, the `commit` command commits to this branch (creating it if necessary). The branch becomes the new default branch of the workspace.

The `commit` command also synthesizes a number of certificates, which it attaches to the new manifest version and copies into your database:

- An **author** cert, indicating the person responsible for the changes leading to the new revision. Normally this defaults to your signing key or the return value of the `get_author` hook; you may override this by passing the `--author` option to `commit`. This is useful when committing a patch on behalf of someone else, or when importing "by hand" from another version control system.
- A **branch** cert, indicating the branch the committed revision belongs to.
- A **date** cert, indicating when the new revision was created. Normally this defaults to the current time; you may override this by passing the `--date` option to `commit`. This is useful when importing "by hand" from another version control system.
- A **changelog** cert, containing the "log message" for these changes. If you provided *logmsg* on the command line, this text will be used, otherwise `commit` will run the Lua hook `edit_comment (commentary, user_log_content)`, which typically invokes an external editor program, in which you can compose and/or review your log message for the change.

```
mtn revert pathname...
```

```
mtn revert --missing pathname...
```

This command changes your workspace, so that changes you have made since the last checkout or update are discarded. The command is restricted the set of files or directories given as arguments. To revert the entire workspace, use

revert "." in the top-level directory. Specifying "." in a subdirectory will restrict **revert** to files changed within the current subdirectory.

If the flag '**--missing**' is given it reverts (ie, restores) any files which monotone has listed in its manifest, but which have been deleted from the workspace. Only missing files matching the given file or directory arguments are reverted.

mtn update

mtn update --revision=revision

Without a '**--revision**' argument, this command incorporates "recent" changes found in your database into your workspace. It does this by performing 3 separate stages. If any of these stages fails, the update aborts, doing nothing. The stages are:

- Examine the ancestry graph of revisions in your database, and (subject to trust evaluation) select the set of all descendants of your workspace's base revision. Call this set the "candidates" of the update.
- Remove any candidates which lack acceptable testresult certificates. From the remaining candidates, select the deepest child by ancestry and call it the "target" of the update.
- Merge the target of the update with the workspace, in memory, and if the merge is successful, write the result over top of the workspace.

With an explicit '**--revision**' argument, the command uses that revision as the update target instead of finding an acceptable candidate.

The effect is always to take whatever changes you have made in the workspace, and to "transpose" them onto a new revision, using monotone's 3-way merge algorithm to achieve good results. Note that with the explicit '**--revision**' argument, it is possible to update "backwards" or "sideways" in history — for example, reverting to an earlier revision, or if your branch has two heads, updating to the other. In all cases, the end result will be whatever revision you specified, with your local changes (and only your local changes) applied.

If a '**--branch**' option is specified, the **update** command tries to select the revision to update to from this branch. The branch becomes the new default branch of the workspace (even if you also specify an explicit '**--revision**' argument).

When running **update**, it is sometimes possible for [Section 3.7 \[Workspace Collisions\]](#), page 57 to occur.

mtn pluck --revision=to

mtn pluck --revision=from --revision=to

This command takes changes made at any point in history, and attempts to edit your current workspace to include those changes. The end result is identical to running **mtn diff -r from -r to | patch -p0**, except that this command uses monotone's merger, and thus intelligently handles renames, conflicts, and so on.

If only one revision is given, applies the changes made in *to* as compared with *to*'s parent. If two revisions are given, applies the changes made to get from *from* to *to*.

Note that this is not a true cherry-pick operation. A true cherry-pick, as that word is used in version control theory, involves applying some changes out of context, and then recording the identity between the original changes and the newly applied changes for the use of later merges. This command does the first part, not the second. As far as monotone is concerned, the changes made by `mtn pluck` are exactly like those made in an editor; the command is simply a convenient way to make certain edits quickly. In practice, this is rarely a problem. `mtn pluck` should almost always be used between branches that will never be merged — for instance, backporting fixes from a development branch to a stable branch.

When you use `pluck` you are going behind monotone's back, and reducing its ability to help you keep track of what has happened in your history. Never use `pluck` where a true merging command like `merge`, `propagate`, or `explicit_merge` will do. If you find yourself using `pluck` often, you should consider carefully whether there is any way to change your workflow to reduce your need for plucking.

When running `pluck`, it is sometimes possible for [Section 3.7 \[Workspace Collisions\]](#), page 57 to occur.

`mtn refresh_inodeprints`

This command puts the current workspace into [Section 3.5 \[Inodeprints\]](#), page 52 mode, if it was not already, and forces a full inodeprints cache refresh. After running this command, you are guaranteed that your workspace is in inodeprints mode, and that the inodeprints cache is accurate and up to date.

`mtn pivot_root [--bookkeep-only] pivot_root new_root put_old`

Most users will never need this command. It is primarily useful in certain tricky cases where one wishes to combine several projects into one, or split one project into several. See also `merge_into_dir`.

Its effect is to rename the directory whose name is currently `new_root` to become the root directory of the versioned tree, and to at the same time rename the directory that is currently the root of the versioned tree to have the name `put_old`. Conceptually, it is equivalent to executing the following commands in the root of the workspace:

```
$ mtn rename . new_root/put_old
$ mtn rename new_root .
```

Except, of course, that these `rename` commands are illegal, because after the first command the tree has no root at all, and there is a directory loop. This illegality is the only reason for `pivot_root`'s existence; internally, the result is treated exactly like two renames, including with respect to merges and updates.

The use of `'--bookkeep-only'` with this command is not recommended. It causes the changes to be made in monotone's records, but not in the filesystem itself.

When running `pivot_root`, it is sometimes possible for [Section 3.7 \[Workspace Collisions\]](#), page 57 to occur.

5.3 Network

```

mtn serve [--bind=[address][:port]]
mtn serve --stdio [--no-transport-auth]
mtn pull [--set-default] [uri-or-address] [glob [...]]
    [--exclude=exclude-glob]]]
mtn push [--set-default] [uri-or-address] [glob [...]]
    [--exclude=exclude-glob]]]
mtn sync [--set-default] [uri-or-address] [glob [...]]
    [--exclude=exclude-glob]]]

```

These commands operate the “netsync” protocol built into monotone. This is a custom protocol for rapidly synchronizing two monotone databases using a hash tree index. The protocol is “peer to peer”, but requires one peer to listen for incoming connections (the server) and the other peer (the client) to connect to the server. When run with ‘`--stdio`’, the server listens for a single connection then terminates. When run with ‘`--bind`’, or with neither option, the server listens for TCP connections and serves them continuously, until it is shut down.

The network *address* given to **serve** as an argument to ‘`--bind`’ should be a host name to listen on, optionally followed by a colon and a port number. The default port number is 4691. If no ‘`--bind`’ option is given, the server listens on port 4691 of every network interface.

If **serve** is run with ‘`--stdio`’, a single netsync session is served over the **stdin** and **stdout** file descriptors. If ‘`--no-transport-auth`’ is provided along with ‘`--stdio`’, transport authentication and access control mechanisms are disabled. Only use ‘`--no-transport-auth`’ if you are certain that the transport channel in use already provides sufficient authentication and authorization facilities.

The *uri-or-address* arguments given to **push**, **pull**, and **sync** can be of two possible forms. If the argument is a URI, a Lua hook may transform the URI into a connection command, and execute the command as a transport channel for netsync. If the argument is a simple hostname (with optional port number), monotone will use a TCP socket to the specified host and port as a transport channel for netsync.

The *glob* parameters indicate a set of branches to exchange. Multiple *glob* and ‘`--exclude`’ options can be specified; every branch which matches a *glob* exactly, and does not match an *exclude-glob*, will be indexed and made available for synchronization.

For example, perhaps Bob and Alice wish to synchronize their **net.venge.monotone.win32** and **net.venge.monotone.i18n** branches. Supposing Alice’s computer has hostname **alice.someisp.com**, then Alice might run:

```
$ mtn --bind=alice.someisp.com serve
```

And Bob might run

```
$ mtn sync alice.someisp.com "net.venge.monotone*"
```

When the operation completes, all branches matching `net.venge.monotone*` will be synchronized between Alice and Bob's databases.

The `pull`, `push`, and `sync` commands only require you pass *address* and *glob* the first time you use one of them; monotone will memorize this use and in the future default to the same server and glob. For instance, if Bob wants to `sync` with Alice again, he can simply run:

```
$ mtn sync
```

Of course, he can still `sync` with other people and other branches by passing an address or address plus globs on the command line; this will not affect his default affinity for Alice. If you ever do want to change your defaults, simply pass the `--set-default` option when connecting to the server and branch pattern that you want to make the new default.

In the server, different permissions can be applied to each branch; see the hooks `get_netsync_read_permitted` and `get_netsync_write_permitted` (see [Chapter 6 \[Hook Reference\]](#), page 143).

If a `--pid-file` option is specified, the command `serve` will create the specified file and record the process identifier of the server in the file. This file can then be read to identify specific monotone server processes.

The syntax for patterns is very simple. `*` matches 0 or more arbitrary characters. `?` matches exactly 1 arbitrary character. `{foo,bar,baz}` matches “foo”, or “bar”, or “baz”. These can be combined arbitrarily. A backslash, `\`, can be prefixed to any character, to match exactly that character — this might be useful in case someone, for some odd reason, decides to put a “*” into their branch name.

5.4 Informative

mtn status

mtn status *pathname...*

This command prints a description of the “status” of your workspace. In particular, it prints:

- The branch currently selected in ‘_MTN/options’ for the workspace.
- The revision id of the “parent” revision of the workspace, on which your in-progress changes are based.
- A list of logical changes between the base and current manifest versions, such as adds, drops, renames, and patches.

Specifying optional *pathname...* arguments to the **status** command restricts the set of changes that are visible and results in only a partial status of the workspace. Changes to files not included in the specified set of pathnames will be ignored.

From within a subdirectory of the workspace the **status** command will, by default, include *all changes* in the workspace. Specifying only the pathname *“.”* will restrict **status** to files changed within the current subdirectory of the workspace.

mtn log

mtn log [--last=*n*] [--next=*n*] [--from=*id* [...]] [--to=*id* [...]] [--brief] [--no-merges] [--no-files] [--diffs] [*file* [...]]

This command prints out a log, in reverse-ancestry order, of small history summaries. Each summary contains author, date, changelog and comment information associated with a revision.

If ‘--brief’ is given, the output consists of one line per revision with the revision ID, the author, the date and the branches (separated with commas).

If ‘--last=*n*’ is given, at most *n* log entries will be given.

If ‘--next=*n*’ is given, at most *n* log entries towards the current head revision will be given from the workspace’s base revision in forward-ancestry order. This is useful to review changes that will be applied to the workspace when **update** is run.

If ‘--from=*id*’ is given, the command starts tracing back through history from these revisions, otherwise it starts from the base revision of your workspace.

If ‘--to=*id*’ is given, log will only print entries for revisions that would not also be printed when logging from the revisions specified in ‘--to’. This is useful for reviewing changes between two points in history.

By default, the log entries for merge nodes are shown. If ‘--no-merges’ is given, the log entries for these nodes will be excluded.

If ‘--no-files’ is given, the log output excludes the list of files changed in each revision.

Specifying ‘--diffs’ causes the log output to include a unified diff of the changes in each revision.

If one or more files are given, the command will only log the revisions where those files are changed.

`mtn annotate file`

`mtn annotate [--revision=id] [--revs-only] file`

Dumps an annotated copy of the file to stdout. The output is in the form `<short revision id>.. by <author> <date>: <line>` Only the first 8 characters of the revision id are displayed, the author cert value is truncated at the first @ or space character and the date field is truncated to remove the time of day.

If ‘`--revs-only`’ is specified, each line of the file is translated to `<revision id>: <line>` in the output, where `<revision id>` is the revision in which that line of the file was last edited.

`mtn complete file partial-id`

`mtn complete [--brief] key partial-id`

`mtn complete [--brief] revision partial-id`

These commands print out all known completions of a partial SHA1 value, listing completions which are `file`, `manifest` or `revision` IDs depending on which variant is used. For example, suppose you enter this command and get this result:

```
$ mtn complete revision fa36
fa36deead87811b0e15208da2853c39d2f6ebe90
fa36b76dd0139177b28b379fe1d56b22342e5306
fa36965ec190bee14c5afcac235f1b8e2239bb2a
```

Then monotone is telling you that there are 3 revisions it knows about, in its database, which begin with the 4 hex digits `fa36`. This command is intended to be used by programmable completion systems, such as those in `bash` and `zsh`.

The `complete` command for keys and revisions have a ‘`--verbose`’ option. Programmable completion systems can use ‘`--verbose`’ output to present users with additional information about each completion option.

For example, verbose output for `revision` looks like this:

```
$ mt complete revision 01f
01f5da490941bee1f0000f0561fc62eabfb2fa23 graydon@dub.net 2003-12-03T03:14:35■
01f992577bd8bcdcade0f89e724fd5dc2d2bbe8a kinetik@orcon.nz 2005-05-11T05:19:29■
01faad191d8d0474777c70b4d606782942333a78 kinetik@orcon.nz 2005-04-11T04:24:01■
```

`mtn diff [--unified] [--show-encloser]`

`mtn diff --context [--show-encloser]`

`mtn diff --external [--diff-args=argstring]`

`mtn diff pathname...`

`mtn diff --revision=id`

`mtn diff --revision=id pathname...`

`mtn diff --revision=id1 --revision=id2`

`mtn diff --revision=id1 --revision=id2 pathname...`

These commands print out GNU “unified diff format” textual difference listings between various manifest versions. With no ‘`--revision`’ options, `diff` will print the differences between the base revision and the current revision in the workspace.

With one ‘`--revision`’ option, `diff` will print the differences between the revision *id* and the current revision in the workspace. With two ‘`--revision`’ options `diff` will print the differences between revisions *id1* and *id2*, ignoring any workspace.

In all cases, monotone will print a textual summary – identical to the summary presented by `mtn status` – of the logical differences between revisions in lines proceeding the diff. These lines begin with a single hash mark `#`, and should be ignored by a program processing the diff, such as `patch`.

Specifying pathnames to the `diff` command restricts the set of changes that are visible and results in only a partial diff between two revisions. Changes to files not included in the specified set of pathnames will be ignored.

From within a subdirectory of the workspace the `diff` command will, by default, include *all changes* in the workspace. Specifying only the pathname `"."` will restrict `diff` to files changed within the current subdirectory of the workspace.

The output format of `diff` is controlled by the options ‘`--unified`’, ‘`--context`’, ‘`--show-encloser`’, and ‘`--external`’. By default, monotone uses its built-in diff algorithm to produce a listing in “unified diff” format (analogous to running the program `diff -u`); you can also explicitly request this with ‘`--unified`’. The built-in diff algorithm can also produce “context diff” format (analogous to `diff -c`), which you request by specifying ‘`--context`’. The short options that `diff` accepts for these modes, ‘`-u`’ and ‘`-c`’, also work.

In either of these modes, you can request that monotone print the name of the top-level code construct that encloses each “hunk” of changes, with ‘`--show-encloser`’. The options that `diff` accepts for this mode, ‘`-p`’ and ‘`--show-c-function`’, also work. Monotone finds the enclosing construct by scanning backward from the first changed line in each hunk for a line that matches a regular expression. The default regular expression is correct for many programming languages. You can adjust the expression used with the Lua hook `get_encloser_pattern`; [Section 6.1 \[Hooks\]](#), [page 144](#). For the regular expression syntax, See [Section 7.5 \[Regexps\]](#), [page 187](#).

‘`--unified`’ requests the “unified diff” format, the default. ‘`--context`’ requests the “context diff” format (analogous to running the program `diff -c`). Both of these formats are generated directly by monotone, using its built-in diff algorithm.

Sometimes, you may want more flexibility in output formats; for these cases, you can use ‘`--external`’, which causes monotone to invoke an external program to generate the actual output. By default, the external program is `diff`, and you can use the option ‘`--diff-args`’ to pass additional arguments controlling formatting. The actual invocation of `diff`, default arguments passed to it, and so on, are controlled by the hook `external_diff`; see [Section 6.1 \[Hooks\]](#), [page 144](#) for more details.

```
mtn list certs id
```

```
mtn ls certs id
```

These commands will print out a list of certificates associated with a particular revision *id*. Each line of the print out will indicate:

- Whether the signature on the certificate is **ok** or **bad**
- The key ID of the signer of the certificate
- The name of the certificate
- The value of the certificate

For example, this command lists the certificates associated with a particular version of monotone itself, in the monotone development branch:

```
$ mtn list certs 4a96
mtn: expanding partial id '4a96'
mtn: expanded to '4a96a230293456baa9c6e7167cafb3c5b52a8e7f'
-----
Key   : graydon@pobox.com
Sig   : ok
Name  : author
Value : graydon@dub.venge.net
-----
Key   : graydon@pobox.com
Sig   : ok
Name  : branch
Value : monotone
-----
Key   : graydon@pobox.com
Sig   : ok
Name  : date
Value : 2003-10-17T03:20:27
-----
Key   : graydon@pobox.com
Sig   : ok
Name  : changelog
Value : 2003-10-16  graydon hoare  <graydon@pobox.com>
:
:      * sanity.hh: Add a const version of idx().
:      * diff_patch.cc: Change to using idx() everywhere.
:      * cert.cc (find_common_ancestor): Rewrite to recursive
:      form, stepping over historic merges.
:      * tests/t_cross.at: New test for merging merges.
:      * testsuite.at: Call t_cross.at.
:
```

```
mtn list keys
```

```
mtn ls keys
```

```
mtn list keys pattern
```

```
mtn ls keys pattern
```

These commands list RSA keys held in your keystore and current database. They do not print out any cryptographic information; they simply list the names of public and private keys you have on hand.

If *pattern* is provided, it is used as a glob to limit the keys listed. Otherwise all keys in your database are listed.

`mtn list branches`

`mtn ls branches`

This command lists all known branches in your database.

`mtn list tags`

`mtn ls tags`

This command lists all known tags in your database.

`mtn list vars`

`mtn ls vars`

`mtn list vars domain`

`mtn ls vars domain`

This command lists all vars in your database, or all vars within a given *domain*.

See [Section 3.9 \[Vars\]](#), page 60 for more information.

`mtn list known`

`mtn ls known`

`mtn list known pathname...`

`mtn ls known pathname...`

This command lists all files which would become part of the manifest of the next revision if you committed your workspace at this point.

Specifying pathnames to the `list known` command restricts the set of paths that are searched for manifest files. Files not included in the specified set of pathnames will not be listed.

From within a subdirectory of the workspace the `list known` command will, by default, search the entire workspace. Specifying only the pathname `"."` will restrict the search for known files to the current subdirectory of the workspace.

`mtn list unknown`

`mtn ls unknown`

`mtn list unknown pathname...`

`mtn ls unknown pathname...`

This command lists all files in your workspace that monotone is either ignoring or knows nothing about.

Specifying pathnames to the `list unknown` command restricts the set of paths that are searched for unknown files. Unknown files not included in the specified set of pathnames will not be listed.

From within a subdirectory of the workspace the `list unknown` command will, by default, search the entire workspace. Specifying only the pathname `"."` will restrict the search for unknown files to the current subdirectory of the workspace.

`mtn list ignored`

`mtn ls ignored`

`mtn list ignored pathname...`

`mtn ls ignored pathname...`

This command lists all files in your workspace that monotone is intentionally ignoring, due to the results of the `ignore_file` (*filename*) hook.

Specifying pathnames to the **list ignored** command restricts the set of paths that are searched for ignored files. Ignored files not included in the specified set of pathnames will not be listed.

From within a subdirectory of the workspace the **list ignored** command will, by default, search the entire workspace. Specifying only the pathname "." will restrict the search for ignored files to the current subdirectory of the workspace.

```
mtn list missing
mtn ls missing
mtn list missing pathname...
mtn ls missing pathname...
```

This command lists all files in your workspace's base manifest, which are not present in the workspace.

Specifying pathnames to the **list missing** command restricts the set of paths that are searched for missing files. Missing files not included in the specified set of pathnames will not be listed.

From within a subdirectory of the workspace the **list missing** command will, by default, search the entire workspace. Specifying only the pathname "." will restrict the search for missing files to the current subdirectory of the workspace.

```
mtn list changed
mtn ls changed
mtn list changed pathname...
mtn ls changed pathname...
```

This command lists all files in your workspace that have changed compared to the base revision, including files that are dropped, added or renamed.

Specifying pathnames to the **list changed** command restricts the set of paths that are checked for changes. Files not included in the specified set of pathnames will not be listed.

From within a subdirectory of the workspace the **list changed** command will, by default, search the entire workspace. Specifying only the pathname "." will restrict the search for known files to the current subdirectory of the workspace.

```
mtn show_conflicts rev rev
```

This command shows what conflicts would need to be resolved in order to merge the given revisions.

5.5 Key and Cert Trust

`mtn genkey keyid`

This command generates an RSA public/private key pair, using a system random number generator, and stores it in your keystore under the key name *keyid*.

The private half of the key is stored in an encrypted form, so that anyone who can read your keystore cannot extract your private key and use it. You must provide a passphrase for your key when it is generated, which is used to determine the encryption key. In the future you will need to enter this passphrase again each time you sign a certificate, which happens every time you `commit` to your database. You can tell monotone to automatically use a certain passphrase for a given key using the `get_passphrase(keypair_id)`, but this significantly increases the risk of a key compromise on your local computer. Be careful using this hook.

`mtn dropkey keyid`

This command drops the public and/or private key. If both exist, both are dropped, if only one exists, it is dropped. This command should be used with caution as changes are irreversible without a backup of the key(s) that were dropped.

`mtn passphrase id`

This command lets you change the passphrase of the private half of the key *id*.

`mtn trusted id certname certval signers`

This command lets you test your revision trust hook `get_revision_cert_trust` (see [Chapter 6 \[Hook Reference\]](#), page 143). You pass it a revision ID, a certificate name, a certificate value, and one or more key IDs, and it will tell you whether, under your current settings, Monotone would trust a cert on that revision with that value signed by those keys.

`mtn ssh_agent_add`

This command will add your monotone keys to your current ssh-agent session. You will be asked for the passphrase for each of your monotone private keys and they will be added to the ssh-agent. Once this is done you should be able to type `ssh-add -l` and see your monotone key listed. When you subsequently use these keys through monotone it will use ssh-agent for signing without asking you for your passphrase.

This command is mainly for use in a session script as monotone will automatically add your keys to ssh-agent on first use if it is available. For example the following two examples are equivalent:

```
$ mtn ssh_agent_add
enter passphrase for key ID [user@example.com]:
$ mtn ci -m"Changed foo to bar"
$ mtn push -k user@example.com

$ mtn ci -m"Changed foo to bar"
enter passphrase for key ID [user@example.com]:
$ mtn push -k user@example.com
```

In the second example, monotone automatically added the key to ssh-agent, making entering the passphrase not needed during the push.

mtn ssh_agent_export filename

This command will export your private key in a format that ssh-agent can read (PKCS8, PEM). You will be asked for your current key's password and a new password to encrypt the key with. The key will be printed to stdout. Once you have put this key in a file simply add it to ssh-agent and you will only have to enter your key password once as ssh-agent will cache the key for you.

```
$ mtn ssh_agent_export ~/.ssh/id_monotone
enter passphrase for key ID [user@example.com]:
enter new passphrase for key ID [user@example.com]:
confirm passphrase for key ID [user@example.com]:
$ chmod 600 ~/.ssh/id_monotone
$ ssh-agent /bin/bash
$ ssh-add ~/.ssh/id_monotone
Enter passphrase for /home/user/.ssh/id_monotone:
Identity added: /home/user/.ssh/id_monotone (/home/user/.ssh/id_monotone)
$ mtn ci -m"Changed foo to bar"
$ mtn push -k user@example.com
```

You can also use the ‘`--ssh-sign`’ option to control whether ssh-agent will be used for signing. If set to *yes*, ssh-agent will be used to sign. If your key has not been added to ssh-agent monotone will fall back to its internal signing code and ask you for your password. If set to *only*, monotone will sign only with ssh-agent. If set to *no*, monotone will always use its internal signing code even if ssh-agent is running and has your monotone key loaded. If set to *check*, monotone will sign with both ssh-agent (if your key is loaded into it) and monotone's internal signing code, then compare the results. *check* will be removed at some future time as it is meant only for testing and will not work with all signing algorithms.

5.6 Certificate

`mtn cert id certname`

`mtn cert id certname certval`

These commands create a new certificate with name *certname*, for a revision with version *id*. The *id* argument can be a selector using certs already on the revision, such as `h:branchname`.

If *certval* is provided, it is the value of the certificate. Otherwise the certificate value is read from `stdin`.

`mtn approve id`

This command is a synonym for `mtn cert id branch branchname` where *branchname* is the current branch name (either deduced from the workspace or from the ‘`--branch`’ option).

`mtn comment id`

`mtn comment id comment`

These commands are synonyms for `mtn cert id comment comment`. If *comment* is not provided, it is read from `stdin`.

`mtn suspend id`

This command is a synonym for `mtn cert id suspend branchname` where *branchname* is the current branch name (either deduced from the workspace or from the ‘`--branch`’ option).

`mtn tag id tagname`

This command associates the symbolic name *tagname* with the revision *id*, so that symbolic name can later be used in [Section 3.2 \[Selectors\]](#), page 47 for specifying revisions for commands like `update` or `diff`.

This command is a synonym for `mtn cert id tag tagname`.

`mtn testresult id 0`

`mtn testresult id 1`

These commands are synonyms for `mtn cert id testresult 0` or `mtn cert id testresult 1`.

5.7 Packet I/O

Monotone can produce and consume data in a convenient, portable form called *packets*. A packet is a sequence of ASCII text, wrapped at 70-columns and easily sent through email or other transports. If you wish to manually transmit a piece of information – for example a public key – from one monotone database to another, it is often convenient to read and write packets.

Note: earlier versions of monotone queued and replayed packet streams for their networking system. This older networking system has been removed, as the netsync protocol has several properties which make it a superior communication system. However, the packet I/O facility will remain in monotone as a utility for moving individual data items around manually.

`mtn automate packets_for_certs id`

This command prints out an `rcert` packet for each cert in your database associated with `id`. These can be used to transport certificates safely between monotone databases. See [Section 5.9 \[Automation\]](#), page 102 for details of this command.

`mtn automate packet_for_fdata id`

`mtn automate packet_for_rdata id`

These commands print out an `fdata` or `rdata` packet for the file, manifest or revision `id` in your database. These can be used to transport files or revisions, in their entirety, safely between monotone databases. See [Section 5.9 \[Automation\]](#), page 102 for details of these commands.

`mtn automate packet_for_fdelta id1 id2`

This command prints out an `fdelta` packet for the differences between file versions `id1` and `id2`, in your database. These can be used to transport file differences safely between monotone databases. See [Section 5.9 \[Automation\]](#), page 102 for details of this command.

`mtn privkey keyid`

`mtn pubkey keyid`

These commands print out an `keypair` or `pubkey` packet for the RSA key `keyid`. These can be used to transport public or private keys safely between monotone databases.

`mtn read`

`mtn read file1 file2...`

This command reads packets from files or `stdin` and stores them in your database.

5.8 Database

mtn set domain name value

Associates the value *value* to *name* in domain *domain*. See [Section 3.9 \[Vars\]](#), [page 60](#) for more information.

mtn unset domain name

Deletes any value associated with *name* in *domain*. See [Section 3.9 \[Vars\]](#), [page 60](#) for more information.

mtn db init --db=*dbfile*

This command initializes a new monotone database at *dbfile*.

mtn db info --db=*dbfile*

This command prints information about the monotone database *dbfile*, including its schema version and various table size statistics.

mtn db version --db=*dbfile*

This command prints out just the schema version of the monotone database *dbfile*.

mtn db dump --db=*dbfile*

This command dumps an SQL statement representing the entire state of *dbfile* to the standard output stream. It is a very low-level command, and produces the most “recoverable” dumps of your database possible. It is sometimes also useful when migrating databases between variants of the underlying SQLite database format.

mtn db load --db=*dbfile*

This command applies a raw SQL statement, read from the standard input stream, to the database *dbfile*. It is most useful when loading a database dumped with the **dump** command.

Note that when reloading a dumped database, the schema of the dumped database is *included* in the dump, so you should not try to **init** your database before a **load**.

mtn db migrate --db=*dbfile*

This command attempts to migrate the database *dbfile* to the newest schema known by the version of monotone you are currently running. If the migration fails, no changes should be made to the database.

If you have important information in your database, you should back up a copy of it before migrating, in case there is an untrapped error during migration.

mtn db check --db=*dbfile*

Monotone always works hard to verify the data it creates and accesses. For instance, if you have hard drive problems that corrupt data in monotone’s database, and you attempt to retrieve this data, then monotone will notice the problem and stop, instead of silently giving you garbage data.

However, it’s also nice to notice such problems early, and in rarely used parts of history, while you still have backups. That’s what this command is for. It systematically checks the database *dbfile* to ensure that it is complete and consistent. The following problems are detected:

- missing files that are referenced by their SHA1 hash from some manifest but do not exist in the database. This is a serious problem; it means that your history is not fully reconstructible. You can fix it by finding the file with the given hash, and loading it into your database with **fload**.
- unreferenced files that exist in the database but are not referenced by their SHA1 hash from any existing manifest. In itself, this only indicates some wasted space, and is not a problem; it's possible it could arise under normal use (for instance, in some strange corner cases following an incomplete netsync). It could also arise, though, as a symptom of some other more serious problem.
- missing manifests that are referenced by their SHA1 hash from some revision but do not exist in the database. This is a serious problem; it means that your history is not fully reconstructible. You can fix it by finding a database containing the manifest, and using **mdata** on that database to create a manifest data packet, which can be loaded into your database with **read**.
- unreferenced manifests that exist in the database but are not referenced by their SHA1 hash from any existing revision. In itself, this only indicates some wasted space, and is not a problem; it's possible it could arise under normal use (for instance, if you have run **db kill_rev_locally**, or in some strange-but-harmless corner cases following an incomplete netsync). It could also arise, though, as a symptom of some other more serious problem.
- incomplete manifests that exist in the database but contain references to files that do not exist in the database. For diagnosis and solution, see “missing files” above.
- missing revisions that are referenced by their SHA1 hash from some other revision or revision cert but do not exist in the database. This may be a serious problem; it may indicate that your history is not fully reconstructible (if the reference is from another revision) or that someone is creating bogus certs (if the reference is from a cert). You can fix it by finding a database containing the revision, and using **rdata** on that database to create a revision data packet, which can be loaded into your database with **read**.
- incomplete revisions that exist in the database but contain references to missing manifests, incomplete manifests or missing revisions. This always occurs with some more detailed error; see above.
- revisions with mismatched parents that disagree with the cached revision ancestry on their parent revisions. This may cause problems in using the database, and suggests the presence of a bug in monotone's caching system, but does not involve data loss.
- revisions with mismatched children that disagree with the cached revision ancestry on their child revisions. This may cause problems in using the database, and suggests the presence of a bug in monotone's caching system, but does not involve data loss.
- revisions with bad history that exist in the database but fail monotone's normal sanity checks for consistent and correct history. This is a seri-

ous problem; it indicates that your history record is somehow malformed. This should not be possible, since monotone carefully checks every revision before storing it into the database, but if it does, then please request assistance on the monotone mailing list. Fixing this generally means you may lose some history — for instance, renames may be degraded into delete/add pairs — but the actual contents of every revision will still be reproducible.

- revisions with missing certs that exist in the database lacking at least one author, branch, changelog or date cert. All revisions are expected to have at least one of each of these certs. In itself, this is not necessarily a problem, but it is peculiar, and some operations such as netsync may behave strangely.
- revisions with mismatched certs that exist in the database with differing numbers of author, changelog and date certs. These certs are expected to appear together, as each revision committed should have an author, changelog and date associated with it. In itself, this is not a problem, but it is peculiar. All operations should behave normally.
- missing keys that have been used to sign certs but do not exist in the database. In itself, this is not a problem, except that monotone will ignore any certs signed by the missing key. You can fix it by finding a database containing the key in question, and using **pubkey** on that database to create a public key packet, which can be loaded into your database with **read**.
- certs with bad signatures that exist in the database with signatures that are invalid. In itself, this is not a problem, except that monotone will ignore any such certs. You may also wish to find out who is creating certs with bad signatures; it may indicate some kind of security attack.
- certs with unchecked signatures that exist in the database but cannot have their signatures checked because the signing key is missing. In itself, this is not a problem, except that monotone will ignore any certs signed by the missing key. You can fix it by finding a database containing the key in question, and using **pubkey** on that database to create a public key packet, which can be loaded into your database with **read**.

This command also verifies that the SHA1 hash of every file, manifest, and revision is correct.

mtn db kill_rev_locally id

This command “kills”, i.e., deletes, a given revision, as well as any certs attached to it. It has an ugly name because it is a dangerous command; it permanently and irrevocably deletes historical information from your database. If you execute this command in a workspace, whose parent revision is the one you are about to delete, the killed revision is re-applied to this workspace which makes it possible for you to fix a problem and commit again later on easily. For this to work, the workspace may not have any changes and/or missing files.

There are a number of other caveats with this command:

- It can only be applied to revisions that have no descendants. If you want to kill a revision that has descendants, you must kill all of the descendants first.

- It only removes the revision from your local database (hence the “locally” in the command name). If you have already pushed this revision out to another database, then the next time you pull from that database it may come back again. There is no way to delete a revision from somebody else’s database except to ask them to delete it for you.
- It does not actually delete the revision’s files or manifest from your database. If you run this command, and then run **db check**, it will note that you have an “unreferenced manifest”. If you wish to eliminate this data for good (and thus free up the space), you may use **netsync** to **pull** from your current database into a new database; this creates a copy of your old database, without the unreferenced data. However, having this data in your database will not cause any problems, and acts as a safety net; if you later realize that you do, after all, need to retrieve the data in *id*, then **db check** will let you see which manifest it was, and with some work you can extract *id*’s data.

mtn db kill_branch_certs_locally *branch*

This command “kills” a branch by deleting all branch certs with that branch name. You should consider carefully whether you want to use it, because it can irrevocably delete important information. It does not modify or delete any revisions or any of the other certificates on revisions in the branch; it simply removes the branch certificates matching the given branch name. Because of this, it can leave revisions without any branch certificate at all. As with **db kill_rev_locally**, it only deletes the information from your local database; if there are other databases that you sync with which have revisions in this branch, the branch certificates will reappear when you sync, unless the owners of those databases also delete those certificates locally.

mtn db kill_tag_locally *tag*

This command “kills” a tag by deleting all tag certs with that tag name. You should consider carefully whether you want to use it, because it can irrevocably delete important information. It does not modify or delete any revisions, or any of the other certificates on tagged revisions; it simply removes all tag certificates with the given name. As with **db kill_rev_locally**, it only deletes the information from your local database; if there are other databases that you sync with which have this tag, the tag certificates will reappear when you sync, unless the owners of those databases also delete those certificates locally.

mtn db execute *sql-statement*

This is a debugging command which executes *sql-statement* against your database, and prints any results of the expression in a tabular form. It can be used to investigate the state of your database, or help diagnose failures.

5.9 Automation

This section contains subcommands of the `mtn automate` command, used for scripting monotone. All give output on `stdout`; they may also give useful chatter on `stderr`, including warnings and error messages.

`mtn automate interface_version`

Arguments:

None.

Added in:

0.0

Purpose:

Prints version of the automation interface. Major number increments whenever a backwards incompatible change is made to the `automate` command; minor number increments whenever any change is made (but is reset when major number increments).

Sample output:

1.2

Output format:

A decimal number, followed by “.” (full stop/period), followed by a decimal number, followed by a newline, followed by end-of-file. The first decimal number is the major version, the second is the minor version.

Error conditions:

None.

`mtn automate heads [branch]`

Arguments:

One branch name, *branch*. If none is given, the current default branch is used.

Added in:

0.0

Purpose:

Prints the heads of branch *branch*.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one head of the given branch. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

If the given branch contains no members or does not exist, then no lines are printed.

```
mtn automate ancestors rev1 [rev2 [...]]
```

Arguments:

One or more revision IDs, *rev1*, *rev2*, etc.

Added in:

0.2

Purpose:

Prints the ancestors of one or more revisions.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one ancestor of the given revisions. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

The output does not include *rev1*, *rev2*, etc., except if *rev2* is itself an ancestor of *rev1*, then *rev2* will be included in the output.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

```
mtn automate common_ancestors rev1 [rev2 [...]]
```

Arguments:

One or more revision IDs, *rev1*, *rev2*, etc.

Added in:

2.1

Purpose:

Prints all revisions which are ancestors of all of the revisions given as arguments.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one common ancestor of all the given revisions. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

The output will include one of the argument revisions only if that revision is an ancestor of all other revisions given as arguments.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

`mtm automate parents rev`

Arguments:

One revision ID, *rev*.

Added in:

0.2

Purpose:

Prints the immediate parents of a revision. This is like a non-recursive version of `automate ancestors`.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one parent of the given revision. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

If the given revision *rev* does not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

`mtm automate descendants rev1 [rev2 [...]]`

Arguments:

One or more revision IDs, *rev1*, *rev2*, etc.

Added in:

0.1

Purpose:

Prints the descendants of one or more revisions.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one descendant of the given revisions. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

The output does not include *rev1*, *rev2*, etc., except that if *rev2* is itself a descendant of *rev1*, then *rev2* will be included in the output.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

`mtm automate children rev`

Arguments:

One revision ID, *rev*.

Added in:

0.2

Purpose:

Prints the immediate children of a revision. This is like a non-recursive version of `automate descendents`.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one child of the given revision. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

If the given revision `rev` does not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

`mtn automate graph`

Arguments:

None.

Added in:

0.2

Purpose:

Prints out the complete ancestry graph of this database.

Sample output:

```
0c05e8ec9c6af4224672c7cc4c9ef05ae8bdb794
27ebcae50e1814e35274cb89b5031a423c29f95a 5830984dec5c41d994bcadfeab4bf1
4e284617c80bec7da03925062a84f715c1b042bd 27ebcae50e1814e35274cb89b5031a
```

Output format:

Zero or more lines, each giving ancestry information for one revision. Each line begins with a revision ID. Following this are zero or more space-prefixed revision IDs. Each revision ID after the first is a parent (in the sense of `automate parents`) of the first. For instance, in the above sample output, `0c05e8ec9c6af4224672c7cc4c9ef05ae8bdb794` is a root node, `27ebcae50e1814e35274cb89b5031a423c29f95a` has one parent, and `4e284617c80bec7da03925062a84f715c1b042bd` has two parents, i.e., is a merge node.

The output as a whole is alphabetically sorted by line; additionally, the parents within each line are alphabetically sorted.

Error conditions:

None.

```
mtn automate erase_ancestors [rev1 [rev2 [...]]]
```

Arguments:

One or more revision IDs, *rev1*, *rev2*, etc.

Added in:

0.1

Purpose:

Prints all arguments, except those that are an ancestor of some other argument. One way to think about this is that it prints the minimal elements of the given set, under the ordering imposed by the “child of” relation. Another way to think of it is if the arguments formed a branch, then we would print the heads of that branch. If there are no arguments, prints nothing.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one descendant of the given revisions. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

```
mtn automate toposort [rev1 [rev2 [...]]]
```

Arguments:

One or more revision IDs, *rev1*, *rev2*, etc.

Added in:

0.1

Purpose:

Prints all arguments, topologically sorted. I.e., if *rev1* is an ancestor of *rev2*, then *rev1* will appear before *rev2* in the output; if *rev2* is an ancestor of *rev1*, then *rev2* will appear before *rev1* in the output; and if neither is an ancestor of the other, then they may appear in either order. If there are no arguments, prints nothing.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

A list of revision IDs, in hexadecimal, each followed by a newline. Revisions are printed in topologically sorted order.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

```
mtn automate ancestry_difference new [old1 [old2 [...]]]
```

Arguments:

A “new” revision ID *new*, followed by zero or more “old” revision IDs *old1*, *old2*, etc.

Added in:

0.1

Purpose:

Prints all ancestors of the revision *new*, that are not also ancestors of one of the old revisions. For purposes of this command, “ancestor” is an inclusive term; for example, if *new* is an ancestor of *old1*, it will not be printed; but if *new* is not an ancestor of any of the “old” revisions, then it will be. Similarly, *old1* will never be printed, because it is considered to be an ancestor of itself. The reason for the names is that if *new* a new revision, and *old1*, *old2*, etc. are revisions that you have processed before, then this command tells you which revisions are new since then.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

A list of revision IDs, in hexadecimal, each followed by a newline. Revisions are printed in topologically sorted order.

Error conditions:

If any of the revisions do not exist, prints nothing to stdout, prints an error message to stderr, and exits with status 1.

```
mtn automate leaves
```

Arguments:

None.

Added in:

0.1

Purpose:

Prints the leaves of the revision graph, i.e. all revision that have no children. This is similar, but not identical to the functionality of **heads**, which prints every revision in a branch, that has no descendants in that branch. If every revision in the database was in the same branch, then they would be identical. Generally, every leaf is the head of some branch, but not every branch head is a leaf.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
```

```
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each a leaf of the revision graph. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

None.

```
mtn automate roots
```

Arguments:

None.

Added in:

4.3

Purpose:

Prints the roots of the revision graph, i.e. all revisions that have no parents.

Sample output:

```
276264b0b3f1e70fc1835a700e6e61bdbe4c3f2f
```

Output format:

Zero or more lines, each a root of the revision graph. Each line consists of a revision ID, in hexadecimal, followed by a newline. The lines are printed in alphabetically sorted order.

Error conditions:

None.

```
mtn automate branches
```

Arguments:

None.

Added in:

2.2

Purpose:

Prints all branch certs present in the revision graph, that are not excluded by the Lua hook `ignore_branch`.

Sample output:

```
net.venge.monotone
net.venge.monotone.win32
```

Output format:

Zero or more lines, each the name of a branch. The lines are printed in alphabetically sorted order.

Error conditions:

None.


```
mtn automate tags [branch_pattern]
```

Arguments:

A branch pattern (optional).

Added in:

2.2

Purpose:

If a branch pattern is given, prints all tags that are attached to revisions on branches matched by the pattern; otherwise prints all tags of the revision graph.

If a branch name is ignored by means of the Lua hook `ignore_branch`, it is neither printed, nor can it be matched by a pattern.

Sample output:

```
format_version "1"
```

```
tag "monotree-0.3"
revision [35cff8e8ba14155f5f7ddf7965073f514fd60f61]
signer "njs@pobox.com"
branches "net.venge.monotone.contrib.monotree"
```

```
tag "monotree-0.2"
revision [5d288b39b49613b0d9dca8ece6b9a42c3773f35b]
signer "njs@pobox.com"
branches "net.venge.monotone.contrib.monotree"
```

```
tag "monotree-0.1"
revision [8a121346ce2920b6f85df68b3b620de96bd14a8d]
signer "njs@pobox.com"
branches "net.venge.monotone.contrib" "net.venge.monotone.contrib.monot"
```

```
tag "monotree-0.4"
revision [f1afc520474f83c58262896ede027ef77226046e]
signer "njs@pobox.com"
branches "net.venge.monotone.contrib.monotree"
```

Output format:

There is one `basic.io` stanza for each tag.

All stanzas are formatted by `basic.io`. Stanzas are separated by a blank line. Values will be escaped, `'\'` to `'\\'` and `'\"'` to `'\\"'`.

Each stanza has exactly the following four entries:

`'tag'` the value of the tag cert, i.e. the name of the tag

`'revision'`
the hexadecimal id of the revision the tag is attached to

‘‘signer’’

the name of the key used to sign the tag cert

‘‘branches’’

a (possibly empty) list of all branches the tagged revision is on

Stanzas are printed in arbitrary order.

Error conditions:

A run-time exception occurs if an illegal branch pattern is specified.

`mtn automate select selector`

Arguments:

One selector (or combined selector).

Added in:

0.2

Purpose:

Print all revisions that match the given selector.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
75156724e0e2e3245838f356ec373c50fa469f1f
```

Output format:

Zero or more lines, each giving the ID of one revision that matches the given selector. Each line consists of a revision ID, in hexadecimal, followed by a newline. Revision ids are printed in alphabetically sorted order.

Error conditions:

None.

`mtn automate identify path`

Arguments:

A file path.

Added in:

4.2

Purpose:

Prints the file ID (aka hash) of the given file.

Sample output:

```
6265ab1312fbe38bdc3aafa92441139cb2b779b0
```

Output format:

A single line with the file’s ID, in hexadecimal, followed by a newline.

Error conditions:

If the file does not exist, is a special file or not readable, prints an error message to stderr and exists with status 1. A single file path

only consisting of "-" is disallowed since it collides with the UNIX stdin marker.

```
mtn automate inventory ['options...'] [files...]
```

Arguments:

One or more file paths (optional). If present, only show an inventory for the given files or directories (and their sub-directories).

'--depth=*n*'

Maximum number of directories to descend.

'--exclude=*exclude-glob*'

File or directory to exclude.

'--no-ignored'

Don't output ignored files or directories.

'--no-unknown'

Don't output unknown directories.

'--no-unchanged'

Don't output files that are known but not changed in any way.

'--no-corresponding-renames'

If restricted to a renamed path, do not output the corresponding old / new paths for this restriction.

Changes:

- 7.0 – added options '--no-ignored', '--no-unknown', '--no-unchanged' and '--no-corresponding-renames'
- 6.0 – converted to basic_io format (restriction support, various fixes)
- 1.0 – initial, line-based format

Purpose:

Prints the inventory of every file found in the workspace or its associated base and revision manifests. Each unique path is listed in a basic_io stanza. Stanzas are separated by blank lines.

Sample output:

All basic status cases:

```
path "added"
new_type "file"
fs_type "file"
status "added" "known"
changes "content"

path "attributes_altered"
old_type "file"
new_type "file"
```

```
fs_type "file"
status "known"
changes "attrs"

    path "dropped"
old_type "file"
fs_type "none"
status "dropped"

    path "ignored~"
fs_type "file"
status "ignored"

    path "missing"
old_type "file"
new_type "file"
fs_type "none"
status "missing"

    path "original"
old_type "file"
new_path "renamed"
fs_type "none"
status "rename_source"

    path "patched"
old_type "file"
new_type "file"
fs_type "file"
status "known"
changes "content"

    path "patched_and_attributes_altered"
old_type "file"
new_type "file"
fs_type "file"
status "known"
changes "content" "attrs"

    path "renamed"
new_type "file"
old_path "original"
fs_type "file"
status "rename_target" "known"

    path "unchanged"
old_type "file"
```

```
new_type "file"
fs_type "file"
status "known"
```

```
path "unknown"
fs_type "file"
status "unknown"
```

Two files swapped in both the revision manifest and the workspace:

```
path "original"
old_type "file"
new_path "unchanged"
new_type "file"
old_path "unchanged"
fs_type "file"
status "rename_source" "rename_target" "known"
```

```
path "unchanged"
old_type "file"
new_path "original"
new_type "file"
old_path "original"
fs_type "file"
status "rename_source" "rename_target" "known"
```

Recorded in the revision manifest that two files were swapped, but they were not actually swapped in the workspace. Thus they both appear as patched:

```
path "original"
old_type "file"
new_path "unchanged"
new_type "file"
old_path "unchanged"
fs_type "file"
status "rename_source" "rename_target" "known"
changes "content"
```

```
path "unchanged"
old_type "file"
new_path "original"
new_type "file"
old_path "original"
fs_type "file"
status "rename_source" "rename_target" "known"
changes "content"
```

Rename (in the manifest and the workspace) ‘foo’ to ‘bar’; add (in the manifest and the workspace) new file ‘foo’:

```

    path "foo"
  old_type "file"
  new_path "bar"
  new_type "file"
  fs_type "file"
  status "rename_source" "added" "known"

```

```

    path "bar"
  new_type "file"
  old_path "foo"
  fs_type "file"
  status "rename_target" "known"

```

Rotated files ‘foo’ -> ‘bar’ -> ‘baz’ -> ‘foo’ (in the manifest and the workspace):

```

    path "foo"
  old_type "file"
  new_path "bar"
  new_type "file"
  old_path "baz"
  fs_type "file"
  status "rename_source" "rename_target" "known"

```

```

    path "bar"
  old_type "file"
  new_path "baz"
  new_type "file"
  old_path "foo"
  fs_type "file"
  status "rename_source" "rename_target" "known"

```

```

    path "baz"
  old_type "file"
  new_path "foo"
  new_type "file"
  old_path "bar"
  fs_type "file"
  status "rename_source" "rename_target" "known"

```

Recorded in the revision manifest the rotation of files ‘foo’ -> ‘bar’ -> ‘baz’ -> ‘foo’, but the actual files in the workspace were not moved, so monotone interprets all files as having been patched:

```

    path "foo"
  old_type "file"
  new_path "bar"
  new_type "file"
  old_path "baz"
  fs_type "file"

```

```

    status "rename_source" "rename_target" "known"
    changes "content"

```

```

    path "bar"
    old_type "file"
    new_path "baz"
    new_type "file"
    old_path "foo"
    fs_type "file"
    status "rename_source" "rename_target" "known"
    changes "content"

```

```

    path "baz"
    old_type "file"
    new_path "foo"
    new_type "file"
    old_path "bar"
    fs_type "file"
    status "rename_source" "rename_target" "known"
    changes "content"

```

Dropped from the manifest but not removed in the workspace and thus unknown:

```

    path "dropped"
    old_type "file"
    fs_type "file"
    status "dropped" "unknown"

```

Added in the manifest but not in the workspace, and thus missing:

```

    path "added"
    new_type "file"
    fs_type "none"
    status "added" "missing"

```

Recorded a rename in the manifest, but not moved in the workspace, and thus unknown source and missing target:

```

    path "original"
    old_type "file"
    new_path "renamed"
    fs_type "file"
    status "rename_source" "unknown"

```

```

    path "renamed"
    new_type "file"
    old_path "original"
    fs_type "none"
    status "rename_target" "missing"

```

Moved in the workspace but no rename recorded in the manifest, and thus missing source and unknown target:

```

    path "original"
old_type "file"
new_type "file"
fs_type "none"
status "missing"

    path "renamed"
fs_type "file"
status "unknown"

```

Renamed in the manifest and the workspace and patched:

```

    path "original"
old_type "file"
new_path "renamed"
fs_type "none"
status "rename_source"

    path "renamed"
new_type "file"
old_path "original"
fs_type "file"
status "rename_target" "known"
changes "content"

```

Renamed and restricted to 'original' or 'renamed':

```

    path "original"
old_type "file"
new_path "renamed"
fs_type "none"
status "rename_source"

    path "renamed"
new_type "file"
old_path "original"
fs_type "file"
status "rename_target" "known"
changes "content"

```

Renamed and restricted to 'original' with the '--no-corresponding-renames' option:

```

    path "original"
old_type "file"
new_path "renamed"
fs_type "none"
status "rename_source"

```


Renamed and restricted to ‘renamed’ with the ‘`--no-corresponding-renames`’ option:

```

    path "renamed"
new_type "file"
old_path "original"
fs_type "file"
    status "rename_target" "known"
changes "content"

```

File is missing, an unversioned directory is in the way:

```

    path "missing_file"
old_type "file"
new_type "file"
fs_type "directory"
    status "invalid"
changes "content"

```

Directory is missing, an unversioned file is in the way:

```

    path "missing_directory"
old_type "directory"
new_type "directory"
fs_type "file"
    status "invalid"

```

Directory ‘source’ renamed to ‘target’, ‘target’ is missing, an unversioned file is in the way:

```

    path "source"
old_type "directory"
new_path "target"
fs_type "none"
    status "rename_source"

```

```

    path "source/a"
old_type "file"
new_path "target/a"
fs_type "none"
    status "rename_source"

```

```

    path "target"
new_type "directory"
old_path "source"
fs_type "file"
    status "rename_target" "invalid"

```

```

    path "target/a"
new_type "file"
old_path "source/a"
fs_type "none"

```

```
status "rename_target" "missing"
```

Output format:

Each path is printed in one `basic_io` stanza. Stanzas are separated by a blank line. Each stanza starts with a `path` line, and contains up to seven lines. The order of the lines is not important, and may change in future revisions, except that the first line will always be `path`.

`'path'` The file or directory path, relative to the workspace root. The file either exists in the workspace, or is listed in the base or revision manifest. `'path'` is always output.

`'old_type'` The type of the node in the base manifest. “type” is either `'file'` or `'directory'`. `'old_type'` is output for all old nodes (i.e. unchanged or dropped paths and rename sources).

`'new_type'` The type of the node in the revision manifest. “type” is either `'file'` or `'directory'`. `'new_type'` is output for all new nodes (i.e. unchanged or added paths and rename targets).

`'fs_type'` The type of the node in the workspace (also called the filesystem). “type” is either `'file'`, `'directory'` or `'none'` (if the path does not exist in the file system). `'fs_type'` is always output.

`'old_path'` The old path for the node, if it has been renamed in the revision manifest. `'old_path'` is only output for rename targets.

`'new_path'` The new path for the node, if it has been renamed in the revision manifest. `'new_path'` is only output for rename sources.

`'status'` `'status'` is always output. Its value is one or more of:

`'rename_source'`

path is part of a rename and denotes the old name of a renamed node.

`'rename_target'`

path is part of a rename and denotes the new name of a renamed node.

`'added'` *path* has been added in the revision manifest, but not existent in the base manifest.

| | |
|------------------------|--|
| <code>'dropped'</code> | <i>path</i> has been deleted in the revision manifest and the workspace. |
| <code>'missing'</code> | <i>path</i> has been deleted in the workspace, but still exists in the revision manifest. |
| <code>'ignored'</code> | <i>path</i> is ignored by monotone. |
| <code>'known'</code> | <i>path</i> exists in the workspace, and in the revision manifest. |
| <code>'unknown'</code> | <i>path</i> exists in the workspace, but not in the revision manifest, i.e. is unversioned. |
| <code>'invalid'</code> | <i>path</i> is versioned and exists in the workspace and revision manifest, but with incompatible types (a versioned missing file is replaced by an unversioned directory and vice versa). |
| <code>'changes'</code> | |
| <code>'content'</code> | The contents of a file have been changed. |
| <code>'attrs'</code> | The attributes of a path (file or directory) have been changed. |

Error conditions:

When executed from outside of a workspace directory, prints an error message to stderr, and exits with status 1.

`mtn automate certs id`

Arguments:

A revision ID *id*, for which any certificates will be printed.

Added in:

1.0

Purpose:

Prints all certificates associated with the given revision ID. Each certificate is contained in a basic IO stanza. For each certificate, the following values are provided:

| | |
|--------------------------|--|
| <code>'key'</code> | a string indicating the key used to sign this certificate.■ |
| <code>'signature'</code> | a string indicating the status of the signature. Possible values of this string are: |
| <code>'ok'</code> | : the signature is correct |
| <code>'bad'</code> | : the signature is invalid |
| <code>'unknown'</code> | : signature was made with an unknown key■ |
| <code>'name'</code> | the name of this certificate |
| <code>'value'</code> | |

```

    the value of this certificate
'trust'
    is this certificate trusted by the defined trust metric?
Possible values of this string are:
    'trusted'    : this certificate is trusted
    'untrusted'  : this certificate is not trusted

```

Sample output:

```

    key "emile@alumni.reed.edu"
signature "ok"
    name "author"
    value "emile@alumni.reed.edu"
    trust "trusted"

    key "emile@alumni.reed.edu"
signature "ok"
    name "branch"
    value "net.venge.monotone"
    trust "trusted"

    key "emile@alumni.reed.edu"
signature "ok"
    name "changelog"
    value "propagate from branch 'net.venge.monotone.annotate' (head 76
        to branch 'net.venge.monotone' (head 2490479a4e4e99243fead6
"
    trust "trusted"

    key "emile@alumni.reed.edu"
signature "ok"
    name "date"
    value "2005-05-20T20:19:25"
    trust "trusted"

```

Output format:

All stanzas are formatted by `basic_io`. Stanzas are separated by a blank line. Values will be escaped, `'\'` to `'\\'` and `'\"'` to `'\"'`.

Error conditions:

If a certificate is signed with an unknown public key, a warning message is printed to `stderr`. If the revision specified is unknown or invalid prints an error message to `stderr` and exits with status 1.

`mtn automate stdio`

Arguments:

none

Changes:

- 3.1 – Added the 'o' item to the recognized input. This change should not break anything.

- 1.0 – Initial version.

Purpose:

Allow multiple automate commands to be run from one instance of monotone.

Sample input:

```
l6:leavese
l7:parents40:0e3171212f34839c2e3263e7282cdeea22fc5378e
o3:key11:foo@bar.come l4:cert40:0e3171212f34839c2e3263e7282cdeea22fc537
```

Input format:

```
[ 'o' <string> <string> [ <string> <string> [ ... ] ] 'e' ]■
'l' <string> [ <string> [ ... ] ] 'e'
```

The input is a series of commands. The command name plus arguments are provided as 'l' <string> [<string> ...] 'e', where <string> = <size> colon <data> . This may optionally be preceded by a set of key=value pairs (command options) as 'o' <string> <string> [<string> <string> ...] 'e', where strings come in pairs, key followed by value. For flag options that don't take values, specify the second string as zero length; 0:.

The space between the ending 'e' of one group of strings and the beginning 'l' or 'o' of the next is reserved. Any characters other than whitespace will cause an error.

Sample output:

```
0:0:l:205:0e3171212f34839c2e3263e7282cdeea22fc5378
1f4ef73c3e056883c6a5ff66728dd764557db5e6
2133c52680aa2492b18ed902bdef7e083464c0b8
23501f8afd1f9ee037019765309b0f8428567f8a
2c295fcf5fe20301557b9b3a5b4d437b5ab8ec8c
1:0:l:41:7706a422ccad41621c958affa999b1a1dd644e79
```

Output format:

The output consists of one or more packets for each command. A packet looks like:

```
<command number>:<err code>:<last?>:<size>:<output>
```

<command number> is a decimal number specifying which command this output is from. It is 0 for the first command, and increases by one each time.

<err code> is 0 for success, 1 for a syntax error, and 2 for any other error.

<last?> is 'l' if this is the last piece of output for this command, and 'm' if there is more output to come.

<size> is the number of bytes in the output.

<output> is a piece of the output of the command.

All but the last packet for a given command will have the <last?> field set to 'm'.

Error conditions:

If a badly formatted or invalid command is received, or a command is given with invalid arguments or options, prints an error message to standard error and exits with nonzero status. Errors in the commands run through this interface do not affect the exit status. Instead, the <err code> field in the output is set to 2, and the output of the command becomes whatever error message would have been given.

```
mtn automate get_revision id
```

Arguments:

The argument *id* specifies the revision id for which the changeset information should be printed.

Added in:

1.0

Changed in:

7.0 (*id* is now mandatory)

Purpose:

Prints change information for the specified revision id.

Sample output:

```
format_version "1"

new_manifest [bfe2df785c07bebeb369e537116ab9bb7a4b5e19]

old_revision [429fea55e9e819a046843f618d90674486695745]

patch "ChangeLog"
  from [7dc21d3a46c6ecd94685ab21e67b131b32002f12]
  to [234513e3838d423b24d5d6c98f70ce995c8bab6e]

patch "std_hooks.lua"
  from [0408707bb6b97eae7f8da61af7b35364dbd5a189]
  to [d7bd0756c48ace573926197709e53eb24dae5f5f]
```

Output format:

There are several changes that are described; each of these is described by a different basic_io stanza. The first string pair of each stanza indicates the type of change represented.

All stanzas are formatted by basic_io. Stanzas are separated by a blank line. Values will be escaped, '\' to '\\' and '"' to '\"'.

Possible values of this first value are along with an ordered list of basic_io formatted stanzas that will be provided are:

```
'format_version'
  used in case this format ever needs to change.
  format: ('format_version', the string "1")
```

```

        occurs: exactly once
'new_manifest'
    represents the new manifest associated with the revision.
    format: ('new_manifest', manifest id)
    occurs: exactly one
'old_revision'
    represents a parent revision.
    format: ('old_revision', revision id)
    occurs: either one or two times
'delete'
    represents a file or directory that was deleted.
    format: ('delete', path)
    occurs: zero or more times
'rename'
    represents a file or directory that was renamed.
    format: ('rename', old filename), ('to', new filename)
    occurs: zero or more times
'add_dir'
    represents a directory that was added.
    format: ('add_dir', path)
    occurs: zero or more times
'add_file'
    represents a file that was added.
    format: ('add_file', path), ('content', file id)
    occurs: zero or more times
'patch'
    represents a file that was modified.
    format: ('patch', filename), ('from', file id), ('to', file id)
    occurs: zero or more times
'clear'
    represents an attr that was removed.
    format: ('clear', filename), ('attr', attr name)
    occurs: zero or more times
'set'
    represents an attr whose value was changed.
    format: ('set', filename), ('attr', attr name), ('value', attr va
    occurs: zero or more times

```

These stanzas will always occur in the order listed here; stanzas of the same type will be sorted by the filename they refer to. The 'delete' and following stanzas will be grouped under the corresponding 'old_revision' one.

Error conditions:

If the revision specified is unknown or invalid prints an error message to stderr and exits with status 1.

```
mtn automate get_current_revision [--exclude excl] [--depth=depth] [path ...]
```

Arguments:

One or more *path* arguments restrict the revision to these paths, otherwise all changes in workspace are taken into account.

Options *excl* and *depth* work just like in *mtn commit*.

Added in:

7.0

Purpose:

Prints change information for the current workspace, optionally restricted by one or more paths.

Sample output:

See *automate get_revision*

Output format:

See *automate get_revision*

Error conditions:

If the command is executed outside of a workspace, there are no changes in the current workspace or the restriction is invalid or has no recorded changes, prints an error message to stderr and exits with status 1.

```
mtn automate get_base_revision_id
```

Arguments:

None.

Added in:

2.0

Purpose:

Prints the revision id the current workspace is based on. This is the “old_revision” value stored in ‘_MTN/revision’.

Sample output:

28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61

Output format:

One line containing the base revision ID of the current workspace.

Error conditions:

If no workspace book keeping _MTN directory is found, prints an error message to stderr, and exits with status 1.

```
mtn automate get_current_revision_id
```

Arguments:

None.

Added in:

2.0

Purpose:

Prints the revision id of the current workspace. This is the id of the revision that would be committed by an unrestricted commit in the workspace.

Sample output:

```
28ce076c69eadb9b1ca7bdf9d40ce95fe2f29b61
```

Output format:

One line containing the current revision id ID of the current workspace.

Error conditions:

If no workspace book keeping `_MTN` directory is found, prints an error message to stderr, and exits with status 1.

```
mtn automate get_manifest_of
mtn automate get_manifest_of revid
```

Arguments:

Specifying the optional *revid* argument outputs the manifest for the revision with the specified ID. Otherwise, outputs the manifest for the current workspace. (You can think of leaving the argument blank as meaning “give me the manifest of THIS”.)

Added in:

2.0

Purpose:

Prints the contents of the manifest associated with the given roster.

Sample output:

```
format_version "1"

dir ""

    file ".htaccess"
content [e3915658cb464d05f21332e03d30dca5d94fe776]

    file "AUTHORS"
content [80d8f3f75c9b517ec462233e155f7dfb93379f67]

    file "ChangeLog"
content [fc74a48c7f73eedcbe1ea709755fbe819b29736c]

    file "LICENSE"
content [dfac199a7539a404407098a2541b9482279f690d]

    file "README"
content [440eec971e7bb61ccbb61634deb2729bb25931cd]
```

```
file "TODO"
content [e0ea26c666b37c5f98ccf80cb933d021ee55c593]

file "branch.psp"
content [b28ece354969314ce996f3030569215d685973d6]

file "common.py"
content [1fdb62e05fb2a9338d2c72ddc58de3ab2b3976fe]

file "config.py.example"
content [64cb5898e3a026b4782c343ca4386585e0c3c275]

file "error.psp"
content [7152c3ff110418aca5d23c374ea9fb92a0e98379]

file "fileinbranch.psp"
content [5d8536100fdf51d505b6f20bc9c16aa78d4e86a8]

file "headofbranch.psp"
content [981df124a0b5655a9f78c42504cfa8c6f02b267a]

file "help.psp"
content [a43d0588a69e622b2afc681678c2a5c3b3b1f342]

file "html.py"
content [18a8bffc8729d7bfd71d2e0cb35a1aed1854fa74]

file "index.psp"
content [c621827db187839e1a7c6e51d5f1a7f6e0aa560c]

file "monotone.py"
content [708b61436dce59f47bd07397ce96a1cfabe81970]

file "revision.psp"
content [a02b1c161006840ea8685e461fd07f0e9bb145a3]

file "rss_feed.gif"
content [027515fd4558abf317d54c437b83ec6bc76e3dd8]

file "tags.psp"
content [638140d6823eee5844de37d985773be75707fa25]

file "tarofbranch.psp"
content [be83f459a152ffd49d89d69555f870291bc85311]

file "test.py"
content [e65aace9237833ec775253cfde97f59a0af5bc3d]
```

```

    attr "mtn:execute" "true"

    file "utility.py"
content [fb51955563d64e628e0e67e4acca1a1abc4cd989]

    file "viewmtn.css"
content [8d04b3fc352a860b0e3240dcb539c1193705398f]

    file "viewmtn.py"
content [7cb5c6b1b1710bf2c0fa41e9631ae43b03424a35]

    file "wrapper.py"
content [530290467a99ca65f87b74f653bf462b28c6cda9]

```

Output format:

There is one `basic_io` stanza for each file or directory in the manifest. All stanzas are formatted by `basic_io`. Stanzas are separated by a blank line. Values will be escaped, `'\'` to `'\\'` and `'"'` to `'\"'`.

Possible values of this first value are along with an ordered list of `basic_io` formatted stanzas that will be provided are:

```

'format_version'
    used in case this format ever needs to change.
    format: ('format_version', the string "1")
    occurs: exactly once
'dir':
    represents a directory. The path "" (the empty string) is used
    to represent the root of the tree.
    format: ('dir', pathname)
    occurs: one or more times
'file':
    represents a file.
    format: ('file', pathname), ('content', file id)
    occurs: zero or more times

```

In addition, `'dir'` and `'file'` stanzas may have `attr` information included. These are appended to the stanza below the basic `dir/file` information, with one line describing each `attr`. These lines take the form `('attr', attr name, attr value)`.

Stanzas are sorted by the path string.

Error conditions:

If the revision ID specified is unknown or invalid prints an error message to `stderr` and exits with status 1.

`mtn automate get_attributes path`

Arguments:

The argument *path* determines which path's attributes should be printed.

Added in:

3.0

Renamed from attributes to get_attributes in:

5.0

Purpose:

Prints all attributes of the given file and the attribute states.

Sample output:

```
format_version "1"

attr "foo" "bar"
state "added"

attr "baz" "bat"
state "dropped"

attr "foobar" "foobat"
state "unchanged"
```

Output format:

There is one `basic_io` stanza for each attribute of the given file.

All stanzas are formatted by `basic_io`. Stanzas are separated by a blank line and ordered by attribute name. Values will be escaped, `'\'` to `'\\'` and `'\"'` to `'\"'`.

Each attribute stanza also contains another entry which tells the status of attribute. This entry can have one of the following four values:

- `'added'`: the attribute has just been added to the file
- `'dropped'`: the attribute has just been dropped from the file
- `'unchanged'`: the attribute has not been changed since the last revision
- `'changed'`: the attribute has been changed since the last revision

The status `'changed'` can come up if an attribute `foo` has been dropped and added afterwards with another value, like

```
$ mtn attr drop file.txt foo ; mtn attr set file.txt foo baz
```

If an attribute has been dropped, the output will still return the previously set value of the dropped attribute for convenience (obviously this is no longer recorded in the current workspace).

The complete format:

```
'format_version'
  used in case this format ever needs to change.
  format: ('format_version', the string "1")
  occurs: exactly once
```

```

'attr':
    represents an attribute.
    format: ('attr', key, value), ('state', [unchanged|changed|added|
    occurs: zero or more times

```

Error conditions:

If the path specified is unknown in the new workspace revision, prints an error message to stderr and exits with status 1.

```
mtn automate set_attribute path key value
```

Arguments:

A path, an attribute key and an attribute value.

Added in:

5.0

Purpose:

Edits the current workspace revision and inserts the given attribute key and value for the specified path. Note that this change is not committed and therefor behaves exactly like `mtn attr set key value`.

Output format:

This command does not print out anything if successful.

Error conditions:

If the path specified is unknown in the new workspace revision, prints an error message to stderr and exits with status 1.

```
mtn automate drop_attribute path [key]
```

Arguments:

A path and an attribute key (optional).

Added in:

5.0

Purpose:

Removes an attribute from the current workspace revision for the specified path. If no attribute key is given, all attributes of this path are removed. Note that this change is not committed and therefor behaves exactly like `mtn attr drop path [key]`.

Output format:

This command does not print out anything if successful.

Error conditions:

If the path specified is unknown in the new workspace revision or the attribute key is not found for this path, prints an error message to stderr and exits with status 1.

```
mtn automate content_diff [--revision=id1 [--revision=id2]] [files ...]
```

Arguments:

One or more *file* arguments restrict the diff output to these files, otherwise all changed files in the given revision(s) and/or current workspace are considered.

If zero or more revisions are given, the command behaves as follows:

- no revision: the diff is done between the workspace revision and the parent (base) revision of this workspace
- one revision: the diff is done between the workspace revision and the given revision ‘id1’,
- two revisions: the diff is done between ‘id1’ and ‘id2’; no workspace is needed in this case.

Added in:

4.0

Purpose:

Prints the content changes between two revisions or a revision and the current workspace. This command differs from `mtn diff` in that way that it only outputs content changes and keeps quite on renames or drops, as the header of `mtn diff` is omitted (this is what `mtn automate get_revision` already provides).

Sample output:

```
=====■
--- guitone/res/i18n/guitone_de.ts      9857927823e1d6a0339b531c120dcaa
+++ guitone/res/i18n/guitone_de.ts      0b4715dc296b1955b0707923d45d79c
@@ -1,6 +1,14 @@
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE TS><TS version="1.1">
<context>
+   <name>AncestryGraph</name>
+   <message>
[...]
```

Output format:

The GNU unified diff format. If there have been no content changes, the output is empty.

Error conditions:

If more than two revisions are given or a workspace is required, but not found, prints to stderr and exits with status 1. If one or more file restrictions can't be applied, the command prints to stderr and exits as well.

```
mtn automate get_file id
```

Arguments:

The *id* argument specifies the file hash of the file to be output.

Added in:

1.0

Purpose:

Prints the contents of the specified file.

Sample output:

If you've downloaded a release, see INSTALL for installation instructions. If you've checked this out, the generated files are not included, and you must use "autoreconf --install" to create them.

"make html" for docs, or read the .info file and / or man page.

Output format:

The file contents are output without modification.

Error conditions:

If the file id specified is unknown or invalid prints an error message to stderr and exits with status 1.

```
mtn automate get_file_of filename [--revision=id]
```

Arguments:

The *filename* argument specifies the filename of the file to be output.

If a revision *id* is given, the file's contents in that specific revision are printed. If no revision is given, the workspace's revision is used.

Added in:

4.0

Purpose:

Prints the contents of the specified file.

Sample output:

If you've downloaded a release, see INSTALL for installation instructions. If you've checked this out, the generated files are not included, and you must use "autoreconf --install" to create them.

"make html" for docs, or read the .info file and / or man page.

Output format:

The file contents are output without modification.

Error conditions:

If the filename specified is unknown in the given revision or invalid, or if the given revision is unknown, prints an error message to stderr and exits with status 1.

```
mtn automate get_option option
```

Arguments:

The *option* argument specifies the option name of the option to be output.

Added in:

3.1

Purpose:

Prints an option from `._MTN/option` of the current workspace.

Sample output:

```
net.venge.monotone
```

Output format:

The option value is written out without modification.

Error conditions:

If the option is unknown, prints an error message to `stderr` and exits with status 1.

```
mtn automate keys
```

Arguments:

None.

Added in:

1.1

Purpose:

Print all keys in `basic_io` format.

Sample output:

```

        name "tbrownaw@gmail.com"
        public_hash [475055ec71ad48f5dfaf875b0fea597b5cbbee64]
        private_hash [7f76dae3f91bb48f80f1871856d9d519770b7f8a]
        public_location "database" "keystore"
        private_location "keystore"

        name "tomfa@debian.org"
        public_hash [3ac4afcd86af28413b0a23b7d22b9401e15027fc]
        public_location "database"

        name "underwater@fishtank.net"
        public_hash [115fdc73d87a5e9901d018462b21a1f53eca33a1]
        private_hash [b520d2cfe7d30e4ea1725fc4f34646fc5469b13d]
        public_location "keystore"
        private_location "keystore"
```

Output format:

For each key, a `basic_io` stanza is printed. The `public_location` and `private_location` items may have multiple values as shown above for `public_location`, one value for each place that the key is stored. If the private key does not exist, then the `private_hash` and `private_location` items will be absent. The keys are ordered alphabetically by name.

Error conditions:

None.

`mtn automate packet_for_rdata id`**Arguments:**The *id* specifies the revision to output an rdata packet for.**Added in:**

2.0

Purpose:

Prints the revision data in packet format

Sample output:

```
[rdata bdf3b10b5df0f17cc6c1b4b3351d84701bda59ed]
H4sIAAAAAAAAA/OXQS27DMAwEOL1PIfgArb4kte62NzACg5SoJEBsF7aRurev0UVzgJl5mLa
E+/jU9ftvsymd33Xzfo9Tjzfm267GSgGwVarz6ValxOKtFYwii9VqUFCqJQ5X7puedRx1ef
r2rwHlSbi+BUSrF4xn1p0RIkxmXTbmwREp/BL97LzfQfN56v+rlc+860dZnMED01jhILkUR
U10KPpGN1ueUwDHyiXF66Ywx+2IGD+0Uqg8aCzikAEzZNRXPmJKlkhMxSHuNzrofx/uq2/J
6njV/bZsu/zMP01b0Y4XJSD5K0rwXGdwpDGdfotZayQHKTai5fRPqUWKcAMMIQfAjOK0nkf
6tFacjYgBPV46X4BtlpiNYUBAAA=
[end]
```

Output format:

Revision data in monotone read compatible packet format.

Error conditions:If *id* is unknown or invalid prints an error message to stderr and exits with status 1.`mtn automate packet_for_certs id`**Arguments:**The *id* specifies the revision to output cert packets for.**Added in:**

2.0

Purpose:

Prints the certs associated with a revision in packet format

Sample output:

```
[rcert bdf3b10b5df0f17cc6c1b4b3351d84701bda59ed
branch
njs@pobox.com
bmV0LnZlbmdlLm1vbm90b25l]
K90i1XHHmaMEMuwbPifFweLThJl0m7jigh2Qq6Z7TBwNJ6IM0jXWCizv73cacZ1CtzzFDVw
SlqhNWiPQWxdcMp+Uuo+V8IFMKmvxVSTuVDukLMuNAQqpGL5S+a+tEj68NMq+KLKuL8kAAP
RoFD7GQlTS35S3RHWA4cnvqn+8U=
[end]
[rcert bdf3b10b5df0f17cc6c1b4b3351d84701bda59ed
date
```

```

njs@pobox.com
MjAwNiOwNCOWOFQxMT01MDowMA==]
araz9A8x6A1K6m6UhwnhUhk7cdyxeE2nvzj2gwaDvkaBx0q4SN23/wnaPqUXx1Ddn8smzyR
HN08xloYc0yNChp3wjbqx20REcsTg3XE4rN/sGcbqqw5hVT22a5ZhqkfKDeoeJvan0R0UBa
ngKY09eLuABNlmFX2onca75JW1E=
[end]
[rcert bdf3b10b5df0f17cc6c1b4b3351d84701bda59ed
author
njs@pobox.com
bmpzQHBvYm94LmNvbQ==]
BLPOYhgLsAN+w7Cw0sv9GfXnG3u7RNF1DTrWdn0AnYE1e+ptgTeMVWUI18H40GL0B7wm08r
Pxx/hvsb8fBn1Kf5HDD02pbjJ0xVzI9+p+TR0y5jJNZ1VSTj+nvtPgvK9NzsdooYWnw1WmJ
b0kAzQcZb8NMh8pbQkdHbR5uzMo=
[end]
[rcert bdf3b10b5df0f17cc6c1b4b3351d84701bda59ed
changelog
njs@pobox.com
MjAwNiOwNCOWOCAgTmF0aGFuaWVsIFNtaXR0ICA8bmpzQHBvYm94LmNvbT4KCgkq
L3Jlc29sdmVfZ2V0aG9zdGJ5bmFtZS5jeHggKHJlc29sdmVfaG9zdG5hbWUp0iAjaWZkZWY
b3V0CglXaW4zMl1pbmNvbXBhdGlibGUgZXJyb3IgcmlvbmVw3J0aW5nIGNhbGwuCg==]
Ncl4L/oEPctzVQixTKA6FrLceeHnLiXfeyeFDNmtUFYg9BMUcjWkeyKmaWknLv0cHortxjt
K6pQ9E8S7zI+TpzFAhssg5a//rFL0+2GJU3t6pcHs6LC0Q4tbqzwKd/5+8GwT1gphbM1wm
KuzKthwqD3pp49GbgTrp8iWMTr0=
[end]

```

Output format:

Cert data in monotone read compatible packet format.

Error conditions:

If *id* is unknown or invalid prints an error message to stderr and exits with status 1.

`mtn automate packet_for_fdata id`

Arguments:

The *id* specifies the file to output an fdata packet for.

Added in:

2.0

Purpose:

Prints the file data in packet format

Sample output:

```

[fdata 229c7f621b65f7e4970ae5aaec993812b9daa1d4]
H4sIAAAAAAAAA/z20027DMBBEe51ioMaNrJzBpQAjTXKBBTW0CJPcgFw6y01DCkG62Q/em83
R9vlRez6naPKzh2CwkipXFBjB08fn7f7HV4LQq4mMYoFzdMYSnMj1xXY/lnuoHt2kB2hQps
PREPZhaxvvchskIKkdU6xsXWvQsk76MOUquGV0lZmmmh0+xxvf7JZ5jCFXbU4KZ1muYkT+K
F0ez5q6uLuh9+9eoQawhez3Fp+VtHJNkfMmDHfALzWYfcAgBAAA=
[end]

```

Output format:

File data in `monotone read` compatible packet format.

Error conditions:

If *id* is unknown or invalid prints an error message to `stderr` and exits with status 1.

```
mtn automate packet_for_fdelta from-id to-id
```

Arguments:

The *from-id* specifies the file to use as the base of the delta, and *to-id* specifies the file to use as the target of the delta.

Added in:

2.0

Purpose:

Prints the file delta in packet format

Sample output:

```
[fdelta 597049a62d0a2e6af7df0b19f4945ec7d6458727
      229c7f621b65f7e4970ae5aaec993812b9daa1d4]
H4sIAAAAAAAAA/OW0yOoEMRBF9/mKS2/c9LQg4t5lw+BGf6BIKtNhkpSkKop/b9II7m4900f
eHp5dnevEj/SHLOaQ75qFAgcQGmcm5RXKjP3t/eP1ekWUh1TVKGeyJNXNoXU/s27AP8sf708
ZEdSSLd1JMaNKzeysY8ps4Iao4oNjM99eFdQDbMOSldDV8ZC3aSx1pxufzJF5jANx6oyS2
c0uh0+0wkpezZhCvK0bf8TVrMLZUo5zi0/I4j4UqPunGA+B+AfHvKEIPAQAA■
[end]
```

Output format:

File delta data in `monotone read` compatible packet format.

Error conditions:

If *from-id* or *to-id* is unknown or invalid prints an error message to `stderr` and exits with status 1.

```
mtn automate get_content_changed id file
```

Arguments:

The *id* specifies a revision ID, from which content change calculations will be based. and *file* specifies the file for which to calculate revisions in which it was last changed.

Added in:

3.2

Purpose:

Returns a list of revision IDs in which the content was most recently changed, relative to the revision ID specified as *id*. This equates to a content mark following the *-merge algorithm.

Sample output:

```
content_mark [276264b0b3f1e70fc1835a700e6e61bdbe4c3f2f]
```

Output format:

Zero or more `basic_io` stanzas, each specifying a revision ID in which a content mark is set.

The complete format:

```
'content_mark'
    the hexadecimal id of the revision the content mark is attached to
```

Error conditions:

If *id* or *file* is unknown or invalid prints an error message to `stderr` and exits with status 1.

```
mtn automate get_corresponding_path source_id file target_id
```

Arguments:

The *source_id* specifies a revision ID in which *file* is current extant. and *file* specifies the file whose name in *target_id* is to be determined; *target_id* specifies a revision ID.

Added in:

3.2

Purpose:

Given a the file name *file* in the source revision *source_id*, a filename will if possible be returned naming the file in the target revision *target_id*. This allows the same file to be matched between revisions, accounting for renames and other changes.

Sample output:

```
file "foo"
```

Output format:

Zero or one `basic_io` stanzas. Zero stanzas will be output if the file does not exist within the target revision; this is not considered an error. If the file does exist in the target revision, a single stanza with the following details is output.

The complete format:

```
'file'
    the file name corresponding to "file name" (arg 2) in the target revision
```

Error conditions:

If the revision IDs *source_id* or *target_id* are unknown or invalid prints an error message to `stderr` and exits with status 1. If the file path *file* does not exist in the revision *source_id* or is invalid, prints an error message to `stderr` and exits with status 1. Note that *file* not existing in the revision *target_id* is not an error.

```
mtn automate get_db_variables [domain]
```

Arguments:

The optional *domain* restricts the output to variables only within this domain.

Changes:

- 7.0 – converted output to `basic_io`, renamed to `'get_db_variables'`
- 4.1 – added as `'db_get'`

Purpose:

Reads and outputs database variables. For more information about variables, see [Section 3.9 \[Vars\]](#), page 60.

Sample output:

```
domain "database"
  entry "default-exclude-pattern" ""
  entry "default-include-pattern" "net.venge.monotone*"
  entry "default-server" "monotone.ca"

domain "known-servers"
  entry "monotone.ca" "3e6f5225bc2fffacbc20c9de37ff2dae1e20892e"
  entry "monotone.mtn-host.prjek.net" "a52f85615cb2445989f525bf17a603250"
  entry "venge.net" "70a0f283898a18815a83df37c902e5f1492e9aa2"
```

Output format:

`basic_io`-formatted stanzas. Each stanza starts with a `'domain'`, followed by one or more `'entry'` lines. Each `'entry'` contains the *name* and the *value* of the respective database variable.

Error conditions:

If the domain is unknown or no variables were found, prints an error message to `stderr` and exits with status 1.

```
mtn automate set_db_variable domain name value
```

Arguments:

The *domain* and *name* specify the database variable which is changed to *value*.

Changes:

- 7.0 – renamed to `'set_db_variable'`
- 4.1 – added as `'db_set'`

Purpose:

Change a database variable, see also [Section 3.9 \[Vars\]](#), page 60.

Sample usage:

```
mtn automate set_db_variable database default-server off.net
```

Output format:

No output.

Error conditions:

None.

```
mtn automate drop_db_variables domain [name]
```

Arguments:

The *domain* and *name* specify the database variable which should be dropped. If *name* is omitted, all database variables in the *domain* are dropped.

Added in:

7.0

Purpose:

Drops one or more database variables, see also [Section 3.9 \[Vars\]](#), [page 60](#).

Sample usage:

```
mtn automate drop_db_variables known-servers
```

Output format:

No output.

Error conditions:

If the specific variable or any variables in the given domain are not found, prints to stderr and exits with status 1.

```
mtn automate put_file [base-id] contents
```

Arguments:

The optional *base-id* specifies a file-id on which the contents are based on. This is used for delta encoding. *contents* are the contents of the new file.

Added in:

4.1

Purpose:

Preparation of a workspace-less commit. See also `automate put_revision`. Normally used via `automate stdio`.

Sample output:

```
70a0f283898a18815a83df37c902e5f1492e9aa2
```

Output format:

The sha1 sum of the contents, hex encoded.

Error conditions:

If the optional base id is unknown prints an error message to stderr and exits with status 1.

```
mtn automate put_revision revision-data
```

Arguments:

revision-data is the new revision. See example below. Note that the new_manifest entry is ignored – `put_revision` will ignore whatever you put here and calculate the correct manifest id itself. (However, for now, you must put 40 hex digits here – it's just that which

Error conditions:

If the revision is invalid prints an error message to stderr and exits with status 1.

5.10 RCS

`mtn rcs_import filename...`

This command imports all the file versions in each RCS file listed in *filename...* These files should be raw RCS files, ending in *,v*. Monotone parses them directly and inserts them into your database. Note that this does not do any revision reconstruction, and is only useful for debugging.

`mtn cvs_import pathname`

This command imports all the file versions in each RCS file found in the tree of files starting at *pathname*, then reconstructs the tree-wide history of logical changes by comparing RCS time stamps and change log entries. For each logical tree-wide change, monotone synthesizes a manifest and revision, and commits them (along with all associated file deltas) to your database. It also copies all change log entries, author identifiers, and date stamps to manifest certificates.

In normal use, *pathname* will be a CVS module, though it is possible to point it at a directory within a module as well. Whatever directory you point it at will become the root of monotone's version of the tree.

6 Hook Reference

Monotone's behavior can be customized and extended by writing *hook functions*, which are written in the **Lua** programming language. At certain points in time, when monotone is running, it will call a hook function to help it make a decision or perform some action. If you provide a hook function definition which suits your preferences, monotone will execute it. This way you can modify how monotone behaves.

You can put new definitions for any of these hook functions in a file `‘$HOME/.monotone/monotonerc’`, or in your workspace in `‘_MTN/monotonerc’`, both of which will be read every time monotone runs. Definitions in `‘_MTN/monotonerc’` shadow (override) definitions made in your `‘$HOME/.monotone/monotonerc’`. You can also tell monotone to interpret extra hook functions from any other *file* using the `‘--rcfile=file’` option; hooks defined in files specified on the command-line will shadow hooks from the the automatic files. By specifying `‘--rcfile=directory’` you can automatically load all the files contained into *directory*.

Monotone provides some default hooks, see [Appendix A \[Default hooks\]](#), page 225 for their complete source. When writing new hooks, it may be helpful to reuse some code from the default ones. Since Lua is a lexically scoped language with closures, this can be achieved with the following code:

```
do
    local old_hook = default_hook
    function default_hook(arg)
        if not old_hook(arg) then
            -- do other stuff
        end
    end
end
end
```

Now the default hook is trapped in a variable local to this block, and can only be seen by the new hook. Since in Lua variables default to the global scope, the new hook is seen from inside monotone.

Monotone also makes available to hook writers a number of helper functions exposing functionality not available with standard Lua.

6.1 Hooks

This section documents the existing hook functions and their default definitions.

6.1.1 Event Notifications and Triggers

There are a number of hooks that are called when noteworthy events occur, such as commits or new revisions arriving over the network. These hooks can be used to feed the events into external notification systems, such as generating email.

By default, these hooks are undefined, so no special external actions are taken.

`note_commit (new_id, revision, certs)`

Called by monotone after the version *new_id* is committed. The second parameter, *revision* is the text of the revision, what would be given by `mtn automate get_revision new_id`. The third parameter, *certs*, is a Lua table containing the set of certificate names and values committed along with this version. There is no default definition for this hook.

Note that since the *certs* table does not contain cryptographic or trust information, and only contains one entry per cert name, it is an incomplete source of information about the committed version. This hook is only intended as an aid for integrating monotone with informal commit-notification systems such as mailing lists or news services. It should not perform any security-critical operations.

`note_netsync_start (session_id, my_role, sync_type, remote_host, remote_keyname, includes, excludes)`

Called by monotone before any other of the netsync notification hooks are called. The *session_id* helps keep track of the current netsync session in case several are happening at the same time, and is used throughout all netsync notification hooks.

The other arguments are:

my_role

This will be either "client" or "server".

sync_type

This will be one of "sync", "push", or "pull".

remote_host

The network address of the remote host. At the client, this will be the name it was told to connect to; at the server, this will use the numerical IP address the connection was received from.

remote_keyname

The name of the key being used by the other end of the connection. This may be set to "-unknown-" at the server if the key used by the client is not present at the server.

includes **and** *excludes*

The include and exclude patterns used by the client.

note_netsync_revision_received (*new_id*, *revision*, *certs*, *session_id*)

Called by monotone after the revision *new_id* is received through netsync. *revision* is the text of the revision, what would be given by `mtn automate get_revision new_id`. *certs* is a Lua table containing one subtable for each cert attached to the revision *new_id*. These subtables have fields named "key", "name", and "value", containing the signing key for the cert, the name of the cert, and the value of the cert. There is no default definition for this hook. *session_id* is used together with `note_netsync_start` and `note_netsync_end`. If you're not interested in that type of tracking, you can ignore that variable entirely.

note_netsync_cert_received (*rev_id*, *key*, *name*, *value*, *session_id*)

Called by monotone after a cert is received through netsync, if the revision that the cert is attached to was not also received in the same netsync operation. *rev_id* is the revision id that the cert is attached to, *key* is the key that the cert is signed with, *name* is the name of the cert, and *value* is the cert value. There is no default definition for this hook. *session_id* is used together with `note_netsync_start` and `note_netsync_end`. If you're not interested in that type of tracking, you can ignore that variable entirely.

note_netsync_pubkey_received (*keyname*, *session_id*)

Called by monotone after a pubkey is received through netsync. *keyname* is the name of the key received. There is no default definition for this hook. *session_id* is used together with `note_netsync_start` and `note_netsync_end`. If you're not interested in that type of tracking, you can ignore that variable entirely.

note_netsync_end (*session_id*, *status*,

bytes_in, *bytes_out*, *certs_in*, *certs_out*, *revs_in*, *revs_out*, *keys_in*, *keys_out*)

Called by monotone after all other the netsync notification hooks have been called. This hook would usually be used for post-netsync purposes, like collecting all the data from all other netsync notification hooks, make some nice output from them and finally send the result somewhere. It could also be used to prepare parallel databases with all the data to be displayed through something like `viewmtn`.

status is a three digit integer that tells whether there was an error, and if so what kind of error it was:

200

No error, connection successful.

211

The connection was interrupted after some data may have been transferred.

212

The connection was interrupted before any data could be transferred.

412

The request is not permitted.

422

The client tried to use a key that the server doesn't know about.

432

The client and server have different epochs for a branch.

512

Protocol error (source/sink confusion).

521

Protocol error (packet received at a time when it doesn't make sense).

532

The client did not identify itself correctly. (Possible replay attack?)

In general, 2xx means there was no error, 4xx means there was a permissions error, and 5xx means there was a protocol error. xx1 means some data may have been transferred, xx2 means no data was transferred, and xx0 means all data was transferred.

`note_mtn_startup (...)`

Called by monotone when it is first started, this hook was added so that usage of monotone could be monitored for user interface testing. Note that by default, no monitoring occurs. The arguments to the hook function are the arguments to monotone, without the initial `mtn` command. They can be accessed through the lua `arg` variable as in this example:

```
function note_mtn_startup(...)
  print("Beginning note_mtn_startup")
  for i = 1, arg.n do
    print(arg[i])
  end
  print("Ending note_mtn_startup")
end
```

6.1.2 User Defaults

These are hooks that can be used to provide smart, context-sensitive default values for a number of parameters the user might otherwise be prompted for.

`get_branch_key (branchname)`

Returns a string which is the name of an RSA private key used to sign certificates in a particular branch *branchname*. There is no default definition for this hook. The command-line option `--key=keyname` overrides any value returned from this hook function. If you have only one private key in your database, you do not need to define this function or provide a `--key=keyname` option; monotone will guess that you want to use the unique private key.

`get_netsync_key(server, include, exclude)`

Returns a string which is the name of the key to use to authenticate the given netsync connection. When called by the `serve` command, *server* is the address monotone is listening on, *include* is `"*"`, and *exclude* is `""`.

There is no default definition of this hook. The command-line option ‘`--key=keyname`’ overrides any value returned from this hook function.

`get_passphrase (keypair_id)`

Returns a string which is the passphrase used to encrypt the private half of *keypair_id* in your database, using the ARC4 symmetric cipher. *keypair_id* is a Lua string containing the label that you used when you created your key — something like “nicole@example.com”. This hook has no default definition. If this hook is not defined or returns false, monotone will prompt you for a passphrase each time it needs to use a private key.

`get_author (branchname, keypair_id)`

Returns a string which is used as a value for automatically generated **author** certificates when you commit changes to *branchname* with the keypair identity *keypair_id*. Generally this hook remains undefined, and monotone selects your signing key name for the author certificate. You can use this hook to override that choice, if you like.

This hook has no default definition, but a couple of possible definitions might be:

```
function get_author(branchname, keypair_id)
    -- Key pair identity ignored.
    local user = os.getenv("USER")
    local host = os.getenv("HOSTNAME")
    if ((user == nil) or (host == nil)) then return nil end
    return string.format("%s@%s", user, host)
end

function get_author(branchname, keypair_id)
    -- Branch name ignored.
    if (keypair_id == "joe@example.com") then
        return "Joe Random <joe@example.com>"
    end
    return keypair_id
end
```

`edit_comment (commentary, user_log_message)`

Returns a log entry for a given set of changes, described in *commentary*. The commentary is identical to the output of `mtn status`. This hook is intended to interface with some sort of editor, so that you can interactively document each change you make. The result is used as the value for a **changelog** certificate, automatically generated when you commit changes.

The contents of ‘`_MTN/log`’ are read and passed as *user_log_message*. This allows you to document your changes as you proceed instead of waiting until you are ready to commit. Upon a successful commit, the contents of ‘`_MTN/log`’ are erased setting the system up for another edit/commit cycle.

For the default definition of this hook, see [Appendix A \[Default hooks\]](#), page 225.

`persist_phrase_ok ()`

Returns **true** if you want monotone to remember the passphrase of a private key for the duration of a single command, or **false** if you want monotone to prompt you for a passphrase for each certificate it generates. Since monotone often

generates several certificates in quick succession, unless you are very concerned about security you probably want this hook to return **true**.

The default definition of this hook is:

```
function persist_phrase_ok()
    return true
end
```

use_inodeprints ()

Returns **true** if you want monotone to automatically enable [Section 3.5 \[Inodeprints\]](#), [page 52](#) support in all workspaces. Only affects working copies created after you modify the hook.

The default definition of this hook is:

```
function use_inodeprints()
    return false
end
```

ignore_file (filename)

Returns **true** if *filename* should be ignored while adding, dropping, or moving files. Otherwise returns **false**. This is most important when performing recursive actions on directories, which may affect multiple files simultaneously.

The default definition of this hook recognises a number of common file types and extensions for temporary and generated file types that users typically don't want to track. If the file `‘.mtn-ignore’` exists, this hook will read a list of regular expressions from the file, one per line, and ignore all files matching one of these expressions. For the default definition of this hook, see [Appendix A \[Default hooks\]](#), [page 225](#).

ignore_branch (branchname)

Returns **true** if *branchname* should be ignored while listing branches. Otherwise returns **false**. This hook has no default definition, therefore the default behavior is to list all branches.

6.1.3 Netsync Permission Hooks

These hooks are used when running a netsync server, via `mtn serve`. They are evaluated by the server for each new connection, based on the certificate used for authentication by the client. Note that a long-running server will need to be restarted in order to reload the hook definitions if the `‘montonerc’` file is changed.

get_netsync_read_permitted (branch, identity)

Returns **true** if a peer authenticated as key *identity* should be allowed to read from your database certs, revisions, manifests, and files associated with *branch*; otherwise **false**. The default definition of this hook reads a file `‘read-permissions’` in the configuration directory. This file looks like

```
pattern "net.example.project.{private,security}*"
allow "joe@example.net"
allow "jim@example.net"

comment "everyone can read these branches"
pattern "net.example.{public,project}*"
allow "*"

```

This example allows everyone access to branches `net.example.project` and `net.example.public` and their sub-branches, except for the branches in

`net.example.project.security` and `net.example.project.private`, which are only readable by Joe and Jim.

The file is divided into stanzas of one `pattern` line followed by any number of `allow` and `deny` lines, and possibly a `continue` line. Anything from the unquoted word `comment` until the next unquoted word is ignored. A stanza is processed if the argument to `pattern` is a glob that matches *branch*. Any keys which match an `allow` line are given access, and any keys which match a `deny` line are denied access. If there is a `continue "true"` line, then if the key is not granted or denied access in this stanza the next matching stanza will be processed. If there is not a `continue "true"` line, then any key which has not been given access will be denied access even if it doesn't match any `deny` lines. Thus, `deny` lines are redundant unless there is also a `continue "true"` line.

If a client connects anonymously, this hook will be called with a *identity* of `nil`.

Note that the *identity* value is a key ID (such as “graydon@pobox.com”) but will correspond to a *unique* key fingerprint (hash) in your database. Monotone will not permit two keys in your database to have the same ID. Make sure you confirm the key fingerprints of each key in your database, as key ID strings are “convenience names”, not security tokens.

`get_netsync_write_permitted (identity)`

Returns `true` if a peer authenticated as key *identity* should be allowed to write into your database certs, revisions, manifests, and files; otherwise `false`. The default definition of this hook reads a file ‘`write-permissions`’ in the configuration directory which contains a list of keys, one per line, which are allowed write access. The special value `*` means to allow access to anyone whose public key we already have.

If a client connects anonymously, it will be unconditionally denied write access; this hook will *not* be called with a *identity* of `nil`.

Note that the *identity* value is a key ID (such as “graydon@pobox.com”) but will correspond to a *unique* key fingerprint (hash) in your database. Monotone will not permit two keys in your database to have the same ID. Make sure you confirm the key fingerprints of each key in your database, as key ID strings are “convenience names”, not security tokens.

Note also that, unlike the equivalent read permission hook, the write permission hook does not take a *branch* name as an argument. There is presently no way to selectively grant write access to different branches via `netsync`, for a number of reasons. Contributions in the database from different authors can be selectively trusted using the [\[Trust Evaluation Hooks\]](#), page 152 instead.

6.1.4 Netsync Transport Hooks

When a monotone client initiates a `netsync` connection, these hooks are called to attempt to parse the host argument provided on the command line. If the hooks fail or return `nil`, monotone will interpret the host argument as a network name (possibly with a port number) and open a TCP socket.

`get_netsync_connect_command(uri, args)`

Returns a table describing a command to run to connect to the specified host.

The `uri` argument is a table containing between 0 and 7 components:

- `uri["scheme"]`, such as "ssh" or "file"
- `uri["user"]`, the name of a remote user
- `uri["host"]`, the name or address of a remote host
- `uri["port"]`, a network port number
- `uri["path"]`, a filesystem path
- `uri["query"]`, for additional parameters
- `uri["fragment"]`, to describe a sub-location within the remote resource

The `args` argument is a table containing between 0 and 3 components:

- `args["include"]`, the branch pattern to include
- `args["exclude"]`, the branch pattern to exclude
- `args["debug"]`, whether to run the connection in debug mode

The default definition of this hook follows:

```

function get_netsync_connect_command(uri, args)

    local argv = nil

    if uri["scheme"] == "ssh"
        and uri["host"]
        and uri["path"] then

        argv = { "ssh" }
        if uri["user"] then
            table.insert(argv, "-l")
            table.insert(argv, uri["user"])
        end
        if uri["port"] then
            table.insert(argv, "-p")
            table.insert(argv, uri["port"])
        end

        table.insert(argv, uri["host"])
    end

    if uri["scheme"] == "file" and uri["path"] then
        argv = { }
    end

    if argv then

        table.insert(argv, get_mtn_command(uri["host"]))

        if args["debug"] then
            table.insert(argv, "--debug")
        else
            table.insert(argv, "--quiet")
        end

        table.insert(argv, "--db")
        table.insert(argv, uri["path"])
        table.insert(argv, "serve")
        table.insert(argv, "--stdio")
        table.insert(argv, "--no-transport-auth")

        if args["include"] then
            table.insert(argv, args["include"])
        end

        if args["exclude"] then
            table.insert(argv, "--exclude")
            table.insert(argv, args["exclude"])
        end
    end

    return argv
end

```

use_transport_auth (uri)

Returns a boolean indicating whether monotone should use transport authentication mechanisms when communicating with *uri*. If this hook fails, the return value is assumed to be **true**. The form of the *uri* argument is a table, identical to the table provided as an argument to `get_netsync_connect_command`.

Note that the return value of this hook must "match" the semantics of the command returned by `get_netsync_connect_command`. In particular, if this hook returns `false`, the `serve` command line arguments passed to the remote end of the connection should include the `'--no-transport-auth'` option. A mismatch between this hook's return value and the command line returned by `get_netsync_connect_command` will cause a communication failure, as the local and remote monotone processes will have mismatched authentication assumptions.

```
function use_transport_auth(uri)
  if uri["scheme"] == "ssh"
  or uri["scheme"] == "file" then
    return false
  else
    return true
  end
end
```

`get_mtn_command(host)`

Returns a string containing the monotone command to be executed on *host* when communicating over `ssh`. The *host* argument is a string containing the name of the host to which `ssh` is connecting, from the server URI. This is useful when there are multiple monotone binaries on the remote host, or the monotone binary is not in the default path.

```
function get_mtn_command(host)
  return "mtn"
end
```

6.1.5 Trust Evaluation Hooks

Monotone makes heavy use of certs to provide descriptive information about revisions. In many projects, not all developers should have the same privileges, or be trusted for the same purposes (indeed, some signers might be automated robots, with very specific purposes).

These hooks allow the user to configure which signers will be trusted to make which kinds of assertions using certs. Monotone uses these certs when selecting available revisions for commands such as `update`.

Each user, or even each workspace, can have their own implementation of these hooks, and thus a different filtered view of valid revisions, according to their own preferences and purposes.

`get_revision_cert_trust(signers, id, name, val)`

Returns whether or not you *trust* the assertion *name=value* on a given revision *id*, given a valid signature from all the keys in *signers*. The *signers* parameter is a table containing all the key names which signed this cert, the other three parameters are strings.

The default definition of this hook simply returns `true`, which corresponds to a form of trust where every key which is defined in your database is trusted. This is a *weak* trust setting; you should change it to something stronger. A possible example of a stronger trust function (along with a utility function for computing the intersection of tables) is the following:

```

function intersection(a,b)
  local s={}
  local t={}
  for k,v in pairs(a) do s[v] = 1 end
  for k,v in pairs(b) do if s[v] ~= nil then table.insert(t,v) end end
  return t
end

function get_revision_cert_trust(signers, id, name, val)
  local trusted_signers = { "bob@happyplace.example.com",
                             "friend@trustedplace.example.com",
                             "myself@home.example.com" }
  local t = intersection(signers, trusted_signers)

  if t == nil then return false end

  if (name ~= "branch" and table.getn(t) >= 1)
    or (name == "branch" and table.getn(t) >= 2)
  then
    return true
  else
    return false
  end
end

```

In this example, any revision certificate is trusted if it is signed by at least one of three “trusted” keys, unless it is an **branch** certificate, in which case it must be signed by *two* or more trusted keys. This is one way of requiring that the revision has been approved by an extra “reviewer” who used the **approve** command.

accept_testresult_change (old_results, new_results)

This hook is used by the update algorithm to determine whether a change in test results between update source and update target is acceptable. The hook is called with two tables, each of which maps a signing key – representing a particular testsuite – to a boolean value indicating whether or not the test run was successful. The function should return **true** if you consider an update from the version carrying the *old_results* to the version carrying the *new_results* to be acceptable.

The default definition of this hook follows:

```

function accept_testresult_change(old_results, new_results)
  for test,res in pairs(old_results)
  do
    if res == true and new_results[test] ~= true
    then
      return false
    end
  end
  return true
end

```

This definition accepts only those updates which preserve the set of **true** test results from update source to target. If no test results exist, this hook has no affect; but once a **true** test result is present, future updates will require it. If you want a more lenient behavior you must redefine this hook.

6.1.6 External Diff Tools

Differences between files can be shown in a number of ways, varying according to user preference and file type. These hooks allow customisation of the way file differences are shown.

`get_encloser_pattern (file_path)`

Called for each file when `diff` is given the ‘`--show-encloser`’ option (and *not* the ‘`--external`’ option). *file_path* is the pathname of the file that is being diffed. The hook should return a string constant containing a regular expression; this regular expression will be used to find lines that, in that file, name the “top-level” constructs enclosing each “hunk” of changes. The default is `^[[:alnum:]]$`, which is correct for many programming languages; a few text authoring packages, like Texinfo, have special regular expressions that match their particular syntax. If you have a better regular expression for some language, you can add it to this hook; and if you send it to the monotone developers, we will likely make it the default for that language. See [Section 7.5 \[Regexps\]](#), page 187, for the regular expression syntax.

`external_diff (file_path, old_data, new_data, is_binary, diff_args, old_rev, new_rev)`

Called for each file when `diff` is given the ‘`--external`’ option. *file_path* is the pathname of the file that is being diffed. *old_data* and *new_data* are the data contents of the old and the new file. If the data is binary, *is_binary* will be true, otherwise false. *old_rev* and *new_rev* are the revision IDs of the old and new data.

If an extra arguments are given via ‘`--diff-args`’, the string will be passed in as *diff_args*. Otherwise *diff_args* will be nil.

The default implementation of this hook calls the program `diff`, and if ‘`--diff-args`’ were not passed, takes default arguments from the Lua variable `external_diff_default_args`. You can override this variable in your configuration file, without overriding the whole hook.

6.1.7 External Merge Tools

Monotone often needs to merge together the work of multiple distributed developers, and uses these hooks to help this process when the merge does not automatically succeed. Often these hooks will be used to invoke an external interactive merge tool.

The [Appendix A \[Default hooks\]](#), page 225 include helper functions used by the hooks below to invoke a number of external merge tools known to monotone, and you can override or extend these hooks if you have a preferred tool, or if you have a tool specific to certain file types.

`merge3 (ancestor_path, left_path, right_path, merged_path, ancestor_text, left_text, right_text)`

This hook is called to resolve merges that monotone could not resolve automatically. The actual ancestor, left, and right contents of the file are passed in the *ancestor_text*, *left_text*, and *right_text* strings. In addition, the hook is given the names that this file had in the ancestor (*ancestor_path*), left (*left_path*),

and right (*right_path*) trees, and the name it will end up having in the merged tree (*merged_path*). These paths are useful for merge tools that can display the names of files in their GUI, since the actual path names are likely more meaningful than the temporary file names the merge tool will actually be working on.

Returns a string, which should be the merger of the given texts. The default definition of this hook delegates the actual merge to the result of `[get_preferred_merge3_command]`, page 155. The default definition of `[get_preferred_merge3_command]`, page 155 checks to see if the `MTN_MERGE` environment variable, or the Lua variable `merger` are set to the name of a merge tool that it recognizes, and if not, then simply searches for whatever is installed on the local system. For details, see the code in [Appendix A \[Default hooks\]](#), page 225.

`get_preferred_merge3_command(tbl)`

Returns the results of running an external merge on three strings. *tbl* wraps up the various arguments for each merge command and is always provided by `[merge3]`, page 154. If there is a particular editor that you would like to use to perform merge3 operations, override this hook to specify it.

6.1.8 Selector Expansion

Monotone’s selectors are a powerful mechanism used to refer to revisions with symbolic names or groupings. Thanks to the hooks described in this section, it is possible to use various forms of shorthand in selection strings; these hooks are designed to recognise shorthand patterns and expand them to their full form.

For more detail on the use of selectors, see [Section 3.2 \[Selectors\]](#), page 47.

`expand_selector (str)`

Attempts to expand *str* as a selector. Expansion generally means providing a type prefix for the selector, such as `a:` for authors or `d:` for dates. This hook is called once for each element of a combined selector string (between / separators) prior to evaluation of the selector. For the default definition of this hook, see [Appendix A \[Default hooks\]](#), page 225.

`expand_date (str)`

Attempts to expand *str* as a date expression. Expansion means recognizing and interpreting special words such as `yesterday` or `6 months ago` and converting them into well formed date expressions. For the default definition of this hook, see [Appendix A \[Default hooks\]](#), page 225.

6.1.9 Attribute Handling

Some files in a project are special; they may require different handling (such as binary or structured files that should always be manually merged – see [Section 3.14 \[Merging\]](#), page 67), or they may represent executable scripts or programs.

Monotone allows each file (or directory) in a repository to carry arbitrary [Section 3.13 \[File Attributes\]](#), page 66. Persistent attributes are stored each revision’s manifest. The hooks in this section allow files to be automatically recognised as having certain attributes

at the time they're added, and for custom triggers to be invoked on each file according to its attributes when the workspace is changed.

`attr_functions [attribute] (filename, value)`

This is not a hook function, but a *table* of hook functions. Each entry in the table `attr_functions`, at table entry *attribute*, is a function taking a file name *filename* and a attribute value *value*. The function should “apply” the attribute to the file, possibly in a platform-specific way.

Hook functions from this table are called for each existing attr, after any command which modifies the workspace. This facility can be used to extend monotone's understanding of files with platform-specific attributes, such as permission bits, access control lists, or special file types.

By default, there is only one entry in this table, for the `mtn:execute` attribute. Its definition is:

```
attr_functions["mtn:execute"] =
  function(filename, value)
    if (value == "true") then
      make_executable(filename)
    end
  end
```

`attr_init_functions [attribute] (filename)`

This is not a hook function, but a *table* of hook functions. Each entry in the table `attr_init_functions`, at table entry *attribute*, is a function taking a file (or directory) name *filename*. Each function defines the attributes that should be set on the file named *filename*. This table of hook functions is called once for each file during an *add*.

By default, there are only two entries in this table, for the `mtn:execute` and `mtn:manual_merge` attributes. Their definition is:

```
attr_init_functions["mtn:execute"] =
  function(filename)
    if (is_executable(filename)) then
      return "true"
    else
      return nil
    end
  end
attr_init_functions["mtn:manual_merge"] =
  function(filename)
    if (binary_file(filename)) then
      return "true" -- binary files must be merged manually
    else
      return nil
    end
  end
```

The `binary_file` function is also defined as a Lua hook. See [Appendix A \[Default hooks\]](#), page 225.

6.1.10 Validation Hooks

If there is a policy decision to make, Monotone defines certain hooks to allow a client to validate or reject certain behaviors.

`validate_commit_message (message, revision_text, branchname)`

This hook is called after the user has entered his/her commit message. *message* is the commit message that the user has entered and *revision_text* is the full text of the changes for this revision, which can be parsed with the `parse_basic_io` function. The *branchname* on which the new revision will be committed if all goes well is passed in as the third parameter. If the hook finds the commit message satisfactory, it can return `true, ""`. If it finds fault, then it can return `false, reason` where *reason* is the reason the message was rejected. By default, this hook rejects empty log messages.

6.2 Additional Lua Functions

This section documents the additional Lua functions made available to hook writers.

`alias_command(original, alias)`

This function adds a new alias for a monotone command. A call to this function would normally be placed directly in the ‘`monotonerc`’ file, rather than in a hook function.

`existonpath(possible_command)`

This function receives a string containing the name of an external program and returns 0 if it exists on path and is executable, -1 otherwise. As an example, `existonpath("xxdiff")` returns 0 if the program `xxdiff` is available. On Windows, this function automatically appends “.exe” to the program name. In the previous example, `existonpath` would search for “`xxdiff.exe`”.

`get_confdir()`

Returns the path to the configuration directory, either implied or given with ‘`--confdir`’.

`get_ostype()`

Returns the operating system flavor as a string.

`guess_binary_file_contents(filespec)`

Returns true if the file appears to be binary, i.e. contains one or more of the following characters:

0x00 thru 0x06
0x0E thru 0x1a
0x1c thru 0x1f

`include(scriptfile)`

This function tries to load and execute the script contained into `scriptfile`. It returns true for success and false if there is an error.

`includedir(scriptpath)`

This function loads and executes in alphabetical order all the scripts contained into the directory `scriptpath`. If one of the scripts has an error, the functions doesn’t process the remaining scripts and immediately returns false.

`includedirpattern(scriptpath, pattern)`

This function loads and executes in alphabetical order all the scripts contained into the directory `scriptpath` that match the given `pattern`. If one of the scripts has an error, the functions doesn’t process the remaining scripts and immediately returns false.

`is_executable(filespec)`

This function returns true if the file is executable, false otherwise. On Windows this function returns always false.

`kill(pid [, signal])`

This function calls the `kill()` C library function on POSIX systems and `TerminateProcess` on Win32 (in that case `pid` is the process handle). If the optional `signal` parameter is missing, `SIGTERM` will be used. Returns 0 on success, -1 on error.

`make_executable(filespec)`

This function marks the named file as executable. On Windows has no effect.

`match(glob, string)`

Returns true if *glob* matches *str*, return false otherwise.

`mkstemp(template)`

Like its C library counterpart, `mkstemp` creates a unique name and returns a file descriptor for the newly created file. The value of *template* should be a pointer to a character buffer loaded with a null-terminated string that consists of contiguous, legal file and path name characters followed by six Xs. The function `mkstemp` replaces the Xs by an alpha-numeric sequence that is chosen to ensure that no file in the chosen directory has that name. Furthermore, subsequent calls to `mkstemp` within the same process each yield different file names. Unlike other implementations, monotone `mkstemp` allows the template string to contain a complete path, not only a filename, allowing users to create temporary files outside the current directory.

Important notice:

To create a temporary file, you must use the `temp_file()` function, unless you need to run monotone with the ‘`--nostd`’ option. `temp_file()` builds on `mkstemp()` and creates a file in the standard TMP/TEMP directories. For the definition of `temp_file()`, see [Appendix A \[Default hooks\]](#), page 225.

`mtn_automate(...)`

The `mtn_automate` Lua function calls the Monotone `automate` command passed in its arguments. The result of the call is a pair consisting of a boolean return code, indicating whether the call was successful or not, and a string being the `stdout` output from the `automate` command. This function is not for use in ordinary Lua hooks, but rather for Lua based commands as defined by the Lua function `register_command`.

`parse_basic_io(data)`

Parse the string *data*, which should be in `basic.io` format. It returns nil if it can't parse the string; otherwise it returns a table. This will be a list of all statements, with each entry being a table having a "name" element that is the symbol beginning the statement and a "values" element that is a list of all the arguments.

For example, given this as input:

```
thingy "foo" "bar"
thingy "baz"
spork
frob "oops"
```

The output table will be:

```
{
  1 = { name = "thingy", values = { 1 = "foo", 2 = "bar" } },
  2 = { name = "thingy", values = { 1 = "baz" } },
  3 = { name = "spork", values = { } },
  4 = { name = "frob", values = { 1 = "oops" } }
}
```

`regex.search(regex, string)`

Returns true if a match for *regex* is found in *str*, return false otherwise. See [Section 7.5 \[Regexps\], page 187](#), for the syntax of *regex*.

`register_command(name, params, abstract, description, function)`

Add a command named *name* to the *user* command group in monotone. This function is normally called directly from a ‘*monotonerc*’ file rather than a hook. When the user issues the registered command, monotone will call the lua *function* name supplied. That function would then normally use `mtn_automate()` calls to service the request.

`server_request_sync(what, address, include, exclude)`

Initiate a netsync connection to the server at *address*, with the given include and exclude patterns, of type ‘*sync*’, ‘*push*’, or ‘*pull*’, as given by the *what* argument.

When called by a monotone instance which is not running the ‘*serve*’ command, this function has no effect.

`sleep(seconds)`

Makes the calling process sleep for the specified number of seconds.

`spawn(executable [, args ...])`

Starts the named executable with the given arguments. Returns the process PID on POSIX systems, the process handle on Win32 or -1 if there was an error. Calls `fork/execvp` on POSIX, `CreateProcess` on Win32.

Important notice:

To spawn a process and wait for its completion, use the `execute()` function, unless you need to run monotone with the ‘*--nostd*’ option. `execute()` builds on `spawn()` and `wait()` in a standardized way.

`spawn_pipe(executable [, args ...])`

Like `spawn()`, but returns three values, where the first two are the subprocess’ standard input and standard output, and the last is the process PID on POSIX systems, the process handle on Win32 or -1 if there was an error.

`spawn_redirected(infile, outfile, errfile, executable [, args ...])`

Like `spawn()`, but with standard input, standard output and standard error redirected to the given files.

`wait(pid)`

Wait until the process with given PID (process handle on Win32) exits. Returns two values: a result value and the exit code of the waited-for process. The exit code is meaningful only if the result value is 0.

7 Special Topics

This chapter describes some “special” issues which are not directly related to monotone’s *use*, but which are occasionally of interest to people researching monotone or trying to learn the specifics of how it works. Most users can ignore these sections.

7.1 Internationalization

Monotone initially dealt with only ASCII characters, in file path names, certificate names, key names, and packets. Some conservative extensions are provided to permit internationalized use. These extensions can be summarized as follows:

- Monotone uses GNU gettext to provide localized progress and error messages. Translations may or may not exist for your locale, but the infrastructure is present to add them.
- All command-line arguments are mapped from your local character set to UTF-8 before processing. This means that monotone can *only* handle key names, file names and certificate names which map cleanly into UTF-8.
- Monotone's control files are stored in UTF-8. This includes: revisions and manifests, both inside the database and when written to the `'_MTN/'` directory of the workspace; the `'_MTN/options'` and `'_MTN/revision'` files. Converting these files to any other character set will cause monotone to break; do not do so.
- File path names in the workspace are converted to the locale's character set (determined via the `LANG` or `CHARSET` environment variables) before monotone interacts with the file system. If you are accustomed to being able to use file names in your locale's character set, this should "just work" with monotone.
- Key and cert names, and similar "name-like" entities are subject to some cleaning and normalization, and conversion into network-safe subsets of ASCII (typically ACE). Generally, you should be able to use "sensible" strings in your locale's character set as names, but they may appear mangled or escaped in certain contexts such as network transmission.
- Monotone's transmission and storage forms are otherwise unchanged. Packets and database contents are 7-bit clean ASCII.

The remainder of this section is a precise specification of monotone's internationalization behavior.

General Terms

Character set conversion

The process of mapping a string of bytes representing wide characters from one encoding to another. Per-file character set conversions are specified by a Lua hook `get_charset_conv` which takes a filename and returns a table of two strings: the first represents the "internal" (database) charset, the second represents the "external" (file system) charset.

| | |
|------------|---|
| LDH | Letters, digits, and hyphen: the set of ASCII bytes 0x2D, 0x30..0x39, 0x41..0x5A, and 0x61..0x7A. |
| stringprep | RFC 3454, a general framework for mapping, normalizing, prohibiting and bidirectionality checking for international names prior to use in public network protocols. |
| nameprep | RFC 3491, a specific profile of stringprep, used for preparing international domain names (IDNs) |

punycode RFC 3492, a "bootstring" encoding of Unicode into ASCII.

IDNA RFC 3490, international domain names for applications, a combination of the above technologies (nameprep, punyencoding, limiting to LDH characters) to form a specific "ASCII compatible encoding" (ACE) of Unicode, signified by the presence of an "unlikely" ACE prefix string "xn-". IDNA is intended to make it possible to use Unicode relatively "safely" over legacy ASCII-based applications. the general picture of an IDNA string is this:

```
{ACE-prefix}{LDH-sanitized(punycode(nameprep(UTF-8-string)))}
```

It is important to understand that IDNA encoding does *not* preserve the input string: it both prohibits a wide variety of possible strings and normalizes non-equal strings to supposedly "equivalent" forms.

By default, monotone does *not* decode IDNA when printing to the console (IDNA names are ASCII, which is a subset of UTF-8, so this normal form conversion can still apply, albeit oddly). this behavior is to protect users against security problems associated with malicious use of "similar-looking" characters. If the hook `display_decoded_idna` returns true, IDNA names are decoded for display.

Filenames

- Filenames are subject to normal form conversion.
- Filenames are subject to an additional normal form stage which adjusts for platform name semantics, for example changing the Windows 0x5C '\' path separator to 0x2F '/'. This extra processing is performed by `boost::filesystem`.
- FIXME: Monotone does not properly handle case insensitivity on Windows.
- A filename (in normal form) is constrained to be a nonempty sequence of path components, separated by byte 0x2F (ASCII /), and without a leading or trailing 0x2F.
- A path component is a nonempty sequence of any UTF-8 character codes except the path separator byte 0x2F and any ASCII "control codes" (0x00..0x1F and 0x7F).
- The path components "." and ".." are prohibited.
- Manifests and revisions are constructed from the normal form (UTF-8). The LC_COLLATE locale category is *not* used to sort manifest or revision entries.

File contents

- Files are subject to character set conversion and line ending conversion.
- File SHA1 values are calculated from the internal form of the conversions. If the external form of a file differs from the internal form, running a 3rd party program such as `sha1sum` will produce different results than those entries shown in a corresponding manifest.

UI messages

UI messages are displayed via calls to `gettext()`.

Host names

Host names are read on the command-line and subject to normal form conversion. Host names are then split at 0x2E (ASCII '.'), each component is subject to IDNA encoding, and the components are rejoined.

After processing, host names are stored internally as ASCII. The invariant is that a host name inside monotone contains only sequences of LDH separated by 0x2E.

Cert names

Read on the command line and subject to normal form conversion and IDNA encoding as a single component. The invariant is that a cert name inside monotone is a single LDH ASCII string.

Cert values

Cert values may be either text or binary, depending on the return value of the hook `cert_is_binary`. If binary, the cert value is never printed to the screen (the literal string "<binary>" is displayed, instead), and is never subjected to line ending or character conversion. If text, the cert value is subject to normal form conversion, as well as having all UTF-8 codes corresponding to ASCII control codes (0x0..0x1F and 0x7F) prohibited in the normal form, except 0x0A (ASCII LF).

Var domains

Read on the command line and subject to normal form conversion and IDNA encoding as a single component. The invariant is that a var domain inside monotone is a single LDH ASCII string.

Var names and values

Var names and values are assumed to be text, and subject to normal form conversion.

Key names

Read on the command line and subject to normal form conversion and IDNA encoding as an email address (split and joined at '.' and '@' characters). The invariant is that a key name inside monotone contains only LDH, 0x2E (ASCII '.') and 0x40 (ASCII '@') characters.

Packets

Packets are 7-bit ASCII. The characters permitted in packets are the union of these character sets:

- The 65 characters of base64 encoding (64 coding + "=" pad).
- The 16 characters of hex encoding.
- LDH, '@' and '.' characters, as required for key and cert names.
- '[' and ']', the packet delimiters.
- ASCII codes 0x0D (CR), 0x0A (LF), 0x09 (HT), and 0x20 (SP).

7.2 Hash Integrity

Some proponents of a competing, proprietary version control system have suggested, in a [usenix paper](#), that the use of a cryptographic hash function such as SHA1 as an identifier for a version is unacceptably unsafe. This section addresses the argument presented in that paper and describes monotone’s additional precautions.

To summarize our position:

- the analysis in the paper is wrong,
- even if it were right, monotone is sufficiently safe.

The analysis is wrong

The paper displays a fundamental lack of understanding about what a *cryptographic* hash function is, and how it differs from a normal hash function. Furthermore it confuses accidental collision with attack scenarios, and mixes up its analysis of the risk involved in each. We will try to untangle these issues here.

A cryptographic hash function such as SHA1 is more than just a uniform spread of inputs to an output range. Rather, it must be designed to withstand attempts at:

- reversal: deriving an input value from the output
- collision: finding two different inputs which hash to the same output

Collision is the problem the paper is concerned with. Formally, an n -bit cryptographic hash should cost 2^n work units to collide against a given value, and $\sqrt{2^n}$ tries to find a random pair of colliding values. This latter probability is sometimes called the hash’s “birthday paradox probability”.

Accidental collision

One way of measuring these bounds is by measuring how single-bit changes in the input affect bits in the hash output. The SHA1 hash has a strong *avalanche property*, which means that flipping *any one bit* in the input will cause on average half the 160 bits in the output code to change. The fanciful VAL1 hash presented in the paper does not have such a property — flipping its first bit when all the rest are zero causes *no change* to any of the 160 output bits — and is completely unsuited for use as a *cryptographic hash*, regardless of the general shape of its probability distribution.

The paper also suggests that birthday paradox probability cannot be used to measure the chance of accidental SHA1 collision on “real inputs”, because birthday paradox probability assumes a uniformly random sample and “real inputs” are not uniformly random. The paper is wrong: the inputs to SHA1 are not what is being measured (and in any case can be arbitrarily long); the collision probability being measured is of *output space*. On output space, the hash is designed to produce uniformly random spread, even given nearly identical inputs. In other words, it is a *primary design criterion* of such a hash that a birthday paradox probability is a valid approximation of its collision probability.

The paper’s characterization of risk when hashing “non-random inputs” is similarly deceptive. It presents a fanciful case of a program which is *storing* every possible 2kb block in a file system addressed by SHA1 (the program is trying to find a SHA1 collision). While this scenario *will* very likely encounter a collision *somewhere* in the course of storing all

such blocks, the paper neglects to mention that we only expect it to collide after storing about 2^{80} of the 2^{16384} possible such blocks (not to mention the requirements for compute time to search, or disk space to store 2^{80} 2kb blocks).

Noting that monotone can only store 2^{41} bytes in a database, and thus probably some lower number (say 2^{32} or so) active rows, we consider such birthday paradox probability well out of practical sight. Perhaps it will be a serious concern when multi-yottabyte hard disks are common.

Collision attacks

Setting aside accidental collisions, then, the paper’s underlying theme of vulnerability rests on the assertion that someone will break SHA1. Breaking a cryptographic hash usually means finding a way to collide it trivially. While we note that SHA1 has in fact resisted attempts at breaking for 8 years already, we cannot say that it will last forever. Someone might break it. We can say, however, that finding a way to trivially collide it only changes the resistance to *active attack*, rather than the behavior of the hash on benign inputs.

Therefore the vulnerability is not that the hash might suddenly cease to address benign blocks well, but merely that additional security precautions might become a requirement to ensure that blocks are benign, rather than malicious. The paper fails to make this distinction, suggesting that a hash becomes “unusable” when it is broken. This is plainly not true, as a number of systems continue to get useful low collision hashing behavior — just not good security behavior — out of “broken” cryptographic hashes such as MD4.

Monotone is probably safe anyways

Perhaps our arguments above are unconvincing, or perhaps you are the sort of person who thinks that practice never lines up with theory. Fair enough. Below we present *practical* procedures you can follow to compensate for the supposed threats presented in the paper.

Collision attacks

A successful collision attack on SHA1, as mentioned, does not disrupt the *probability* features of SHA1 on benign blocks. So if, at any time, you believe SHA1 is “broken”, it does *not* mean that you cannot use it for your work with monotone. It means, rather, that you cannot base your *trust* on SHA1 values anymore. You must trust who you communicate with.

The way around this is reasonably simple: if you do not trust SHA1 to prevent malicious blocks from slipping into your communications, you can always augment it by enclosing your communications in more security, such as tunnels or additional signatures on your email posts. If you choose to do this, you will still have the benefit of self-identifying blocks, you will simply cease to trust such blocks unless they come with additional authentication information.

If in the future SHA1 (or, indeed, RSA) becomes accepted as broken we will naturally upgrade monotone to a newer hash or public key scheme, and provide migration commands to recalculate existing databases based on the new algorithm.

Similarly, if you do not trust our vigilance in keeping up to date with cryptography literature, you can modify monotone to use any stronger hash you like, at the cost of isolating your own communications to a group using the modified version. Monotone is free

software, and runs atop `botan`, so it is both legal and relatively simple to change it to use some other algorithm.

7.3 Rebuilding ancestry

As described in [Section 1.3 \[Historical records\]](#), page 6, monotone revisions contain the SHA1 hashes of their predecessors, which in turn contain the SHA1 hashes of *their* predecessors, and so on until the beginning of history. This means that it is *mathematically impossible* to modify the history of a revision, without some way to defeat SHA1. This is generally a good thing; having immutable history is the point of a version control system, after all, and it turns out to be very important to building a *distributed* version control system like monotone.

It does have one unfortunate consequence, though. It means that in the rare occasion where one *needs* to change a historical revision, it will change the SHA1 of that revision, which will change the text of its children, which will change their SHA1s, and so on; basically the entire history graph will diverge from that point (invalidating all certs in the process).

In practice there are two situations where this might be necessary:

- bugs: monotone has occasionally allowed nonsense, uninterpretable changesets to be generated and stored in the database, and this was not detected until further work had been based off of them.
- advances in crypto: if or when SHA1 is broken, we will need to migrate to a different secure hash.

Obviously, we hope neither of these things will happen, and we’ve taken lots of precautions against the first recurring; but it is better to be prepared.

If either of these events occur, we will provide migration commands and explain how to use them for the situation in question; this much is necessarily somewhat unpredictable. In the past we’ve used the (now defunct) `db rebuild` command, and more recently the `db rosterify` command, for such changes as monotone developed. These commands were used to recreate revisions with new formats. Because the revision id’s changed, all the existing certs that you trust also must be reissued, signed with your key.¹

While such commands can reconstruct the ancestry graph in *your* database, there are practical problems which arise when working in a distributed work group. For example, suppose our group consists of the fictional developers Jim and Beth, and they need to rebuild their ancestry graph. Jim performs a rebuild, and sends Beth an email telling her that he has done so, but the email gets caught by Beth’s spam filter, she doesn’t see it, and she blithely syncs her database with Jim’s. This creates a problem: Jim and Beth have combined the pre-rebuild and post-rebuild databases. Their databases now contain two complete, parallel (but possibly overlapping) copies of their project’s ancestry. The “bad” old revisions that they were trying to get rid of are still there, mixed up with the “good” new revisions.

To prevent such messy situations, monotone keeps a table of branch *epochs* in each database. An epoch is just a large bit string associated with a branch. Initially each branch’s epoch is zero. Most monotone commands ignore epochs; they are relevant in only two circumstances:

¹ Regardless of who originally signed the certs, after the rebuild they will be signed by you. This means you should be somewhat careful when rebuilding, but it is unavoidable — if you could sign with other people’s keys, that would be a rather serious security problem!

- When monotone rebuilds ancestry, it generates a new *random* epoch for each branch in the database.
- When monotone runs netsync between databases, it checks to make sure that all branches involved in the synchronization have the same epochs. If any epochs differ, the netsync is aborted with no changes made to either database. If either side is seeing a branch for the first time, it adopts the epoch of the other side.

Thus, when a user rebuilds their ancestry graph, they select a new epoch and thus effectively disassociate with the group of colleagues they had previously been communicating with. Other members of that group can then decide whether to follow the rebuild user into a new group — by pulling the newly rebuilt ancestry — or to remain behind in the old group.

In our example, if Jim and Beth have epochs, Jim’s rebuild creates a new epoch for their branch, in his database. This causes monotone to reject netsync operations between Jim and Beth; it doesn’t matter if Beth loses Jim’s email. When she tries to synchronize with him, she receives an error message indicating that the epoch does not match. She must then discuss the matter with Jim and settle on a new course of action — probably pulling Jim’s database into a fresh database on Beth’s end — before future synchronizations will succeed.

Best practices

The previous section described the theory and rationale behind rebuilds and epochs. Here we discuss the practical consequences of that discussion.

If you decide you must rebuild your ancestry graph — generally by announcement of a bug from the monotone developers — the first thing to do is get everyone to sync their changes with the central server; if people have unshared changes when the database is rebuilt, they will have trouble sharing them afterwards.

Next, the project should pick a designated person to take down the netsync server, rebuild their database, and put the server back up with the rebuilt ancestry in it. Everybody else should then pull this history into a fresh database, check out again from this database, and continue working as normal.

In complicated situations, where people have private branches, or ancestries cross organizational boundaries, matters are more complex. The basic approach is to do a local rebuild, then after carefully examining the new revision IDs to convince yourself that the rebuilt graph is the same as the upstream subgraph, use the special `db epoch` commands to force your local epochs to match the upstream ones. (You may also want to do some fiddling with certs, to avoid getting duplicate copies of all of them; if this situation ever arises in real life we’ll figure out how exactly that should work.) Be very careful when doing this; you’re explicitly telling monotone to let you shoot yourself in the foot, and it will let you.

Fortunately, this process should be extremely rare; with luck, it will never happen at all. But this way we’re prepared.

7.4 Mark-Merge

Monotone makes use of the Mark-Merge (also known as *-merge) algorithm. The emails reproduced below document the algorithm. Further information can be found at revctrl.org.

Initial mark-merge proposal

From: Nathaniel Smith <njs <at> pobox.com>
 Subject: [cdv-devel] more merging stuff (bit long...)
 Newsgroups: gmane.comp.version-control.codeville.devel, gmane.comp.version-control.monotone
 Date: 2005-08-06 09:08:09 GMT

I set myself a toy problem a few days ago: is there a really, truly, right way to merge two heads of an arbitrary DAG, when the object being merged is as simple as possible: a single scalar value?

I assume that I'm given a graph, and each node in the graph has a value, and no other annotation; I can add annotations, but they have to be derived from the values and topology. Oh, and I assume that no revision has more than 2 parents; probably things can be generalized to the case of indegree 3 or higher, but it seems like a reasonable restriction...

So, anyway, here's what I came up with. Perhaps you all can tell me if it makes sense.

User model

Since the goal was to be "really, truly, right", I had to figure out what exactly that meant... basically, what I'm calling a "user model" -- a formal definition of how the user thinks about merging, to give an operational definition of "should conflict" and "should clean merge". My rules are these:

- 1) whenever a user explicitly sets the value, they express a claim that their setting is superior to the old setting
- 2) whenever a user chooses to commit a new revision, they implicitly affirm the validity of the decisions that led to that revision's parents

Corollary of (1) and (2): whenever a user explicitly sets the value, they express that they consider their new setting to be superior to all old settings

- 3) A "conflict" should occur if, and only if, the settings on each side of the merge express parallel claims.

This in itself is not an algorithm, or anything close to it; the hope is that it's a good description of what people actually want out of a merge algorithm, expressed clearly enough that we can create an algorithm that fits these desiderata.

Algorithm

I'll use slightly novel notation. Lower case letters represent values that scalar the scalar takes. Upper case letters represent nodes in the graph.

Now, here's an algorithm, that is supposed to just be a transcription of the above rules, one step more formal:

First, we need to know where users actively expressed an intention. Intention is defined by (1), above. We use * to mark where this occurred:

- i) a* graph roots are always marked

- ii) a
 | no mark, value was not set
 a

- iii) a
 | b != a, so b node marked
 b*

- iv) a b
 \ /
 c*

 c is totally new, so marked

- a a
 \ /
 c*

- v) a b we're marking places where users expressed
 \ / intention; so b should be marked iff this
 b? was a conflict (!)

- vi) a a for now I'm not special-casing the coincidental
 \ / clean merge case, so let's consider this to be
 a? a subclass of (v).

That's all the cases possible. So, suppose we go through and annotate our graph with *s, using the above rules; we have a graph with some *s peppered through it, each * representing one point that a user took action.

Now, a merge algorithm per se: Let's use *(A) to mean the unique nearest marked ancestor of node A. Suppose we want to merge A and

B. There are exactly 3 cases:

- $*(A)$ is an ancestor of B, but not vice versa: B wins.
- $*(B)$ is an ancestor of A, but not vice versa: A wins.
- $*(A)$ is not an ancestor of B, and vice versa: conflict, escalate to user

Very intuitive, right? If B supercedes the intention that led to A, then B should win, and vice-versa; if not, the user has expressed two conflicting intentions, and that, by definition, is a conflict.

This lets us clarify what we mean by "was a conflict" in case (v) above. When we have a merge of a and b that gives b, we simple calculate $*(a)$; if it is an ancestor of 'b', then we're done, but if it isn't, then we mark the merge node. (Subtle point: this is actually not quite the same as detecting whether merging 'a' and 'b' would have given a conflict; if we somehow managed to get a point in the graph that would have clean merged to 'a', but in fact was merged to 'b', then this algorithm will still mark the merge node.) For cases where the two parents differ, you have to do this using the losing one; for cases where the two parents are the same, you should check both, because it could have been a clean merge two different ways. If $*(a1) = *(a2)$, i.e., both sides have the same nearest marked ancestor, consider that a clean merge.

That's all.

Examples

Of course, I haven't shown you this is well-defined or anything, but to draw out the suspense a little, have some worked examples (like most places in this document, I draw graphs with two leaves and assume that those are being merged):

graph:

```

      a*
     / \
    a   b*
```

result: $*(a)$ is an ancestor of b, but $*(b)$ is not an ancestor of a;
clean merge with result 'b'.

graph:

```

      a*
     / \
    b*  c*
```

result: $*(b) = b$ is not an ancestor of c, and $*(c) = c$ is not an ancestor of b; conflict.


```

graph:
    a*
    / \
    b* c* <--- these are both marked, by (iii)
    |\ /|
    | X |
    | / \ |
    b* c* <--- which means these were conflicts, and thus marked
result: the two leaves are both marked, and thus generate a conflict,
as above.

```

Right, enough of that. Math time.

Math

Theorem: In a graph marked following the above rules, every node N will have a unique least marked ancestor M , and the values of M and N will be the same.

Proof: By downwards induction on the graph structure. The base case are graph roots, which by (i) are always marked, so the statement is trivially true. Proceeding by cases, (iii) and (iv) are trivially true, since they produce nodes that are themselves marked. (ii) is almost as simple; in a graph ' a ' \rightarrow ' a ', the child obviously inherits the parent's unique least marked ancestor, which by inductive hypothesis exists. The interesting case is (v) and (vi):

```

a    b
 \  /
  b

```

If the child is marked, then again the statement is trivial; so suppose it is not. By definition, this only occurs when $*(a)$ is an ancestor of ' b '. But, by assumption, ' b ' has a unique nearest ancestor, whose value is ' b '. Therefore, $*(a)$ is also an ancestor of $*(b)$. If we're in the weird edge case (vi) where $a = b$, then these may be the same ancestor, which is fine. Otherwise, the fact that $a \neq b$, and that $*(a)$'s value = a 's value, $*(b)$'s value = b 's value, implies that $*(a)$ is a strict ancestor of $*(b)$. Either way, the child has a unique least marked ancestor, and it is the same ULMA as its same-valued parent, so the ULMA also has the right value. QED.

Corollary: $*(N)$ is a well-defined function.

Corollary: The three cases mentioned in the merge algorithm are the only possible cases. In particular, it cannot be that $*(A)$ is an ancestor of B and $*(B)$ is an ancestor of A simultaneously, unless the two values being merged are identical (and why are you running

your merge algorithm then?). Or in other words: ambiguous clean merge does not exist.

Proof: Suppose $*(A)$ is an ancestor of B , and $*(B)$ is an ancestor of A .

$*(B)$ is unique, so $*(A)$ must also be an ancestor of $*(B)$.

Similarly, $*(B)$ must be an ancestor of $*(A)$. Therefore:

$$*(A) = *(B)$$

We also have:

$$\text{value}(*(A)) = \text{value}(A)$$

$$\text{value}(*(B)) = \text{value}(B)$$

which implies

$$\text{value}(A) = \text{value}(B). \quad \text{QED.}$$

Therefore, the above algorithm is well-defined in all possible cases.

We can prove another somewhat interesting fact:

Theorem: If A and B would merge cleanly with A winning, then any descendent D of A will also merge cleanly with B , with D winning.

Proof: $*(B)$ is an ancestor of A , and A is an ancestor of D , so $*(B)$ is an ancestor of D .

I suspect that this is enough to show that clean merges are order invariant, but I don't have a proof together ATM.

Not sure what other properties would be interesting to prove; any suggestions? It'd be nice to have some sort of proof about "once a conflict is resolved, you don't have to resolve it again" -- which is the problem that makes ambiguous clean merge so bad -- but I'm not sure how to state such a property formally. Something about it being possible to fully converge a graph by resolving a finite number of conflicts or something, perhaps?

Funky cases

There are two funky cases I know of.

Coincidental clean merge:

```

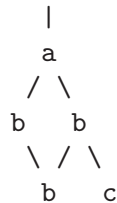
  |
  a
 / \
b*  b*
```

Two people independently made the same change. When we're talking about textual changes, some people argue this should give a conflict (reasoning that perhaps the same line `_should_` be inserted twice). In our context that argument doesn't even apply, because these are just scalars; so obviously this should be a clean merge. Currently, the

only way this algorithm has to handle this is to treat it as an "automatically resolved conflict" -- there's a real conflict here, but the VCS, acting as an agent for the user, may decide to just go ahead and resolve it, because it knows perfectly well what the user will do. In this interpretation, everything works fine, all the above stuff applies; it's somewhat dissatisfying, though, because it's a violation of the user model -- the user has not necessarily looked at this merge, but we put the * of user-assertion on the result anyway. Not a show-stopper, I guess...

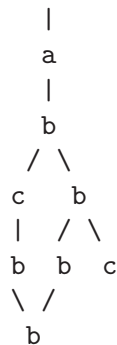
It's quite possible that the above stuff could be generalized to allow non-unique least marked ancestors, that could only arise in exactly this case.

I'm not actually sure what the right semantics would be, though. If we're merging:



Should that be a clean merge? 'b' was set twice, and only one of these settings was overridden; is that good enough?

Do you still have the same opinion if the graph is:



? Here the reason for the second setting of 'b' was that a change away from it was reverted; to make it extra cringe-inducing, I threw in that change being reverted was another change to 'c'... (this may just be an example of how any merge algorithm has some particular case you can construct where it will get something wrong, because it doesn't actually know how to read the users's minds).

Supporting these cases may irresistably lead back to ambiguous clean, as well:



```

      / \
     b*  c*
    / \ / \
   c*  X  b*
    \ / \ /
     c   b

```

The other funky case is this thing (any clever name suggestions?):

```

      a
     / \
    b*  c*
     \ / \
      c* d*

```

Merging here will give a conflict, with my algorithm; 3-way merge would resolve it cleanly. Polling people on #monotone and #revctrl, the consensus seems to be that they agree with 3-way merge, but giving a conflict is really not *that* bad. (It also seems to cause some funky effects with darcs-merge; see zooko's comments on #revctrl and darcs-users.)

This is really a problem with the user model, rather than the algorithm. Apparently people do not interpret the act of resolving the b/c merge to be "setting" the result; They seem to interpret it as "selecting" the result of 'c'; the 'c' in the result is in some sense the "same" 'c' as in the parent. The difference between "setting" and "selecting" is the universe of possible options; if you see

```

  a   b
   \ /
    c

```

then you figure that the person doing the merge was picking from all possible resolution values; when you see

```

  a   b
   \ /
    b

```

you figure that the user was just picking between the two options given by the parents. My user model is too simple to take this into account. It's not a huge extension to the model to do so; it's quite possible that an algorithm could be devised that gave a clean merge here, perhaps by separately tracking each node's nearest marked ancestor and the original source of its value as two separate things.

Relation to other work

This algorithm is very close to the traditional codeville-merge approach to this problem; the primary algorithmic difference is the marking of conflict resolutions as being "changes". The more

important new stuff here, I think, are the user model and the proofs.

Traditionally, merge algorithms are evaluated by coming up with some set of examples, eyeballing them to make some guess as to what the "correct" answer was, comparing that to the algorithm's output, and then arguing with people whose intuitions were different. Fundamentally, merging is about deterministically guessing the user's intent in situations where the user has not expressed any intent. Humans are very good at guessing intent; we have big chunks of squishy hardware designed to form sophisticated models of others intents, and it's completely impossible for a VCS to try and duplicate that in full. My suggestion here, with my "user model", is to seriously and explicitly study this part of the problem. There are complicated trade-offs between accuracy (correctly modeling intention), conservatism (avoiding incorrectly modeling intention), and implementability (describing the user's thought processes exactly isn't so useful if you can't apply it in practice). It's hard to make an informed judgement when we don't have a name for the thing we're trying to optimize, and hard to evaluate an algorithm when we can't even say what it's supposed to be doing.

I suspect the benefit of the proofs is obvious to anyone who has spent much time banging their head against this problem; until a few days ago I was skeptical there was a way to design a merge algorithm that didn't run into problems like ambiguous clean merge.

I'm still skeptical, of course, until people read this; merging is like crypto, you can't trust anything until everyone's tried to break it... so let's say I'm cautiously optimistic. If this holds up, I'm quite happy; between the user model and the proofs, I'm far more confident that this does something sensible in all cases and has no lurking edge cases than I have been in any previous algorithm. The few problem cases I know of display a pleasing conservatism -- perhaps more cautious than they need to be, but even if they do cause an occasional unnecessary conflict, once the conflict is resolved it should stay resolved.

So... do your worst!

-- Nathaniel

--

So let us espouse a less contested notion of truth and falsehood, even if it is philosophically debatable (if we listen to philosophers, we must debate everything, and there would be no end to the discussion).

-- Serendipities, Umberto Eco

Replies and further discussion concerning this email can be found in the [monotone-devel archives](#).

Improvements to *-merge

From: Nathaniel Smith <njs@...>

Subject: improvements to *-merge

Newsgroups: gmane.comp.version-control.revctrl, gmane.comp.version-control.monotone.devel

Date: 2005-08-30 09:21:18 GMT

This is a revised version of *-merge:

<http://thread.gmane.org/gmane.comp.version-control.monotone.devel/4297>
that properly handles accidental clean merges. It does not improve any of the other parts, just the handling of accidental clean merges. It shows a way to relax the uniqueness of the *() operator, while still preserving the basic results from the above email. For clarity, I'll say 'unique-*-merge' to refer to the algorithm given above, and 'multi-*-merge' to refer to this one.

This work is totally due to Timothy Brownawell <tbrownaw@...>.

All I did was polish up the proofs and write it up. He has a more complex version at:

<http://article.gmane.org/gmane.comp.version-control.monotone.devel/4496>
that also attempts to avoid the conflict with:

```

      a
     /\
    b* c*
     \/ \
      c* d*

```

and has some convergence in it, but the analysis for that is not done.

So:

User model

We keep exactly the same user model as unique-*-merge:

- 1) whenever a user explicitly sets the value, they express a claim that their setting is superior to the old setting
 - 2) whenever a user chooses to commit a new revision, they implicitly affirm the validity of the decisions that led to that revision's parents
- Corollary of (1) and (2): whenever a user explicitly sets the value, they express that they consider their new setting to be superior to all old settings
- 3) A "conflict" should occur if, and only if, the settings on each

side of the merge express parallel claims.

The difference is that unique-* merge does not *_quite_* fulfill this model, because in real life your algorithm will automatically resolve coincidental clean merge cases without asking for user input; but unique-* is not smart enough to take this into account when inferring user intentions.

Algorithm

We start by marking the graph of previous revisions. For each node in the graph, we either mark it (denoted by a *), or do not. A mark indicates our inference that a human expressed an intention at this node.

- i) a* graph roots are always marked

- ii) a1
 | no mark, value was not set
 a2

- iii) a
 | b != a, so 'b' node marked
 b*

- iv) a b
 \ /
 c* 'c' is totally new, so marked

- a1 a2
 \ /
 c*

- v) a b1 we're marking places where users expressed
 \ / intention; so 'b' should be marked iff this
 b2? was a conflict

- a1 a2 'a' matches parents, and so is not marked
vi) \ / (alternatively, we can say this is a special
 a3 case of (v), that is never a conflict)

Case (vi) is the only one that differs from unique-* merge. However, because of it, we must use a new definition of *():

Definition: By *(A), we mean we set of minimal marked ancestors of A. "Minimal" here is used in the mathematical sense of a node in a graph

that has no descendants in that graph.

Algorithm: Given two nodes to merge, A and B, we consider four cases:

- a) $\text{value}(A) = \text{value}(B)$: return the shared value
- b) $*(A) > B$: return $\text{value}(B)$
- c) $*(B) > A$: return $\text{value}(A)$
- d) else: conflict; escalate to user

Where " $*(A) > B$ " means "all elements of the set $*(A)$ are non-strict ancestors of the revision B". The right way to read this is as "try (a) first, and then if that fails try (b), (c), (d) simultaneously".

Note that except for the addition of rule (a), this is a strict generalization of the unique-* algorithm; if $*(A)$ and $*(B)$ are single-element sets, then this performs exactly the same computations as the unique-* algorithm.

Now we can say what we mean by "was a conflict" in case (v) above: given $a \rightarrow b_2$, $b_1 \rightarrow b_2$, we leave b_2 unmarked if and only if $*(a) > b_1$.

Examples

1.

```

  a1*
 /  \
a2   b*
```

result: $*(a_2) = \{a_1\}$, $a_1 > b$, so b wins.

2.

```

  a*
 /  \
b*   c*
```

result: $*(b) = \{b\}$, $*(c) = \{c\}$, neither $*(b) > c$ nor $*(c) > b$, so conflict.

3.

```

  a*
 /  \
b1* b2*
 \ / \
  b3  c1*
```

result: $*(b_3) = \{b_1, b_2\}$; $b_2 > c_1$, but b_1 is not $> c$, so c does not win. $*(c_1) = \{c_1\}$, which is not $> b_3$. conflict.

note: this demonstrates that this algorithm does not do convergence. Instead, it takes the conservative position that for one node to silently beat another, the winning node must pre-empt all the intentions that created the losing node. While it's easy to come up with just-so stories where this is the correct thing to do (e.g., b1 and b2 each contain some other changes that independently require 'a' to become 'b'; c1 will have fixed up b2's changes, but not b1's), this doesn't actually mean much. Whether this is good or bad behavior a somewhat unresolved question, that may ultimately be answered by which merge algorithms turn out to be more tractable...

4.

```

      a*
     /\
    b1* b2*
   /\ /\
  |X|
  /\ /\
 b3  c*
```

result: $*(b3) = \{b1, b2\} > c$. $*(c) = \{c\}$, which is not $> b3$. c wins cleanly.

5.

```

      a*
     /\
    b1* c1*
   /\ /\
  c2* X  b2*
   /\ /\
  c3  b3
```

result: $*(c3) = \{c1, c2\}$; $c1 > b3$ but $c2$ is not $> b3$, so $b3$ does not win. likewise, $*(b3) = \{b1, b2\}$; $b1 > c3$ but $b2$ is not $> c3$, so $c3$ does not win either. conflict.

6.

```

      a*
     /\
    b1* c1*
   /\ /\
  c2* X  b2*
   /\ /\
  c3  b3
   /\ /\
  |X|
  /\ /\
```

c4* b4*

(this was my best effort to trigger an ambiguous clean merge with this algorithm; it fails pitifully:)

result: *(c4) = {c4}, *(b4) = {b4}, obvious conflict.

Math

The interesting thing about this algorithm is that all the unique-* proofs still go through, in a generalized form. The key one that makes *-merge tractable is:

Theorem: In a graph marked by the above rules, given a node N, all nodes in *(N) will have the same value as N.

Proof: By induction. We consider the cases (i)-(vi) above. (i) through (iv) are trivially true. (v) is interesting. b2 is marked when *(a) not > b1. b2 being marked makes that case trivial, so suppose *(a) > b1. All elements of *(a) are marked, and are ancestors of b1; therefore, by the definition of *() and "minimal", they are also all ancestors of things in *(b1). Thus no element of *(a) can be a minimal marked ancestor of b2.

(vi) is also trivial, because *(a3) = *(a1) union *(a2). QED.

We also have to do a bit of extra work because of the sets:

Corollary 1: If *(A) > B, and any element R of *(B) is R > A, then value(A) = value(B).

Proof: Let such an R be given. R > A, and R marked, imply that there is some element S of *(A) such that R > S.

On the other hand, *(A) > B implies that S > B. By similar reasoning to the above, this means that there is some element T of *(B) such that S > T. So, recapping, we have:

nodes: R > S > T

from: *(B) *(A) *(B)

*(B) is a set of minimal nodes, yet we have R > T and R and T both in *(B). This implies that R = T. R > S > R implies that S = R, because we are in a DAG. Thus

value(A) = value(S) = value(R) = value(B)

QED.

Corollary 2: If *(A) > B and *(B) > A, then not only does value(A) = value(B), but *(A) = *(B).

Proof: By above, each element of *(B) is equal to some element of *(A), and vice-versa.

This is good, because it means our algorithm is well-defined. The

only time when options (b) and (c) (in the algorithm) can simultaneously be true, is when the two values being merged are identical to start with. I.e., no somewhat anomalous "4th case" of ambiguous clean merge.

Actually, this deserves some more discussion. With `*`() returning a set, there are some more subtle "partial ambiguous clean" cases to think about -- should we be worrying about cases where some, but not all, of the marked ancestors are pre-empted? This is possible, as in example 5 above:

```

      a*
     /\
    b1* c1*
   /\ /\
  c2* X  b2*
   \ /\ /
    c3  b3

```

A hypothetical (convergence supporting?) algorithm that said A beats B if `_any_` elements of `*(A)` are `> B` would give an ambiguous clean merge on this case. (Maybe that wouldn't be so bad, so long as we marked the result, but I'm in no way prepared to do any sort of sufficient analysis right now...)

The nastiest case of this is where `*(A) > B`, but some elements of `*(B)` are `> A` -- so we silently make B win, but it's really not `_quite_` clear that's a good idea, since A also beat B sometimes -- and we're ignoring those user's intentions.

This is the nice thing about Corollary 1 (and why I didn't just collapse it into Corollary 2) -- it assures us that the only time this `_weak_` form of ambiguous clean can happen is when A and B are already identical. This `_can_` happen, for what it's worth:

```

      a*
     /\
    /\
   /\
  /\
 b1* b2* d*
 |\  /\ /
 | \ / \
 |  X  b3*
 | /\ /
 |/\  b4
 b5

```

Here `*(b5) = {b3, b2}`, `*(b6) = {b2, b4}`. If we ignore for a moment that b4 and b5 have the same value, this is a merge that b4 would win and b5 would lose, even though one of b4's ancestors, i.e. b1, is

pre-empted by b5. However, it can only happen if we ignore that they have the same value...

The one other thing we proved about unique-* merge also still applies; the proof goes through word-for-word:

Theorem: If A and B would merge cleanly with A winning, then any descendent D of A will also merge cleanly with B, with D winning.

Proof: $*(B) > A$, and $A > D$, so $*(B) > D$.

Discussion

This algorithm resolves one of the two basic problems I observed for unique-* merge -- coincidental clean merges are now handled, well, cleanly, and the user model is fully implemented. However, we still do not handle the unnamed case (you guys totally let me down when I requested names for this case last time):

```

      a
     /\
    b* c*
     \/ \
      c* d*

```

which still gives a conflict. We also, of course, continue to not support more exotic features like convergence or implicit rollback.

Not the most exciting thing in the world. OTOH, it does strictly increase the complexity of algorithms that are tractable to formal analysis.

Comments and feedback appreciated.

-- Nathaniel

--

"The problem...is that sets have a very limited range of activities -- they can't carry pianos, for example, nor drink beer."

Replies and further discussion concerning this email can be found in the [monotone-devel archives](#).

More on "mark-merge"

From: Timothy Brownawell <tbrownaw@...>

Subject: more on "mark-merge"

Newsgroups: [gmmane.comp.version-control.revctrl](#), [gmmane.comp.version-control.monotone.devel](#)

Prerequisite:

<http://thread.gmane.org/gmane.comp.version-control.monotone.devel/4297>

A user can make 2 types of merge decisions:

- (1): One parent is better than the other (represented by *)
- (2): Both parents are wrong (represented by ^)

Since there are 2 types of merge decisions, it would be bad to treat all merge decisions the same. Also, in the case of $\text{merge}(a, a) = a$, it is possible for there to be multiple least decision ancestors.

=====

Define: \hat{A} is the set of ancestors of A that it gets its value from
(found by setting $N=A$ and iterating $N = *(N)$ until there is no change)
 $*(A)$ is the set of least ancestors of A in which the user made a decision

note that $\text{erase_ancestors}(\hat{A}) = \hat{A}$,
and $\text{erase_ancestors}(*(A)) = *(A)$

=====

& is intersection, | is union

$*(A)$ has the same properties as before, except that it is not a single ancestor, but a set. This set can acquire more than one member only in the case of

$$\begin{array}{cc} Aa & Ba \\ & \backslash / \\ & Ca \end{array}$$

, where $*(A)$ and $*(B)$ are different; $*(C)$ will be $\text{erase_ancestors}(*(A) \mid *(B))$

The ancestry corollary becomes:

any ancestor C of A with $\text{value}(C) \neq \text{value}(A)$ will be an ancestor of at least one member of $*(A)$

When merging A and B:

if one side knows of `_all_` places that the other side was chosen, it wins

(1)

set $X = \text{erase_ancestors}(*(A) \mid *(B))$

if $X \& *(B) = \{\}$, A wins

if $X \& *(A) = \{\}$, B wins

else, X contains members of both $*(A)$ and $*(B)$

```
# if one side knows of _all_ places that the other side originated, it
wins
```

```
(2)
```

```
set Y = erase_ancestors(*(A) | ^(B))
```

```
set Z = erase_ancestors(*(B) | ^(A))
```

```
    if Y & ^(B) = {} and Z & ^(A) = {}, conflict
```

```
    if Y & ^(B) = {}, A wins
```

```
    if Z & ^(A) = {}, B wins
```

```
# if one side knows of _any_ places that the other side originated, it
wins
```

```
(3)
```

```
    if Y & ^(B) != ^(B) and Z & ^(A) != ^(A), conflict
```

```
    if Y & ^(B) != ^(B), A wins
```

```
    if Z & ^(A) != ^(A), B wins
```

```
# else, nobody knows anything
```

```
(4) conflict
```

(3) is convergence, and can be safely left out if unwanted

```
====
```

"Funky cases"

Coincidental clean does not exist; a mark is only needed when there is user intervention.

```

  |
  a
 / \
b   b
 \ / \
  b   c

```

and the example after it will resolve cleanly iff (3) is included.

```

  |
  a
 / \
b*  c*
 / \ / \
c*  X  b*
 \ / \ /
  c   b

```

will be a conflict.

a

```

    / \
   b*  c*
    \ / \
   c*  d*

```

This ("the other funky case") is handled by (2), and resolves cleanly.

Tim

Replies and further discussion concerning this email can be found in the [monotone-devel archives](#).

7.5 Regular Expression Syntax

Monotone expects user-provided regular expressions in `.mtn-ignore` files and as the result of the `get_encloser_pattern` Lua hook (for the `--show-encloser` option to `diff`). User-written Lua hooks may also use the function `regex.search` as they see fit. All these regular expressions should be written with the same syntax, which is that expected by the Perl-Compatible Regular Expression library (PCRE).

7.5.1 Regexp Syntax Summary

This is a quick-reference summary of the regular expression syntax used in Monotone.

Quoting

`\x` where `x` is non-alphanumeric is a literal `x`
`\Q... \E` treat enclosed characters as literal

Characters

`\a` alarm, that is, the BEL character (hex 07)
`\cx` "control-`x`", where `x` is any character
`\e` escape (hex 1B)
`\f` formfeed (hex 0C)
`\n` newline (hex 0A)
`\r` carriage return (hex 0D)
`\t` tab (hex 09)
`\ddd` character with octal code `ddd`, or backreference
`\xhh` character with hex code `hh`
`\x{hhh...}` character with hex code `hhh...`

Character Types

`.` any character except newline; in `dotall` mode, any character whatsoever
`\C` one byte, even in UTF-8 mode (best avoided)

| | |
|---------------------|---|
| <code>\d</code> | a decimal digit |
| <code>\D</code> | a character that is not a decimal digit |
| <code>\h</code> | a horizontal whitespace character |
| <code>\H</code> | a character that is not a horizontal whitespace character |
| <code>\p{xx}</code> | a character with the <code>xx</code> property |
| <code>\P{xx}</code> | a character without the <code>xx</code> property |
| <code>\R</code> | a newline sequence |
| <code>\s</code> | a whitespace character |
| <code>\S</code> | a character that is not a whitespace character |
| <code>\v</code> | a vertical whitespace character |
| <code>\V</code> | a character that is not a vertical whitespace character |
| <code>\w</code> | a “word” character |
| <code>\W</code> | a “non-word” character |
| <code>\X</code> | an extended Unicode sequence |

`'\d'`, `'\D'`, `'\s'`, `'\S'`, `'\w'`, and `'\W'` recognize only ASCII characters.

General category property codes for `'\p'` and `'\P'`

| | |
|---------------------|--|
| <code>C</code> | Other |
| <code>Cc</code> | Control |
| <code>Cf</code> | Format |
| <code>Cn</code> | Unassigned |
| <code>Co</code> | Private use |
| <code>Cs</code> | Surrogate |
| <code>L</code> | Letter |
| <code>Ll</code> | Lower case letter |
| <code>Lm</code> | Modifier letter |
| <code>Lo</code> | Other letter |
| <code>Lt</code> | Title case letter |
| <code>Lu</code> | Upper case letter |
| <code>L&</code> | <code>Ll</code> , <code>Lu</code> , or <code>Lt</code> |
| <code>M</code> | Mark |
| <code>Mc</code> | Spacing mark |
| <code>Me</code> | Enclosing mark |

| | |
|-----------|-----------------------|
| Mn | Non-spacing mark |
| N | Number |
| Nd | Decimal number |
| Nl | Letter number |
| No | Other number |
| P | Punctuation |
| Pc | Connector punctuation |
| Pd | Dash punctuation |
| Pe | Close punctuation |
| Pf | Final punctuation |
| Pi | Initial punctuation |
| Po | Other punctuation |
| Ps | Open punctuation |
| S | Symbol |
| Sc | Currency symbol |
| Sk | Modifier symbol |
| Sm | Mathematical symbol |
| So | Other symbol |
| Z | Separator |
| Zl | Line separator |
| Zp | Paragraph separator |
| Zs | Space separator |

Script names for ‘\p’ and ‘\P’

Arabic, Armenian, Balinese, Bengali, Bopomofo, Braille, Buginese, Buhid, Canadian_Aboriginal, Cherokee, Common, Coptic, Cuneiform, Cypriot, Cyrillic, Deseret, Devanagari, Ethiopic, Georgian, Glagolitic, Gothic, Greek, Gujarati, Gurmukhi, Han, Hangul, Hanunoo, Hebrew, Hiragana, Inherited, Kannada, Katakana, Kharoshthi, Khmer, Lao, Latin, Limbu, Linear_B, Malayalam, Mongolian, Myanmar, New-Tai-Lue, Nko, Ogham, Old_Italic, Old_Persian, Oriya, Osmanya, Phags-Pa, Phoenician, Runic, Shavian, Sinhala, Syloti_Nagri, Syriac, Tagalog, Tagbanwa, Tai_Le, Tamil, Telugu, Thaana, Thai, Tibetan, Tifinagh, Ugaritic, Yi.

Character Classes

| | |
|-------------------------|--|
| <code>[...]</code> | positive character class |
| <code>[^...]</code> | negative character class |
| <code>[x-y]</code> | range (can be used for hex characters) |
| <code>[[:xxx:]]</code> | positive POSIX named set |
| <code>[[:^xxx:]]</code> | negative POSIX named set |
| <code>alnum</code> | alphanumeric |
| <code>alpha</code> | alphabetic |
| <code>ascii</code> | 0-127 |
| <code>blank</code> | space or tab |
| <code>cntrl</code> | control character |
| <code>digit</code> | decimal digit |
| <code>graph</code> | printing, excluding space |
| <code>lower</code> | lower case letter |
| <code>print</code> | printing, including space |
| <code>punct</code> | printing, excluding alphanumeric |
| <code>space</code> | whitespace |
| <code>upper</code> | upper case letter |
| <code>word</code> | same as <code>'\w'</code> |
| <code>xdigit</code> | hexadecimal digit |

In PCRE, POSIX character set names recognize only ASCII characters. You can use `'\Q...\E'` inside a character class.

Quantifiers

| | |
|-----------------|-----------------------|
| <code>?</code> | 0 or 1, greedy |
| <code>?+</code> | 0 or 1, possessive |
| <code>??</code> | 0 or 1, lazy |
| <code>*</code> | 0 or more, greedy |
| <code>*+</code> | 0 or more, possessive |
| <code>*?</code> | 0 or more, lazy |
| <code>+</code> | 1 or more, greedy |
| <code>++</code> | 1 or more, possessive |

| | |
|---------------------|--|
| <code>+?</code> | 1 or more, lazy |
| <code>{n}</code> | exactly <i>n</i> |
| <code>{n,m}</code> | at least <i>n</i> , no more than <i>m</i> , greedy |
| <code>{n,m}+</code> | at least <i>n</i> , no more than <i>m</i> , possessive |
| <code>{n,m}?</code> | at least <i>n</i> , no more than <i>m</i> , lazy |
| <code>{n,}</code> | <i>n</i> or more, greedy |
| <code>{n,}+</code> | <i>n</i> or more, possessive |
| <code>{n,}?</code> | <i>n</i> or more, lazy |

Anchors and Simple Assertions

| | |
|-----------------|---|
| <code>\b</code> | word boundary |
| <code>\B</code> | not a word boundary |
| <code>^</code> | start of subject also after internal newline in multiline mode |
| <code>\A</code> | start of subject |
| <code>\$</code> | end of subject also before newline at end of subject also before internal newline in multiline mode |
| <code>\Z</code> | end of subject also before newline at end of subject |
| <code>\z</code> | end of subject |
| <code>\G</code> | first matching position in subject |

Match Point Reset

| | |
|-----------------|----------------------|
| <code>\K</code> | reset start of match |
|-----------------|----------------------|

Alternation

`expr | expr | expr ...`

Capturing

| | |
|----------------------------------|---|
| <code>(...)</code> | capturing group |
| <code>(?<name>...)</code> | named capturing group (like Perl) |
| <code>(?'name'...)</code> | named capturing group (like Perl) |
| <code>(?P<name>...)</code> | named capturing group (like Python) |
| <code>(?:...)</code> | non-capturing group |
| <code>(?!...)</code> | non-capturing group; reset group numbers for capturing groups in each alternative |

Atomic Groups

(?>...) atomic, non-capturing group

Comment

(?#...) comment (not nestable)

Option Setting

(?i) caseless
 (?J) allow duplicate names
 (?m) multiline
 (?s) single line (dotall)
 (?U) default ungreedy (lazy)
 (?x) extended (ignore white space)
 (?-...) unset option(s)

Lookahead and Lookbehind Assertions

(?=...) positive look ahead
 (?!...) negative look ahead
 (?<=...) positive look behind
 (?<!...) negative look behind

Each top-level branch of a look behind must be of a fixed length.

Backreferences

\n reference by number (can be ambiguous)
 \gn reference by number
 \g{n} reference by number
 \g{-n} relative reference by number
 \k<name> reference by name (like Perl)
 \k' name ' reference by name (like Perl)
 \g{name} reference by name (like Perl)
 \k{name} reference by name (like .NET)
 (?P=name) reference by name (like Python)

Subroutine References (possibly recursive)

| | |
|---------------------------|---------------------------------------|
| <code>(?R)</code> | recurse whole pattern |
| <code>(?n)</code> | call subpattern by absolute number |
| <code>(?+n)</code> | call subpattern by relative number |
| <code>(?-n)</code> | call subpattern by relative number |
| <code>(?&name)</code> | call subpattern by name (like Perl) |
| <code>(?P>name)</code> | call subpattern by name (like Python) |

Conditional Patterns

| | |
|---|---------------------------------------|
| <code>(?(condition)yes-pattern)</code> | |
| <code>(?(condition)yes-pattern no-pattern)</code> | |
| <code>(?(n)...</code> | absolute reference condition |
| <code>(?(+n)...</code> | relative reference condition |
| <code>(?(-n)...</code> | relative reference condition |
| <code>(?(<name>)...</code> | named reference condition (like Perl) |
| <code>(?('name')...</code> | named reference condition (like Perl) |
| <code>(?(name)...</code> | named reference condition (PCRE only) |
| <code>(?(R)...</code> | overall recursion condition |
| <code>(?(Rn)...</code> | specific group recursion condition |
| <code>(?(R&name)...</code> | specific recursion condition |
| <code>(?(DEFINE)...</code> | define subpattern for reference |
| <code>(?(assert)...</code> | assertion condition |

Backtracking Control

The following act immediately they are reached:

| | |
|------------------------|--|
| <code>(*ACCEPT)</code> | force successful match |
| <code>(*FAIL)</code> | force backtrack; synonym ‘ <code>(*F)</code> ’ |

The following act only when a subsequent match failure causes a backtrack to reach them. They all force a match failure, but they differ in what happens afterwards. Those that advance the start-of-match point do so only if the pattern is not anchored.

- (***COMMIT**) overall failure, no advance of starting point
- (***PRUNE**) advance to next starting character
- (***SKIP**) advance start to current matching position
- (***THEN**) local failure, backtrack to next alternation

Newline Conventions

These are recognized only at the very start of the pattern or after a ‘(***BSR_...**)’ option.

- (***CR**)
- (***LF**)
- (***CRLF**)
- (***ANYCRLF**)
- (***ANY**)

What ‘\R’ Matches

These are recognized only at the very start of the pattern or after a ‘(***...**)’ option that sets the newline convention.

- (***BSR_ANYCRLF**)
- (***BSR_UNICODE**)

7.5.2 Regexp Details

The syntax and semantics of PCRE regular expressions, as used in Monotone, are described in detail below. Regular expressions in general are covered in a number of books, some of which have copious examples. Jeffrey Friedl’s “Mastering Regular Expressions,” published by O’Reilly, covers regular expressions in great detail. This description is intended as reference material.

Characters and Metacharacters

A regular expression is a pattern that is matched against a subject string from left to right. Most characters stand for themselves in a pattern, and match the corresponding characters in the subject. As a trivial example, the pattern

The quick brown fox

matches a portion of a subject string that is identical to itself. When caseless matching is specified, letters are matched independently of case.

The power of regular expressions comes from the ability to include alternatives and repetitions in the pattern. These are encoded in the pattern by the use of *metacharacters*, which do not stand for themselves but instead are interpreted in some special way.

There are two different sets of metacharacters: those that are recognized anywhere in the pattern except within square brackets, and those that are recognized within square brackets. Outside square brackets, the metacharacters are as follows:

| | |
|-----------------|--|
| <code>\</code> | general escape character with several uses |
| <code>^</code> | assert start of string (or line, in multiline mode) |
| <code>\$</code> | assert end of string (or line, in multiline mode) |
| <code>.</code> | match any character except newline (by default) |
| <code>[</code> | start character class definition |
| <code> </code> | start of alternative branch |
| <code>(</code> | start subpattern |
| <code>)</code> | end subpattern |
| <code>?</code> | extends the meaning of ‘ <code>(</code> ’ also 0 or 1 quantifier also quantifier minimizer |
| <code>*</code> | 0 or more quantifier |
| <code>+</code> | 1 or more quantifier also “possessive quantifier” |
| <code>{</code> | start min/max quantifier |

Part of a pattern that is in square brackets is called a "character class". In a character class the only metacharacters are:

| | |
|----------------|--|
| <code>\</code> | general escape character |
| <code>^</code> | negate the class, but only if the first character |
| <code>-</code> | indicates character range |
| <code>[</code> | POSIX character class (only if followed by POSIX syntax) |
| <code>]</code> | terminates the character class |

The following sections describe the use of each of the metacharacters.

Backslash

The backslash character has several uses. Firstly, if it is followed by a non-alphanumeric character, it takes away any special meaning that character may have. This use of backslash as an escape character applies both inside and outside character classes.

For example, if you want to match a ‘`*`’ character, you write ‘`*`’ in the pattern. This escaping action applies whether or not the following character would otherwise be interpreted as a metacharacter, so it is always safe to precede a non-alphanumeric with backslash to specify that it stands for itself. In particular, if you want to match a backslash, you write ‘`\\`’.

If a pattern is compiled with the ‘`(?x)`’ option, whitespace in the pattern (other than in a character class) and characters between a ‘`#`’ outside a character class and the next newline are ignored. An escaping backslash can be used to include a whitespace or ‘`#`’ character as part of the pattern.

If you want to remove the special meaning from a sequence of characters, you can do so by putting them between ‘`\Q`’ and ‘`\E`’. The ‘`\Q... \E`’ sequence is recognized both inside and outside character classes.

Non-printing Characters

A second use of backslash provides a way of encoding non-printing characters in patterns in a visible manner. There is no restriction on the appearance of non-printing characters, apart from the binary zero that terminates a pattern, but when a pattern is being prepared by text editing, it is usually easier to use one of the following escape sequences than the binary character it represents:

| | |
|-------------------------|---|
| <code>\a</code> | alarm, that is, the BEL character (hex 07) |
| <code>\cx</code> | "control- <i>x</i> ", where <i>x</i> is any character |
| <code>\e</code> | escape (hex 1B) |
| <code>\f</code> | formfeed (hex 0C) |
| <code>\n</code> | linefeed (hex 0A) |
| <code>\r</code> | carriage return (hex 0D) |
| <code>\t</code> | tab (hex 09) |
| <code>\ddd</code> | character with octal code <i>ddd</i> , or backreference |
| <code>\xhh</code> | character with hex code <i>hh</i> |
| <code>\x{hhh...}</code> | character with hex code <i>hhh...</i> |

The precise effect of `\cx` is as follows: if *x* is a lower case letter, it is converted to upper case. Then bit 6 of the character (hex 40) is inverted. Thus `\cz` becomes hex 1A (the SUB control character, in ASCII), but `\c{` becomes hex 3B (`';`), and `\c;` becomes hex 7B (`'{'`).

After `\x`, from zero to two hexadecimal digits are read (letters can be in upper or lower case). Any number of hexadecimal digits may appear between `\x{` and `}`, but the value of the character code must be less than 256 in non-UTF-8 mode, and less than 2^{31} in UTF-8 mode. That is, the maximum value in hexadecimal is 7FFFFFFF. Note that this is bigger than the largest Unicode code point, which is 10FFFF.

If characters other than hexadecimal digits appear between `\x{` and `}`, or if there is no terminating `}`, this form of escape is not recognized. Instead, the initial `\x` will be interpreted as a basic hexadecimal escape, with no following digits, giving a character whose value is zero.

Characters whose value is less than 256 can be defined by either of the two syntaxes for `\x`. There is no difference in the way they are handled. For example, `\xdc` is exactly the same as `\x{dc}`.

After `\0` up to two further octal digits are read. If there are fewer than two digits, just those that are present are used. Thus the sequence `\0\x\07` specifies two binary zeros followed by a BEL character (octal 007). Make sure you supply two digits after the initial zero if the pattern character that follows is itself an octal digit.

The handling of a backslash followed by a digit other than 0 is complicated. Outside a character class, PCRE reads it and any following digits as a decimal number. If the number is less than 10, or if there have been at least that many previous capturing left parentheses in the expression, the entire sequence is taken as a *back reference*. A description of how this works is given later, following the discussion of parenthesized subpatterns.

Inside a character class, or if the decimal number is greater than 9 and there have not been that many capturing subpatterns, PCRE re-reads up to three octal digits following the backslash, and uses them to generate a data character. Any subsequent digits stand for themselves. In non-UTF-8 mode, the value of a character specified in octal must be less than `\400`. In UTF-8 mode, values up to `\777` are permitted. For example:

| | |
|--------------------|---|
| <code>\040</code> | is another way of writing a space |
| <code>\40</code> | is the same, provided there are fewer than 40 previous capturing subpatterns |
| <code>\7</code> | is always a back reference |
| <code>\11</code> | might be a back reference, or another way of writing a tab |
| <code>\011</code> | is always a tab |
| <code>\0113</code> | is a tab followed by the character ‘3’ |
| <code>\113</code> | might be a back reference, otherwise the character with octal code 113 |
| <code>\377</code> | might be a back reference, otherwise the byte consisting entirely of 1 bits |
| <code>\81</code> | is either a back reference, or a binary zero followed by the two characters ‘8’ and ‘1’ |

Note that octal values of 100 or greater must not be introduced by a leading zero, because no more than three octal digits are ever read.

All the sequences that define a single character value can be used both inside and outside character classes. In addition, inside a character class, the sequence ‘`\b`’ is interpreted as the `\BS` character (hex 08), and the sequences ‘`\R`’ and ‘`\X`’ are interpreted as the characters ‘`R`’ and ‘`X`’, respectively. Outside a character class, these sequences have different meanings (see below).

Absolute and Relative Back References

The sequence ‘`\g`’ followed by an unsigned or a negative number, optionally enclosed in braces, is an absolute or relative back reference. A named back reference can be coded as ‘`\g{name}`’. Back references are discussed later, following the discussion of parenthesized subpatterns.

Generic character types

Another use of backslash is for specifying generic character types. The following are always recognized:

| | |
|-----------------|---|
| <code>\d</code> | any decimal digit |
| <code>\D</code> | any character that is not a decimal digit |
| <code>\h</code> | any horizontal whitespace character |
| <code>\H</code> | any character that is not a horizontal whitespace character |
| <code>\s</code> | any whitespace character |
| <code>\S</code> | any character that is not a whitespace character |
| <code>\v</code> | any vertical whitespace character |
| <code>\V</code> | any character that is not a vertical whitespace character |
| <code>\w</code> | any “word” character |
| <code>\W</code> | any “non-word” character |

Each pair of escape sequences partitions the complete set of characters into two disjoint sets. Any given character matches one, and only one, of each pair.

These character type sequences can appear both inside and outside character classes. They each match one character of the appropriate type. If the current matching point is at the end of the subject string, all of them fail, since there is no character to match.

For compatibility with Perl, ‘`\s`’ does not match the `\VT` character (code 11). This makes it different from the the POSIX “space” class. The ‘`\s`’ characters are `\TAB` (9), `\LF` (10), `\FF` (12), `\CR` (13), and `\SPACE` (32).

In UTF-8 mode, characters with values greater than 128 never match `\d`, `\s`, or `\w`, and always match `\D`, `\S`, and `\W`. These sequences retain their original meanings from before UTF-8 support was available, mainly for efficiency reasons.

The sequences `\h`, `\H`, `\v`, and `\V` are Perl 5.10 features. In contrast to the other sequences, these do match certain high-valued codepoints in UTF-8 mode. The horizontal space characters are:

| | |
|--------|---------------------------|
| U+0009 | Horizontal tab |
| U+0020 | Space |
| U+00A0 | Non-break space |
| U+1680 | Ogham space mark |
| U+180E | Mongolian vowel separator |
| U+2000 | En quad |
| U+2001 | Em quad |
| U+2002 | En space |
| U+2003 | Em space |
| U+2004 | Three-per-em space |
| U+2005 | Four-per-em space |
| U+2006 | Six-per-em space |
| U+2007 | Figure space |
| U+2008 | Punctuation space |
| U+2009 | Thin space |
| U+200A | Hair space |
| U+202F | Narrow no-break space |
| U+205F | Medium mathematical space |
| U+3000 | Ideographic space |

The vertical space characters are:

| | |
|--------|---------------------|
| U+000A | Linefeed |
| U+000B | Vertical tab |
| U+000C | Formfeed |
| U+000D | Carriage return |
| U+0085 | Next line |
| U+2028 | Line separator |
| U+2029 | Paragraph separator |

A “word” character is an underscore or any character less than 256 that is a letter or digit. The definition of letters and digits is that used for the “C” locale.

Newline Conventions

PCRE supports five different conventions for indicating line breaks in strings: a single CR (carriage return) character, a single LF (linefeed) character, the two-character sequence CRLF, any of the three preceding, or any Unicode newline sequence. The default is to match any Unicode newline sequence. It is possible to override the default newline convention by starting a pattern string with one of the following five sequences:

```

(*CR)      carriage return
(*LF)      linefeed
(*CRLF)    carriage return, followed by linefeed
(*ANYCRLF)
            any of the three above
(*ANY)     all Unicode newline sequences

```

For example, the pattern

```
(*CR)a.b
```

changes the convention to CR. That pattern matches ‘a\nb’ because LF is no longer a newline. Note that these special settings, which are not Perl-compatible, are recognized only at the very start of a pattern, and that they must be in upper case. If more than one of them is present, the last one is used.

The newline convention does not affect what the ‘\R’ escape sequence matches. By default, this is any Unicode newline sequence, for Perl compatibility. However, this can be changed; see the description of ‘\R’ below. A change of ‘\R’ setting can be combined with a change of newline convention.

Newline Sequences

Outside a character class, by default, the escape sequence ‘\R’ matches any Unicode newline sequence. This is a Perl 5.10 feature. In non-UTF-8 mode ‘\R’ is equivalent to the following:

```
(?>\r\n|\n|\x0b|\f|\r|\x85)
```

This is an example of an "atomic group", details of which are given below. This particular group matches either the two-character sequence `\r\n` followed by `\n`, or one of the single characters `\f` (linefeed, U+000A), `\v` (vertical tab, U+000B), `\F` (formfeed, U+000C), `\r` (carriage return, U+000D), or `\x85` (next line, U+0085). The two-character sequence is treated as a single unit that cannot be split. In UTF-8 mode, two additional characters whose codepoints are greater than 255 are added: `\LS` (line separator, U+2028) and `\PS` (paragraph separator, U+2029).

It is possible to change the meaning of ‘\R’ by starting a pattern string with one of the following sequences:

```

(*BSR_ANYCRLF)
    \r, \f, or \r\n only
(*BSR_UNICODE)
    any Unicode newline sequence (the default)

```

Note that these special settings, which are not Perl-compatible, are recognized only at the very start of a pattern, and that they must be in upper case. If more than one of them is present, the last one is used. They can be combined with a change of newline convention, for example, a pattern can start with:

```
(*ANY)(*BSR_ANYCRLF)
```

Inside a character class, ‘\R’ matches the letter ‘R’.

Unicode Character Properties

Three additional escape sequences match characters with specific Unicode properties. When not in UTF-8 mode, these sequences are of course limited to testing characters whose codepoints are less than 256, but they do work in this mode. The extra escape sequences are:

| | |
|---------------------|--|
| <code>\p{xx}</code> | a character with the <code>xx</code> property |
| <code>\P{xx}</code> | a character without the <code>xx</code> property |
| <code>\X</code> | an extended Unicode sequence |

The property names represented by `xx` above are limited to the Unicode script names, the general category properties, and ‘`Any`’, which matches any character (including newline). Other properties such as ‘`InMusicalSymbols`’ are not currently supported by PCRE. Note that ‘`\P{Any}`’ does not match any characters, so always causes a match failure.

Sets of Unicode characters are defined as belonging to certain scripts. A character from one of these sets can be matched using a script name. For example:

```
\p{Greek}
\P{Han}
```

Those that are not part of an identified script are lumped together as “Common.” The current list of scripts is:

Arabic, Armenian, Balinese, Bengali, Bopomofo, Braille, Buginese, Buhid, Canadian_Aboriginal, Cherokee, Common, Coptic, Cuneiform, Cypriot, Cyrillic, Deseret, Devanagari, Ethiopic, Georgian, Glagolitic, Gothic, Greek, Gujarati, Gurmukhi, Han, Hangul, Hanunoo, Hebrew, Hiragana, Inherited, Kannada, Katakana, Kharoshthi, Khmer, Lao, Latin, Limbu, Linear_B, Malayalam, Mongolian, Myanmar, New_Tai_Lue, Nko, Ogham, Old_Italic, Old_Persian, Oriya, Osmanya, Phags_Pa, Phoenician, Runic, Shavian, Sinhala, Syloti_Nagri, Syriac, Tagalog, Tagbanwa, Tai_Le, Tamil, Telugu, Thaana, Thai, Tibetan, Tifinagh, Ugaritic, Yi.

Each character has exactly one general category property, specified by a two-letter abbreviation. For compatibility with Perl, negation can be specified by including a circumflex between the opening brace and the property name. For example, ‘`\p{~Lu}`’ is the same as ‘`\P{Lu}`’.

If only one letter is specified with ‘`\p`’ or ‘`\P`’, it includes all the general category properties that start with that letter. In this case, in the absence of negation, the curly brackets in the escape sequence are optional; these two examples have the same effect:

```
\p{L}
\pL
```

The following general category property codes are supported:

| | |
|-----------------|-------------|
| <code>C</code> | Other |
| <code>Cc</code> | Control |
| <code>Cf</code> | Format |
| <code>Cn</code> | Unassigned |
| <code>Co</code> | Private use |
| <code>Cs</code> | Surrogate |

| | |
|----|-----------------------|
| L | Letter |
| Ll | Lower case letter |
| Lm | Modifier letter |
| Lo | Other letter |
| Lt | Title case letter |
| Lu | Upper case letter |
| M | Mark |
| Mc | Spacing mark |
| Me | Enclosing mark |
| Mn | Non-spacing mark |
| N | Number |
| Nd | Decimal number |
| Nl | Letter number |
| No | Other number |
| P | Punctuation |
| Pc | Connector punctuation |
| Pd | Dash punctuation |
| Pe | Close punctuation |
| Pf | Final punctuation |
| Pi | Initial punctuation |
| Po | Other punctuation |
| Ps | Open punctuation |
| S | Symbol |
| Sc | Currency symbol |
| Sk | Modifier symbol |
| Sm | Mathematical symbol |
| So | Other symbol |
| Z | Separator |
| Zl | Line separator |
| Zp | Paragraph separator |
| Zs | Space separator |

The special property ‘L&’ is also supported: it matches a character that has the ‘Lu’, ‘Ll’, or ‘Lt’ property, in other words, a letter that is not classified as a modifier or “other.”

The ‘Cs’ (Surrogate) property applies only to characters in the range U+D800 to U+DFFF. Such characters are not valid in UTF-8 strings (see RFC 3629) and so cannot be tested by PCRE.

The long synonyms for these properties that Perl supports (such as ‘\p{Letter}’) are not supported by PCRE, nor is it permitted to prefix any of these properties with ‘Is’.

No character that is in the Unicode table has the ‘Cn’ (unassigned) property. Instead, this property is assumed for any code point that is not in the Unicode table.

Specifying caseless matching does not affect these escape sequences. For example, ‘\p{Lu}’ always matches only upper case letters.

The ‘\X’ escape matches any number of Unicode characters that form an extended Unicode sequence. ‘\X’ is equivalent to

`(?>\PM\pM*)`

That is, it matches a character without the “mark” property, followed by zero or more characters with the “mark” property, and treats the sequence as an atomic group (see below). Characters with the “mark” property are typically accents that affect the preceding character. None of them have codepoints less than 256, so in non-UTF-8 mode ‘\X’ matches any one character.

Matching characters by Unicode property is not fast, because PCRE has to search a structure that contains data for over fifteen thousand characters. That is why the traditional escape sequences such as ‘\d’ and ‘\w’ do not use Unicode properties in PCRE.

Resetting the Match Start

The escape sequence ‘\K’, which is a Perl 5.10 feature, causes any previously matched characters not to be included in the final matched sequence. For example, the pattern:

`foo\Kbar`

matches ‘foobar’, but reports that it has matched ‘bar’. This feature is similar to a lookbehind assertion (described below). However, in this case, the part of the subject before the real match does not have to be of fixed length, as lookbehind assertions do. The use of ‘\K’ does not interfere with the setting of captured substrings. For example, when the pattern

`(foo)\Kbar`

matches ‘foobar’, the first substring is still set to ‘foo’.

Simple assertions

The final use of backslash is for certain simple assertions. An assertion specifies a condition that has to be met at a particular point in a match, without consuming any characters from the subject string. The use of subpatterns for more complicated assertions is described below. The backslashed assertions are:

| | |
|-----------------|---|
| <code>\b</code> | matches at a word boundary |
| <code>\B</code> | matches when not at a word boundary |
| <code>\A</code> | matches at the start of the subject |
| <code>\Z</code> | matches at the end of the subject also matches before a newline at the end of the subject |
| <code>\z</code> | matches only at the end of the subject |
| <code>\G</code> | matches at the first matching position in the subject |

These assertions may not appear in character classes (but note that ‘\b’ has a different meaning, namely the backspace character, inside a character class).

A word boundary is a position in the subject string where the current character and the previous character do not both match ‘\w’ or ‘\W’ (i.e. one matches ‘\w’ and the other matches ‘\W’), or the start or end of the string if the first or last character matches ‘\w’, respectively.

The ‘\A’, ‘\Z’, and ‘\z’ assertions differ from the traditional circumflex and dollar (described in the next section) in that they only ever match at the very start and end of the subject string, whatever options are set. Thus, they are independent of multiline mode.

The difference between ‘\Z’ and ‘\z’ is that ‘\Z’ matches before a newline at the end of the string as well as at the very end, whereas ‘\z’ matches only at the end.

The ‘\G’ assertion is true only when the current matching position is at the start point of the match. As used in Monotone, ‘\G’ is always equal to ‘\A’.

Circumflex and Dollar

Outside a character class, in the default matching mode, the circumflex character, ‘^’, is an assertion that is true only if the current matching point is at the start of the subject string. Inside a character class, circumflex has an entirely different meaning (see below).

Circumflex need not be the first character of the pattern if a number of alternatives are involved, but it should be the first thing in each alternative in which it appears if the pattern is ever to match that branch. If all possible alternatives start with a circumflex, that is, if the pattern is constrained to match only at the start of the subject, it is said to be an “anchored” pattern. (There are also other constructs that can cause a pattern to be anchored.)

A dollar character, ‘\$’, is an assertion that is true only if the current matching point is at the end of the subject string, or immediately before a newline at the end of the string (by default). Dollar need not be the last character of the pattern if a number of alternatives are involved, but it should be the last item in any branch in which it appears. Dollar has no special meaning in a character class.

The meanings of the circumflex and dollar characters are changed if the ‘(?m)’ option is set. When this is the case, a circumflex matches immediately after internal newlines as well as at the start of the subject string. It does not match after a newline that ends the string. A dollar matches before any newlines in the string, as well as at the very end, when ‘(?m)’ is set. When newline is specified as the two-character sequence `\r\n`, isolated `\r` and `\n` characters do not indicate newlines.

For example, the pattern ‘^abc\$’ matches the subject string ‘def\nabc’ (where ‘\n’ represents a newline) in multiline mode, but not otherwise. Consequently, patterns that are anchored in single line mode because all branches start with ^ are not anchored in multiline mode.

Note that the sequences ‘\A’, ‘\Z’, and ‘\z’ can be used to match the start and end of the subject in both modes, and if all branches of a pattern start with ‘\A’ it is always anchored.

Full Stop (Period, Dot)

Outside a character class, a dot in the pattern matches any one character in the subject string except (by default) a character that signifies the end of a line. In UTF-8 mode, the matched character may be more than one byte long.

When a line ending is defined as a single character, dot never matches that character; when the two-character sequence `\r\n` is used, dot does not match `\r` if it is immediately followed by `\n`, but otherwise it matches all characters (including isolated `\r`s and `\n`s). When any Unicode line endings are being recognized, dot does not match `\r` or `\n` or any of the other line ending characters.

The behaviour of dot with regard to newlines can be changed. If the ‘(?s)’ option is set, a dot matches any one character, without exception. If the two-character sequence `\r\n` is present in the subject string, it takes two dots to match it.

The handling of dot is entirely independent of the handling of circumflex and dollar, the only relationship being that they both involve newlines. Dot has no special meaning in a character class.

Matching a Single Byte

Outside a character class, the escape sequence ‘\C’ matches any one byte, both in and out of UTF-8 mode. Unlike a dot, it always matches any line-ending characters. The feature is provided in Perl in order to match individual bytes in UTF-8 mode. Because it breaks up UTF-8 characters into individual bytes, what remains in the string may be a malformed UTF-8 string. For this reason, the ‘\C’ escape sequence is best avoided.

PCRE does not allow ‘\C’ to appear in lookbehind assertions (described below), because in UTF-8 mode this would make it impossible to calculate the length of the lookbehind.

Square Brackets and Character Classes

An opening square bracket introduces a character class, terminated by a closing square bracket. A closing square bracket on its own is not special. If a closing square bracket is required as a member of the class, it should be the first data character in the class (after an initial circumflex, if present) or escaped with a backslash.

A character class matches a single character in the subject. In UTF-8 mode, the character may occupy more than one byte. A matched character must be in the set of characters defined by the class, unless the first character in the class definition is a circumflex, in which case the subject character must not be in the set defined by the class. If a circumflex is actually required as a member of the class, ensure it is not the first character, or escape it with a backslash.

For example, the character class ‘[aeiou]’ matches any lower case vowel, while ‘[^aeiou]’ matches any character that is not a lower case vowel. Note that a circumflex is just a convenient notation for specifying the characters that are in the class by enumerating those that are not. A class that starts with a circumflex is not an assertion: it still consumes a character from the subject string, and therefore it fails if the current pointer is at the end of the string.

In UTF-8 mode, characters with values greater than 255 can be included in a class as a literal string of bytes, or by using the ‘\x{’ escaping mechanism.

When caseless matching is set, any letters in a class represent both their upper case and lower case versions, so for example, a caseless ‘[aeiou]’ matches ‘A’ as well as ‘a’, and a caseless ‘[^aeiou]’ does not match ‘A’, whereas a careful version would. In UTF-8 mode, PCRE always understands the concept of case for characters whose values are less than 128, so caseless matching is always possible. For characters with higher values, the concept of case is supported if PCRE is compiled with Unicode property support, but not otherwise. If you want to use caseless matching for characters 128 and above, you must ensure that PCRE is compiled with Unicode property support as well as with UTF-8 support.

Characters that might indicate line breaks are never treated in any special way when matching character classes, whatever line-ending sequence is in use, and whatever setting of the ‘(?s)’ and ‘(?m)’ options is used. A class such as ‘[a]’ always matches one of these characters.

The minus (hyphen) character can be used to specify a range of characters in a character class. For example, `[d-m]` matches any letter between ‘d’ and ‘m’, inclusive. If a minus character is required in a class, it must be escaped with a backslash or appear in a position where it cannot be interpreted as indicating a range, typically as the first or last character in the class.

It is not possible to have the literal character ‘]’ as the end character of a range. A pattern such as `[W-]46]` is interpreted as a class of two characters (‘W’ and ‘-’) followed by a literal string ‘46]’, so it would match `W46]` or `-46]`. However, if the ‘]’ is escaped with a backslash it is interpreted as the end of range, so `[W-\]46]` is interpreted as a class containing a range followed by two other characters. The octal or hexadecimal representation of ‘]’ can also be used to end a range.

Ranges operate in the collating sequence of character values. They can also be used for characters specified numerically, for example `[\000-\037]`. In UTF-8 mode, ranges can include characters whose values are greater than 255, for example `[\x{100}-\x{2ff}]`.

If a range that includes letters is used when caseless matching is set, it matches the letters in either case. For example, `[W-c]` is equivalent to `[[] [\^_‘wxyzabc]`, matched caselessly.

The character types `\d`, `\D`, `\p`, `\P`, `\s`, `\S`, `\w`, and `\W` may also appear in a character class, and add the characters that they match to the class. For example, `[\dADEF]` matches any hexadecimal digit. A circumflex can conveniently be used with the upper case character types to specify a more restricted set of characters than the matching lower case type. For example, the class `[\^W_]` matches any letter or digit, but not underscore.

The only metacharacters that are recognized in character classes are backslash, hyphen (only where it can be interpreted as specifying a range), circumflex (only at the start), opening square bracket (only when it can be interpreted as introducing a POSIX class name—see the next section), and the terminating closing square bracket. However, escaping other non-alphanumeric characters does no harm.

POSIX Character Classes

Perl supports the POSIX notation for character classes. This uses names enclosed by `[:]` and `[:]` within the enclosing square brackets. PCRE also supports this notation. For example,

```
[01[:alpha:]]%
```

matches ‘0’, ‘1’, any alphabetic character, or ‘%’. The supported class names are

| | |
|---------------------|---|
| <code>alnum</code> | letters and digits |
| <code>alpha</code> | letters |
| <code>ascii</code> | character codes 0 – 127 |
| <code>blank</code> | space or tab only |
| <code>cntrl</code> | control characters |
| <code>digit</code> | decimal digits (same as ‘ <code>\d</code> ’) |
| <code>graph</code> | printing characters, excluding space |
| <code>lower</code> | lower case letters |
| <code>print</code> | printing characters, including space |
| <code>punct</code> | printing characters, excluding letters and digits |
| <code>space</code> | white space (not quite the same as ‘ <code>\s</code> ’) |
| <code>upper</code> | upper case letters |
| <code>word</code> | “word” characters (same as ‘ <code>\w</code> ’) |
| <code>xdigit</code> | hexadecimal digits |

The “space” characters are `\HT` (9), `\LF` (10), `\VT` (11), `\FF` (12), `\CR` (13), and space (32). Notice that this list includes the `\VT` character (code 11). This makes "space" different to ‘`\s`’, which does not include `\VT` (for Perl compatibility).

The name “word” is a Perl extension, and “blank” is a GNU extension from Perl 5.8. Another Perl extension is negation, which is indicated by a ‘`^`’ character after the colon. For example,

```
[12[:^digit:]]
```

matches ‘1’, ‘2’, or any non-digit. PCRE (and Perl) also recognize the POSIX syntax ‘`[.ch.]`’ and ‘`[=ch=]`’ where *ch* is a “collating element,” but these are not supported, and an error is given if they are encountered.

In UTF-8 mode, characters with values greater than 128 do not match any of the POSIX character classes.

Vertical Bar

Vertical bar characters are used to separate alternative patterns. For example, the pattern

```
gilbert|sullivan
```

matches either ‘gilbert’ or ‘sullivan’. Any number of alternatives may appear, and an empty alternative is permitted (matching the empty string). The matching process tries each alternative in turn, from left to right, and the first one that succeeds is used. If the alternatives are within a subpattern (defined below), "succeeds" means matching the rest of the main pattern as well as the alternative in the subpattern.

Internal Option Setting

The behavior of the matching engine can be adjusted from within the pattern by a sequence of option letters enclosed between ‘`(?`’ and ‘`)`’. The option letters are

| | |
|---|---|
| i | Caseless: characters in one case match the corresponding characters in other cases as well. |
| m | Multiline: ‘^’ and ‘\$’ match at newlines as well as at beginning and end of string. |
| s | Dotall: dot matches any character, including newline characters. |
| x | Extended syntax: unescaped white space is ignored and embedded comments are possible. |
| J | Dupnames: names for capturing subpattern need not be unique. |
| U | Ungreedy: quantifiers match as few times as possible by default. |
| X | Extra: for forward compatibility, give an error if any escape sequence with no defined meaning appears. |

For example, ‘(?im)’ sets caseless, multiline matching. It is also possible to unset these options by preceding the letters with a hyphen, and a combined setting and unsetting such as ‘(?im-sx)’ is also permitted. (This would set the caseless and multiline options while unsetting the dotall and extended-syntax options.) If a letter appears both before and after the hyphen, the option is unset. The lowercase option letters are Perl-compatible; the uppercase ones are PCRE only.

When an option change occurs at top level (that is, not inside subpattern parentheses), the change applies to the remainder of the pattern that follows. An option change within a subpattern (see below for a description of subpatterns) affects only that part of the current pattern that follows it, so

`(a(?i)b)c`

matches ‘abc’ and ‘aBc’ and no other strings. By this means, options can be made to have different settings in different parts of the pattern. Any changes made in one alternative do carry on into subsequent branches within the same subpattern. For example,

`(a(?i)b|c)`

matches ‘ab’, ‘aB’, ‘c’, and ‘C’, even though when matching ‘C’ the first branch is abandoned before the option setting. This is because the effects of option settings happen when the pattern is parsed. There would be some very weird behaviour otherwise.

Note: Unlike these options, the similar, PCRE-specific option sequences that start with ‘(*)’ may appear only at the very beginning of the pattern. Details of these sequences are given in the section entitled “Newline sequences,” above.

Subpatterns

Subpatterns are delimited by parentheses (round brackets), which can be nested. Turning part of a pattern into a subpattern does two things:

1. It localizes a set of alternatives. For example, the pattern

`cat(aract|erpillar|)`

matches one of the words ‘cat’, ‘cactaract’, or ‘caterpillar’. Without the parentheses, it would match ‘cactaract’, ‘erpillar’ or an empty string.

2. It sets up the subpattern as a capturing subpattern. As used in Monotone this only means that during matching, the portion of the subject string that matched the subpattern is available for back references. Captured subpatterns are, for instance, not

available to callers of `regex.search`. Opening parentheses are counted from left to right (starting from 1) to obtain numbers for the capturing subpatterns.

For example, if the string ‘the red king’ is matched against the pattern

```
the ((red|white) (king|queen))
```

the captured substrings are ‘red king’, ‘red’, and ‘king’, and are numbered 1, 2, and 3, respectively.

The fact that plain parentheses fulfil two functions is not always helpful. There are often times when a grouping subpattern is required without a capturing requirement. If an opening parenthesis is followed by a question mark and a colon, the subpattern does not do any capturing, and is not counted when computing the number of any subsequent capturing subpatterns. For example, if the string ‘the white queen’ is matched against the pattern

```
the ((?:red|white) (king|queen))
```

the captured substrings are ‘white queen’ and ‘queen’, and are numbered 1 and 2. The maximum number of capturing subpatterns is 65535.

As a convenient shorthand, if any option settings are required at the start of a non-capturing subpattern, the option letters may appear between the ‘?’ and the ‘:’. Thus the two patterns

```
(?i:saturday|sunday)
(?:(?i)saturday|sunday)
```

match exactly the same set of strings. Because alternative branches are tried from left to right, and options are not reset until the end of the subpattern is reached, an option setting in one branch does affect subsequent branches, so the above patterns match ‘SUNDAY’ as well as ‘Saturday’.

Duplicate Subpattern Numbers

Perl 5.10 introduced a feature whereby each alternative in a subpattern uses the same numbers for its capturing parentheses. Such a subpattern starts with ‘(?!’ and is itself a non-capturing subpattern. For example, consider this pattern:

```
(?!(Sat)ur|(Sun))day
```

Because the two alternatives are inside a ‘(?!’ group, both sets of capturing parentheses are numbered one. Thus, when the pattern matches, you can look at captured substring number one, whichever alternative matched. This construct is useful when you want to capture part, but not all, of one of a number of alternatives. Inside a ‘(?!’ group, parentheses are numbered as usual, but the number is reset at the start of each branch. The numbers of any capturing buffers that follow the subpattern start after the highest number used in any branch. The following example is taken from the Perl documentation. The numbers underneath show in which buffer the captured content will be stored.

```
# before -----branch-reset----- after
/ ( a ) (?! x ( y ) z | (p (q) r) | (t) u (v) ) ( z ) /x
# 1           2           2 3           2     3     4
```

A backreference or a recursive call to a numbered subpattern always refers to the first one in the pattern with the given number.

An alternative approach to using this “branch reset” feature is to use duplicate named subpatterns, as described in the next section.

Named Subpatterns

Identifying capturing parentheses by number is simple, but it can be very hard to keep track of the numbers in complicated regular expressions. Furthermore, if an expression is modified, the numbers may change. To help with this difficulty, PCRE supports the naming of subpatterns. This feature was not added to Perl until release 5.10. Python had the feature earlier, and PCRE introduced it at release 4.0, using the Python syntax. PCRE now supports both the Perl and the Python syntax.

In PCRE, a subpattern can be named in one of three ways: ‘(?(<name>...)’ or ‘(?’name’...)’ as in Perl, or ‘(?P<name>...)’ as in Python. References to capturing parentheses from other parts of the pattern, such as backreferences, recursion, and conditions, can be made by name as well as by number.

Names consist of up to 32 alphanumeric characters and underscores. Named capturing parentheses are still allocated numbers as well as names, exactly as if the names were not present.

By default, a name must be unique within a pattern, but it is possible to relax this constraint by setting the ‘(?J)’ option. This can be useful for patterns where only one instance of the named parentheses can match. Suppose you want to match the name of a weekday, either as a 3-letter abbreviation or as the full name, and in both cases you want to extract the abbreviation. This pattern (ignoring the line breaks) does the job:

```
(?Jx)
(?<DN>Mon|Fri|Sun)(?:day)?|
(?<DN>Tue)(?:sday)?|
(?<DN>Wed)(?:nesday)?|
(?<DN>Thu)(?:rday)?|
(?<DN>Sat)(?:urday)?
```

There are five capturing substrings, but only one is ever set after a match. (An alternative way of solving this problem is to use a “branch reset” subpattern, as described in the previous section.)

Repetition

Repetition is specified by *quantifiers*, which can follow any of the following items:

- a literal data character
- the dot metacharacter
- the ‘\C’ escape sequence
- the ‘\X’ escape sequence (in UTF-8 mode with Unicode properties)
- the ‘\R’ escape sequence
- an escape such as ‘\d’ that matches a single character
- a character class
- a back reference (see next section)
- a parenthesized subpattern (unless it is an assertion)

The general repetition quantifier specifies a minimum and maximum number of permitted matches, by giving the two numbers in curly brackets (braces), separated by a comma. The numbers must be less than 65536, and the first must be less than or equal to the second. For example:

`z{2,4}`

matches ‘zz’, ‘zzz’, or ‘zzzz’. A closing brace on its own is not a special character. If the second number is omitted, but the comma is present, there is no upper limit; if the second number and the comma are both omitted, the quantifier specifies an exact number of required matches. Thus

`[aeiou]{3,}`

matches at least 3 successive vowels, but may match many more, while

`\d{8}`

matches exactly 8 digits. An opening curly bracket that appears in a position where a quantifier is not allowed, or one that does not match the syntax of a quantifier, is taken as a literal character. For example, ‘{,6}’ is not a quantifier, but a literal string of four characters.

In UTF-8 mode, quantifiers apply to UTF-8 characters rather than to individual bytes. Thus, for example, ‘`\x{100}{2}`’ matches two UTF-8 characters, each of which is represented by a two-byte sequence. Similarly, ‘`\X{3}`’ matches three Unicode extended sequences, each of which may be several bytes long (and they may be of different lengths).

The quantifier ‘{0}’ is permitted, causing the expression to behave as if the previous item and the quantifier were not present.

For convenience, the three most common quantifiers have single-character abbreviations:

| | |
|----------------|-------------------------------------|
| <code>*</code> | is equivalent to <code>{0,}</code> |
| <code>+</code> | is equivalent to <code>{1,}</code> |
| <code>?</code> | is equivalent to <code>{0,1}</code> |

It is possible to construct infinite loops by following a subpattern that can match no characters with a quantifier that has no upper limit, for example:

`(a?)*`

Earlier versions of Perl and PCRE used to give an error at compile time for such patterns. However, because there are cases where this can be useful, such patterns are now accepted, but if any repetition of the subpattern does in fact match no characters, the loop is forcibly broken.

By default, the quantifiers are *greedy*, that is, they match as much as possible (up to the maximum number of permitted times), without causing the rest of the pattern to fail. The classic example of where this gives problems is in trying to match comments in C programs. These appear between ‘`/*`’ and ‘`*/`’, and within the comment, individual ‘`*`’ and ‘`/`’ characters may appear. An attempt to match C comments by applying the pattern

`/*.**/`

to the string

`/* first comment */ not comment /* second comment */`

fails, because it matches the entire string owing to the greediness of the ‘`.*`’ item.

However, if a quantifier is followed by a question mark, it ceases to be greedy, and instead matches the minimum number of times possible, so the pattern

`/*.*?*/`

does the right thing with the C comments. The meaning of the various quantifiers is not otherwise changed, just the preferred number of matches. Do not confuse this use of question mark with its use as a quantifier in its own right. Because it has two uses, it can sometimes appear doubled, as in

```
\d??\d
```

which matches one digit by preference, but can match two if that is the only way the rest of the pattern matches.

If the ‘(?U)’ option is set (an option that is not available in Perl), the quantifiers are not greedy by default, but individual ones can be made greedy by following them with a question mark. In other words, it inverts the default behaviour.

When a parenthesized subpattern is quantified with a minimum repeat count that is greater than 1 or with a limited maximum, more memory is required for the compiled pattern, in proportion to the size of the minimum or maximum.

If a pattern starts with ‘.*’ or ‘.{0,}’ and the ‘(?s)’ option is set, thus allowing the dot to match newlines, the pattern is implicitly anchored, because whatever follows will be tried against every character position in the subject string, so there is no point in retrying the overall match at any position after the first. PCRE normally treats such a pattern as though it were preceded by ‘\A’.

In cases where it is known that the subject string contains no newlines, it is worth setting ‘(?s)’ in order to obtain this optimization, or alternatively using ‘^’ or ‘\A’ to indicate anchoring explicitly.

However, there is one situation where the optimization cannot be used. When .* is inside capturing parentheses that are the subject of a backreference elsewhere in the pattern, a match at the start may fail where a later one succeeds. Consider, for example:

```
(.*)abc\1
```

If the subject is ‘xyz123abc123’ the match point is the fourth character. For this reason, such a pattern is not implicitly anchored.

When a capturing subpattern is repeated, the value captured is the substring that matched the final iteration. For example, after

```
(tweedle[dume]{3}\s*)+
```

has matched ‘tweedledum tweedledee’ the value of the captured substring is ‘tweedledee’. However, if there are nested capturing subpatterns, the corresponding captured values may have been set in previous iterations. For example, after

```
(a|(b))+
```

matches ‘aba’ the value of the second captured substring is ‘b’.

Atomic Grouping and Possessive Quantifiers

With both maximizing (*greedy*) and minimizing (*ungreedy* or *lazy*) repetition, failure of what follows normally causes the repeated item to be re-evaluated to see if a different number of repeats allows the rest of the pattern to match. Sometimes it is useful to prevent this, either to change the nature of the match, or to cause it fail earlier than it otherwise might, when the author of the pattern knows there is no point in carrying on.

Consider, for example, the pattern ‘\d+foo’ when applied to the subject line


```
123456bar
```

After matching all 6 digits and then failing to match ‘foo’, the normal action of the matcher is to try again with only 5 digits matching the ‘\d+’ item, and then with 4, and so on, before ultimately failing. *Atomic grouping* (a term taken from Jeffrey Friedl’s book) provides the means for specifying that once a subpattern has matched, it is not to be re-evaluated in this way.

If we use atomic grouping for the previous example, the matcher gives up immediately on failing to match ‘foo’ the first time. The notation is a kind of special parenthesis, starting with ‘(?’ as in this example:

```
(?>\d+)foo
```

This kind of parenthesis “locks up” the part of the pattern it contains once it has matched, and a failure further into the pattern is prevented from backtracking into it. Backtracking past it to previous items, however, works as normal. Atomic grouping subpatterns are not capturing subpatterns.

An alternative description is that a subpattern of this type matches the string of characters that an identical standalone pattern would match, if anchored at the current point in the subject string.

Simple cases such as the above example can be thought of as a maximizing repeat that must swallow everything it can. So, while both ‘\d+’ and ‘\d+?’ are prepared to adjust the number of digits they match in order to make the rest of the pattern match, ‘(?’\d+)’ can only match an entire sequence of digits.

Atomic groups in general can of course contain arbitrarily complicated subpatterns, and can be nested. However, when the subpattern for an atomic group is just a single repeated item, as in the example above, a simpler notation, called a *possessive quantifier*, can be used. This consists of an additional ‘+’ character following a quantifier. Using this notation, the previous example can be rewritten as

```
\d++foo
```

Note that a possessive quantifier can be used with an entire group, for example:

```
(abc|xyz){2,3}+
```

Possessive quantifiers are always greedy; the setting of the ‘(?U)’ option is ignored. They are a convenient notation for the simpler forms of atomic group. However, there is no difference in the meaning of a possessive quantifier and the equivalent atomic group, though there may be a performance difference; possessive quantifiers should be slightly faster.

The possessive quantifier syntax is an extension to the Perl 5.8 syntax. Jeffrey Friedl originated the idea (and the name) in the first edition of his book. Mike McCloskey liked it, so implemented it when he built Sun’s Java package, and PCRE copied it from there. It ultimately found its way into Perl at release 5.10.

PCRE has an optimization that automatically “possessifies” certain simple pattern constructs. For example, the sequence ‘A+B’ is treated as ‘A++B’ because there is no point in backtracking into a sequence of ‘A’s when ‘B’ must follow.

When a pattern contains an unlimited repeat inside a subpattern that can itself be repeated an unlimited number of times, the use of an atomic group is the only way to avoid some failing matches taking a very long time indeed. The pattern


```
(\D+|<\d+>)*[!?]
```

matches an unlimited number of substrings that either consist of non-digits, or digits enclosed in '<>', followed by either '!' or '?'. When it matches, it runs quickly. However, if it is applied to

```
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```

it takes a long time before reporting failure. This is because the string can be divided between the internal '\D+' repeat and the external '*' repeat in a large number of ways, and all have to be tried. (The example uses '[!?]' rather than a single character at the end, because both PCRE and Perl have an optimization that allows for fast failure when a single character is used. They remember the last single character that is required for a match, and fail early if it is not present in the string.) If the pattern is changed so that it uses an atomic group, like this:

```
((?>\D+)|<\d+>)*[!?]
```

sequences of non-digits cannot be broken, and failure happens quickly.

Back References

Outside a character class, a backslash followed by a digit greater than 0 (and possibly further digits) is a back reference to a capturing subpattern earlier (that is, to its left) in the pattern, provided there have been that many previous capturing left parentheses.

However, if the decimal number following the backslash is less than 10, it is always taken as a back reference, and causes an error only if there are not that many capturing left parentheses in the entire pattern. In other words, the parentheses that are referenced need not be to the left of the reference for numbers less than 10. A “forward back reference” of this type can make sense when a repetition is involved and the subpattern to the right has participated in an earlier iteration.

It is not possible to have a numerical “forward back reference” to a subpattern whose number is 10 or more using this syntax because a sequence such as '\50' is interpreted as a character defined in octal. See the subsection entitled “Non-printing characters” above for further details of the handling of digits following a backslash. There is no such problem when named parentheses are used. A back reference to any subpattern is possible using named parentheses (see below).

Another way of avoiding the ambiguity inherent in the use of digits following a backslash is to use the '\g' escape sequence, which is a feature introduced in Perl 5.10. This escape must be followed by an unsigned number or a negative number, optionally enclosed in braces. These examples are all identical:

```
(ring), \1
(ring), \g1
(ring), \g{1}
```

An unsigned number specifies an absolute reference without the ambiguity that is present in the older syntax. It is also useful when literal digits follow the reference. A negative number is a relative reference. Consider this example:

```
(abc(def)ghi)\g{-1}
```

The sequence '\g{-1}' is a reference to the most recently started capturing subpattern before '\g', that is, is it equivalent to '\2'. Similarly, '\g{-2}' would be equivalent to '\1'.

The use of relative references can be helpful in long patterns, and also in patterns that are created by joining together fragments that contain references within themselves.

A back reference matches whatever actually matched the capturing subpattern in the current subject string, rather than anything matching the subpattern itself (see “Subpatterns as subroutines” below for a way of doing that). So the pattern

```
(sens|respons)e and \1ibility
```

matches ‘sense and sensibility’ and ‘response and responsibility’, but not ‘sense and responsibility’. If careful matching is in force at the time of the back reference, the case of letters is relevant. For example,

```
((?i)rah)\s+\1
```

matches ‘rah rah’ and ‘RAH RAH’, but not ‘RAH rah’, even though the original capturing subpattern is matched caselessly.

There are several different ways of writing back references to named subpatterns. The .NET syntax ‘\k{name}’ and the Perl syntax ‘\k<name>’ or ‘\k’name’’ are supported, as is the Python syntax ‘(?P=name)’. Perl 5.10’s unified back reference syntax, in which ‘\g’ can be used for both numeric and named references, is also supported. We could rewrite the above example in any of the following ways:

```
(?<p1>(i)rah)\s+\k<p1>
(?’p1’(i)rah)\s+\k{p1}
(?P<p1>(i)rah)\s+(?P=p1)
(?<p1>(i)rah)\s+\g{p1}
```

A subpattern that is referenced by name may appear in the pattern before or after the reference.

There may be more than one back reference to the same subpattern. If a subpattern has not actually been used in a particular match, any back references to it always fail. For example, the pattern

```
(a|(bc))\2
```

always fails if it starts to match ‘a’ rather than ‘bc’. Because there may be many capturing parentheses in a pattern, all digits following the backslash are taken as part of a potential back reference number. If the pattern continues with a digit character, some delimiter must be used to terminate the back reference. If the ‘(?x)’ option is set, this can be whitespace. Otherwise an empty comment (see “Comments” below) can be used.

A back reference that occurs inside the parentheses to which it refers fails when the subpattern is first used, so, for example, ‘(a\1)’ never matches. However, such references can be useful inside repeated subpatterns. For example, the pattern

```
(a|b\1)+
```

matches any number of ‘a’s and also ‘aba’, ‘ababbaa’ etc. At each iteration of the subpattern, the back reference matches the character string corresponding to the previous iteration. In order for this to work, the pattern must be such that the first iteration does not need to match the back reference. This can be done using alternation, as in the example above, or by a quantifier with a minimum of zero.

Assertions

An assertion is a test on the characters following or preceding the current matching point that does not actually consume any characters. The simple assertions coded as `'\b'`, `'\B'`, `'\A'`, `'\G'`, `'\Z'`, `'\z'`, `'^'` and `'$'` are described above.

More complicated assertions are coded as subpatterns. There are two kinds: those that look ahead of the current position in the subject string, and those that look behind it. An assertion subpattern is matched in the normal way, except that it does not cause the current matching position to be changed.

Assertion subpatterns are not capturing subpatterns, and may not be repeated, because it makes no sense to assert the same thing several times. If any kind of assertion contains capturing subpatterns within it, these are counted for the purposes of numbering the capturing subpatterns in the whole pattern. However, substring capturing is carried out only for positive assertions, because it does not make sense for negative assertions.

Lookahead Assertions

Lookahead assertions start with `'(?='` for positive assertions and `'(?!'` for negative assertions. For example,

```
\w+(?=;)
```

matches a word followed by a semicolon, but does not include the semicolon in the match, and

```
foo(?!bar)
```

matches any occurrence of `'foo'` that is not followed by `'bar'`. Note that the apparently similar pattern

```
(?!foo)bar
```

does not find an occurrence of `'bar'` that is preceded by something other than `'foo'`; it finds any occurrence of `'bar'` whatsoever, because the assertion `'(?!foo)'` is always true when the next three characters are `'bar'`. A lookbehind assertion is needed to achieve the other effect.

If you want to force a matching failure at some point in a pattern, the most convenient way to do it is with `'(?!)'` because an empty string always matches, so an assertion that requires there not to be an empty string must always fail.

Lookbehind Assertions

Lookbehind assertions start with `'(?<='` for positive assertions and `'(?<!'` for negative assertions. For example,

```
(?<!foo)bar
```

matches an occurrence of `'bar'` that is not preceded by `'foo'`. The contents of a lookbehind assertion are restricted such that all the strings it matches must have a fixed length. However, if there are several top-level alternatives, they do not all have to have the same fixed length. Thus

```
(?<=bullock|donkey)
```

is permitted, but

```
(?<!dogs?|cats?)
```

causes an error at compile time. Branches that match different length strings are permitted only at the top level of a lookbehind assertion. This is an extension compared with Perl (at least for 5.8), which requires all branches to match the same length of string. An assertion such as

```
(?<=ab(c|de))
```

is not permitted, because its single top-level branch can match two different lengths, but it is acceptable if rewritten to use two top-level branches:

```
(?<=abc|abde)
```

In some cases, the Perl 5.10 escape sequence ‘\K’ (see above) can be used instead of a lookbehind assertion; this is not restricted to a fixed-length.

The implementation of lookbehind assertions is, for each alternative, to temporarily move the current position back by the fixed length and then try to match. If there are insufficient characters before the current position, the assertion fails.

PCRE does not allow the ‘\C’ escape (which matches a single byte in UTF-8 mode) to appear in lookbehind assertions, because it makes it impossible to calculate the length of the lookbehind. The ‘\X’ and ‘\R’ escapes, which can match different numbers of bytes, are also not permitted.

Possessive quantifiers can be used in conjunction with lookbehind assertions to specify efficient matching at the end of the subject string. Consider a simple pattern such as

```
abcd$
```

when applied to a long string that does not match. Because matching proceeds from left to right, PCRE will look for each ‘a’ in the subject and then see if what follows matches the rest of the pattern. If the pattern is specified as

```
^.*abcd$
```

the initial ‘.*’ matches the entire string at first, but when this fails (because there is no following ‘a’), it backtracks to match all but the last character, then all but the last two characters, and so on. Once again the search for ‘a’ covers the entire string, from right to left, so we are no better off. However, if the pattern is written as

```
^.*+(?<=abcd)
```

there can be no backtracking for the ‘.*+’ item; it can match only the entire string. The subsequent lookbehind assertion does a single test on the last four characters. If it fails, the match fails immediately. For long strings, this approach makes a significant difference to the processing time.

Using multiple assertions

Several assertions (of any sort) may occur in succession. For example,

```
(?<=\d{3})(?<!999)foo
```

matches ‘foo’ preceded by three digits that are not ‘999’. Notice that each of the assertions is applied independently at the same point in the subject string. First there is a check that the previous three characters are all digits, and then there is a check that the same three characters are not ‘999’. This pattern does *not* match ‘foo’ preceded by six characters, the first of which are digits and the last three of which are not ‘999’. For example, it doesn’t match ‘123abcfoo’. A pattern to do that is

```
(?<=\d{3}...)(?<!999)foo
```

This time the first assertion looks at the preceding six characters, checking that the first three are digits, and then the second assertion checks that the preceding three characters are not ‘999’.

Assertions can be nested in any combination. For example,

```
(?<=(?<!foo)bar)baz
```

matches an occurrence of ‘baz’ that is preceded by ‘bar’ which in turn is not preceded by ‘foo’, while

```
(?<=\d{3}(?!999)...)foo
```

is another pattern that matches ‘foo’ preceded by three digits and any three characters that are not ‘999’.

Conditional Subpatterns

It is possible to cause the matching process to obey a subpattern conditionally or to choose between two alternative subpatterns, depending on the result of an assertion, or whether a previous capturing subpattern matched or not. The two possible forms of conditional subpattern are

- `(?(condition)yes-pattern)`
- `(?(condition)yes-pattern|no-pattern)`

If the *condition* is satisfied, the *yes-pattern* is used; otherwise the *no-pattern* (if present) is used. If there are more than two alternatives in the subpattern, a compile-time error occurs.

There are four kinds of condition: references to subpatterns, references to recursion, a pseudo-condition called ‘DEFINE’, and assertions.

Checking for a used subpattern by number

If the text between the parentheses consists of a sequence of digits, the condition is true if the capturing subpattern of that number has previously matched. An alternative notation is to precede the digits with a plus or minus sign. In this case, the subpattern number is relative rather than absolute. The most recently opened parentheses can be referenced by ‘`(?-1)`’, the next most recent by ‘`(-2)`’, and so on. In looping constructs it can also make sense to refer to subsequent groups with constructs such as ‘`(?+2)`’.

Consider the following pattern, which contains non-significant white space to make it more readable and to divide it into three parts for ease of discussion (assume a preceding ‘`(?x)`’):

```
( \ ( ) ?      [ ^ ( ) ] +      ( ? ( 1 ) \ ) )
```

The first part matches an optional opening parenthesis, and if that character is present, sets it as the first captured substring. The second part matches one or more characters that are not parentheses. The third part is a conditional subpattern that tests whether the first set of parentheses matched or not. If they did, that is, if subject started with an opening parenthesis, the condition is true, and so the yes-pattern is executed and a closing parenthesis is required. Otherwise, since no-pattern is not present, the subpattern matches nothing. In other words, this pattern matches a sequence of non-parentheses, optionally enclosed in parentheses.

If you were embedding this pattern in a larger one, you could use a relative reference:

```
...other stuff... ( \ ( ) ?    [ ^ ( ) ] +    ( ? ( - 1 ) \ ) ) ...
```

This makes the fragment independent of the parentheses in the larger pattern.

Checking for a used subpattern by name

Perl uses the syntax ‘`(?(<name>)...)`’ or ‘`(?('name')...)`’ to test for a used subpattern by name. For compatibility with earlier versions of PCRE, which had this facility before Perl, the syntax ‘`(?(name)...)`’ is also recognized. However, there is a possible ambiguity with this syntax, because subpattern names may consist entirely of digits. PCRE looks first for a named subpattern; if it cannot find one and the name consists entirely of digits, PCRE looks for a subpattern of that number, which must be greater than zero. Using subpattern names that consist entirely of digits is not recommended.

Rewriting the above example to use a named subpattern gives this:

```
(?<OPEN> \ ( ) ?    [ ^ ( ) ] +    ( ? ( <OPEN> ) \ ) )
```

Checking for pattern recursion

If the condition is the string ‘`(R)`’, and there is no subpattern with the name ‘`R`’, the condition is true if a recursive call to the whole pattern or any subpattern has been made. If digits or a name preceded by ampersand follow the letter ‘`R`’, for example:

```
(?(R3)... ) or (?(R&name)... )
```

the condition is true if the most recent recursion is into the subpattern whose number or name is given. This condition does not check the entire recursion stack.

At “top level,” all these recursion test conditions are false. Recursive patterns are described below.

Defining subpatterns for use by reference only

If the condition is the string ‘`(DEFINE)`’, and there is no subpattern with the name ‘`DEFINE`’, the condition is always false. In this case, there may be only one alternative in the subpattern. It is always skipped if control reaches this point in the pattern; the idea of `DEFINE` is that it can be used to define *subroutines* that can be referenced from elsewhere. (The use of subroutines is described below.) For example, a pattern to match an IPv4 address could be written like this (ignore whitespace and line breaks):

```
(?(DEFINE) (?<byte> 2[0-4]\d | 25[0-5] | 1\d\d | [1-9]?\d) )
\b (?&byte) (\.(?&byte)){3} \b
```

The first part of the pattern is a `DEFINE` group inside which a another group named “byte” is defined. This matches an individual component of an IPv4 address (a number less than 256). When matching takes place, this part of the pattern is skipped because `DEFINE` acts like a false condition.

The rest of the pattern uses references to the named group to match the four dot-separated components of an IPv4 address, insisting on a word boundary at each end.

Assertion conditions

If the condition is not in any of the above formats, it must be an assertion. This may be a positive or negative lookahead or lookbehind assertion. Consider this pattern, again containing non-significant white space, and with the two alternatives on the second line:

```
(?(?=[^a-z]*[a-z])
\d{2}-[a-z]{3}-\d{2}  |  \d{2}-\d{2}-\d{2} )
```

The condition is a positive lookahead assertion that matches an optional sequence of non-letters followed by a letter. In other words, it tests for the presence of at least one letter in the subject. If a letter is found, the subject is matched against the first alternative; otherwise it is matched against the second. This pattern matches strings in one of the two forms ‘*dd-aaa-dd*’ or ‘*dd-dd-dd*’, where *aaa* are letters and *dd* are digits.

Comments

The sequence ‘(?’ marks the start of a comment that continues up to the next closing parenthesis. Nested parentheses are not permitted. The characters that make up a comment play no part in the pattern matching at all.

If the ‘(?x)’ option is set, an unescaped ‘#’ character outside a character class introduces a comment that continues to immediately after the next newline in the pattern.

Recursive Patterns

Consider the problem of matching a string in parentheses, allowing for unlimited nested parentheses. Without the use of recursion, the best that can be done is to use a pattern that matches up to some fixed depth of nesting. It is not possible to handle an arbitrary nesting depth.

PCRE supports special syntax for recursion of the entire pattern, and also for individual subpattern recursion. After its introduction in PCRE and Python, this kind of recursion was introduced into Perl at release 5.10.

A special item that consists of ‘(?’ followed by a number greater than zero and a closing parenthesis is a recursive call of the subpattern of the given number, provided that it occurs inside that subpattern. (If not, it is a subroutine call, which is described in the next section.) The special item ‘(?R)’ or ‘(?0)’ is a recursive call of the entire regular expression.

In PCRE (like Python, but unlike Perl), a recursive subpattern call is always treated as an atomic group. That is, once it has matched some of the subject string, it is never re-entered, even if it contains untried alternatives and there is a subsequent matching failure.

This PCRE pattern solves the nested parentheses problem (whitespace is insignificant):

```
\( ( (?>[^()]+) | (?R) )* \)
```

First it matches an opening parenthesis. Then it matches any number of substrings which can either be a sequence of non-parentheses, or a recursive match of the pattern itself (that is, a correctly parenthesized substring). Finally there is a closing parenthesis.

If this were part of a larger pattern, you would not want to recurse the entire pattern, so instead you could use this:

```
( \ ( ( (?>[^()]+) | (?1) )* \ ) )
```

We have put the pattern into parentheses, and caused the recursion to refer to them instead of the whole pattern.

In a larger pattern, keeping track of parenthesis numbers can be tricky. This is made easier by the use of relative references. (A Perl 5.10 feature.) Instead of ‘(?1)’ in the pattern above you can write ‘(?-2)’ to refer to the second most recently opened parentheses

Subpatterns as Subroutines

If the syntax for a recursive subpattern reference (either by number or by name) is used outside the parentheses to which it refers, it operates like a subroutine in a programming language. The called subpattern may be defined before or after the reference. A numbered reference can be absolute or relative, as in these examples:

```
(...(absolute)...)(?2)...
...(relative)...(?-1)...
...(?!+1)...(relative)...
```

An earlier example pointed out that the pattern

```
(sens|respons)e and \1ibility
```

matches ‘sense and sensibility’ and ‘response and responsibility’, but not ‘sense and responsibility’. If instead the pattern

```
(sens|respons)e and (?1)ibility
```

is used, it does match ‘sense and responsibility’ as well as the other two strings. Another example is given in the discussion of DEFINE above.

Like recursive subpatterns, a subroutine call is always treated as an atomic group. That is, once it has matched some of the subject string, it is never re-entered, even if it contains untried alternatives and there is a subsequent matching failure.

When a subpattern is used as a subroutine, processing options such as case-independence are fixed when the subpattern is defined. They cannot be changed for different calls. For example, consider this pattern:

```
(abc)(?i:(?-1))
```

It matches ‘abcabc’. It does not match ‘abcABC’ because the change of processing option does not affect the called subpattern.

Backtracking Control

Perl 5.10 introduced a number of special *backtracking control verbs*, which are described in the Perl documentation as “experimental and subject to change or removal in a future version of Perl.” It goes on to say: “Their usage in production code should be noted to avoid problems during upgrades.” The same remarks apply to the PCRE features described in this section.

The new verbs make use of what was previously invalid syntax: an opening parenthesis followed by an asterisk. In Perl, they are generally of the form ‘(**VERB*:*ARG*)’ but PCRE does not support the use of arguments, so its general form is just ‘(**VERB*)’. Any number of these verbs may occur in a pattern. There are two kinds:

Verbs that act immediately

The following verbs act as soon as they are encountered:

(*ACCEPT)

This verb causes the match to end successfully, skipping the remainder of the pattern. When inside a recursion, only the innermost pattern is ended immediately. PCRE differs from Perl in what happens if the ‘(*ACCEPT)’ is inside capturing parentheses. In Perl, the data so far is captured: in PCRE no data is captured. For example:

`A(A|B(*ACCEPT)|C)D`

This matches ‘AB’, ‘AAD’, or ‘ACD’, but when it matches ‘AB’, no data is captured.

(*FAIL) or (*F)

This verb causes the match to fail, forcing backtracking to occur. It is equivalent to ‘(?!)’ but easier to read. It is not clear whether there is any use for this without the ability to execute code in the middle of the pattern (which Perl has but PCRE in Monotone does not).

Verbs that act after backtracking

The following verbs do nothing when they are encountered. Matching continues with what follows, but if there is no subsequent match, a failure is forced. The verbs differ in exactly what kind of failure occurs.

(*COMMIT)

This verb causes the whole match to fail outright if the rest of the pattern does not match. Even if the pattern is unanchored, no further attempts to find a match by advancing the start point take place. Once **(*COMMIT)** has been passed, the regular expression engine is committed to finding a match at the current starting point, or not at all. For example:

`a+(*COMMIT)b`

This matches ‘xxaab’ but not ‘aacaab’. It can be thought of as a kind of dynamic anchor, or “I’ve started, so I must finish.”

(*PRUNE)

This verb causes the match to fail at the current position if the rest of the pattern does not match. If the pattern is unanchored, the normal “bump-along” advance to the next starting character then happens. Backtracking can occur as usual to the left of **(*PRUNE)**, or when matching to the right of **(*PRUNE)**, but if there is no match to the right, backtracking cannot cross **(*PRUNE)**. In simple cases, the use of **(*PRUNE)** is just an alternative to an atomic group or possessive quantifier, but there are some uses of **(*PRUNE)** that cannot be expressed in any other way.

(*SKIP)

This verb is like **(*PRUNE)**, except that if the pattern is unanchored, the “bumpalong” advance is not to the next character, but to the position in the subject where **(*SKIP)** was encountered. **(*SKIP)** signifies that whatever text was matched leading up to it cannot be part of a successful match. Consider:

`a+(*SKIP)b`

If the subject is ‘aaaac...’, after the first match attempt fails (starting at the first character in the string), the starting point skips on to start the next attempt at ‘c’. Note that a possessive quantifier does not have the same effect in this example; although it would suppress backtracking during the first match attempt, the second attempt would start at the second character instead of skipping on to ‘c’.

(*THEN)

This verb causes a skip to the next alternation if the rest of the pattern does not match. That is, it cancels pending backtracking, but only within the current

alternation. Its name comes from the observation that it can be used for a pattern-based if-then-else block:

```
( COND1 (*THEN) FOO
  | COND2 (*THEN) BAR
  | COND3 (*THEN) BAZ ) ...
```

If the ‘COND1’ pattern matches, ‘FOO’ is tried (and possibly further items after the end of the group if ‘FOO’ succeeds); on failure the matcher skips to the second alternative and tries ‘COND2’, without backtracking into COND1. If (*THEN) is used outside of any alternation, it acts exactly like (*PRUNE).

Appendix A Default hooks

This section contains the entire source code of the standard hook file, that is built in to the monotone executable, and read before any user hooks files (unless ‘`--nostd`’ is passed). It contains the default values for all hooks.

```
-- this is the standard set of lua hooks for monotone;
-- user-provided files can override it or add to it.

function temp_file(namehint)
    local tdir
    tdir = os.getenv("TMPDIR")
    if tdir == nil then tdir = os.getenv("TMP") end
    if tdir == nil then tdir = os.getenv("TEMP") end
    if tdir == nil then tdir = "/tmp" end
    local filename
    if namehint == nil then
        filename = string.format("%s/mtn.XXXXXX", tdir)
    else
        filename = string.format("%s/mtn.%s.XXXXXX", tdir, namehint)
    end
    local name = mkstemp(filename)
    local file = io.open(name, "r+")
    return file, name
end

function execute(path, ...)
    local pid
    local ret = -1
    pid = spawn(path, unpack(arg))
    if (pid ~= -1) then ret, pid = wait(pid) end
    return ret
end

function execute_redirected(stdin, stdout, stderr, path, ...)
    local pid
    local ret = -1
    io.flush();
    pid = spawn_redirected(stdin, stdout, stderr, path, unpack(arg))
    if (pid ~= -1) then ret, pid = wait(pid) end
    return ret
end

-- Wrapper around execute to let user confirm in the case where a subprocess
-- returns immediately
-- This is needed to work around some brokenness with some merge tools
-- (e.g. on OS X)
```

```

function execute_confirm(path, ...)
    ret = execute(path, unpack(arg))

    if (ret ~= 0)
    then
        print(gettext("Press enter"))
    else
        print(gettext("Press enter when the subprocess has completed"))
    end
    io.read()
    return ret
end

-- attributes are persistent metadata about files (such as execute
-- bit, ACLs, various special flags) which we want to have set and
-- re-set any time the files are modified. the attributes themselves
-- are stored in the roster associated with the revision. each (f,k,v)
-- attribute triple turns into a call to attr_functions[k](f,v) in lua.

if (attr_init_functions == nil) then
    attr_init_functions = {}
end

attr_init_functions["mtn:execute"] =
    function(filename)
        if (is_executable(filename)) then
            return "true"
        else
            return nil
        end
    end

attr_init_functions["mtn:manual_merge"] =
    function(filename)
        if (binary_file(filename)) then
            return "true" -- binary files must be merged manually
        else
            return nil
        end
    end

if (attr_functions == nil) then
    attr_functions = {}
end

attr_functions["mtn:execute"] =
    function(filename, value)

```

```

        if (value == "true") then
            make_executable(filename)
        end
    end
end

function dir_matches(name, dir)
    -- helper for ignore_file, matching files within dir, or dir itself.
    -- eg for dir of 'CVS', matches CVS/, CVS/*, */CVS/ and */CVS/*
    if (string.find(name, "^" .. dir .. "/")) then return true end
    if (string.find(name, "^" .. dir .. "$")) then return true end
    if (string.find(name, "/" .. dir .. "/")) then return true end
    if (string.find(name, "/" .. dir .. "$")) then return true end
    return false
end

function ignore_file(name)
    -- project specific
    if (ignored_files == nil) then
        ignored_files = {}
        local ignfile = io.open(".mtn-ignore", "r")
        if (ignfile ~= nil) then
            local line = ignfile:read()
            while (line ~= nil) do
                if line ~= "" then
                    table.insert(ignored_files, line)
                end
                line = ignfile:read()
            end
            io.close(ignfile)
        end
    end
end

local warn_reported_file = false
for i, line in pairs(ignored_files)
do
    if (line ~= nil) then
        local pcallstatus, result = pcall(function()
            return regex.search(line, name)
        end)
        if pcallstatus == true then
            -- no error from the regex.search call
            if result == true then return true end
        else
            -- regex.search had a problem, warn the user their
            -- .mtn-ignore file syntax is wrong
            if not warn_reported_file then
                io.stderr:write("mtn: warning: while matching file '"

```

```

        .. name .. "':\n")
        warn_reported_file = true
    end
    io.stderr:write(".mtn-ignore:" .. i .. ": warning: " .. result
        .. "\n\t- skipping this regex for "
        .. "all remaining files.\n")
    ignored_files[i] = nil
end
end
end
end

local file_pats = {
    -- c/c++
    "%.a$", "%.so$", "%.o$", "%.la$", "%.lo$", "^core$",
    "/core$", "/core%.%d+$",
    -- java
    "%.class$",
    -- python
    "%.pyc$", "%.pyo$",
    -- gettext
    "%.g?mo$",
    -- intltool
    "%.intltool%-merge%-cache$",
    -- TeX
    "%.aux$",
    -- backup files
    "%.bak$", "%.orig$", "%.rej$", "%~$",
    -- vim creates .foo.swp files
    "%.[^/]*%.swp$",
    -- emacs creates #foo# files
    "%#[^/]*%#$",
    -- other VCSes (where metadata is stored in named files):
    "%.scc$",
    -- desktop/directory configuration metadata
    "^%.DS_Store$", "%/.DS_Store$", "^desktop%.ini$", "/desktop%.ini$"
}

local dir_pats = {
    -- autotools detritus:
    "autom4te%.cache", "%.deps", "%.libs",
    -- Cons/SCons detritus:
    "%.consign", "%.sconsign",
    -- other VCSes (where metadata is stored in named dirs):
    "CVS", "%.svn", "SCCS", "_darcs", "%.cdv", "%.git", "%.bzzr", "%.hg"
}

for _, pat in ipairs(file_pats) do

```



```

        if string.find(name, pat) then return true end
    end
    for _, pat in ipairs(dir_pats) do
        if dir_matches(name, pat) then return true end
    end

    return false;
end

-- return true means "binary", false means "text",
-- nil means "unknown, try to guess"
function binary_file(name)
    -- some known binaries, return true
    local bin_pats = {
        "%.gif$", "%.jpe?g$", "%.png$", "%.bz2$", "%.gz$", "%.zip$",
        "%.class$", "%.jar$", "%.war$", "%.ear$"
    }

    -- some known text, return false
    local txt_pats = {
        "%.cc?$", "%.cxx$", "%.hh?$", "%.hxx$", "%.cpp$", "%.hpp$",
        "%.lua$", "%.texi$", "%.sql$", "%.java$"
    }

    local lowname=string.lower(name)
    for _, pat in ipairs(bin_pats) do
        if string.find(lowname, pat) then return true end
    end
    for _, pat in ipairs(txt_pats) do
        if string.find(lowname, pat) then return false end
    end

    -- unknown - read file and use the guess-binary
    -- monotone built-in function
    return guess_binary_file_contents(name)
end

-- given a file name, return a regular expression which will match
-- lines that name top-level constructs in that file, or "", to disable
-- matching.
function get_encloser_pattern(name)
    -- texinfo has special sectioning commands
    if (string.find(name, "%.texi$")) then
        -- sectioning commands in texinfo: @node, @chapter, @top,
        -- @((sub)?sub)?section, @unnumbered(((sub)?sub)?sec)?,
        -- @appendix(((sub)?sub)?sec)?, @(|major|chap|sub(sub)?|)heading
        return ("^@("

```

```

        .. "node|chapter|top"
        .. "|((sub)?sub)?section"
        .. "|(unnumbered|appendix)(((sub)?sub)?sec)?"
        .. "|(major|chap|sub(sub)?)?heading"
        .. ")")
    end
    -- LaTeX has special sectioning commands. This rule is applied to ordinary
    -- .tex files too, since there's no reliable way to distinguish those from
    -- latex files anyway, and there's no good pattern we could use for
    -- arbitrary plain TeX anyway.
    if (string.find(name, "%.tex$")
        or string.find(name, "%.ltx$")
        or string.find(name, "%.latex$")) then
        return ("\\\\\\("
            .. "part|chapter|paragraph|subparagraph"
            .. "|((sub)?sub)?section"
            .. ")")
    end
    -- There's no good way to find section headings in raw text, and trying
    -- just gives distracting output, so don't even try.
    if (string.find(name, "%.txt$")
        or string.upper(name) == "README") then
        return ""
    end
    -- This default is correct surprisingly often -- in pretty much any text
    -- written with code-like indentation.
    return "^[:alnum:]+$_"
end

function edit_comment(basetext, user_log_message)
    local exe = nil
    if (program_exists_in_path("vi")) then exe = "vi" end
    if (string.sub(get_ostype(), 1, 6) ~= "CYGWIN" and program_exists_in_path("notepad.exe"))
    local debian_editor = io.open("/usr/bin/editor")
    if (debian_editor ~= nil) then
        debian_editor:close()
        exe = "/usr/bin/editor"
    end
    local visual = os.getenv("VISUAL")
    if (visual ~= nil) then exe = visual end
    local editor = os.getenv("EDITOR")
    if (editor ~= nil) then exe = editor end

    if (exe == nil) then
        io.write("Could not find editor to enter commit message\n"
            .. "Try setting the environment variable EDITOR\n")
        return nil
    end
end

```

```

end

local tmp, tname = temp_file()
if (tmp == nil) then return nil end
basetext = "MTN: " .. string.gsub(basetext, "\n", "\nMTN: ") .. "\n"
tmp:write(user_log_message)
if user_log_message == "" or string.sub(user_log_message, -1) ~= "\n" then
    tmp:write("\n")
end
tmp:write(basetext)
io.close(tmp)

if (execute(exe, tname) ~= 0) then
    io.write(string.format(gettext("Error running editor '%s' to enter log message\n"),
                                exe))
    os.remove(tname)
    return nil
end

tmp = io.open(tname, "r")
if (tmp == nil) then os.remove(tname); return nil end
local res = ""
local line = tmp:read()
while(line ~= nil) do
    if (not string.find(line, "^MTN:")) then
        res = res .. line .. "\n"
    end
    line = tmp:read()
end
io.close(tmp)
os.remove(tname)
return res
end

function persist_phrase_ok()
    return true
end

function use_inodeprints()
    return false
end

-- trust evaluation hooks

```

```

function intersection(a,b)
    local s={}
    local t={}
    for k,v in pairs(a) do s[v] = 1 end
    for k,v in pairs(b) do if s[v] ~= nil then table.insert(t,v) end end
    return t
end

function get_revision_cert_trust(signers, id, name, val)
    return true
end

function get_manifest_cert_trust(signers, id, name, val)
    return true
end

function get_file_cert_trust(signers, id, name, val)
    return true
end

function accept_testresult_change(old_results, new_results)
    local reqfile = io.open("_MTN/wanted-testresults", "r")
    if (reqfile == nil) then return true end
    local line = reqfile:read()
    local required = {}
    while (line ~= nil)
    do
        required[line] = true
        line = reqfile:read()
    end
    io.close(reqfile)
    for test, res in pairs(required)
    do
        if old_results[test] == true and new_results[test] ~= true
        then
            return false
        end
    end
    return true
end

-- merger support

-- Fields in the mergers structure:
-- cmd      : a function that performs the merge operation using the chosen
--            program, best try.
-- available : a function that checks that the needed program is installed and

```

```

--          in $PATH
-- wanted    : a function that checks if the user doesn't want to use this
--              method, and returns false if so. This should normally return
--              true, but in some cases, especially when the merger is really
--              an editor, the user might have a preference in EDITOR and we
--              need to respect that.
--              NOTE: wanted is only used when the user has NOT defined the
--              'merger' variable or the MTN_MERGE environment variable.
mergers = {}

-- This merger is designed to fail if there are any conflicts without trying to resolve them
mergers.fail = {
  cmd = function (tbl) return false end,
  available = function () return true end,
  wanted = function () return true end
}

mergers.meld = {
  cmd = function (tbl)
    io.write (string.format("\nWARNING: 'meld' was chosen to perform external 3-way merge\n"
      "You should merge all changes to *CENTER* file due to limitation of program\n"..
      "arguments.\n\n"))
    local path = "meld"
    local ret = execute(path, tbl.lfile, tbl.afilename, tbl.rfile)
    if (ret ~= 0) then
      io.write(string.format(gettext("Error running merger '%s'\n"), path))
      return false
    end
    return tbl.afilename
  end ,
  available = function () return program_exists_in_path("meld") end,
  wanted = function () return true end
}

mergers.tortoise = {
  cmd = function (tbl)
    local path = "tortoisemerge"
    local ret = execute(path,
      string.format("/base:%s", tbl.afilename),
      string.format("/theirs:%s", tbl.lfile),
      string.format("/mine:%s", tbl.rfile),
      string.format("/merged:%s", tbl.outfile))
    if (ret ~= 0) then
      io.write(string.format(gettext("Error running merger '%s'\n"), path))
      return false
    end
    return tbl.outfile
  end
}

```

```

end ,
available = function() return program_exists_in_path ("tortoisemerge") end,
wanted = function () return true end
}

mergers.vim = {
  cmd = function (tbl)
    io.write (string.format("\nWARNING: 'vim' was choosen to perform external 3-way merge
      "You should merge all changes to *LEFT* file due to limitation of program\n"..
      "arguments. The order of the files is ancestor, left, right.\n\n"))
    local vim
    local exec
    if os.getenv ("DISPLAY") ~= nil and program_exists_in_path ("gvim") then
      vim = "gvim"
      exec = execute_confirm
    else
      vim = "vim"
      exec = execute
    end
    local ret = exec(vim, "-f", "-d", "-c", string.format("file %s", tbl.outfile),
      tbl.ancestor, tbl.lfile, tbl.rfile)
    if (ret ~= 0) then
      io.write(string.format(gettext("Error running merger '%s'\n"), vim))
      return false
    end
    return tbl.outfile
  end ,
  available =
    function ()
      return program_exists_in_path("vim") or
        program_exists_in_path("gvim")
    end ,
  wanted =
    function ()
      local editor = os.getenv("EDITOR")
      if editor and
        not (string.find(editor, "vim") or
          string.find(editor, "gvim")) then
        return false
      end
      return true
    end
}

mergers.rcsmerge = {
  cmd = function (tbl)
    -- XXX: This is tough - should we check if conflict markers stay or not?

```

```

-- If so, we should certainly give the user some way to still force
-- the merge to proceed since they can appear in the files (and I saw
-- that). --pasky
local merge = os.getenv("MTN_RCSMERGE")
if execute(merge, tbl.lfile, tbl.afile, tbl.rfile) == 0 then
    copy_text_file(tbl.lfile, tbl.outfile);
    return tbl.outfile
end
local ret = execute("vim", "-f", "-c", string.format("file %s", tbl.outfile
),
    tbl.lfile)
if (ret ~= 0) then
    io.write(string.format(gettext("Error running merger '%s'\n"), "vim"))
    return false
end
return tbl.outfile
end,
available =
function ()
    local merge = os.getenv("MTN_RCSMERGE")
    return merge and
        program_exists_in_path(merge) and program_exists_in_path("vim")
end ,
wanted = function () return os.getenv("MTN_RCSMERGE") ~= nil end
}

-- GNU diffutils based merging
mergers.diffutils = {
    -- merge procedure execution
    cmd = function (tbl)
        -- parse options
        local option = {}
        option.partial = false
        option.diff3opts = ""
        option.sdiffopts = ""
        local options = os.getenv("MTN_MERGE_DIFFUTILS")
        if options ~= nil then
            for spec in string.gmatch(options, "%s*(%w[,]*)%s*,?") do
                local name, value = string.match(spec, "^(%w+)=([,]*)")
                if name == nil then
                    name = spec
                    value = true
                end
                if type(option[name]) == "nil" then
                    io.write("mtn: " .. string.format(gettext("invalid \"diffutils\" merger
return false
                end
            end
        end
    end
}

```

```

        option[name] = value
    end
end

-- determine the diff3(1) command
local diff3 = {
    "diff3",
    "--merge",
    "--label", string.format("%s [left]",    tbl.left_path ),
    "--label", string.format("%s [ancestor]", tbl.anc_path  ),
    "--label", string.format("%s [right]",    tbl.right_path),
}
if option.diff3opts ~= "" then
    for opt in string.gmatch(option.diff3opts, "%s*([~%s]+)%s*") do
        table.insert(diff3, opt)
    end
end
table.insert(diff3, string.gsub(tbl.lfile, "\\ ", "/") .. "")
table.insert(diff3, string.gsub(tbl.afe, "\\ ", "/") .. "")
table.insert(diff3, string.gsub(tbl.rfile, "\\ ", "/") .. "")

-- dispatch according to major operation mode
if option.partial then
    -- partial batch/non-modal 3-way merge "resolution":
    -- simply merge content with help of conflict markers
    io.write("mtn: " .. gettext("3-way merge via GNU diffutils, resolving conflicts
local ret = execute_redirected("", string.gsub(tbl.outfile, "\\ ", "/"), "", unp
if ret == 2 then
    io.write("mtn: " .. gettext("error running GNU diffutils 3-way difference/m
    return false
end
return tbl.outfile
else
    -- real interactive/modal 3/2-way merge resolution:
    -- display 3-way merge conflict and perform 2-way merge resolution
    io.write("mtn: " .. gettext("3-way merge via GNU diffutils, resolving conflicts

    -- display 3-way merge conflict (batch)
    io.write("\n")
    io.write("mtn: " .. gettext("---- CONFLICT SUMMARY -----
local ret = execute(unpack(diff3))
if ret == 2 then
    io.write("mtn: " .. gettext("error running GNU diffutils 3-way difference/m
    return false
end

    -- perform 2-way merge resolution (interactive)

```



```

        io.write("\n")
        io.write("mtn: " .. gettext("---- CONFLICT RESOLUTION -----"))
        local sdiff = {
            "sdiff",
            "--diff-program=diff",
            "--suppress-common-lines",
            "--minimal",
            "--output=" .. string.gsub(tbl.outfile, "\\ ", "/")
        }
        if option.sdiffopts ~= "" then
            for opt in string.gmatch(option.sdiffopts, "%s*([~%s]+)%s*") do
                table.insert(sdiff, opt)
            end
        end
        table.insert(sdiff, string.gsub(tbl.lfile, "\\ ", "/") .. "")
        table.insert(sdiff, string.gsub(tbl.rfile, "\\ ", "/") .. "")
        local ret = execute(unpack(sdiff))
        if ret == 2 then
            io.write("mtn: " .. gettext("error running GNU diffutils 2-way merging tool"))
            return false
        end
        return tbl.outfile
    end
end,

-- merge procedure availability check
available = function ()
    -- make sure the GNU diffutils tools are available
    return program_exists_in_path("diff3") and
           program_exists_in_path("sdiff") and
           program_exists_in_path("diff");
end,

-- merge procedure request check
wanted = function ()
    -- assume it is requested (if it is available at all)
    return true
end

}

mergers.emacs = {
    cmd = function (tbl)
        local emacs
        if program_exists_in_path("xemacs") then
            emacs = "xemacs"
        else
            emacs = "emacs"
        end
    end
}

```

```

end
local elisp = "(ediff-merge-files-with-ancestor \"%s\" \"%s\" \"%s\" nil \"%s\")"
-- Converting backslashes is necessary on Win32 MinGW; emacs
-- lisp string syntax says '\\' is an escape.
local ret = execute(emacs, "--eval",
                    string.format(elisp,
                                   string.gsub(tbl.lfile, "\\ ", "/"),
                                   string.gsub(tbl.rfile, "\\ ", "/"),
                                   string.gsub(tbl.afe, "\\ ", "/"),
                                   string.gsub(tbl.outfile, "\\ ", "/")))

if (ret ~= 0) then
    io.write(string.format(gettext("Error running merger '%s'\n"), emacs))
    return false
end
return tbl.outfile
end,
available =
function ()
    return program_exists_in_path("xemacs") or
           program_exists_in_path("emacs")
end ,
wanted =
function ()
    local editor = os.getenv("EDITOR")
    if editor and
       not (string.find(editor, "emacs") or
            string.find(editor, "gnu")) then
        return false
    end
    return true
end
}

mergers.xxdiff = {
    cmd = function(tbl)
        local path = "xxdiff"
        local ret = execute(path,
                             "--title1", tbl.left_path,
                             "--title2", tbl.right_path,
                             "--title3", tbl.merged_path,
                             tbl.lfile, tbl.afe, tbl.rfile,
                             "--merge",
                             "--merged-filename", tbl.outfile,
                             "--exit-with-merge-status")
        if (ret ~= 0) then
            io.write(string.format(gettext("Error running merger '%s'\n"), path))
            return false
        end
    end
}

```

```

        end
        return tbl.outfile
    end,
    available = function () return program_exists_in_path("xxdiff") end,
    wanted = function () return true end
}

mergers.kdiff3 = {
    cmd = function (tbl)
        local path = "kdiff3"
        local ret = execute(path,
            "--L1", tbl.anc_path,
            "--L2", tbl.left_path,
            "--L3", tbl.right_path,
            tbl.afe, tbl.lfile, tbl.rfile,
            "--merge",
            "--o", tbl.outfile)

        if (ret ~= 0) then
            io.write(string.format(gettext("Error running merger '%s'\n"), path))
            return false
        end
        return tbl.outfile
    end,
    available = function () return program_exists_in_path("kdiff3") end,
    wanted = function () return true end
}

mergers.opendiff = {
    cmd = function (tbl)
        local path = "opendiff"
        -- As opendiff immediately returns, let user confirm manually
        local ret = execute_confirm(path,
            tbl.lfile, tbl.rfile,
            "-ancestor", tbl.afe,
            "-merge", tbl.outfile)

        if (ret ~= 0) then
            io.write(string.format(gettext("Error running merger '%s'\n"), path))
            return false
        end
        return tbl.outfile
    end,
    available = function () return program_exists_in_path("opendiff") end,
    wanted = function () return true end
}

function write_to_temporary_file(data, namehint)
    tmp, filename = temp_file(namehint)

```

```

    if (tmp == nil) then
        return nil
    end;
    tmp:write(data)
    io.close(tmp)
    return filename
end

function copy_text_file(srcname, destname)
    src = io.open(srcname, "r")
    if (src == nil) then return nil end
    dest = io.open(destname, "w")
    if (dest == nil) then return nil end

    while true do
        local line = src:read()
        if line == nil then break end
        dest:write(line, "\n")
    end

    io.close(dest)
    io.close(src)
end

function read_contents_of_file(filename, mode)
    tmp = io.open(filename, mode)
    if (tmp == nil) then
        return nil
    end
    local data = tmp:read("*a")
    io.close(tmp)
    return data
end

function program_exists_in_path(program)
    return existsonpath(program) == 0
end

function get_preferred_merge3_command(tbl)
    local default_order = {"kdiff3", "xxdiff", "opendiff", "tortoise", "emacs", "vim", "meld"}
    local function existmerger(name)
        local m = mergers[name]
        if type(m) == "table" and m.available(tbl) then
            return m.cmd
        end
    end
    return nil
end

```

```

local function trymerger(name)
  local m = mergers[name]
  if type(m) == "table" and m.available(tbl) and m.wanted(tbl) then
    return m.cmd
  end
  return nil
end

-- Check if there's a merger given by the user.
local mkey = os.getenv("MTN_MERGE")
if not mkey then mkey = merger end
if not mkey and os.getenv("MTN_RCSMERGE") then mkey = "rcsmerge" end
-- If there was a user-given merger, see if it exists. If it does, return
-- the cmd function. If not, return nil.
local c
if mkey then c = existmerger(mkey) end
if c then return c,mkey end
if mkey then return nil,mkey end
-- If there wasn't any user-given merger, take the first that's available
-- and wanted.
for _,mkey in ipairs(default_order) do
  c = trymerger(mkey) ; if c then return c,mkey end
end
end

function merge3 (anc_path, left_path, right_path, merged_path, ancestor, left, right)
  local ret = nil
  local tbl = {}

  tbl.anc_path = anc_path
  tbl.left_path = left_path
  tbl.right_path = right_path

  tbl.merged_path = merged_path
  tbl.afe = nil
  tbl.lfile = nil
  tbl.rfile = nil
  tbl.outfile = nil
  tbl.meld_exists = false
  tbl.lfile = write_to_temporary_file (left, "left")
  tbl.afe = write_to_temporary_file (ancestor, "ancestor")
  tbl.rfile = write_to_temporary_file (right, "right")
  tbl.outfile = write_to_temporary_file ("", "merged")

  if tbl.lfile ~= nil and tbl.rfile ~= nil and tbl.afe ~= nil and tbl.outfile ~= nil
  then
    local cmd,mkey = get_preferred_merge3_command (tbl)
    if cmd ~=nil

```

```

then
    io.write ("mtn: " .. string.format(gettext("executing external 3-way merge via \"%
    ret = cmd (tbl)
    if not ret then
        ret = nil
    else
        ret = read_contents_of_file (ret, "r")
        if string.len (ret) == 0
        then
            ret = nil
        end
    end
end
else
    if mkey then
        io.write (string.format("The possible commands for the "..mkey.." merger aren't
            "You may want to check that $MTN_MERGE or the lua variable 'merger' is set\
            "to something available.  If you want to use vim or emacs, you can also\n".
            "set $EDITOR to something appropriate.\n"))
    else
        io.write (string.format("No external 3-way merge command found.\n"..
            "You may want to check that $EDITOR is set to an editor that supports 3-way
            "merge, set this explicitly in your get_preferred_merge3_command hook,\n"..
            "or add a 3-way merge program to your path.\n"))
    end
end
end
end

os.remove (tbl.lfile)
os.remove (tbl.rfile)
os.remove (tbl.afe)
os.remove (tbl.outfile)

return ret
end

-- expansion of values used in selector completion

function expand_selector(str)

    -- something which looks like a generic cert pattern
    if string.find(str, "[^=]*=.*$")
    then
        return ("c:" .. str)
    end

    -- something which looks like an email address
    if string.find(str, "[%w%-_]+@[%w%-_]+")

```

```

then
    return ("a:" .. str)
end

-- something which looks like a branch name
if string.find(str, "[%w%-]+%. [%w%-]+")
then
    return ("b:" .. str)
end

-- a sequence of nothing but hex digits
if string.find(str, "^%x+$")
then
    return ("i:" .. str)
end

-- tries to expand as a date
local dtstr = expand_date(str)
if dtstr ~= nil
then
    return ("d:" .. dtstr)
end

return nil
end

-- expansion of a date expression
function expand_date(str)
    -- simple date patterns
    if string.find(str, "^19%d%d%-%d%d")
        or string.find(str, "^20%d%d%-%d%d")
    then
        return (str)
    end

    -- "now"
    if str == "now"
    then
        local t = os.time(os.date('!*t'))
        return os.date("%FT%T", t)
    end

    -- today don't uses the time          # for xgettext's sake, an extra quote
    if str == "today"
    then
        local t = os.time(os.date('!*t'))
        return os.date("%F", t)
    end
end

```

```

end

-- "yesterday", the source of all hangovers
if str == "yesterday"
then
    local t = os.time(os.date('!*t'))
    return os.date("%F", t - 86400)
end

-- "CVS style" relative dates such as "3 weeks ago"
local trans = {
    minute = 60;
    hour = 3600;
    day = 86400;
    week = 604800;
    month = 2678400;
    year = 31536000
}
local pos, len, n, type = string.find(str, "(%d+) ([minutehourdaywk]+)s? ago")
if trans[type] ~= nil
then
    local t = os.time(os.date('!*t'))
    if trans[type] <= 3600
    then
        return os.date("%FT%T", t - (n * trans[type]))
    else
        return os.date("%F", t - (n * trans[type]))
    end
end
end

return nil
end

external_diff_default_args = "-u"

-- default external diff, works for gnu diff
function external_diff(file_path, data_old, data_new, is_binary, diff_args, rev_old, rev_new)
    local old_file = write_to_temporary_file(data_old);
    local new_file = write_to_temporary_file(data_new);

    if diff_args == nil then diff_args = external_diff_default_args end
    execute("diff", diff_args, "--label", file_path .. "\told", old_file, "--label", file_path .. "\tnew", new_file);

    os.remove (old_file);
    os.remove (new_file);
end

```



```

-- netsync permissions hooks (and helper)

function globish_match(glob, str)
    local pcallstatus, result = pcall(function() if (globish.match(glob, str)) then return true end)
    if pcallstatus == true then
        -- no error
        return result
    else
        -- globish.match had a problem
        return nil
    end
end

function get_netsync_read_permitted(branch, ident)
    local permfile = io.open(get_confdir() .. "/read-permissions", "r")
    if (permfile == nil) then return false end
    local dat = permfile:read("*a")
    io.close(permfile)
    local res = parse_basic_io(dat)
    if res == nil then
        io.stderr:write("file read-permissions cannot be parsed\n")
        return false
    end
    local matches = false
    local cont = false
    for i, item in pairs(res)
    do
        -- legal names: pattern, allow, deny, continue
        if item.name == "pattern" then
            if matches and not cont then return false end
            matches = false
            cont = false
            for j, val in pairs(item.values) do
                if globish_match(val, branch) then matches = true end
            end
        elseif item.name == "allow" then if matches then
            for j, val in pairs(item.values) do
                if val == "*" then return true end
                if val == "" and ident == nil then return true end
                if globish_match(val, ident) then return true end
            end
        end
        elseif item.name == "deny" then if matches then
            for j, val in pairs(item.values) do
                if val == "*" then return false end
                if val == "" and ident == nil then return false end
                if globish_match(val, ident) then return false end
            end
        end
    end
end

```

```

        end
    end elseif item.name == "continue" then if matches then
        cont = true
        for j, val in pairs(item.values) do
            if val == "false" or val == "no" then cont = false end
        end
    end elseif item.name ~= "comment" then
        io.stderr:write("unknown symbol in read-permissions: " .. item.name .. "\n")
        return false
    end
end
return false
end

function get_netsync_write_permitted(ident)
    local permfile = io.open(get_confdir() .. "/write-permissions", "r")
    if (permfile == nil) then
        return false
    end
    local matches = false
    local line = permfile:read()
    while (not matches and line ~= nil) do
        local _, _, ln = string.find(line, "%s*([~%s]*)%s*")
        if ln == "*" then matches = true end
        if globish_match(ln, ident) then matches = true end
        line = permfile:read()
    end
    io.close(permfile)
    return matches
end

-- This is a simple function which assumes you're going to be spawning
-- a copy of mtn, so reuses a common bit at the end for converting
-- local args into remote args. You might need to massage the logic a
-- bit if this doesn't fit your assumptions.

function get_netsync_connect_command(uri, args)

    local argv = nil

    if uri["scheme"] == "ssh"
        and uri["host"]
        and uri["path"] then

        argv = { "ssh" }
        if uri["user"] then
            table.insert(argv, "-l")

```

```

        table.insert(argv, uri["user"])
    end
    if uri["port"] then
        table.insert(argv, "-p")
        table.insert(argv, uri["port"])
    end

    -- ssh://host/~dir/file.mtn or
    -- ssh://host/~user/dir/file.mtn should be home-relative
    if string.find(uri["path"], "~/~") then
        uri["path"] = string.sub(uri["path"], 2)
    end

    table.insert(argv, uri["host"])
end

if uri["scheme"] == "file" and uri["path"] then
    argv = { }
end

if uri["scheme"] == "ssh+ux"
    and uri["host"]
    and uri["path"] then

    argv = { "ssh" }
    if uri["user"] then
        table.insert(argv, "-l")
        table.insert(argv, uri["user"])
    end
    if uri["port"] then
        table.insert(argv, "-p")
        table.insert(argv, uri["port"])
    end

    -- ssh://host/~dir/file.mtn or
    -- ssh://host/~user/dir/file.mtn should be home-relative
    if string.find(uri["path"], "~/~") then
        uri["path"] = string.sub(uri["path"], 2)
    end

    table.insert(argv, uri["host"])
    table.insert(argv, get_remote_unix_socket_command(uri["host"]))
    table.insert(argv, "-")
    table.insert(argv, "UNIX-CONNECT:" .. uri["path"])
else
    -- start remote monotone process
    if argv then

```

```

        table.insert(argv, get_mtn_command(uri["host"]))

        if args["debug"] then
            table.insert(argv, "--debug")
        else
            table.insert(argv, "--quiet")
        end

        table.insert(argv, "--db")
        table.insert(argv, uri["path"])
        table.insert(argv, "serve")
        table.insert(argv, "--stdio")
        table.insert(argv, "--no-transport-auth")

    end
end
return argv
end

function use_transport_auth(uri)
    if uri["scheme"] == "ssh"
    or uri["scheme"] == "ssh+ux"
    or uri["scheme"] == "file" then
        return false
    else
        return true
    end
end

function get_mtn_command(host)
    return "mtn"
end

function get_remote_unix_socket_command(host)
    return "socat"
end

do
    -- Hook functions are tables containing any of the following 6 items
    -- with associated functions:
    --
    --   startup           Corresponds to note_mtn_startup()
    --   start             Corresponds to note_netsync_start()
    --   revision_received Corresponds to note_netsync_revision_received()
    --   cert_received     Corresponds to note_netsync_cert_received()
    --   pubkey_received   Corresponds to note_netsync_pubkey_received()

```

```

--      end                                Corresponds to note_netsync_end()
--
-- Those functions take exactly the same arguments as the corresponding
-- global functions, but return a different kind of value, a tuple
-- composed of a return code and a value to be returned back to monotone.
-- The codes are strings:
-- "continue" and "stop"
-- When the code "continue" is returned and there's another notifier, the
-- second value is ignored and the next notifier is called. Otherwise,
-- the second value is returned immediately.
local hook_functions = {}
local supported_items = {
    "startup",
    "start", "revision_received", "cert_received", "pubkey_received", "end"
}

function _hook_functions_helper(f,...)
    local s = "continue"
    local v = nil
    for _,n in pairs(hook_functions) do
        if n[f] then
            s,v = n[f](...)
        end
        if s ~= "continue" then
            break
        end
    end
    return v
end

function note_mtn_startup(...)
    return _hook_functions_helper("startup",...)
end

function note_netsync_start(...)
    return _hook_functions_helper("start",...)
end

function note_netsync_revision_received(...)
    return _hook_functions_helper("revision_received",...)
end

function note_netsync_cert_received(...)
    return _hook_functions_helper("cert_received",...)
end

function note_netsync_pubkey_received(...)
    return _hook_functions_helper("pubkey_received",...)
end

function note_netsync_end(...)
    return _hook_functions_helper("end",...)
end

```

```

function add_hook_functions(functions, precedence)
  if type(functions) ~= "table" or type(precedence) ~= "number" then
    return false, "Invalid type"
  end
  if hook_functions[precedence] then
    return false, "Precedence already taken"
  end

  local unknown_items = ""
  local warning = nil
  local is_member =
    function (s,t)
      for k,v in pairs(t) do if s == v then return true end end
      return false
    end

  for n,f in pairs(functions) do
    if type(n) == "string" then
      if not is_member(n, supported_items) then
        if unknown_items ~= "" then
          unknown_items = unknown_items .. ","
        end
        unknown_items = unknown_items .. n
      end
      if type(f) ~= "function" then
        return false, "Value for functions item "..n.." isn't a function"
      end
    else
      warning = "Non-string item keys found in functions table"
    end
  end

  if warning == nil and unknown_items ~= "" then
    warning = "Unknown item(s) " .. unknown_items .. " in functions table"
  end

  hook_functions[precedence] = functions
  return true, warning
end

function push_hook_functions(functions)
  local n = table.maxn(hook_functions) + 1
  return add_hook_functions(functions, n)
end

-- Kept for backward compatibility
function add_netsync_notifier(notifier, precedence)

```

```
        return add_hook_functions(notifier, precedence)
    end
    function push_netsync_notifier(notifier)
        return push_hook_functions(notifier)
    end
end
```


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