StoreBackup 3.1

http://storebackup.org

May 23, 2009

1 Super Quick Start

StoreBackup is a disk-to-disk backup tool for GNU/Linux. Additional details and help are provided in later sections of this document.
In these brief quick start steps we make certain simplifying assumptions. If you are OK with that, then proceed as follows:

1. Download the source from http://download.savannah.gnu.org/releases/storebackup/
2. Unpack it (using `tar -jxvf`) into `/opt` (it will make the folder `/opt/storeBackup`.)[1]
3. Create symbolic links. In a terminal, run these 2 commands (the 2nd line ends with: space,dot):

   ```
   # cd /usr/local/bin
   # ln -s /opt/storeBackup/bin/* .
   ```

4. Run your first backup with this command (substituting your actual username in the command):

   ```
   storeBackup.pl --sourceDir /home/your_username --backupDir /tmp/my_backup_destination
   ```

   This may take a while. Open a second shell and see what happens in the backup directory. You have now backed up your home directory to `/tmp/my_backup_destination`.

For more details, please continue reading; especially see installation, section 2 and storeBackup.pl, section 5.2. If the above steps gave you any challenges, don't worry. This document will cover everything from storeBackup installation to NFS server settings in much more detail.

storeBackup's Top Features

- restore easily – even without storeBackup! The most important aspect of a backup tool is easy restoring
- transparent (native) storage format
- recognizes when files have been copied, moved or renamed and does not waste time or space to duplicate the backup of such files
- copied, renamed or moved files with identical *contents* are hardlinked (so each backup set is totally complete, independent and autonomous)
- copies / compresses files to another disk and generates backups with time stamps
- splits big image files (from eg. TrueCrypt, mbox, Xen, KVM, VMware, etc.) or complete devices into small pieces and saves only differences to existing backups, thereby saving space and time
- sophisticated including and excluding possibilities for files and directories
- fast backups even over slow or high latency network connections

[1]You need root permissions to install storeBackup at `/opt/storeBackup` and to follow the next steps. You can also unpack and run storeBackup from a place where you do not have root permissions. If you start storeBackup without root permissions, it will run with the permissions you have at that moment.

Why should you back up your files?

Simple answer. Two reasons:

1. To restore the last state after eg. a hardware or software crash.
2. To recover old versions of a file or folder because it was deleted / destroyed unnoticed (eg. by a software bug) or you discover later it was deleted by mistake.

New releases are announced at http://freshmeat.net/projects/storebackup. Please subscribe to get actual information.

If you have any hints, comments or questions, send an email to hjclaes at web.de

Heinz-Josef Claes with support of contributors, May 23, 2009

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2 Installation

Installation is straightforward.
Download the archive from http://download.savannah.gnu.org/releases/storebackup/ and go to a directory where you want to unpack it:
If you are not sure where to unpack it, allow me to suggest `/opt`. (You need root permissions to write at `/opt`.) If you chose `/opt`, then in the example below *path* is equal to `/opt`.

```
$ cd path
$ tar jxvf pathToArchive/storeBackup-3.1.tar.bz2
```

This will create a directory storeBackup where you will find four sub directories: `bin`, `lib`, `man`, and `doc`.
If you do not want to type the whole path every time to start storeBackup.pl (or any of the programs in `bin`), there are two easy choices.

One choice is to set your `$PATH` variable:

```
$ cd storeBackup/bin
$ export PATH=‘pwd‘:$PATH
```

(The quotes around the `pwd` must be back quotes, ascii code 96; some pdf readers will render them as them as normal quotes in this document!)
Also set `$PATH` in your .bashrc or whatever shell you are using.

The second choice is to make symbolic links from a place where `$PATH` is already set. If eg. your `$PATH` also points to `/usr/local/bin` (and you have write permissions), you can do:

```
# cd /usr/local/bin
# ln -s path/storeBackup/bin/* .
```

Don't use hard links for that. StoreBackup will not find it's libraries if you do so.

If you want to have access to the man pages via the man command, you should set `MANPATH`:

```
$ cd storeBackup/man
$ export MANPATH=‘pwd‘:$MANPATH
```

Naturally, you have to change the path after `cd` depending on your location in the filesystem.
Also, you should set `MANPATH` in your .bashrc or whatever shell you are using.

Please have a look into the file `README.1ST` which is located in the `doc` folder.

3 Getting Started

Let's make your first backup.
Let's imagine, you want to backup your home directory to `/tmp/my_backup_destination`. (If your home directory is too big to do this, choose a small directory inside your home directory.)
Go into your home directory and type:

```
$ mkdir /tmp/my_backup_destination
$ cd
$ storeBackup.pl --sourceDir . --backupDir /tmp/my_backup_destination
```

If storeBackup.pl is not in your path, you will get an error message from the shell and need to set `$PATH` or type the full path to storeBackup.pl.[2]
Depending on how much data is in your home directory, this can take a while, because storeBackup.pl will compress your files. It will use all cores of your system for this. Because of these compressions, the first backup is very slow.
After the backup is finished, create a new file, copy a file and rename a file and or directory and start a second run:

```
$ cd
$ storeBackup.pl --sourceDir . --backupDir /tmp/my_backup_destination
```

You will see, it's much faster now.

Go to `/tmp/my_backup_destination`. You will see a directory called `default`. This is called a series because this directory will hold a series of backups for your computer. You can easily change the default series name from "default" to the name of your computer. This is easily accomplished with the storeBackup configuration file (explained later).
Inside of the `default` directory you will see two sub directories whose names reflect the date and time of the two backups you just completed. Go into these directories (use two shells, one for each) and look at the files with the command:
`$ ls -li`
Option "`i`" tells ls to show the inode number, which you can see in the very left column. Check, that files with the same content (especially the ones you copied, renamed, moved and the ones in renamed directories) refer to the same inode — so the file exists only once on disk thanks to storeBackup's efficient technology.

If you used storeBackup in Versions prior to 2.0 and simply made a backup with

```
storeBackup.pl -s sourceDir -t targetDir    # !!! old syntax !!!
```

and now want to continue making backups with version 2.0 or above, use

```
storeBackup.pl -s sourceDir --backupDir targetDir -S .
```

Where the parameters of `sourceDir` and `targetDir` are the same in both versions.

4 The Idea behind it

4.1 abstract

StoreBackup is a disk-to-disk backup tool for GNU/Linux. It also runs on other Unix-like machines. You can directly browse through the backed-up files (locally or via NFS, SAMBA, SSH[3] or almost any other network file system). This gives the users the ability to restore files easily and quickly. The user only has to copy (and optionally uncompress) to restore the files. There is also a tool for easily restoring (sub) trees for the administrator. Every single backup from a specific time can be deleted without affecting the other existing backups.
StoreBackup recognizes files by their content rather than just by their name or location. It can recognize when files have been copied, renamed or moved. If the file is identical, but differs by name or location, storeBackup has an efficient way (hardlinks) to include that file in the current backup without copying

[2]see installation, section 2 if you do not know what this means
[3]see FAQ4 for details about making a backup via SSH

it again. When a user reorganizes their photo collection or music collection, most backup software must transfer all those files over the network and store them again in the backup location, wasting time and space. StoreBackup will simply hardlink to the identical content that is already stored in the backup location, saving a lot of time and space.
StoreBackup can split big image files in little pieces and needs only the space for changes in these splits. Restoring these parts to the full image is also possible easily with simple tools: `cat` or possibly `bzcat` (or whatever you used for compression). Naturally, storeBackup delivers a tool to restore everything easier. You can also split devices (like `/dev/sdb1`) in the same way.
StoreBackup offers itself to the general user who does not necessarily own a tape backup but a second hard drive or another computer. It offers itself to the users in the professional environment for extremely fast and comfortable access to their backups, also to save on the costs of tapes as well as administrative expenses.
StoreBackup is a command line tool. You can start it via cron automatically. You normally don't want a graphical surface on a server and most important: If your machine crashed, you probably do not have a running gui.
Storage on hard drives, memory sticks or similar devices offers itself as an alternative or additional resource to data backup on tapes. StoreBackup performs well, saves storage capacity, and increases administrative flexibility:

- Directories, including their tree structure, may be copied to another location (e.g. `/home` $\longrightarrow$ `/var/bkup/2003.12.13_02.04.26`). Permissions to the files remain, enabling users to access the backup directly. The most important aspect of a backup tool is easy and safe restoring.
- The content of each file being backed up is compared with the existing backup to make sure there is only one backup for each file. That means files with the same content exist physically only once in the backup.
- Identical files are hard linked and appear in the backup in the same locations as in the original.
- You can exclude files from the backup by excluding whole directories or by specifying rules depending on regular expressions, file size and other criteria.
- Backed up files will be compressed, unless they are marked 'exclude'. Compression may also be excluded entirely.
- Image files or mass storage devices, where only parts change from backup to backup can be evaluated for differences. In the backup, you will only need the space for the changed blocks (which can be compressed).
- Backup series, generated independently (e.g. from different machines) may refer through hard links to shared files. Full or partial backups may be executed with this method, always under the condition that files with the same content may exist only once in the backup.
- The final result of running storeBackup is always a full backup. These can be automatically deleted with easy or high sophisticated deletion rules.
- StoreBackup supports a lot of other options. They are described in this document.

4.2 Another Backup Tool? / Roots of storeBackup

Possibly, there are thousands of backup programs. So, why another one? The reason arose from my activities as a consultant. The entire week I was moving around and I had no way to secure my data during the week at home. All I had was a 250MB ZIP drive connected to the parallel port of my laptop. The backup on the ZIP drive did not give me a lot of storage space and I had to live with a low bandwidth (about 200KB/s) and high latency. In contradiction to that I wanted fast, simple access to my data - I did not like the usual options of full, differential and incremental backups (e.g. with tar or dump): on one hand it is usually too cumbersome to retrieve one of the versions, on the other hand it is not possible to delete an old backup at will, this has to be planned carefully at the generation of the backup.
It was my goal to be able to backup quickly during my work and find my files quickly and without hassle.

So, at the end of 1999 the first version of storeBackup was created, it was, however, not suitable for large environments. It was not performing well enough, did not scale sufficiently and was not able do deal with nasty file names (e.g. '\n' in a name).
Based on that experience with the first version I wrote a new one which was published a little bit less than a year later under the GPL. In the meantime the number of users had grown - from home user applications, securing of (mail) directories at ISPs or hospitals as well as universities and for general archiving.

4.3 What would be an ideal Backup Tool?

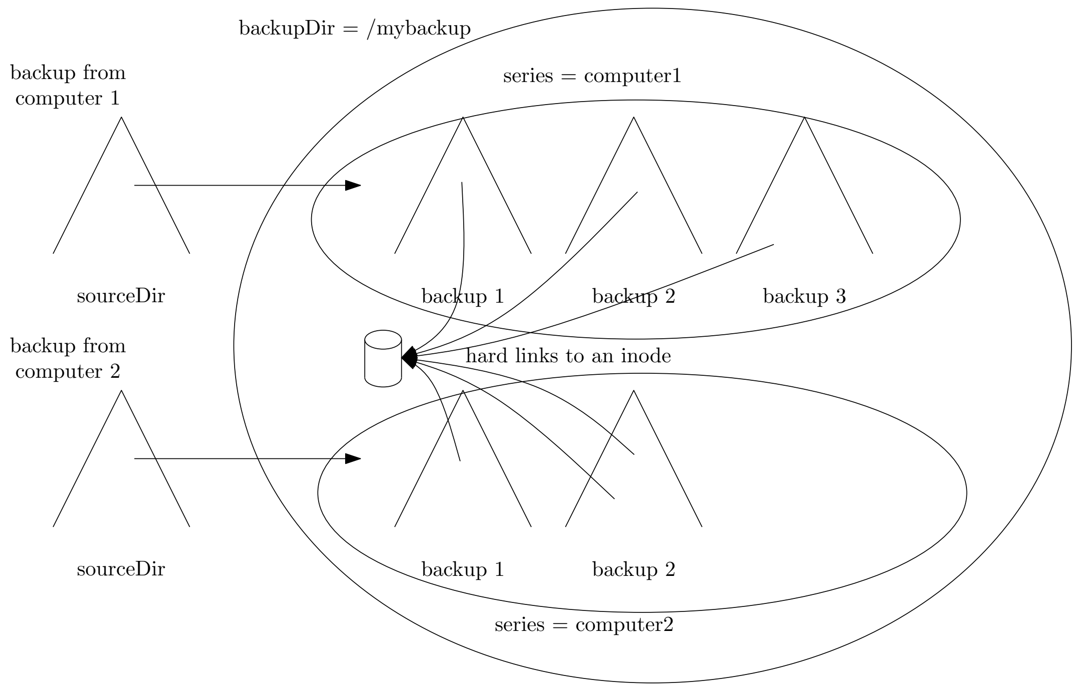
The most important aspect of a backup is that you are not only able to restore but to do this easily. The following reflects backups of files, not databases.
The ideal backup tool would create every day a complete copy of the entire data system (including the applicable access rights) on another data system with minimal effort for the administrator and maximal comfort for the user. The computer and hard disk systems to make this possible should be in a distant, secure building, of course. With the help of a file system browser the user could search and access the data and copy data directly back. The backup would be usable directly and restoring possible without problems or special learnings. Dealing with backups would become something *normal* - since the route over the administration would in general be unnecessary.
The process described here has a “small” disadvantage: it needs a lot of hard drive space and it is quite slow because each time the total amount of data needs to be copied.

4.4 How storeBackup works

StoreBackup tries to accomplish the “ideal backup” and to solve the two problems: storage space and performance.

4.4.1 Illustration

storeBackup is a disk-to-disk backup tool for GNU/Linux based on hard links. Have a look at the picture:



Imagine you have two computers you want to backup onto one file server via NFS [4]. (Even if you only want to backup on an external disk (eg. usb or e-sata), you should also read the following to understand the basic parameters.)

[4]See section 6.7 how to configure NFS properly – you must have write access to the directory where you want to save your backup. If you are root, you should have root permissions on this mounted directory.

The default values of all storeBackup options are designed in a way that you can use storeBackup with only two parameters: --sourceDir and --backupDir. (The shortforms of these two parameters are -s and -b.) Everything else works with acceptable default values. The way you can define soureDir is very flexible [5]

First, you have to define a "backupDir" directory, where all your backups will reside. Let's say, this is `/my_backup_destination`. To separate your different backups from multiple computers, you will make a separate directory for each; in the illustration, it's `computer1` and `computer2`.

In storeBackup terminology, `computer1` is a series and `computer2` is a series. The term "series" is used because e.g. `computer1` will contain a set of sequential backups (i.e., a series) that belong to computer1. These are shown as backup 1, backup 2 and backup 3 in the illustration.

You will identify these directories each as a "series" in storeBackup's configuration file. The full path to these directories is `/my_backup_destination/computer1` and `/my_backup_destination/computer2`. In each "series" directory you will generate a *series of backups* for the sourceDir on the computer associated with that series. You will see that it is all organized very logically and the organization is natural and easy to follow.

storeBackup will find all files that already exist in your backup repository ("my_backup_destination") with the same content (either within a single backup or across multiple backups, or even across multiple backups for multiple computers!).

storeBackup will hard link all these files to only one inode (see section 6.8). Changing names or paths of the files does not present a problem, because storeBackup can tell if files are the same based on the content. In the picture above, you see that in backup 3 of computer 1 the location of the file has moved (perhaps also renamed), or in backup 2 of computer 2 the file has been copied. StoreBackup will recognize this and always links to the same inode.

storeBackup supports multiple series of backups (e.g., daily or weekly backups) from different sources (e.g., different servers or workstations). As mentioned, the default name for a series is `default`. However, if you plan to back up multiple computers, each series should be configured with a name that describes the computer (e.g., the source) using the --series parameter (short form -S) on the command line or simply "series" in the config file. See storeBackup.pl, section 5.2.

The next few sections will go into further details about the details of how storeBackup works.

4.4.2 Reducing Disk Space

Saving files as a whole

The first measure to decrease the necessary hard drive storage space would be the compression of data – if that makes sense. storeBackup allows the use of any compression algorithm as an external program. The default is `bzip2`.

Looking at the stored data closely, it is apparent that from backup to backup relatively few files change – which is the reason for incremental backups. We also find that many files with the same content may be found in a backup because users copy files or a version administration program (like cvs) is active. In addition, files or directory structures are re-named by users, in incremental backups they are again (unnecessarily) secured. The solution to this is to check the backup for files with the same content (possibly compressed) and to refer to those. Within storeBackup, a hard link is used for referencing. With this trick of adding hard links, which were already created in existing backup files, each file is present in each backup although it exists physically on the hard drive only once. Copying and renaming of files or directories takes only the storage space of the hard links – nearly nothing.

Most likely not only one computer needs to be secured but a number of them. They often have a high proportion of identical files, especially with directories like `/etc`, `/usr` or `/home`. Obviously, there should be only one copy of identical files stored on the backup drive. To mount all directories from the backup server and to backup all computers in one sweep would be the most simple solution. This way duplicate files get detected and hard linked. However, this procedure has the disadvantage that all machines to be secured have to be available for the backup time. That procedure can in many cases not be feasible, for example, if notebooks shall be backed up using storeBackup. Specifically with notebooks we can find a high overlap rate of files since users create local copies. In such cases or if servers are backed up independently from one another, and the available hard drive space shall be utilized optimally through

[5] If you want to backup more than one top-level directory tree at a time, you should have a look at option followLinks in section 5.2.

hard links, storeBackup is able to hard link files in independent backups (meaning: independent from each other, possibly from different machines).

Splitting files into parts: blocked files

The method of compressing and hard linking files works pretty well for “normal” files like office, configuration, program code and all other type of small files.
It more or less fails for big image files where only parts are changed. Such a file with eg. 3 GB has only a few megabytes of changes, but the method described above would copy or compress the whole 3 GB into the backup, which is neither space nor time efficient. To solve this problem, storeBackup can handle such files in a special way.
In the configuration file you can specify which should be handled as “blocked files”. For these blocked files, a directory instead of a plain file is created in the backup. (The name of the directory is identical to the original file name.) The affected file from the source is not stored as a whole in the backup – instead it is stored as (small) numbered blocks in the created directory. These blocks can be compressed.
In the next backup (after something has changed in the original file,) storeBackup checks which of these blocks have changed and only copies / compresses that blocks. For the now missing *unchanged* blocks a hard link is generated to the fitting blocks in the old backup(s). This md5 sum based comparison is also done with other blocked files, so if you duplicate a VM for different use, storeBackup will find the identical blocks. It will also find identical blocks within one blocked file. (This sometimes happens when unused areas in an image are blanked.)
As a result the needed space is reduced dramatically (compared with copying / compressing the whole file) and it is still possible to restore the contents of the original file without a running storeBackup which is the philosophy of storebackup (restoring is the most important part of a backup) and might be useful in eg. 10 years. (Who knows what’s happening then!?)

Deleting Backups

For the deletion of files storeBackup offers a set of options. It is a great advantage for deletion when each backup is a full backup, those may be deleted indiscriminately. Unlike with traditional backups, there is no need to consider if an incremental backup is depending on previous backups. The options permit the deletion or saving of backups on specific workdays, first or last existing backup of the week/month or year. It can be assured that a set of a minimum number of backups remains. This is especially useful if backups are not generated on a regular basis. It is possible to keep the last backups of a laptop until the end of a four week vacation even though the period to keep it is set to three weeks. Furthermore it is possible to define the maximal number of backups. There are more options to resolve the existence of conflicts between contradictory rules (by using common sense).

4.4.3 Performance

The procedure described above assumes that an existing backup is being checked for identical files prior to a new backup of a file. This applies to files in the previous backup as well as to the newly created one. Of course it does not make much sense to directly compare every file to be backed up with the previous backup. So, the md5 sums of the previous backup are being compared with the md5 sum of the file to be backed up with the utilization of the hash table.
Computing the md5 sum is fast, but in case of a large amount of data it is still not fast enough. For this reason storeBackup checks initially if the file was altered since the last backup (path + file name, ctime, mtime and size are the same). If that is the case, the md5 sum of the last backup is being adopted and the hard link set. If the initial check shows a difference, the md5 sum is being computed and a check takes place to see if another file with the same md5 sum exists. (The comparison with a number of backup series uses an expanded but similarly efficient process). For this approach only a few md5 sums need to be calculated for a backup. If you want to tune storeBackup, especially if you save via NFS, there are two things you can do:

- tune NFS (see section 6.7)
- use the lateLinks option of storeBackup, and possibly delete your old backups independent from the backup process.
  Using storeBackup with lateLinks is like using an asynchronous client / server application or to be more precisely like using multiple batches on (normally) multiple machines:

  - Checking the source directory to know what has changed and to be compressed and save the relevant data to a save (another) place (on the backup server).
  - Take this information and restore a "normal" fully linked backup.
  - Delete old backups depending on the rules for the deletion.

The follwing performance measurements only show the direct backup time (without calling storeBackupUpdateBackup.pl (if necessary)[6]). They have been done with a beta version of storeBackup 2.0.
Some background information to the following numbers: The backup was run on an Athlon X2, 2.3 GHz, 4 GB RAM. The NFS server was an Athlon XP, 1.84 GHz, 1.5 GB RAM. The network was running with 100 MBit/s, storeBackup was used with standard parameters. The units of the measurements are in hours:minutes:seconds or minutes:seconds. The size of sourceDir was 12GB, the size of the backup done with storeBackup was 9.2 GB. The backups were done with 4769 directories and 38499 files. StoreBackup.pl linked 5038 files internally which means these were duplicates. The source for the data were my files and the "Desktop" from my Windows XP Laptop, so "real" data.
The first table shows the time for copying the data to the nfs server with standard programs. The nfs server is mounted with option `async`[7], which is a performance optimization and not the standard configuration.

command	duration	size of backup
cp -a	28:46	12 GB
tar jcf	01:58:20	9.4 GB
tar cf	21:06	12 GB

All is like it was to expect: tar with compression is much slower than the other ones; and cp is slower than tar, because it has to create lots of files. There is one astonishing number: The size of the backup file of `tar jcf` ist 9.4 GB, while the resulting size of the backup with storeBackup.pl is only 9.2 GB. We see the reason for this in the internal linked 5038 files – the duplicates are stored only once with storeBackup.

We do not see the effect of comparing the contents in this benchmark again, but it makes a lot of differences in performance and especially used disk space. If the time stamp of a file is changed, then traditional backup software will store this file in an incremental backup — storeBackup will only create a hard link.

Now let's run storeBackup.pl on the same contents. The nfs server is still mounted with option `async`. There are no changes in the source directory between the first to the second or third backup.

storeBackup	1.19, Standard		2.0, Standard		2.0, lateLinks		mount with `async`
1. backup	49:51	100%	49:20	99%	31:14	63%	
2. backup	02:45	100%	02:25	88%	00:42	25%	file system read cache empty
3. backup	01:51	100%	01:54	100%	00:26	23%	file system read cache filled

We can see the following:

- The first run of storeBackup.pl is faster than `tar jcf` (tar with compression.) It's easy to understand why: storeBackup.pl uses both cores of the machine, while the compression with tar uses only one. But if you look a little bit deeper to the number, you see that storeBackup.pl needs less than half the time (42%) of tar with compression. It naturally additionally calculates *all* md5 sums and has to perform the overhead of creating thousands of files (look at the difference between `cp` and tar cf above). The effect of reducing the time for copying more than 50% comes from two effects: storeBackup.pl does not compress all files (depending on their suffix, eg. `.bz2` files are not compressed again) and it recognizes files with the same content and sets just a hard link (also the reason for 9.2 instead of 9.4 GB).

- The second backup was done with a new mount of the source directory, so the read cache for it was not filled. You can see some improvement between version 1.19 and 2.0 because of better parallelization reading the data in storeBackup itself.
  You see no difference in the third run between version 1.19 and 2.0, because reading the source directory entries is now in the file system cache, which means that the blocking factor is now the speed of the nfs server — and that's the same in both runs.

[6]This is only necessary if you use storeBackup.pl with option lateLinks. The necessary time for running storeBackupUpdateBackup.pl can be seen in the next section 4.4.4.
[7]see configuring nfs, section 6.7

- With option lateLinks, you can see an improvement by a factor of 4. The time you see depends massively on the time needed for reading the source directory (plus reading the information from the previous backup, which is always the same).

Now let's do the same with an nfs mount without "tricks" like configuring `async`:

command	duration	size of backup
cp -a	37:51	12 GB
tar jcf	02:02:01	9.4 GB
tar cf	25:05	12 GB

storeBackup	1.19, Standard		2.0, Standard		2.0, lateLinks		mount with `sync`
1. backup	53:35	100%	49:20	100%	38:53	63%	
2. backup	05:36	100%	05:24	96%	00:43	13%	file system read cache empty
3. backup	05:10	100%	04:54	95%	00:27	9%	file system read cache filled

We can see the following:

- Everything is more or less slower, because of higher latency due to the synchronous communication with the nfs server. If only one file is written (like with) tar, the difference to the backups with `async` is smaller, if many files are written, it's bigger.
- We see that the difference between `sync` and `async` using lateLinks is very small and the reason is simple. Only a few files are written over nfs, so the latency only has a small impact on the overall time for the backup. This results in the fact, that the backup with lateLinks and a very fast source directory (cache) is now *10 times* faster.
- Because the latency is not important for making a backup, I mounted this file server over a vpn[8] over the Internet. This means very high latency and a bandwidth of about 20KByte/s from the nfs server and 50KByte/s to the nfs server (seen on a network monitoring tool). With same same boundary conditions as before (mounted with `async`, source directory file system in cache, no changes) I got a speed up with lateLinks (compared with non-lateLinks backup) by a *factor of 70*.
  So if your changed or new files are not too big compared with the available bandwidth, you can also use storeBackup (with lateLinks) for making a backup over a vpn on high latency lines.[9] Naturally you should not choose option lateCompress in such a case. Another advantage with lateLinks in such cases is, that parallelization works much better, because reading unchanged data in the source directory nearly needs no action on the NFS mount.

Conclusion: If you mount with nfs, you can make it really fast using option lateLinks. See section 6.5 how to configure it.

Using "blocked files" also improves performance a lot because only a small percentage of an image file has to be copied or compressed. See the description about using blocked files (see section 6.4) for the influence of this option to performance and space needed.

4.4.4 Example of a Run

Here you can see the statistical output of a big backup I ran on my laptop and saved to an NFS server. (I'm running this backup including OS once or twice a week and a smaller one every day, similar to the description of example 3, section 7.4.) I had to backup more than 500,000 entries:

```
STATISTIC 2008.09.08 23:40:17  3961  [sec] |      user|    system
STATISTIC 2008.09.08 23:40:17  3961 -------+----------+----------
STATISTIC 2008.09.08 23:40:17  3961 process|    386.30|    166.27
STATISTIC 2008.09.08 23:40:17  3961 childs |    209.02|    116.96
STATISTIC 2008.09.08 23:40:17  3961 -------+----------+----------
STATISTIC 2008.09.08 23:40:17  3961 sum    |    595.32|    283.23 => 878.55 (14m39s)
STATISTIC 2008.09.08 23:40:17  3961                     directories = 43498
STATISTIC 2008.09.08 23:40:17  3961                           files = 482516
STATISTIC 2008.09.08 23:40:17  3961                  symbolic links = 12024
```

[8] The vpn software was openvpn, the connection was tunneled trough several firewalls.

[9] You also can exclude too big files with option exceptRule of storeBackup.pl from the backup and save them later when you have access to a better line.

```
STATISTIC 2008.09.08 23:40:17  3961                     late links = 462267
STATISTIC 2008.09.08 23:40:17  3961                    named pipes = 3
STATISTIC 2008.09.08 23:40:17  3961                        sockets = 48
STATISTIC 2008.09.08 23:40:17  3961                  block devices = 0
STATISTIC 2008.09.08 23:40:17  3961              character devices = 0
STATISTIC 2008.09.08 23:40:17  3961      new internal linked files = 178
STATISTIC 2008.09.08 23:40:17  3961               old linked files = 462089
STATISTIC 2008.09.08 23:40:17  3961                unchanged files = 0
STATISTIC 2008.09.08 23:40:17  3961                   copied files = 2896
STATISTIC 2008.09.08 23:40:17  3961               compressed files = 5204
STATISTIC 2008.09.08 23:40:17  3961    excluded files because rule = 78
STATISTIC 2008.09.08 23:40:17  3961    included files because rule = 0
STATISTIC 2008.09.08 23:40:17  3961         max size of copy queue = 22
STATISTIC 2008.09.08 23:40:17  3961  max size of compression queue = 361
STATISTIC 2008.09.08 23:40:17  3961             calculaed md5 sums = 50606
STATISTIC 2008.09.08 23:40:17  3961                    forks total = 9176
STATISTIC 2008.09.08 23:40:17  3961                      forks md5 = 3957
STATISTIC 2008.09.08 23:40:17  3961                     forks copy = 12
STATISTIC 2008.09.08 23:40:17  3961                    forks bzip2 = 5204
STATISTIC 2008.09.08 23:40:17  3961                  sum of source =  10G (10965625851)
STATISTIC 2008.09.08 23:40:17  3961              sum of target all = 10.0G (10731903808)
STATISTIC 2008.09.08 23:40:17  3961              sum of target all = 97.87%
STATISTIC 2008.09.08 23:40:17  3961              sum of target new = 109M (114598007)
STATISTIC 2008.09.08 23:40:17  3961              sum of target new = 1.05%
STATISTIC 2008.09.08 23:40:17  3961            sum of md5ed files = 744M (779727492)
STATISTIC 2008.09.08 23:40:17  3961            sum of md5ed files = 7.11%
STATISTIC 2008.09.08 23:40:17  3961     sum internal linked (copy) =  32k (32472)
STATISTIC 2008.09.08 23:40:17  3961    sum internal linked (compr) = 6.2M (6543998)
STATISTIC 2008.09.08 23:40:17  3961          sum old linked (copy) = 3.3G (3515951642)
STATISTIC 2008.09.08 23:40:17  3961         sum old linked (compr) = 6.6G (7094777689)
STATISTIC 2008.09.08 23:40:17  3961           sum unchanged (copy) = 0.0  (0)
STATISTIC 2008.09.08 23:40:17  3961          sum unchanged (compr) = 0.0  (0)
STATISTIC 2008.09.08 23:40:17  3961                 sum new (copy) =  11M (11090534)
STATISTIC 2008.09.08 23:40:17  3961                sum new (compr) =  99M (103507473)
STATISTIC 2008.09.08 23:40:17  3961     sum new (compr), orig size = 321M (336637589)
STATISTIC 2008.09.08 23:40:17  3961                 sum new / orig = 32.96%
STATISTIC 2008.09.08 23:40:17  3961       size of md5CheckSum file =  16M (16271962)
STATISTIC 2008.09.08 23:40:17  3961     size of temporary db files = 0.0  (0)
STATISTIC 2008.09.08 23:40:17  3961            precommand duration = 1s
STATISTIC 2008.09.08 23:40:17  3961            deleted old backups = 0
STATISTIC 2008.09.08 23:40:17  3961            deleted directories = 0
STATISTIC 2008.09.08 23:40:17  3961                  deleted files = 0
STATISTIC 2008.09.08 23:40:17  3961           (only) removed links = 0
STATISTIC 2008.09.08 23:40:17  3961 freed space in old directories = 0.0  (0)
STATISTIC 2008.09.08 23:40:17  3961       add. used space in files = 125M (130869969)
STATISTIC 2008.09.08 23:40:17  3961                backup duration = 27m3s
STATISTIC 2008.09.08 23:40:17  3961 over all files/sec (real time) = 297.30
STATISTIC 2008.09.08 23:40:17  3961  over all files/sec (CPU time) = 549.22
STATISTIC 2008.09.08 23:40:17  3961                      CPU usage = 54.13%
```

It took about 27 minutes to run the backup.
But look at the number of calculated md5 sums: 50,606. This is the number of files, a "normal" backup (which does not examine the contents) would have saved because a time stamp has changed or they have moved (I didn't move files around, the changes were mainly from OS updates.). StoreBackup calculates the md5 sums and recognises that only 8,100 files (copied + compressd files) have changed.
So only 16% of the files which normally whould have been saved had to be stored. Over the time, this makes a big differnce in the space you need for your backups. And naturally, the files in the backup are compressed (if reasonable).

Because the backup ran with option lateLinks, I later had to run (via cron) storeBackupUpdateBackup.pl to set all the links etc.:

```
INFO      2008.09.09 02:17:52 13323 updating </disk1/store-backup/fschjc-gentoo-all/2008.09.08_23.13.14>
INFO      2008.09.09 02:17:52 13323 phase 1: mkdir, symlink and compressing files
STATISTIC 2008.09.09 02:18:18 13323 created 43498 directories
STATISTIC 2008.09.09 02:18:18 13323 created 12024 symbolic links
STATISTIC 2008.09.09 02:18:18 13323 compressed 0 files
STATISTIC 2008.09.09 02:18:18 13323 used 0.0  instead of 0.0  (0 <- 0)
INFO      2008.09.09 02:18:18 13323 phase 2: setting hard links
STATISTIC 2008.09.09 02:27:55 13323 linked 462267 files
INFO      2008.09.09 02:27:55 13323 phase 3: setting file permissions
STATISTIC 2008.09.09 02:31:05 13323 set permissions for 482442 files
INFO      2008.09.09 02:31:05 13323 phase 4: setting directory permissions
STATISTIC 2008.09.09 02:31:47 13323 set permissions for 43498 directories
```

It took about 14 minutes to “complete” the backup for 500,000 entries.

5 Components / Programs to use

storeBackup.pl	performs the backup, is able to generate a configuration file for itself
storeBackupUpdateBackup.pl	If you choose the option 'lateLinks' in storeBackup.pl, it will not directly perform all the necessary hard links and is therefore much faster, especially when storing via nfs. This program will check all your dependencies and generate the hard links. As a result, your backup will have the same structure as calling storeBackup.pl without 'lateLinks'.
storeBackupRecover.pl	Recovers files or (sub) trees from the backup. Uncompresses, restores all permissions and re-creates hard links like they were in the source.
storeBackupVersion.pl	Analyse the versions of backed up files.
storeBackupls.pl	Lists backed up directories (versions) with additional information (week day, age of backup)
storeBackupDel.pl	Delete old backups using the same rules as in storeBackup.pl. This can be used to delete backups asynchronously. It can read the configuration file of storeBackup.pl
storeBackupMount.pl	You can use this program if you want to make a backup via nfs. It pings the server, mounts file system(s), calls storeBackup.pl and umounts the file system(s). It writes a log file and has a detailed error handling.
storeBackup_du.pl	Evaluates the disk usage in one or more backup directories.
storeBackupConvertBackup.pl	Convert (very) old backups to new format. Only use this if storeBackup.pl tells you to do.
llt	Shows atime, ctime and mtime of files.
multitail.pl	Allows you to show (multiple) log files. You can also write multiple log files to one. It's more robust than ‘tail -f‘.

You can get a description of the options by calling the programs above with option '`-h`'.

5.1 Supported Platforms

The storeBackup tools have been reported to run on GNU/Linux, FreeBSD, Solaris and AIX. They should be able to run on all Unix platforms. Perl was used as the programming language, so you need a working perl implementation for starting one of the programs described above.
StoreBackup is developed and tested on GNU/Linux. For all programs, you will get a short help message if you call it with option `-h`.

5.2 storeBackup.pl

This is the basic program to make a backup. Beside a lot of options, there are two modes you can use:

1. Directly making a backup and do all the necessary copying, compressing, linking, permission settings etc. If you are not familiar with storeBackup, you should start with this mode.
2. Only do the absolutely necessary and left the rest to storeBackupUpdateBackup.pl which you have to run later. This is a kind of client / server mode.

```
usage:
storeBackup.pl --help
or
storeBackup.pl -g configFile
or
storeBackup.pl [-f configFile] [-s sourceDir]
      [-b backupDirectory] [-S series] [--print]
```

```
[-T tmpdir] [-L lockFile] [--unlockBeforeDel]
[--exceptDirs dir1,dir2,dir3] [--contExceptDirsErr]
[--includeDirs dir1,dir2,dir3]
[--exceptRule rule] [--includeRule rule]
[--exceptTypes types] [--cpIsGnu] [--linkSymlinks]
[--precommand job] [--postcommand job] [--followLinks depth]
[--ignorePerms] [--lateLinks [--lateCompress]]
[--checkBlocksSuffix rule] [--checkBlocksMinSize size]
[--checkBlocksBS]
       [--checkBlocksRule0 rule [--checkBlocksBS0 size]
        [--checkBlocksCompr0] [--checkBlocksRead0 filter]
        [--checkBlocksParallel0]]
       [--checkBlocksRule1 rule [--checkBlocksBS1 size]
        [--checkBlocksCompr1] [--checkBlocksRead1 filter]
        [--checkBlocksParallel1]]
       [--checkBlocksRule2 rule [--checkBlocksBS2 size]
        [--checkBlocksCompr2] [--checkBlocksRead2 filter]
        [--checkBlocksParallel2]]
       [--checkBlocksRule3 rule [--checkBlocksBS3 size]
        [--checkBlocksCompr3] [--checkBlocksRead3 filter]
        [--checkBlocksParallel3]]
       [--checkBlocksRule4 rule [--checkBlocksBS4 size]
        [--checkBlocksCompr4] [--checkBlocksRead4 filter]
        [--checkBlocksParallel4]]
       [--checkDevices0 list [--checkDevicesDir0]
        [--checkDevicesBS0] [checkDevicesCompr0]
        [--checkDevicesParallel0]]
       [--checkDevices1 list [--checkDevicesDir1]
        [--checkDevicesBS1] [checkDevicesCompr1]
        [--checkDevicesParallel1]]
       [--checkDevices2 list [--checkDevicesDir2]
        [--checkDevicesBS2] [checkDevicesCompr2]
        [--checkDevicesParallel2]]
       [--checkDevices3 list [--checkDevicesDir3]
        [--checkDevicesBS3] [checkDevicesCompr3]
        [--checkDevicesParallel3]]
       [--checkDevices4 list [--checkDevicesDir4]
        [--checkDevicesBS4] [checkDevicesCompr4]
        [--checkDevicesParallel1]]
[--checkDevicesBS4 size] [--checkDevicesCompr4]
[--saveRAM] [-c compress] [-u uncompress] [-p postfix]
[--noCompress number] [--queueCompress number]
[--noCopy number] [--queueCopy number]
[--withUserGroupStat] [--userGroupStatFile filename]
[--exceptSuffix suffixes] [--addExceptSuffix suffixes]
[--minCompressSize size] [--comprRule]
[--doNotCompressMD5File] [--chmodMD5File] [-v]
[-d level][--progressReport number] [--printDepth]
[--ignoreReadError] [--suppressWarning key] [--linkToRecent name]
[--doNotDelete] [--deleteNotFinishedDirs]
[--resetAtime] [--keepAll timePeriod] [--keepWeekday entry]
[[--keepFirstOfYear] [--keepLastOfYear]
 [--keepFirstOfMonth] [--keepLastOfMonth]
 [--firstDayOfWeek day] [--keepFirstOfWeek] [--keepLastOfWeek]
 [--keepDuplicate] [--keepMinNumber] [--keepMaxNumber]
  | [--keepRelative] ]
[-l logFile
 [--plusLogStdout] [--suppressTime] [-m maxFilelen]
 [[-n noOfOldFiles] | [--saveLogs]]
 [--compressWith compressprog]]
[--logInBackupDir [--compressLogInBackupDir]
 [--logInBackupDirFileName logFile]]
```

```
[otherBackupSeries ...]
```

You have to set at least two options: `--sourceDir` *and* `--backupDir`*. It doesn't matter if you set them on the command line, in the configuration file or mixed.*

Options which can be used only on command line. There is always a long option (like `--file`) and sometimes also a shortcut (`-f`).

`--help` Generate a long help message with a short description of all options.

`--generate / -g` Generate a template for a configuration file. After generation, you can edit it with the editor of your choice. It is recommended to use the configuration file if you want to configure more than a simple backup.

`--print` Print the options used (from command line *and* from the configuration file) and stop after printing the options. In case of difficult quoting (especially on the command line) this gives you the chance to see what's really used in the program.

`--file / -f` Name of the configuration file you want to use when calling storeBackup.pl for a backup run.

5.2.1 storeBackup.pl Options

The following options can be used on the command line and in the configuration file (see section 6.1). There is a long option for the command line (like `--sourceDir`), sometimes also a shortcut for the command line (like `-s`) and the name of the term used in the configuration file (like `sourceDir`)).

`--sourceDir / -s / sourceDir` The path to the directory you want to backup. You can only backup *one* directory with storeBackup.pl. If you want to backup more than one directory, you can use `--includeDir`, `--excludeDir` or the recommended option better `--followLinks` (see below).

`--backupDir / -b / backupDir` The repository, where *all* your backups are stored. If you have one series of backups (eg. from one computer), this will normally be similar to the directory where your backups are. In this case, set the following option (`series`) to "`.`". Example:

```
backupDir = /backup
series = .
```

Then you will see your backups directly in `/backup`:

```
$ ls -l /backup
drwxr-xr-x 14 root root 528 Aug 24 21:33 2008.08.22_02.18.43
drwxr-xr-x 14 root root 528 Aug 24 21:33 2008.08.23_02.01.11
drwxr-xr-x 14 root root 528 Aug 24 21:33 2008.08.24_02.03.51
drwxr-xr-x 14 root root 528 Aug 24 21:33 2008.08.24_13.04.55
```

If you have different series of backups in your repository, you normally will create sub directories for each different backup series (perhaps from different computers) and configure `series` to these directory names. Let's assume, you have three different computers to backup, "bob", "joe" and "bill". Then you can create three different directories:

```
$ ls -l /backup
drwxr-xr-x 2 root root 40 Aug 25 17:02 bill
drwxr-xr-x 2 root root 40 Aug 25 17:02 bob
drwxr-xr-x 2 root root 40 Aug 25 17:02 joe
```

Below these directories, you will find the individual backups for "bill", "bob" and "joe". Eg. for "bill" you will set:

```
backupDir = /backup
series = bill
```

Then you will see your backup in `/backup/bill`:

```
$ ls -l /backup
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.20_02.18.25
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.21_02.11.53
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.22_02.36.18
```

```
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.23_02.17.18
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.24_02.15.45
drwxr-xr-x 11 root root 432 Aug 24 21:33 2008.08.24_13.17.21
```

`--series / -S / series` see option `backupDir` above.
The default value for `series` is "default". To rename an existing series do the following:

- Run storeBackupUpdateBackup.pl so no unresolved lateLinks (see option `lateLinks` below) exists.
- Rename the directory below the directory specified with option `backupDir` to whatever name you want.
- Configure this option (`series` to the name of the directory you have chosen in the step before.

`--tmpDir / -T /tmpDir` Directory for temporary files, the default value is picked from the environment variable `$tmpdir`. If it does not exist, `/tmp` is set as the default value.

`--lockFile / -L / lockFile` storeBackup.pl uses a lock file to avoid it running multiple times. The default name of the lock file is `/tmp/storeBackup.lock`.

`--unlockBeforeDel / unlockBeforeDel` Remove the lock file before deleting old backups. Default is to delete the lock file after removing old backups. This "shortens" the time for a backup from some perspective.

`--exceptDirs / -e / exceptDirs` You can specify a list of directories to be excluded from the backup. It must be a *relative path* from the point specified with option sourceDir. You can also use wildcards. To give an example, if all your users reside below *sourceDir*`/home` and you want to avoid to backup the directory `tmp` in each home directory, you can say:
`exceptDirs = home/*/tmp`
For interpreting the wildcards, storeBackup.pl uses a shell. So if the resulting list of directories is too long (about 4K), then this will not work any more. Then you should use option `exceptRule` (see below).
If you want to specify a list of directories, in the configuration file simply write:
`exceptDirs = home/*/tmp 'otherdir/temp'`
On the command line, simply repeat the option:
`-e 'home/*/tmp' -e 'otherdir/tmp'`
Here, quoting `home/*/tmp` is important to avoid the expansion of the term by the shell.

`--contExceptDirsErr / contExceptDirsErr` storeBackup.pl will continue to backup even if one or more directories specified with `exceptDirs` does not exist. Default is to print and error message and stop.

`--includeDirs / -i / includeDirs` If this option is set, then only files which are in the directories specified here are backed up. StoreBackup.pl will only include files which are *not in* the exceptDirs and *in* the includeDirs.
This option can be used in the way as described for exceptDirs.

`--exceptRule / exceptRule` If this rule matches, the affected file is excluded from the backup. The rules are executed on regular files. You can read more about rules in section 6.3.

`--includeRule / includeRule` If a definition for this option exists then only files which match this rule are backup up. StoreBackup.pl will back up files which are *not* excluded by the backup and *match* the includeRule. You can read more about rules in section 6.3.

`--writeExcludeLog / writeExcludeLog` This option tells storeBackup.pl to write a file with the names of files which have been excluded because of rules. The file will be stored in the top level of the actual backup with the name `.storeBackup.notSaved.bz2`. It's compressed with bzip2.

`--exceptTypes / exceptTypes` Do not save the files of the specified type. StoreBackup.pl knows:
`S` — file is a socket
`b` — file is a block special file
`c` — file is a character special file
`f` — file is a plain file

`p` — file is a named pipe
`l` — file is a symbolic link
`Sbc` can only be stored if you have gnu-cp in your path and activate the "gnucp´´ option (see below).
If you specify
`exceptTypes = Sbc`
then files of these types will not be stored in the backup and no warning will be generated. This rule is evaluated before "exceptRule" and "includeRule". If you want to exclude some file types in general, use this option (it's faster and easier to use).

`--cpIsGnu / cpIsGnu` If you choose this option, you will be able to backup (and restore) file of type `Sbc` (see above). For restauring with storeBackupRecover.pl, you also need gnu-cp. If you are using a linux system, your cp will be gnu cp.

`--linkSymlinks / linkSymlinks` If you store your backups on a file system which supports hard links to symbolic links, you should activate this option. GNU/Linux does support this feature. Default is not to hard link symbolic links.

`--precommand / precommand` You can define *one* command (or script) to be executed before storeBackup.pl starts the backup. It will only start after the lock file is checked. If the return value of this command / script is != 0, then storeBackup.pl will stop immediately. The output of this command to stdin is printed as a warning to the storeBackup.pl log file, the output to stderr is printed as an error.
The cli parameter to this option is parsed like a line in the configuration file and normally has to be quoted. This means, you can use parameters, eg.:
`precommand = /backup/pre.sh param1 param2`
is the same as:
`--precommand '/backup/pre.sh param1 param2'`

`--postcommand / postcommand` This command is executed after finishing the backup, but before starting the deletion of old backups. StoreBackup.pl reports, if the exit status is != 0.
The cli parameter to this option is parsed like a line in the configuration file, see option "precommand".

`--followLinks / followLinks` If you want to backup more than one directory, you should use this option. For instance, if you want to backup `/boot`, `/etc` and `/home/tom`, then you should do (as root) something similar to:

```
# mkdir /backup
# cd /backup
# ln -s /boot boot
# ln -s /etc etc
# ln -s /home/tom home_tom
# ln -s . backup
# storeBackup.pl -g stbu.conf
```

Then you should configure your backup by editing file `stbu.conf`. Configure (among others):

```
# sourceDir = /backup
# followLinks = 1
```

This will tell storeBackup.pl to take the fist level of symbolic links below `/backup` like directories. With "`ln -s . backup`" you will get a sub directory inside of your backup which exactly reflects `/backup`.
"followLinks" configures storeBackup.pl to treat n levels of directories or symbolic links as directories. Simply by adding or deleting a symbolic link to your backup directory, you can add or remove any directory in your file system to `/` from your backup.

`--ignorePerms / ignorePerms` With this option, files in the backup will not necessarily have the same permissions and owners as the original ones. This speeds up the backup. Recovery with storeBackupRecover.pl will restore the permissions and owners correctly. There are several possibilities to improve performance, see section 4.4.3.

`--lateLinks / lateLinks` This option will reduce your *direct* backup time at the cost of a second process you have to run later. For a local backup onto another disk, you will see an improvement of 30–50%. If you write a backup over NFS, you will see an improvement by a *factor* of 5 to 10. This value can vary depending on how many new files you have to backup and how fast your network is. Saving over a vpn over the Internet I measured an improvement with lateLinks by a factor of 70.
If you want to use "lateLinks" you have to read section 6.5.

`--lateCompress / lateCompress` This option can only be used if "lateLinks" is set. Compression of files $\geq$ "minCompressSize" will be done later when starting storeBackupUpdateBackup.pl. See also section 6.5.

`--checkBlocksSuffix` The configuration is similar to `exceptSuffix`, a list of suffixes which are checked for a match, eg. `\.vdmk` for VMware images. They simply mean that the last part of the backup must be similar to what you define here.
The next options described here are only used if `checkBlocksSuffix` is set.
See blocked files (section 6.4) for more information about the options with "`block`" in their name.

`--checkBlocksMinSize` Only files with this minimum size will the treated as blocked files. You can use the same shortcuts as described in defining rules, see section 6.3, eg. 50M means 50 megabytes. The default value is 100M.

`--checkBlocksBS` Defines the block size in which the files which matches has to be split by storeBackup.pl. The format is equal to `checkBlocksMinSize`. The default value is 1M. The minimal value is 10k.

`--checkBlocksCompr` Defines if the blocks are compressed. Possible values are `yes` or `no`, the default value is `no`. On the command line, use `--checkBlocksCompr` to switch to compression mode.
This flag only affects files selected with `checkBlocksSuffix`.

`--checkBlocksRule`*i* The *i*th rule specifying files to treat as blocked files in the backup. You can define 5 rules, beginning from `checkBlocksRule0` to `checkBlocksRule4`.
See blocked files (section 6.4) for more information about the options with "`block`" in their name.

`--checkBlocksBS`*i* The corresponding block size for the blocks in the backup. The default value is 1 megabyte (1M). The minimal value is 10k.

`--checkBlocksCompr`*i* If set to `yes`, the blocks will be compressed. The default value is `no`.

`--checkBlocksRead`*i* Defines a filter for reading the specified file in `sourceDir`, eg. *gunzip* or *gzip -d*. This parameter is useful if you have to save an already compressed image file. (Using the "blocked file" feature of storeBackup with already compressed files compressed as a whole does not make sense.)

`--checkBlocksParallel`*i* Read the files specified hier in parallel to the files *not* specified in checkBlocksRule*i* or checkDevices*i*. This normally only makes sense if the files specified here are small or if the are on a separate device.
Default is `no`, which means not to parallelize.
You have to know, that files and devices specified in checkBlocksRule*i* or checkDevices*i* are *never* parallelized.

`--checkDevices`*i* List of devices (eg. `/dev/sdd2 /dev/sde1`) to backup.

`--checkDevicesDir`*i* Directory where the devices are stored in the backup (*relative* path). The image file will be restored in that directory also if you restore the backup with storeBackupRecover.pl (if you use default options). Into this directory storeBackup will create a subdirectory which name is generated from the parameters of `checkDevices`, eg. `/dev/sdc` will result in `dev_sdc`.

`--checkDevicesBS`*i* Defines the block size in which the devices specified have to be split by storeBackup.pl. The format is equal to `checkBlocksMinSize`. The default value is 1M. The minimal value is 10k.

`--checkDevicesCompr`*i* If set to `yes`, the blocks will be compressed. The default value is `no`.

`--checkDevicesParallel`*i* Read the devices specified hier in parallel to the files *not* specified in checkBlocksRule*i* or checkDevices*i*. This normally only makes sense if the files specified here are small or if the are on a separate device.
Default is `no`, which means not to parallelize.
You have to know, that files and devices specified in checkBlocksRule*i* or checkDevices*i* are *never* parallelized.

`--saveRAM / saveRAM` Use this option if storeBackup.pl runs on a system with very low memory configuration. You will then see some dbm files in "tmpDir". This will slow down storeBackup.pl a little bit, so do this only if you run into problems without it. On modern computers, it should only be necessary to use this option if you backup millions of files.

`--compress / -c / compress` The command, storeBackup.pl uses for compression. Default is `bzip2`.
The cli parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line. This means, you can use parameters, eg.:
`compress = gzip -9`
which is similar to:
`--compress 'gzip -9'`

`--uncompress / -u / uncompress` The command storeBackup.pl uses for uncompressing the files in the backup with storeBackupRecover.pl. Default is "`bzip2 -d`". It must fit to the parameter of option "compress".
The cli parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line. This means, you can use parameters, eg.:
`uncompress = gzip -d`
which is similar to:
`--uncompress 'gzip -d'`

`--postfix / -p /postfix` The postfix storeBackup.pl will use for compressed files. This should fit to option compress. Default is `.bz2`.

`--noCompress / noCompress` Maximal number of parallel compression operations. With GNU/Linux, the default value is chosen automatically as the number of cores plus 1.

`--queueCompress / queueCompress` Maximal length of a queue to store files before they are compressed. Default value is 1000.

`--noCopy / noCopy` Maximal number of parallel copy operations. The default value is 1.

`--queueCopy / queueCopy` Maximal length of a queue to store files before they are copied. Default value is 1000.

`--withUserGroupStat / withUserGroupStat` Write statistics about used space in sourceDir by user and groups in the log file.

`--userGroupStatFile / userGroupStatFile` Write statistics about used space in sourceDir by user and groups in this file. The file will be overridden each time.

`--exceptSuffix / exceptSuffix` Do not compress files with these suffixes. On the command line, you can repeat this option multiple times. The default value is:

```
exceptSuffix = '\.zip' '\.bz2' '\.gz' '\.tgz' '\.jpg' '\.gif' '\.tiff'
    '\.tif' '\.mpeg' '\.mpg' '\.mp3' '\.ogg' '\.gpg' '\.png'
```

You should use a backslash (\) to mask the dot. If you do not do so, the dot is interpreted as any character.
If you do not want to compress any file, you can use:
`exceptSuffix = .*`

`--addExceptSuffix / addExceptSuffix` If you only want to *add* suffixes to the above, use this option. On the command line, you can repeat this option multiple times. See the examples above (option exeptSuffix) how to use it in the configuration file.

`--minCompressSize / minCompressSize` Files with a size smaller than this value will not be compressed. The default value is 1024.
If you change this value from one backup to the next (eg. you make the fist backup with the default value and the second with 512), then this change affects only files which have a new content. Files with a content which exists already in the backup will be linked to the ones in the old backup. (So in the example a (new) file with 600 bytes will not be compressed in the second backup if there already were a file with the same content in the first backup.)

`--comprRule / comprRule` As an alternative to options `exceptSuffix` and `minCompressSize`. If this rule is set, `exceptSuffix`, `addExceptSuffix` and `minCompressSize` are ignored. See defining rules (section 6.3) to understand how to configure rules. You can eg. define a rule that the data of serveral uses will not be compressed for easier restore by the users itself.
The default rule generated from option `exceptSuffix` and `minCompressSize` above is:

```
comprRule = '\$size > 1024' and not
    '\$file =~
    /\.zip\Z|\.bz2\Z|\.gz\Z|\.tgz\Z|\.jpg\Z|\.gif\Z|\.tiff\Z|\.tif\Z|\.mpeg\Z|\.mpg\Z|
                                          \.mp3\Z|\.ogg\Z|\.gpg\Z|\.png\Z/i'
```

(The line break in the pattern is syntactically not correct. It's only printed for readability.)

`--doNotCompressMD5File / doNotCompressMD5File` StoreBackup.pl stores information about each file in the backup in the top level directory of each backup in a file called `.md5CheckSums`. It normally is compressed with bzip2. Using this option avoids this compression. Use this, if your computer is very slow and has only one core. It will speed up things a little bit.

`--chmodMD5File` Everybody who wants to use storeBackupRecover.pl needs to be able to read the file `.md5CheckSums` (see option above). Default permission on this file is 0600, which means only the one who generated the backup has access to it. With this option you can give access to other people. If you do so, this can be a kind of a security hole: for all files `.md5CheckSums` stores md5sum, times, uid, gid, mode (and some other information).

`--verbose / -v / verbose` Generate verbose messages.

`--debug / -d / debug` Generates debug messages:
0 — no debug messages (default)
1 — some debug messages
2 — many debug messages
This option is especially helpful in combination with options exceptRule and includeRule

`--resetAtime / resetAtime` Restores the access time in the backups (same as in source), but changes ctime (time of last modification of file status information). Normally, you will not use this option.

`--linkToRecent` After a successful backup, a symbolic link to most recent backup of this series (that's the backup just done) is created with the name specified by this option. If an older symbolic link exists, it will be deleted. If you change the name of this symbolic link in the configuration, the old link will *not* be removed – you have to delete it manually.

`--doNotDelete / doNotDelete` Do all checks what backups should be deleted, but don't delete anything. This option is useful in combination with storeBackupDel.pl which can read the configuration file of storeBackup.pl. StoreBackupDel.pl can delete old backups later asynchronously.
For understanding the rules what file should be deleted, see the "keep∗" options below.

`--deleteNotFinishedDirs / deleteNotFinishedDirs` Delete backups which have not been finished and are therefore not complete. StoreBackup.pl or storeBackupDel.pl will only delete unfinished backups if option "doNotDelete" is set to "no" (the default value) or is *unset*. If "doNotDelete" is set to "yes", nothing is deleted. "Backups which have not been finished" are those for which option lateLinks was used, but for which storeBackupUpdate.pl was not run yet.

`--keepAll / keepAll` Keep all backups of a series for the specified amount of time. This is like a default value for *all* days in option keepWeekday (see below). Deletion of old backups is done after the actual backup is finished or with storeBackupDel.pl. The time range has to be specified in format

"dhms", eg. "10d2h" means 10 days and 2 hours. To do so is useful if you want to specify 10 days, because if you define this exactly, then checking a few minutes or seconds before or later can result in 9 days. StoreBackups internal calculation is in seconds.
The default value is "30d".

`--keepWeekday / keepWeekday` This option overwrites the settings of option keepAll for special days of the week. `Mon,Wed:40d5m Sat:60d10m` means:

- keep backups from Monday and Wednesday 40 days + 5 minutes
- keep backups from Saturday 60 days + 10 minutes
- keep backups from the rest of the weekdays like specified via option keepAll.

You can also use the "archive flag" which means not to delete the affected directories because option "keepMaxNumber" hits. `Mon,Wed:a40d5m Sat:60d10m` means:

- keep backups from Monday and Wednesday 40 days + 5 minutes + archive
  If you have more than "keepMaxNumber" backups, then Monday and Wednesday backups falling in this category will not be deleted.
- keep backups from Saturday 60 days + 10 minutes
  If you have more than "keepMaxNumber" backups, then Saturday Backups falling in this category will be deleted.
- keep backups from the rest of the weekdays like specified via option keepAll. If you have more than "keepMaxNumber" backups, then they will be deleted if they are falling in this category.

On the command line, the parameter to this option is parsed like a line in the configuration file and therefore normally has to be quoted on the command line.

`--keepFirstOfYear / keepFirstOfYear` Do not delete the first existing backup of a year. The format is a time period (see option keepAll) with a possible "archive flag".

`--keepLastOfYear / keepLastOfYear` Do not delete the last existing backup of a year. The format is a time period (see option keepAll) with a possible "archive flag".

`--keepFirstOfMonth / keepFirstOfMonth` Do not delete the first existing backup of a month. The format is a time period (see option keepAll) with a possible "archive flag".

`--keepLastOfMonth / keepLastOfMonth` Do not delete the last existing backup of a month. The format is a time period (see option keepAll) with a possible "archive flag".

`--firstDayOfWeek / firstDayOfWeek` Sets the first day of the week for the calculations depending on options keepFirstOfWeek and keepLastOfWeek.
Default value is "Sun".

`--keepFirstOfWeek / keepFirstOfWeek` Do not delete the first existing backup of a week. The format is a time period (see option keepAll) with a possible "archive flag".

`--keepLastOfWeek / keepLastOfWeek` Do not delete the last existing backup of a week. The format is a time period (see option keepAll) with a possible "archive flag".

`--keepDuplicate / keepDuplicate` Keep multiple backups of one day up to the specified value. If it's older than specified here, delete all except the oldest backup of that day. Usage of the "archive" flag is not possible. The format is like described for option keepAll.
The default value is "7d".

`--keepMinNumber / keepMinNumber` Keep that minimum of backups. Multiple backups of one day are counted as one backup. The default value is "10".

`--keepMaxNumber / keepMaxNumber` Try to keep only that maximum number of backups. If you have more backups than specified here, the following sequence of deletion will happen:

- Delete all duplicates of a day, beginning with the oldest ones, except the last of every day.

- If this is not enough, delete the rest of the backups beginning with oldest, but *never* a backup with the "archive flag" or the last backup. See option keepWeekday for explanations of the "archive flag".

`--keepRelative / -R / keepRelative` This is a alternative deletion scheme. If this option is set, all other keep∗ options are ignored. On the command line, the parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line.
This backup deletion scheme allows you to specify the relative age of the backups you would like to have rather then the period over which a backup should be kept.
Imagine that you always want to have the following backups available:

- 1 backup from yesterday
- 1 backup from last week
- 1 backup from last month
- 1 backup from 3 months ago

Note that this is most likely *not* what you really want to have, because it simply means that you have to do daily backups and have to keep every backup for exactly 3 months. Otherwise you wouldn't always have a backup that is of *exactly* the requested age.
What you really want to have is therefore probably something like this:

- 1 backup of age 1 hour to 24 hours / 1 day
- 1 backup of age 1 day to 7 days
- 1 backup of age 14 days to 31 days
- 1 backup of age 80 days to 100 days

This is now a very common backup strategy, but you would have difficulty to achieve this with the usual keepFirstOf∗ options, especially if you don't do backups with perfect regularity. However, you can implement it very easily using keepRelative. All you need to write is:
```
keepRelative = 1h 1d 7d 14d 31d 80d 100d
```
i.e. you list all the intervals for which you want to have backups. storeBackup will delete backups in such a way that you come as close as possible (if you don't do backups often enough, there is of course nothing that storeBackup can do) to your requested backup scheme.
Note that this may mean that storeBackup keeps more backups that you think it has to, i.e. it may keep two backups in the same period. In this case storeBackup "looks into the future" and determines that both backups will *later* be necessary in order to have a backups for all periods. This is also the reason why in the above example you have somehow implicitly specified the period 7 days to 14 days, although you didn't really want to have a backup in this period – in order to have backups in the next period (14 days to 31 days) you always need to have a backup in the period 7 days to 14 days as well. Therefore the syntax doesn't allow you to exclude some periods.
Finally you should be aware that storeBackup shifts all the intervals if it cannot find a recent enough backup: if your first intervals is from 10 days to 20 days, but your most recent backup is actually 25 days old, all subsequent periods will be extended by 5 days. This ensures that if you haven't made any backups over a large period, this period is not taken into account for your backup scheme. To give an example why this is useful: if you wanted to have backups 1, 3, 7 and 10 days old and then went on vacation for 14 days, it is pretty unlikely that you want all your backups deleted when you come back, hence storeBackup ignores these 14 days and keeps the backups appropriately longer.

`--progressReport / -P / progressReport` Print a progress report after the specified number of files.

`--printDepth / -D / printDepth` Print depth of actually read directories during the backup.

`--ignoreReadError / ignoreReadError` Setting this option lets storeBackup.pl ignore read errors in the source directory — not readable directories do not cause storeBackup.pl to stop processing. This option was implemented for reading shares from a windows server which sometimes generated such faults.
Normally, you should not use this option.

`--suppressWarning / suppressWarning` Suppresses (unwanted) warnings that would normally be written to the log (and/or standard output). This is an advanced option. *For normal use of storeBackup, you can ignore this option.* In some situations, an advanced user may not want to see certain warnings. This option allows the user to turn those warnings off. This feature is only available for certain non-critical warnings: missing excluded directories, files changed during backup, and creation of the 'default' series. [10]

- Using the `crSeries` key suppresses the warning that storeBackup had to create a directory for the 'default' series.
- Using the `fileChange` key suppresses any warning when storeBackup notices that a file has changed since the current backup began.
- Using suppressWarning with the `excDir` key suppresses the warning that an excluded directory does not exist.

`--linkToRecent / linkToRecent` Name of the symbolic link. If this option is configured, storeBackup will automatically create a symbolic link pointing to the most recent backup in the series. This can be useful for some scripts and automated tools. It can also be used purely for convenience. Normally, the most recent backup is in a directory with a name based on the timestamp (e.g., `2009.05.02_02.15.01`). One could find the last backup directory in a script with a line similar to this:

```
MOST_RECENT_BACKUP=‘ls -d1 20??.??.??_??.??.?? | tail -1‘
```

However, for users who, for various reasons, are not able to use a shell command such as that, using this option is an easy and convenient way to have a consistent path to the most recent backup. This option makes the last backup available via a symbolic link with the name defined in this option. Continuing the above example, if the parameter value used for this option is "mostRecentBackup", the symbolic link would look like this: mostRecentBackup ⟶ `2009.05.02_02.15.01` When the next backup in the future is completed, this symlink will be automatically updated to point to the new (last) backup. *If there is an error in the backup, this symlink will not be updated.* It will continue to point the the last backup that was completed without errors. The default behavior (if this option is unused) is to *not* make this symbolic link (e.g., no link is created).

`--logFile / -l / logFile` Name of the log file. Default is stdout.

`--plusLogStdout / plusLogStdout` If option logFile is set, here you can configure storeBackup.pl to also print the log messages to stdout.

`--supressTime / supressTime` Suppress the output of the actual time in the log file.

`--maxFilelen / -m / maxFilelen` Maximal size of a log file. After reaching this size, the log file will be rotated (see option noOfOldFiles) or compressed (see option saveLogs).

`--noOfOldFiles / -n / noOfOldFiles` Number of old rotated log files, default is 5. With default values, it will look like this:

[10] The logic behind the suppressWarning option is that *r*epeated non-critical warnings can cause the user to ignore most warnings in general. Here is an example of how you could benefit from this option. Say you have defined a list of directories to exclude from the backup such as temporary directories. Sometimes you limit your list of included directories also. If you limit the included directories in such a way that the excluded directories are not part of the backup, storeBackup would normally generate a warning for every such "missing" excluded directory. However, you may choose to leave the excluded directories defined in the configuration file because when you expand your included directory list you do not want to risk forgetting to again define the excluded directories. But you also do not want the warnings because too many non-critical warnings might prevent you from seeing an important warning. In that situation, you can use this option. It means that when altering your included directories list, you only have to make one change (includeDirs) rather than two changes (includeDirs and exceptDirs). However, there is a situation where using this option to suppress warnings of missing excluded directories could have a negative consequence. Say you have an excluded temporary directory named `testing` that you do not want to back up. Say you rename `testing` to `app1_testing` (but you still don't want it backed up. If you do not update your storeBackup config file, and if `app1_testing` is under an included directory, it will now be backed up. However, if you have not suppressed this class of warning, storeBackup will alert you that `testing` (the previously excluded directory name) cannot be found. That will probably remind you of your change and let you update your configuration. So use this option with caution. If you are not sure whether you should use it, you probably should not.

```
$ ls -l /tmp/storebackup.log*
-rw------- 1 hjc  root  328815 30. Aug 12:12 /tmp/storebackup.log
-rw------- 1 root root 1000087 27. Aug 21:18 /tmp/storebackup.log.1
-rw------- 1 root root 1000038 20. Aug 19:02 /tmp/storebackup.log.2
-rw------- 1 root root 1000094 11. Aug 18:51 /tmp/storebackup.log.3
-rw------- 1 root root 1000147 11. Aug 18:49 /tmp/storebackup.log.4
-rw------- 1 root root 1000030 11. Aug 18:49 /tmp/storebackup.log.5
```

Older log files than *.5 have been deleted automatically.

`--saveLogs / saveLogs` Save the log files with a time and date stamp instead of deleting them after rotating. (Setting this option overwrites the default value of option noOfOldFiles.)

`--compressWith / compressWith` Specifies the program to compress the saved log files (eg. with `gzip -9`). Default value is `bzip2`.
On the command line, the parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line.

`--logInBackupDir / logInBackupDir` Write the log file (also) in the backup directory (default name is `.storeBackup.log`, also see option logInBackupDirFileName below). This log file as the case may be does not contain all error messages like the one specified with option logFile. (The backup directory must exist before any message can be written into this log file.)
This is useful for having a (historical) log file, while the "global" log file (from option logFile) is useful for monitoring.

`--compressLogInBackupDir / compressLogInBackupDir` The log file in the backup directory will be compressed if you specify this option.

`--logInBackupDirFileName / logInBackupDirFileName` File name of the log file to be stored in the backup directory. Default is `.storeBackup.log`.

`...otherBackupSeries... / otherBackupSeries` On the command line, this is not an option; it is a list parameter. So you have to write on the command line eg.:

```
# storeBackup.pl <all_options> 0:server2 0-2:server3
```

In the configuration file this is similar to:
`otherBackupSeries = 0:server2 0-2:server3`
Here you can specify a list of other backup directories to consider for hard linking. The path to their backup directories must be a relative path from backupDir!
Format (examples):

```
otherSeries/2002.08.29_08.25.28 -> consider exactly this otherSeries
```

or

```
0:otherSeries -> last (youngest) in <backupDir>/otherSeries
1:otherSeries -> first before last in <backupDir>/otherSeries
n:otherSeries -> n'th before last in <backupDir>/otherSeries
3-5:otherSeries -> 3rd, 4th and 5th in <backupDir>/otherSeries
all:otherSeries -> all in <backupDir>/otherSeries
```

If you do not specify `otherBackupSeries` then automatically the youngest backup from all series in the top level directory you specified with option `backupDir` are considered.

5.3 storeBackupUpdateBackup.pl

You only need to run this program if you use option lateLinks in storeBackup.pl. See section 4.4.3 about performance why you perhaps want to use this option and section 6.5 how to use it.
StoreBackupUpdateBackup.pl does the job of generation hard links, directories, symbolic links, compression of files and setting permissions storeBackup.pl does not do with option lateLinks. Before it starts doing this, it will check the consistency of your references resulting from the use of lateLinks in your backup repository, eg. it detects if one backup is missing.
To correct inconsistencies, use storeBackupUpdateBackup.pl in interactive mode (option `--interactive`).

```
usage:
       storeBackupUpdateBackup.pl -b backupDirectory [--autorepair]
             [--print] [--verbose] [--debug] [--lockFile] [--noCompress]
             [--progressReport number] [--checkOnly]
             [--logFile
              [--suppressTime] [-m maxFilelen]
              [[-n noOfOldFiles] | [--saveLogs]]
              [--compressWith compressprog]]

       storeBackupUpdateBackup.pl --interactive -b topLevlDir
             [--autorepair] [--print]
```

The only option you have to specify is backupDir, the rest of the options are optional. This program only accepts parameters on the command line. It is not possible to use a configuration file.

`--interactive / -i` Interactive mode for repairing / deleting currupted backups created with option lateLinks.

`--backupDir` The repository, where *all* your backups are stored. If you have one series of backup (eg. from one computer), this will normally be similar to the directory where you backups are. The meaning of this parameter is similar to the option backupDir of storeBackup, see section 5.2.

`--autorepair / -a` If storeBackupUpdateBackup.pl detects inconsistencies which do not harm your repository, it will repair the reference files automatically without asking you. It will only write an ERROR message in the log file and tells you what it repaired.
If you eg. delete your *last* backup with lateLinks with `rm` (which you should not do before successfully running this program!), then the internal referencing structure of your backups is inconsistent. StoreBackupUpdateBackup.pl (and also storeBackup.pl) will recognize, that a backup which referenced to another one is missing. But correcting the reference structure does not lead to a loss of data, so this is an example when it can be repaired without user intervention. (For more information see section 6.6 about special files.)

`--print` Prints the options used and stops after printing the options. In case of difficult quoting (especially on the command line) this gives you the chance to see what's really used in the program.

`--verbose / -v` Generate verbose messages.

`--debug / -d` Generate detailed information about linking, compressing, etc.

`--lockFile / -L` Specify a lock file. If the lock file exists and a process with the id stored in it is running, then the program will immediately stop to avoid running it multiple times (which is a very bad idea). The default is `/tmp/storeBackupUpdateBackup.lock`. You should also not run storeBackupUpdateBackup.pl in parallel to storeBackup.pl.

`--noCompress / noCompress` Maximal number of parallel compression operations. Default value is chosen automatically as the number of cores plus 1.

`--checkOnly / -c` Do not perform any action, only check the consistency. Use this in combination with option –debug to get detailed information.

`--progressReport` Print a progress report:
after each *number* files when compressing
after each *number * 1000* files when linking
after each *number * 10000* files when performing chmod

`--logFile / -l / logFile` Name of the log file. Default is stdout.

`--supressTime / supressTime` Suppress the output of the actual time in the log file.

`--maxFilelen / -m / maxFilelen` Maximal size of a log file. After reaching this size, the log file will be rotated (see option noOfOldFiles) or compressed (see option saveLogs).

`--noOfOldFiles / -n / noOfOldFiles` Number of old rotated log files, default is 5. With default values, it will look like this:

```
$ ls -l /tmp/storebackup.log*
-rw------- 1 hjc  root  328815 30. Aug 12:12 /tmp/storebackup.log
-rw------- 1 root root 1000087 27. Aug 21:18 /tmp/storebackup.log.1
-rw------- 1 root root 1000038 20. Aug 19:02 /tmp/storebackup.log.2
-rw------- 1 root root 1000094 11. Aug 18:51 /tmp/storebackup.log.3
-rw------- 1 root root 1000147 11. Aug 18:49 /tmp/storebackup.log.4
-rw------- 1 root root 1000030 11. Aug 18:49 /tmp/storebackup.log.5
```

Older log files than *.5 have been deleted automatically.

`--saveLogs / saveLogs` Save the log files with a time and date stamp instead of deleting them after rotating. (Setting this option overwrites the default value of option noOfOldFiles.)

`--compressWith / compressWith` Specifies the program to compress the saved log files (eg. with `gzip -9`). Default value is `bzip2`.
On the command line, the parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line.

5.4 storeBackupRecover.pl

Restores the backup tree or parts of the backup tree.

```
storeBackupRecover.pl -r restore [-b root] -t series [--flat]
        [-o] [--tmpdir] [--noHardLinks] [-p number] [-v] [-n]
        [--cpIsGnu] [--noGnuCp]
```

To restore one file or a small number of files, the easiest way is to use cp or a file system browser. This tool is intended to restore (and if necessary uncompress files). It recreates the backed up data in the same way it was in the original source directory: permissions are set (even if option ignorePerms was set in storeBackup.pl; this option affects only the permissions in the backup tree) and also existing hard links which were in the source tree are reconstructed.

You have to use at least two options: restoreTree and series. StoreBackupRecover.pl only supports command line arguments.

`--restoreTree / -r` Backup tree or part of a backup tree to restore. The easiest way to restore something is to go into the backup directory where the tree you want to restore is located. I now assume its name is `mydir`. Then type:
`# storeBackupRecover.pl -r mydir -t /tmp/myRestorePlace`
where `/tmp/myRestorePlace` is the place where you want that directory and all of its content to be restored (see option series).

`--backupRoot / -b` Normally there should be no need to use this option! When you restore a directory, storeBackupRecover.pl does this by searching for `.md5CheckSum.info` which is in the root directory of each backup. If it find more than one of these files it generates an ERROR message. This normally will happen if you make a storeBackup backup of a storeBackup backup and want to restore.
If you get an error message like "found info file a second time ...", you need to specify the root of this backup (where you recover with option restoreTree).

`--series / -t` The directory where you want the recovered files to be stored. Unless you use option flat, storeBackup always restores the complete backup path to the tree you specified with option restoreTree.

`--flat` The directory structure is not restored. All files are stored directly in "series". This is only useful if you recover a small number of files.

`--overwrite / -o` Overwrite existing files. Normally not a good idea. It's better to restore in a separate directory an move files around later.

`--tmpDir / -T /tmpDir` Directory for temporary files, default is picked from environment variable `$tmpdir`. If It does not exist, `/tmp` is set as the default value.

`--noHardLinks` Do not reconstruct hard links in the restore tree, always copy files.

`--noRestoreParallel / -p` Maximal number or parallel started processes to uncompress the files in the backup. Default is 12.

`--verbose / -v` Print verbose messages.

`--noRestored / -n` At the end of restoring, print the number of restored dirs, hard links, symbolic links, files, ...

`--noGnuCp` If you configured storeBackup.pl to use gnucp (option cpIsGnu), so it can backup special files like character devices, then storeBackupRecover.pl reads this information in the backup. But If the computer where you restore the backup has no gnucp installed, you can configure storeBackupRecover.pl not to use cp.
If you made your backup without gnucp, storeBackcupRecover.pl will not use it's functionality. There's no need to do so, because no special files could be backed up.

5.5 storeBackupVersion.pl

storeBackupVersion.pl locates different versions of a file saved with storeBackup.pl. This is the right program if you want to see how many different versions of a specific file exist and where a file with a specific contents is located anywhere in a backup series.
If you want to make a more "high sophisticated" search depending on file names, sizes, dates or other stuff, have a look at storeBackupSearch, see section 5.6.

```
storeBackupVersion.pl -f file [-b root]  [-v]
 [-l [-a | [-s] [-u] [-g] [-M] [-c] [-m]]]
```

This program only accepts options on the command line. The only option you have to set is `--file`.

`--file / -f` The name (and path) of the file in the backup. Write the file name exactly as it is written in the backup.

`--backupRoot / -b` Normally there should be no need to use this option! When you restore a directory, storeBackupRecover.pl does this by searching for `.md5CheckSum.info` which is in the root directory of each backup. If it find more than one of these files it generates an ERROR message. This normally will happen if you make a storeBackup backup of a storeBackup backup and want to restore.
If you get an error message like "found info file a second time ...", you need to specify the root of this backup (where you recover with option restoreTree).

`--verbose / -v` Print verbose messages.

`--locateSame / -l` Locate files with the same contents in the backup.

`--showAll / -A` same as `-s -u -g -M -c -m`

`--size / -s` show the size (human readable) of the source file

`--uid / -u` show the uid of the source file

`--gid / -g` show the gid of the source file

`--mode / -M` show the permissions of the source file

`--ctime / -c` show the creation time of the source file

`--mtime / -m` show the modify time of the source file

`--atime / -a` show the access time of the source file

5.6 storeBackupSearch.pl

storeBackupSearch.pl allows you to search in specific backups, in a backup series or in all backups under backupDir. You can define any rule build from combinations of file name, size, mode (permissions), owner (uid, gid), creation time, modify time and file type — naturally the ones of the original source directory. See section 6.3 how to define rules. It will help you if you have at least some very basic knowledge about scripting or programming.

```
storeBackupSearch.pl -g configFile

storeBackupSearch.pl [-f configFile] [-b backupDirectory]
      [-s rule]  [--absPath] [-w file] [--parJobs number]
      [-d level] [--once] [--print] [backupRoot . . .]
```

This program allows you to set option on the command line and in a configuration file. You have to set options backupDir and searchRule.

First, the options which can be used only on command line. There is always a long option (like `--file`) and sometimes also a shortcut (`-f`).

`--generate / -g` Generate a template for a configuration file. After generation, you can edit it with the editor of your choice. It is easier to write rules in the configuration file, because on the command line the shell strips quotes.

`--print` Prints the options used (from command line *and* from the configuration file) and stops after printing the options. In case of difficult quoting (especially on the command line) this gives you the chance to see what's really used in the program.

`--file / -f` Name of the configuration file you want to use.

The following options can be used on the command line and in the configuration file (see section 6.1). There is a long option for the command line (like `--searchRule`), sometimes also a shortcut for the command line (like `-s`) and the name of the term used in the configuration file (like `searchRule`)).

`--backupDir / backupDir` The repository, where *all* your backups are stored. If you have only one series of backup (eg. from one computer), this will normally be similar to the directory where you backups are. The meaning of this parameter is similar to the option backupDir of storeBackup, see section 5.2.

`--searchRule / -s / searchRule` rule for searching, see section 6.3 how to define rules.

`--absPath / -a / absPath` the files found will be printed with absolute path names

`--writeToFile / -w / writeToFile` write the result of the search to the specified file, default is stdout

`--parJobs / -p / parJobs` Maximum number of parallel search operations. The default value is chosen automatically as the number of cores plus 1.

`--debug / -d / debug` debug level, possible values are 0, 1, 2; default = 0

`--once / -o / once` show every file found only once (depending on the contence respectively the md5 sum of each file)

`...backupRoot... / backupRoot` On the command line, this is not an option; this is a list parameter. So you have to write on the command line eg.:

```
# storeBackupSearch.pl <all_options> 2008.08.27_16.59.01 2008.08.30_10.13.38
```

In the configuration file this is similar to:
`backupRoot = 2008.08.27_16.59.01 2008.08.30_10.13.38`
You can define a *relative path* to directories below backupDir where to search. This can be a specific backup itself (like in this example), a whole backup series or a directory in which directories with backup series are stored (and so on). You can configure storeBackupSearch.pl to search in multiple directories.
If you do not specify any directory, then all backups below backupDir are used for the search.
You need read permissions for the `.md5CheckSum.*`-files in the backups.

5.7 storeBackupls.pl

storeBackupls.pl gives you information about the age and deletion rules of a backup series.

```
storeBackupls.pl -f configFile [--print] [storeBackup-dir]
storeBackupls.pl [-v] [--print] storeBackup-dir
```

There are two possible styles to call it (with examples):

```
# /opt/test/storeBackup/bin/storeBackupls.pl .
  1  Fri Jul 04 2008   2008.07.04_20.17.13   -61
  2  Sat Jul 05 2008   2008.07.05_21.19.09   -60
  3  Sun Jul 06 2008   2008.07.06_17.38.22   -59
  4  Mon Jul 07 2008   2008.07.07_17.31.43   -58
  5  Fri Jul 11 2008   2008.07.11_19.20.14   -54
  6  Sat Jul 12 2008   2008.07.12_18.17.21   -53
  7  Sun Jul 13 2008   2008.07.13_17.07.53   -52
  8  Mon Jul 14 2008   2008.07.14_06.28.29   -51
  9  Tue Jul 15 2008   2008.07.15_07.44.41   -50
 10  Wed Jul 16 2008   2008.07.16_17.56.35   -49
 11  Thu Jul 17 2008   2008.07.17_10.13.47   -48
 12  Fri Jul 18 2008   2008.07.18_14.13.26   -47
 13  Sat Jul 19 2008   2008.07.19_16.03.40   -46
 14  Fri Jul 25 2008   2008.07.25_09.29.39   -40
 15  Mon Jul 28 2008   2008.07.28_19.01.04   -37
 16  Wed Jul 30 2008   2008.07.30_17.25.43   -35
 17  Thu Jul 31 2008   2008.07.31_16.45.56   -34
 18  Fri Aug 01 2008   2008.08.01_16.43.56   -33
 19  Mon Aug 04 2008   2008.08.04_17.26.42   -30
 20  Thu Aug 07 2008   2008.08.07_16.16.21   -27
 21  Fri Aug 08 2008   2008.08.08_20.59.46   -26
 22  Sat Aug 09 2008   2008.08.09_20.48.31   -25
 23  Sun Aug 10 2008   2008.08.10_14.29.18   -24
 24  Mon Aug 11 2008   2008.08.11_19.51.32   -23
 25  Tue Aug 12 2008   2008.08.12_14.13.02   -22
 26  Wed Aug 13 2008   2008.08.13_20.41.43   -21
 27  Thu Aug 14 2008   2008.08.14_16.44.02   -20
 28  Fri Aug 15 2008   2008.08.15_19.47.29   -19
 29  Mon Aug 18 2008   2008.08.18_18.29.06   -16
 30  Tue Aug 19 2008   2008.08.19_17.58.42   -15
 31  Wed Aug 20 2008   2008.08.20_18.53.46   -14
 32  Thu Aug 21 2008   2008.08.21_19.56.03   -13
 33  Fri Aug 22 2008   2008.08.22_23.32.10   -12
 34  Sun Aug 24 2008   2008.08.24_12.57.36   -10
 35  Tue Aug 26 2008   2008.08.26_10.34.06   -8  not finished
 36  Tue Aug 26 2008   2008.08.26_10.59.46   -8
 37  Tue Aug 26 2008   2008.08.26_13.07.08   -8
```

You see, that backup number 35 was not finished. Using option verbose results in:

```
# /opt/test/storeBackup/bin/storeBackupls.pl -v .
. . .
 37  Tue Aug 26 2008   2008.08.26_13.07.08   -8
version -> 1.3
date -> 2008.08.26 13.07.08
sourceDir -> '/backup'
followLinks -> 1
compress -> 'bzip2'
uncompress -> 'bzip2' '-d'
postfix -> '.bz2'
exceptSuffix -> '.bz2' '.gif' '.gpg' '.gz' '.jpg' '.mp3' '.mpeg' '.mpg' '.ogg' '.png' '.tgz' '.tif' '.tiff' '.zip'
exceptDirs -> '/backup/home_hjc/nosave'
includeDirs ->
exceptRule -> '$file =~ /arconis.*tib/' 'or' '$file =~ m#/te?mp/#' 'or' '$file =~ m#/\.thumbnails/#'
includeRule ->
exceptTypes ->
preservePerms -> yes
lateLinks -> yes
lateCompress -> no
cpIsGnu -> yes
```

Only the output for the last backup is shown here. You can see, which options of storeBackup.pl where used to generate the backup.

`storeBackupls.pl -f configFile [--print] [storeBackup-dir]` or
`storeBackupls.pl --file configFile [--print] [storeBackup-dir]`
Here it will read the configuration file of storeBackup.pl and tells something about the deletion status of each backup:

```
# storeBackupls.pl -f /backup/stbu-gentoo.conf .
. . .
WARNING   backup <./2008.08.26_10.34.06> not finished
analysis of old Backups in <.>:
   Fri 2008.07.04_20.17.13 (61): will be deleted
   Sat 2008.07.05_21.19.09 (60): keepWeekDays(60d)
   Sun 2008.07.06_17.38.22 (59): keepWeekDays(60d)
   Mon 2008.07.07_17.31.43 (58): keepWeekDays(60d)
   Fri 2008.07.11_19.20.14 (54): keepWeekDays(60d)
   Sat 2008.07.12_18.17.21 (53): keepMinNumber30, keepWeekDays(60d)
   Sun 2008.07.13_17.07.53 (52): keepMinNumber29, keepWeekDays(60d)
   Mon 2008.07.14_06.28.29 (51): keepMinNumber28, keepWeekDays(60d)
   Tue 2008.07.15_07.44.41 (50): keepMinNumber27, keepWeekDays(60d)
   Wed 2008.07.16_17.56.35 (49): keepMinNumber26, keepWeekDays(60d)
   Thu 2008.07.17_10.13.47 (48): keepMinNumber25, keepWeekDays(60d)
   Fri 2008.07.18_14.13.26 (47): keepMinNumber24, keepWeekDays(60d)
   Sat 2008.07.19_16.03.40 (46): keepMinNumber23, keepWeekDays(60d)
   Fri 2008.07.25_09.29.39 (40): keepMinNumber22, keepWeekDays(60d)
   Mon 2008.07.28_19.01.04 (37): keepMinNumber21, keepWeekDays(60d)
   Wed 2008.07.30_17.25.43 (35): keepMinNumber20, keepWeekDays(60d)
   Thu 2008.07.31_16.45.56 (34): keepMinNumber19, keepWeekDays(60d)
   Fri 2008.08.01_16.43.56 (33): keepMinNumber18, keepWeekDays(60d)
   Mon 2008.08.04_17.26.42 (30): keepMinNumber17, keepWeekDays(60d)
   Thu 2008.08.07_16.16.21 (27): keepMinNumber16, keepWeekDays(60d)
   Fri 2008.08.08_20.59.46 (26): keepMinNumber15, keepWeekDays(60d)
   Sat 2008.08.09_20.48.31 (25): keepMinNumber14, keepWeekDays(60d)
   Sun 2008.08.10_14.29.18 (24): keepMinNumber13, keepWeekDays(60d)
   Mon 2008.08.11_19.51.32 (23): keepMinNumber12, keepWeekDays(60d)
   Tue 2008.08.12_14.13.02 (22): keepMinNumber11, keepWeekDays(60d)
   Wed 2008.08.13_20.41.43 (21): keepMinNumber10, keepWeekDays(60d)
   Thu 2008.08.14_16.44.02 (20): keepMinNumber9, keepWeekDays(60d)
   Fri 2008.08.15_19.47.29 (19): keepMinNumber8, keepWeekDays(60d)
   Mon 2008.08.18_18.29.06 (16): keepMinNumber7, keepWeekDays(60d)
   Tue 2008.08.19_17.58.42 (15): keepMinNumber6, keepWeekDays(60d)
   Wed 2008.08.20_18.53.46 (14): keepMinNumber5, keepWeekDays(60d)
   Thu 2008.08.21_19.56.03 (13): keepMinNumber4, keepWeekDays(60d)
   Fri 2008.08.22_23.32.10 (12): keepMinNumber3, keepWeekDays(60d)
   Sun 2008.08.24_12.57.36 (10): keepMinNumber2, keepWeekDays(60d)
   Tue 2008.08.26_10.59.46 (8): will be deleted
   Tue 2008.08.26_13.07.08 (8): keepMinNumber1, keepWeekDays(60d)
```

. . . and using option –print we see the parameters used from the command line:

```
# storeBackupls.pl -f /backup/stbu-gentoo.conf . --print
combined configuration and command line options
options with parameters:
file </backup/stbu-gentoo.conf>
firstDayOfWeek <Sun>
keepAll <60d>
keepDuplicate <7d>
keepFirstOfMonth <undef>
keepFirstOfWeek <undef>
keepFirstOfYear <undef>
keepLastOfMonth <undef>
keepLastOfWeek <undef>
keepLastOfYear <undef>
keepMaxNumber <0>
keepMinNumber <30>
```

```
keepRelative <undef>
keepWeekday <undef>
options without parameters:
list parameters:
<.>
```

5.8 storeBackupDel.pl

storeBackupDel.pl deletes old backups regarding the rules you defined. These rules (keep∗) are described as options of storeBackup.pl in section 5.2. You should configure storeBackup.pl with a configuration file and read this configuration file with storeBackupDel.pl if you want to delete old backups asynchronously from the backup itself (see also Example 6, section 7.7).

```
$prog [-f configFile] [--print]
 [-b backupDirectory] [-S series] [--doNotDelete]
 [--deleteNotFinishedDirs] [-L lockFile]
 [--keepAll timePeriod] [--keepWeekday entry] [--keepFirstOfYear]
 [--keepLastOfYear] [--keepFirstOfMonth] [--keepLastOfMonth]
 [--keepFirstOfWeek] [--keepLastOfWeek]
 [--keepDuplicate] [--keepMinNumber] [--keepMaxNumber]
 [-l logFile
  [--plusLogStdout] [--suppressTime] [-m maxFilelen]
  [[-n noOfOldFiles] | [--saveLogs]
  [--compressWith compressprog]]
```

You have to set at least two options: `--backupDir` *and* `--series`*. It doesn't matter if you set them on the command line, in the configuration file or mixed.*

First the options which can be used only on command line. There is always a long option (like `--configFile`) and sometimes also a shortcut (`-f`).

`--print` Prints the options used (from command line *and* from the configuration file) and stops after printing the options. In case of difficult quoting (especially on the command line) this gives you the chance to see what's really used in the program.

`--configFile / -f` Name of the configuration file you want to use.

You can easily overwrite options in the configuration file (especially changing backupDir and unsetting doNotDelete) on the command line. See also section 6.1.
The following parameters are identical to the ones in storeBackup.pl:

- backupDir
- series
- lockFile
- doNotDelete
- deleteNotFinishedDirs
- keepAll
- keepWeekday
- keepFirstOfYear
- keepLastOfYear
- keepFirstOfMonth
- keepLastOfMonth
- firstDayOfWeek

- keepFirstOfWeek
- keepLastOfWeek
- keepDuplicate
- keepMinNumber
- keepMaxNumber
- keepRelative
- logFile
- plusLogStdout
- suppressTime
- maxFilelen
- noOfOldFiles
- saveLogs
- compressWith

5.9 storeBackupMount.pl

storeBackupMount.pl gives you a "script" to mount the needed directories for the backup, start storeBackup.pl and umount the directories. Before trying to mount, it can check via ping if a server is reachable. If these directories are always (or already) mounted, there is no need to use storeBackupMount.pl.

```
storeBackupMount.pl -c configFile [-s server] [-l logFile]
[-d] [-p pathToStoreBackup] [-k killTime] [-m] mountPoints...
```

To be able to mount the directories, you need an entry in `/etc/fstab` like the following ones:

```
/dev/sda5 /add reiserfs noatime 0 1
lotte:/disk1 /backup nfs rsize=8192,wsize=8192,user,exec,async,noatime 1 1
```

The first mount point `/add` is on a local device. In this example, it's the device with a file system to be saved. The second one (`/backup`) is located on `/disk1` on the nfs server lotte. The rest are nfs parameters — see section 6.7 about the configuration of nfs.
If you have these kind of entries in `/etc/fstab`, you can mount the file systems with:

```
mount /add
mount /backup
```

and that's exactly what storeBackupMount.pl does.

You must at least configure option –configFile.
The command line options storeBackupMount.pl accepts are:

`--server / -s` Name or ip address of the of the nfs server. Default is "localhost". This name is used for pinging.

`--configFile / -c` Configuration file for storeBackup.pl. StoreBackupMount.pl reads option *logFile* from the configuration file of storeBackup.pl. If this log file is different from the one specified for this program, then the storeBackup.pl log file is read online and the lines are printed into the log file of storeBackupMount.pl. This is especially useful if the log from storeBackupMount.pl is directed to stdout.

`--logFile / -l` Log file for this process, default is stdout. You can log into the same log file as storeBackup.pl. If storeBackup.pl writes to stdout, this output will be redirected into this log file, *but not till then it finished.*

`--debug / -d` Generate some extra messages.

`--pathStbu / -p` Path to storeBackup.pl. Has to be set if storeBackup.pl is not in your environment variable `$PATH`.

`--killTime / -k` Time until storeBackup.pl will be killed if it didn't finish before. The time range has to be specified in format 'dms', eg. 10d4h means 10 days and 4 hours.
Default are 365 days.

`--keepExistingMounts / -m` If some mounts already exists at starting time of the program, do not umount these mounts after running storeBackup.pl.

`...mountPoints...` List of mount points needed to perform the backup. This must be a list of paths which have to be defined in /etc/fstab.

exit status:

0 everything is fine

1 error message from storeBackup.pl

2 error from storeBackupMount.pl

3 error from both programs

5.10 storeBackupCheckBackup.pl

storeBackupCheckBackup.pl verifies the consistency of a backup by using the md5 sums generated during the backup in `.md5CheckSums` (see section 6.6) and compares these with just calculated ones.

```
storeBackupCheckBackup.pl -b backupDir [-v level] [-p number] [backupRoot...]
```

`--print` print the configuration parameters and stop processing

`--backupDir` The repository, where *all* your backups are stored. If you have one series of backup (eg. from one computer), this will normally be similar to the directory where you backups are. The meaning of this parameter is similar to the option backupDir of storeBackup, see section 5.2.
You have to specify this parameter.

`--verbose / -v` Verbose. Print some extra messages so you see what's happening.

`--parJobs / -p / parJobs` Maximum number of parallel search operations. The default value is chosen automatically as the number of cores plus 1.

`backupRoot...` Root directories of backups where to search relative to backupDir. If no directories are specified, all backups below backupDir are chosen.

5.11 storeBackup_du.pl

storeBackup_du.pl evaluates the disk usage in one or more backup directories.

```
storeBackup_du.pl [-v] [-l] backupdirs ...
```

`--verbose / -v` Print accumulated values for multiple versions (days) of backed up files. Shows the steps when calculating the space used by the specified backups

`--links / -l` Also print statistic about how many links the files have and how much space this saves.

`...backupdirs...` the backup directories to evaluate

5.12 storeBackupConvertBackup.pl

You only have to call this program when storeBackup.pl tells you to do so.
converts old backups created with storeBackup.pl to the newest version
current version of the backup format is 1.3
you can see the version by typing:

```
head -1 < ...<storeBackupDir>/date_time/.md5CheckSums.info
```

Call storeBAckupConvertBackup.pl with the backup directories to convert:

```
    storeBackupConvertBackup.pl storeBackup-dir
```

5.13 llt

list create, access and modification times of files

```
       llt [-r] [-i] [-a|-m|-c] [files] [dirs]
```

`--help / -h` print a help message

`--reverse / -r` sort in reverse order according to file names

`--insensitive / -i` sort case insensitively

`--access / -a` sort according to access time

`--modification / -m` sort according to modification time

`--creation / -c` sort according to creation time

`--unixTime / -u` show Unix time (unsigned integer)

5.14 multitail.pl

multitail.pl reads one or multiple log files. The files read can be written in anther log file and saved. This way, you can mix multiple log files.
It's very robust, so it doesn't care if a file is deleted, moved or newly created. You can also start it with a file name which does not exist at that time.

```
       multitail.pl [-a] [-d delay] [-p begin|end] [-t]
                 [-o outFile [-m max] [-P]
                 [[-n noFiles] | [-s [-c compressprog]] ]
                ] files...
```

All options are optional, you simply have to use one or more log file names as parameter.

`--addName / -a` Add the file name from which the line is read to the output.

`--delay / -d` Delay in seconds between checking each file for new data. The value can by smaller than 1, eg. `0.2`. The default value is 5.

`--position / -p` Read from the begin or end of the file; allowed parameters are `begin` or `end`. Default is `begin`.

`--withTime -t` Add a time stamp to the output.

`--out / -o` write output to a file, default is stdout

`--maxFilelen / -m` Maximal size of a log file. After reaching this size, the log file will be rotated (see option noOfOldFiles) or compressed (see option saveLogs).

`--withPID / -P` write pid of multitail.pl to the log file; default is not to write it

`--maxlines / -l` Maximum number of line to read in one chunk from a log file. Default is 100. If you configure "`--delay 3`" then every three seconds multitail.pl will read a maximum of 100 lines. The reason for this restriction is to avoid that multitail.pl will consume too much power if a log file is written too heavily.

`--noOfOldFiles / -n` Number of old rotated log files, default is 5. With default values, it will look like this:

```
$ ls -l /tmp/storebackup.log*
-rw------- 1 hjc  root  328815 30. Aug 12:12 /tmp/storebackup.log
-rw------- 1 root root 1000087 27. Aug 21:18 /tmp/storebackup.log.1
-rw------- 1 root root 1000038 20. Aug 19:02 /tmp/storebackup.log.2
-rw------- 1 root root 1000094 11. Aug 18:51 /tmp/storebackup.log.3
-rw------- 1 root root 1000147 11. Aug 18:49 /tmp/storebackup.log.4
-rw------- 1 root root 1000030 11. Aug 18:49 /tmp/storebackup.log.5
```

Older log files than *.5 have been deleted automatically.

`--saveLogs / -s` Save the log files with a time and date stamp instead of deleting them after rotating. (Setting this option overwrites the default value of option noOfOldFiles.)

`--compressWith / -c` Specifies the program to compress the saved log files (eg. with `gzip -9`). Default value is `bzip2`.
On the command line, the parameter to this option is parsed like a line in the configuration file and normally has to be quoted on the command line.

6 General concepts

6.1 configuration file and command line

In all these programs a module is used which can handle the combination of command line and configuration file usage. Because in all programs always the same module is used, this description is valid for all of them. Nevertheless, there are some programs which support both interfaces (like storeBackup.pl) and others which support only command line (like storeBackupMount.pl). In general, programs which support a complex configuration have both interfaces, while the ones with a more simple configuration only support command line.

configuration file
The structure of the configuration file is:

```
keyword = list of parameters
```

There is no difference in writing:

```
keyword=list   of     parameters
```

If you have too much parameters for an optical nice length of the line in the configuration file, you can continue in the next line if you add one or more white space (space or tab) in the beginning of that line:

```
keyword = list of parameters but now really really really
    too much for one single line
```

You can add comments by setting a hash sign at the beginning of a line:

```
# this is a comment
```

You can also make a comment by typing a semicolon (`;`) at the beginning of a line. For better readability, storebackup uses this when writing (not specified) keywords in configuration files.
You can use environ variables like in a shell, here it's `$VAR`:

```
keyword = $VAR ${VAR}var
```

If `$VAR` was set to `XXX`, this will be equal to:

```
keyword = XXX XXXvar
```

You can use quotes:

```
keyword = 1 2 "1 2" '1 2' $VAR "$VAR 1" '$VAR' '$VAR 1'
```

This will be expanded (internally) to (the brackets are only used to show the grouping of parameters, they do not exist in reality):

```
keyword = <1> <2> <1 2> <1 2> <XXX> <XXX 1> <$VAR> <$VAR 1>
```

Next thing you can do is masking of special characters. Special characters you can mask with backslash (\) are:

```
$ { } " '
```

It depends on the keyword, how many "words" you can assign to them. There are also underlying rules, that some keywords are only allowed if others are set. And finally, not all characters are allowed for all keywords.

command line
On the command line, you always have a long option and sometimes a shortcut. The long option begins with `--`, while the short one simply begins with a `-`. Example:

```
# storeBackup.pl --file backup.config
# storeBackup.pl -f backup.conf
```

is equivalent. This also shows an option, which can have exactly *one* parameter (the file name).
There are others option which can have more than one parameter:

```
# storeBackup.pl .... -e /proc -e /tmp -e /var/tmp
```

In this example, option `-e` (same as `--exceptDirs`) is used to define multiple directories not to backup. You can simply repeat the option. It does not matter if you use the long or the short form or a mixture of them.
Now let's look at an option to define the program to uncompress the files in the backup. Let's choose `gzip -d`, a program with a parameter:

```
# storeBackup.pl .... --uncompress "gzip -d"
```

As documented in the description of storeBackup.pl in section5.2, the parameter of this option is parsed as if it were written in the configuration file (the quoting is stripped by the shell):

```
uncompress = gzip -d
```

In this way, storeBackup.pl will see two parameters (`gzip` and `-d`) of option `--uncompress`.
Sometimes, you can also use list parameters (parameters without an option). Eg. in storeBackup.pl they are called `otherBackupDirs`.

bringing both together
In some programs (like storeBackup.pl) you can use both command line options and a configuration file. Normally, it's easier to use and more clearly arranged by using the configuration file.
But in some situations it's very convenient to be able to overwrite an option set in the configuration file. You can simply do this by additionally setting that option on the command line. In programs delivered with storeBackup the command line will overrule the settings in the configuration file.
There is one special kind of situation when this normally would not be possible. Imagine, you wrote in the configuration file of storeBackup.pl:

```
doNotDelete = yes
```

This means, storeBackup.pl will not delete any old backup, because you want to do this later with storeBackupDel.pl. But the only thing storeBackupDel.pl has to offer is an option as a flag: `--doNotDelete` which only means *yes* in the configuration file. There's no special option to say *no*. Instead of introducing dozens of options for such cases, these programs use the following syntax:

```
# storeBackupDel.pl -f backup.config --unset doNotDelete
```

This will “unset” the `doNotDelete` option set in the configuration file.
You can also write:

```
# storeBackupDel.pl -f backup.config --unset --doNotDelete
```

which is the name of this option on the command line.

For list parameters, there is a mapping from the list parameters without option to a special option in the configuration file — for storeBackup.pl that’s *otherBackupDirs*, for storeBackupSearch.pl it’s *backupRoot*. This is documented for the individual programs (see description).

6.2 Deletion of old Backups

The more standard Approach

StoreBackup gives you a lot of possibilities to delete or not delete your old backups. If you have a backup which should never be deleted, the simplest way to achieve this is to rename its name, eg:
`$ mv 2003.07.28_06.12.41 2003.07.28_06.12.41-archive`
IMPORTANT: If you use option lateLinks of storeBackup.pl, only do this after a successful run of storeBackupUpdateBackup.pl!
To archive with a simple renaming is possible because storeBackup.pl and storeBackupDel.pl only delete directories which match *exactly* the pattern YYYY.MM.DD_hh.mm.ss .
The most simple way to delete a specific directory is to use `rm -rf`. *Do not do this if you use option lateLinks of storeBackup.pl!* If you want to delete backups which are too old depending on rules, there are several options you can choose. You can specify the time to keep old backups on the basis of weekdays (with a default value for all weekdays in keepAll which can be overwritten with keepWeekday). You can also specify to keep them with keepFirstOfYear, keepLastOfYear, keepFirstOfMonth and keepLastOfMonth. or with keepFirstOfWeek and keepLastOfWeek where you can define the first weekday of your definition of a week. In all of these cases, you have to specify a time period. How to specify a time period is described with the options of storeBackup.pl.
Now imagine you are making your backups on an irregular basis, perhaps from a laptop to a server or you make your backups when you think you have finished an important step of your work. In such cases, it is useful to say “only keep the last backup of a day in a long time range” (with keepDuplicate). If you were in holidays for a month and have set keepAll to `30d` (30 days), then you probably do not want that storeBackup deletes all of your old backups when you start it for the first time when you’re back. You can avoid this with the parameter keepMinNumber. On the other hand, if you have limited space on your backup disk, you want to limit the total number of backups, for this, you can use keepMaxNumber.
With keepDuplicate you specify a time period in which storeBackup keeps duplicate backups of a day. After this time period only the last backup of a day will survive.
With keepMinNumber you specify the minimal number of backups storeBackup (or storeBackupDel) will *not* delete. The logic is as follows:

- Do not delete backups specified with keepAll . . . keepLastOfWeek and keepDuplicate.
- If this is not enough, do not delete other ones beginning with the newest backups. Duplicates of a day are not affected by this parameter.

With keepMaxNumber you specify the maximal number of backups. StoreBackup will then delete the oldest backups if necessary. To prevent special backups from deletion, you can specify an “archive flag” with keepAll . . . keepLastOfWeek. Backups matching an archive flag will never be delete by keepMaxNumber. In this way it is possible that more backups will remain than specified with this parameter, but the archive flag is useful to prevent special backups like “last backup of a month” or “last backup of a week” to be deleted.

Using –keepRelative as a Deletion Strategy

This option activates an alternative backup deletion scheme that allows you to specify the relative age of the backups you would like to have rather then the period over which a backup should be kept.
Imagine that you always want to have the following backups available:

- 1 backup from yesterday

- 1 backup from last week
- 1 backup from last month
- 1 backup from 3 months ago

Note that this is most likely *not* what you really want to have, because it simply means that you have to do daily backups and have to keep every backup for exactly 3 months. Otherwise you wouldn't always have a backup that is of *exactly* the requested age.
What you really want to have is therefore probably something like this:

- 1 backup of age 1 hour to 24 hours / 1 day
- 1 backup of age 1 day to 7 days
- 1 backup of age 14 days to 31 days
- 1 backup of age 80 days to 100 days

This is now a very common backup strategy, but you would have difficulty to achieve this with the usual keepFirstOf* options, especially if you don't do backups with perfect regularity. However, you can implement it very easily using keepRelative. All you need to write is:

```
keepRelative = 1h 1d 7d 14d 31d 80d 100d
```

i.e. you list all the intervals for which you want to have backups. storeBackup will delete backups in such a way that you come as close as possible (if you don't do backups often enough, there is of course nothing that storeBackup can do) to your requested backup scheme.
Note that this may mean that storeBackup keeps more backups that you think it has to, i.e. it may keep two backups in the same period. In this case storeBackup "looks into the future" and determines that both backups will *later* be necessary in order to have a backups for all periods. This is also the reason why in the above example you have somehow implicitly specified the period 7 days to 14 days, although you didn't really want to have a backup in this period — in order to have backups in the next period (14 days to 31 days) you always need to have a backup in the period 7 days to 14 days as well. Therefore the syntax doesn't allow you to exclude some periods.
Finally you should be aware that storeBackup shifts all the intervals if it cannot find a recent enough backup: if your first intervals is from 10 days to 20 days, but your most recent backup is actually 25 days old, all subsequent periods will be extended by 5 days. This ensures that if you haven't made any backups over a large period, this period is not taken into account for your backup scheme. To give an example why this is useful: if you wanted to have backups 1, 3, 7 and 10 days old and then went on vacation for 14 days, it is pretty unlikely that you want all your backups deleted when you come back, hence storeBackup ignores these 14 days and keeps the backups appropriately longer.

6.3 Defining rules

Rules can be defined in storeBackup.pl, see section 5.2 (options excludeRule and includeRule) and in storeBackupSearch.pl, see section 5.6 (option searchRule). Both support the definition in configuration files and on the command line.

This part of the description shows how to use rules in storeBackup. If you are not familiar with pattern matching and perl you should try to change the examples very carefully a little bit. But you can run easily into error messages you will not understand.
First, all the examples are explained for being written in a configuration file. Mostly I will use the key word from storeBackup.pl (exceptRule), but the rules are identical to the ones you can use for includeRule and searchRule. Later, we will see how to use rules on the command line.
All the values we a talking about now, are the ones from the files backed up at the point in time when the backup was performed, *not* from the files in the backup!
In general, rules are a piece of perl with some specialities. We start with some easy and typical examples:

Example 1:

```
exceptRule = '$size > 1610612736'
```

(Take care of the quotes. Generate a configuration file with storeBackup.pl or storeBackupSearch.pl and read the comments in the beginning how quoting and environment variables are interpreted.)
This rule will match for all files with more than 1.5GB ($1.5 * 1024^3$) bytes. `$size` represents the size of each individual file. In this example, all files bigger than 1.5GB will not be saved. This is not very easy to read, and you can write instead:

```
exceptRule = '$size > &::SIZE("1.5G")'
```

(Take care of all quotes.) This will have the same effect as the rule before. &::SIZE is a function which calculates the real value from the string "1.5G". You can use identifiers from 'k' to 'P' with the following meaning:

`1k`	1 kilobyte = 1024 Byte
`1M`	1 Megabyte = 1024^2 Byte
`1G`	1 Gigabyte = 1024^3 Byte
`1T`	1 Terabyte = 1024^4 Byte
`1P`	1 Petabyte = 1024^5 Byte

Eg: `&::SIZE("0.4T")` is valid, while `&::SIZE("1G1M")` is not.

Example 2:

```
exceptRule = '$file =~ m#\.bak$#'
```

(Take care of the quotes.) This rule will match for all files ending with '.bak' which means they will not be saved. `$file` represents the individual file name with the *relative path* below the parameter of option *sourceDir* from storeBackup.pl. If you do not understand the strange thing right to `$file`, it's called pattern matching or regular expression. See *man perlretut* (perl regular expressions tutorial) for detailed explanation. But you should be able to expand this to simple needs:

```
exceptRule = '$file =~ m#\.bak$#' or '$file =~ m#\.mpg$#'
```

(Take care of the quotes and *all* blanks.) This rule will match and therefore not save files ending with '.bak' or '.mpg'.

```
exceptRule = '$file =~ m#\.bak$#' or '$file =~ m#\.mpg$#'
   or '$file =~ m#\.avi$#'
```

It should not be a surprise, that you will not backup files ending with '.bak', '.mpg' or '.avi'.
Now we want to create a rule which will prevent the backup of all files which end with '.bak', '.mpg' or '.avi' and also all files bigger than 500 Megabyte:

```
exceptRule = '$file =~ m#\.bak$#' or '$file =~ m#\.mpg$#'
   or '$file =~ m#\.avi$#' or '$size > &::SIZE("0.5G")'
```

If you set 'debug = 2', you can see if and how the rule matches for individual files. If you set 'debug = 1', you can see if the rule matches for each file. With 'debug = 0' (default), you will not get a message.

You can use the following 'preset variables':

`$file`	file name with relative path from original sourceDir
`$size`	size of the file in bytes
`$mode`	mode of the file (integer, use 0... to compare with octal value, eg. `$mode = 0644`
`$ctime`	creation time in seconds since epoch (Jan 1 1970), see below
`$mtime`	modify time in seconds since epoch, see below
`$uid`	user id (string if defined in operating systems), eg. `$uid eq "bob"`
`$uidn`	user id (numerical value), eg. `$uidn = 1001`
`$gid`	group id (string if defined in operating system), see `$uid`
`$gidn`	group id (numerical value), see `$uidn`
`$type`	type of the file, can be one of `SbcFpl`, see option exceptTypes in storeBackup

If you use ctime or mtime, it's not pure fun to calculate the number of seconds since epoch every time. For this reason, storeBackup supports a special function &::DATE to make your live cosy:

Example 3:

```
searchRule = '$mtime > &::DATE("14d")' and '$mtime < &::DATE("3d12h")'
```

With this search rule (in storeBackupSearch.pl) you will find all files which are younger than exactly 14 days and older than 3 days and 12 hours. The syntax understood by &::DATE is:

1.

`d`	day
`h`	hour
`m`	minute
`s`	second

So "3d2h50s" means 3 days, 2 hours and 50 seconds. With the format above, you specify "now" minus that period.

2.

`YYYY.MM.DD`	year.month.day
`YYYY.MM.DD_hh.mm.ss`	same format as backup dirs
`2008.04.30`	specifies April 30 2008, 0:00,
`2008.04.30_14.03.05`	specifies April 30 2008, at 2 o'clock, 3 min. and 5 sec. in the afternoon.

With the format above, you specify a fixed point in time.

You already saw some possibilities to group the checking of the "variables" by using: `and` and `or`. You can use:

```
and, or, not, (, )
```

Everything is like in perl. (To be honest, it is evaluated by the perl interpreter.). But you should surround each of these with one (or more) blanks (white spaces) if you want `debug = 2` to work correctly!

Example 4:

```
searchRule = ( '$mtime > &::DATE("14d")' and '$mtime < &::DATE("3d12h")' )
     and not '$file =~ m#\.bak$'
```

Finds all files younger than 14 days and older than 3 days, 12 hours, but only if they do not end with `.bak`.
See how `and`, `not`, `(` and `)` have at least one white space surrounding it.

using rules on the command line
Let's take a look at:

```
exceptRule = '$size > &::SIZE("1.5G")'
```

If we try to use the command line like this:

```
--exceptRule '$size > &::SIZE("1.5G")'               ### WRONG ###
```

we will get some nasty error messages because the shell strips the single quotes and storeBackup tries to interpret the result the same way as in the configuration file (see description in each configuration file at the top). Here, storeBackup will complain about not knowing the environment variable `$size`. (The $-sign is not masked any more because the shell removed the single quote.) So we have to mask the $-sign. We also have to mask the double quotes, because normally, storeBackup will interpret them as grouping quotes and will not bypass them directly to perl. The right way specifying this option is:

```
--exceptRule '\$size > &::SIZE(\"1.5G\")'            ### CORRECT ###
```

We have to write example 4 in the following way:

```
--searchRule '( \$mtime > &::DATE(\"14d\") and \
   \$mtime < &::DATE(\"3d12h\") ) and not \$file =~ m#\.bak\$#'
```

In case of problems, you should read the perl error massage which shows what perl really gets. Beside this, option `--print` will show each parameter after being parsed through shell and storeBackup. You can use `--print` in combination with configuration files also.

6.4 Saving Image Files / raw Devices / Blocked Files

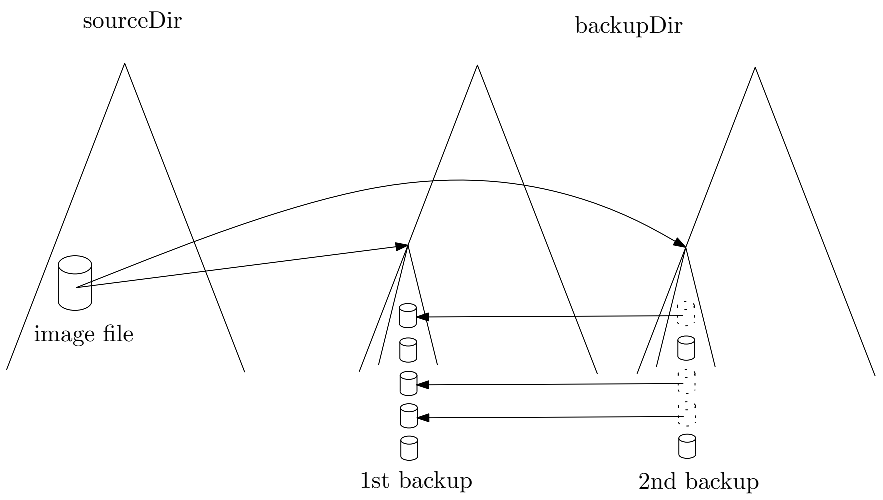
The scope of blocked files

Saving big images files which change only in parts completely every backup is inefficient: very time and space consuming. To give some examples:

- Some mailers use traditional mbox (mailbox) format to save email. This is convenient, because it's a well supported format. But you will get a big file of perhaps multiple gigabyte with all your mails in it. Backing up such a file means backing up everything despite the fact that only a very little portion of it has changed.
  The same category are the `.pst` files from Outlook. If you have to save these kind of files (and if they are big), you should think about using "blocked files".
- If you use an image file with an encrypted file system in it like eg. TrueCrypt does, you should backup the encrypted data, not the files in it. If you backup the files in it you need another encrypted container, which means the backup program has to know all passwords to run automatically which is a perfect security hole.
  For that reason you should backup the binary image data as it is. If you make a simple copy, it will take the size of the image each time (you also cannot compress this data). This is a perfect situation to use the storeBackup blocked files feature (without compression), where you can have lots of historic versions of the image without needing too much space and without a security whole (storeBackup doesn't need to now and doesn't know anything about the content it saves).
- Images for Hypervisors like Xen, KVM or VMware are another example which you can save very successful as "blocked files".
- Do not use blocked files which are encrypted as a whole like jpegs or other types of compressed or encrypted files (`.gz`, `.bz2`, `.gpg`, openoffice files, etc.). Changing something in that files result mostly in a complete change of all blocks.
- The feature of blocked files is also not suitable for database dump files, because storeBackup (up to now) works with fixed blocks. If you add one byte in the beginning of a file, all blocks will be different.

How it works

If you specify a file to be saved blocked (see below how to do this), then storeBackup.pl will do the following (first backup):



1. Create a directory with the same combination of path and file name of the original image file in the backup.
2. Split the source file into blocks and save them into the new directory. (If there are duplicates of a block, they will be hard linked.)

3. The md5 sum of all these files will be stored in a special file called `.md5BlockCheckSums.bz2` in that directory. These md5 sums are also stored in the file `.md5BlockCheckSums.bz2` in the root directory of the backup.

4. storeBackup.pl will also calculate the md5 sum of the whole file and store it in `.md5CheckSum`.

In the second and all later runs, storeBackup.pl will do the following:

1. Create the directory as described above.

2. Split the source file into blocks and see, if any of these blocks exist anywhere in a backup (see option `otherBackupDirs` of storeBackup.pl). If a block already exists, a hard link is generated, if it does not exist, the block will be copied or stored compressed.

3. The additional information about the blocks (like the md5 sums) is written into the files described above.

Because all files are referenced via hard links, every backup is a full backup. There are no "original" files. If you use option lateLinks, see section 6.5, the links will be set later. If you also use option lateCompress, the compression will be done later also.

how to save image files

There are two ways to configure which files storeBackup.pl should treat as blocked files:

1. The easiest way is using the following options:

   `checkBlocksSuffix` The configuration is similar to `exceptSuffix`, a list of suffixes which are checked for a match, eg. `\.vdmk` for VMware images. They simply mean that the last part of the backup must be similar to what you define here.
   The next options described here are only used if `checkBlocksSuffix` is set.

   `checkBlocksMinSize` Only files with this minimum size will the treated as blocked files. You can use the same shortcuts as described in defining rules, see section 6.3, eg. 50M means 50 megabytes. The default value is 100M.

   `checkBlocksBS` Defines the block size in which the files which matches has to be split by storeBackup.pl. The format is equal to `checkBlocksMinSize`. The default value is 1M. The minimal value is 10k.

   `checkBlocksCompr` Defines if the blocks are compressed. Possible values are `yes` or `no`, the default value is `no`. On the command line, use `--checkBlocksCompr` to switch to compression mode. This flag only affects files selected with `checkBlocksSuffix`.

   Example:
   You want to backup all your VMware images and you also have to backup some Outlook `.pst` files. The blocked file feature will be chosen from storeBackup for files with a minimum size of 50 megabyte ending with `.vmdk` or `.pst`. The block size chosen is 500k and the resulting blocks in the backup will be compressed:

   ```
   checkBlocksSuffix = '\.vmdk' '\.pst'
   checkBlocksMinSize = 50M
   checkBlocksBS = 500k
   checkBlocksCompr0 = yes
   ```

2. The more flexible way to specify the handling of blocked files is to use rules like described in defining rules, see section 6.3. The following options are available five times, so there is a `checkBlocksRule0`, `checkBlocksRule1`, `checkBlocksRule2`, `checkBlocksRule3` and `checkBlocksRule4`:

   `checkBlocksRule`*i* The *i*th rule specifying files to treat as blocked files in the backup.

   `checkBlocksBS`*i* The corresponding block size for the blocks in the backup. The default value is 1 megabyte. The minimal value is 10k.

   `checkBlocksCompr`*i* If set to `yes`, the blocks will be compressed. The default value is `no`.

`checkBlocksRead`*i* Defines a filter for reading the specified file in `sourceDir`, eg. *gunzip* or *gzip -d*. This parameter is useful if you have to save an already compressed image file. (Using the "blocked file" feature of storeBackup with already compressed files compressed as a whole does not make sense.)

Example:
Let's assume, you have a TrueCrypt image on your disk and want to have a backup of it each time you start storeBackup.pl. You chose the unremarkable name `myPics.iso`, block size is 1M, no compression. So you define rule 0:

```
checkBlocksRule0= '$file =~ m#/myPics\.iso$#'
#checkBlocksBS0=
#checkBlocksCompr0=
checkBlocksRule1= '$size > &::SIZE("50M")' and
        ( '$file =~ m#\.pst$#' or '$file =~ m#windows_D/Outlook/#' )
checkBlocksBS1=200k
checkBlocksCompr1=yes
```

You also defined rule 1, which match for all files bigger than 50 megabytes which end with `.pst` *or* are located in the *relative* path `windows_D/Outlook/` in the backup. (I'm using this to backup the data of my dual boot laptop.) If you are not familiar with rules in storeBackup, you should read section 6.3.

You can use `checkBlocksSuffix` and `checkBlocksRule`*i* at the same time in one configuration file. StoreBackup first evaluates `checkBlocksRule`*i* (in ascending order) and then `checkBlocksSuffix`.

how to save mass storage devices

Backing up a mass storage device (like `/dev/sdc` or `/dev/sdc1`) works in the same way as saving an image file with storeBackup. You choose the device(s) with `checkDevices`*i*, the block size in the backup with `checkDevicesBS`*i* and switch compression on or off with `checkDevicesCompr`*i*. Additionally, you have to specify the relative path with `checkDevicesDir`*i* in the backup where the contents of the devices will be stored.
The blocks in the backup resulting from image files or devices are hard linked if storeBackup finds the same contents.
The parameters are in detail:

`checkDevices`*i* List of devices (eg. `/dev/sdd2 /dev/sde1`) to backup.

`--checkDevicesDir`*i* Directory where the devices are stored in the backup (*relative* path). The image file will be restored in that directory also if you restore the backup with storeBackupRecover.pl (if you use default options.) Into this directory storeBackup will create a subdirectory which name is generated from the parameters of `checkDevices`, eg. `/dev/sdc` will result in `dev_sdc`.

`checkDevicesBS`*i* Defines the block size in which the devices specified have to be split by storeBackup.pl. The format is equal to `checkBlocksMinSize`. The default value is 1M. The minimal value is 10k.

`checkDevicesCompr`*i* If set to `yes`, the blocks will be compressed. The default value is `no`.

choosing the block size

There is no fix rule about the "best" block size. I made some measurements about the block size and the used space. The second backup was done with lateLinks (see section 6.5), so I could use `df` again to see how much space was really needed. The used file system was reiserfs with tail packing. If you use a file system without tail packing (like ext2 or ext3), the overhead will be bigger and small block sizes are less attractive (same if you use compression). The results also depend on the application writing to your source image file.
All the examples are done without compression (for performance reasons). They were done with real data. Naturally, I'm using compression in my real backups. The 2nd backup shows the space needed for the changed data. The percentage line below shows the relation between the first and the second backup. The sums line shows the sum of the first and second backup, the next line (1x) the relationship between that sum depending on the last value with 5M (5 megabyte blocks). The last line show the

same relationship regarding the size of the first backup and 10 times the second one (extrapolating 10 backups). So this should be the most interesting value.

The first example shows the results when storing a big Outlook `.pst` file of 1.2GB with the changes I had from one day to the other:

BlockSize	50k	100k	200k	1M	5M
1. backup [kB]	1219253	1172263	1172863	1173801	1173724
2. backup [kB]	7692	13445	22720	73826	240885
	0.63%	1.15%	1.94%	6.29%	20.52%
sum [kB]	1226945	1185708	1195583	1247627	1414609
1x	86.73%	83.82%	84.52%	88.20%	100.00%
10x	36.18%	36.47%	39.08%	53.37%	100.00%

The second example was done with a smaller Outlook file of 117 megabyte. This is the one for the input folder. The numbers show a different behavior than in the first example.

BlockSize	50k	100k	200k	1M	5M
1. backup [kB]	122487	118221	118891	119184	119181
2. backup [kB]	33400	51240	74424	107632	119181
	27.27%	43.34%	62.60%	90.31%	100.00%
sum [kB]	155887	169461	193315	226816	238362
1x	65.40%	71.09%	81.10%	95.16%	100.00%
10x	34.82%	48.10%	65.84%	91.19%	100.00%

The third example shows the results when storing a VMware image of 2.1 GB. Between the first and the second backup The image was booted, a program for updating my navigational system was updated and I connected the navigational system for an update also.

BlockSize	50k	100k	200k	1M	5M
1. backup [kB]	2162595	2106781	2112547	2117178	2117094
2. backup [kB]	53656	80609	131701	438241	1112652
	2.48%	3.83%	6.23%	20.70%	52.56%
sum [kB]	2216251	2187390	2244248	2555419	3229746
1x	68.62%	67.73%	69.49%	79.12%	100.00%
10x	20.38%	21.99%	25.90%	49.08%	100.00%

There is one additional important aspect about the block size: If you choose a small block size, the performance will also go down. To be able to achieve acceptable performance, the following optimizations are implemented:

- If you do not compress the the blocks within storeBackup.pl (no compression at all or later compression via option lateCompress), no parallelizing is used.
- If you compress the blocks within storeBackup.pl and configure a block size of 1 megabyte or more, parallelizing is used.
- If you compress the blocks within storeBackup.pl with bzip2 and configure a block size of less than 1 megabyte, storeBackup.pl tries to use the perl module `IO::Compress::Bzip2`. If it is installed on your system, it will be used.

It's best to make your own tests to get a feeling of useful block sizes in your use cases.

6.5 using option lateLinks

You can use storeBackup as one program (storeBackup.pl) which does everything alone or you can split the different tasks into several pieces. There is mostly one advantage to run different programs for the different tasks: the time for backup itself from the perspective of the saved computer (or) data is lower.

It makes sense to use option lateLinks if you store your Backup on an nfs server and if you think it's a good idea to speed up (see section 4.4.3, performance). Configuring lateLinks is a little bit more complicated than using storeBackup.pl as a standalone programe because you have to manage multiple programs.

StoreBackup.pl as a standalone program does the following tasks:

1. The link consistency of all backups (from all backup series) is checked. We will see late what this means.
2. Loading information from one or more old backups. This task is like an initialisation, where it gets file names, md5 sums, dates, times and some other information from the old backups.
3. Checking for all files to backup if another file with that specific content is already in those old backups from where the file names, md5 sums etc. were loaded.
4. The changed data is transferred to the backup: By copying, by compression or by hard linking. Naturally, also the directory structure is generated. For every file, the owner and permissions are set in the same way as in the source directory.
5. The permissions and owners of the directories are set to the same values as in the source directory.
6. Depending on the rules defined with the keep∗ options of storeBackup.pl, old backups are deleted.

If you start storeBackup.pl with option lateLinks, then the transfer of data (see step 4) and the actions on the remote file system are reduced to the absolutely necessary minimum:

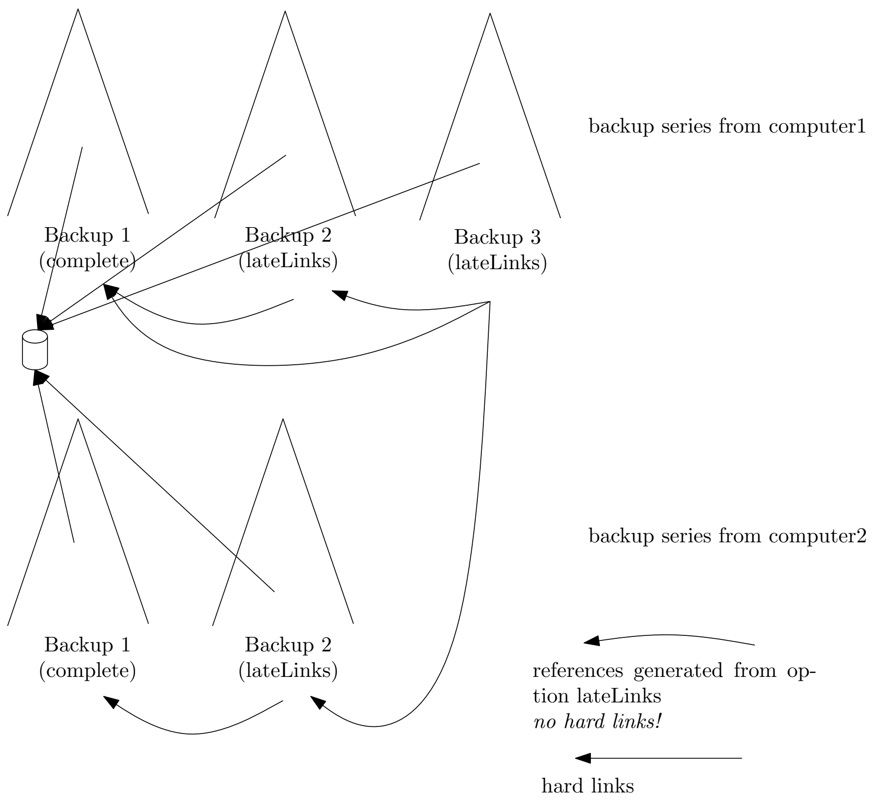
- The changed or new files (including special files) are copied. Changed files which should be compressed are only copied if option lateCompress is set. It depends on your situation if usage of lateCompress makes sense or not.
- Hard links are not generated in the new backup.
- Directories are only created if they are needed for copying / compressing.
- An additional file is created in the new backup: `.storeBackupLinks/linkFile.bz2`. It contains all the information what should have been done to complete a "full" backup with all hard links, directory entries and compressions. The correct permissions (which are also not set) are stored in the file `.md5CheckSums` in the top level of the backup. This file is also generated in a "full" backup run of storeBackup.pl. It is used for restoring data (storeBackupRecover.pl).

Independent of option lateLinks you can always configure storeBackup.pl to not perform step 6, the deletion of old backups. Especially if you are writing your backup on an nfs mount, this will take some time and lengthen you backup. Use storeBackupDel.pl (which can read the configuration file of storeBackup.pl) to split the deletion of old backups from the direct backup process.

It is important to understand that using option lateLinks creates an unfinished backup. Such backups do contain all the data which was intended to be backed up, so the core backup is complete. But storeBackup's job is not completed in the following ways:

- Directory entries are missing.
- Files are not compressed (if you use option lateCompress).
- Hard links are not set at all.
- Permissions are not set correctly, neither for files nor for directories.
- Not that all the information that's necessary to complete to a full backup is available! In the case of hard links this means that there is a reference in the file `linkFile.bz2` which points to a file in an older backup. In that older backup, there also can be only a reference in its file `linkFile.bz2`, and so on. Naturally, at one point there *must* (and will) be a real file. But you should be aware: if you delete one of these referenced backups, you will destroy *all backups* which are referencing (directly in indirectly) to that backup. **Only delete backups with storeBackup.pl or storeBackupDel.pl — never use "rm" or something similar!** These two programs take care of the dependency just described. If you really want to delete files with "rm", then make sure, that storeBackupUpdateBackup.pl completed all backups successfully. When all links are set, there are absolutely no dependencies (beside hard links) between the different backups.

The following picture shows two cross linked backup series (from different computers).[11] You see, that the references resulting from the lateLinks option can be complex. The hard links are never a problem, because there is no original or "real" reference — every hard link is an original pointer to the file or more precise to the inode (see section 6.8). The file will only be deleted if the last hard link has gone. But the references created by lateLinks are just some file names in a file which has nothing to do with the file system.



To complete an unfinished backup (make all those nasty linking and compressing and so on), use storeBackupUpdateBackup.pl, see section 5.3. It also will analyse your backups (below "backupDir") and find the right order to complete them. *After running* storeBackupUpdateBackup.pl *successfully your backups will be in the same state as if you ran your backup without option lateLinks.* Among some others, file `.storeBackupLinks/linkFile.bz2` is deleted and everything is hard linked (and compressed), also the permissions are set like in the source directory (except if set option ignorePerms in storeBackup.pl).
If you use option lateLinks, your should run storeBackupUpdateBackup.pl regularly, eg. every night and check if there were some ERROR messages.
Summary:

- An unfinished backup is a backup that was made with lateLinks and that has not yet been finished via storeBackupUpdateBackup.pl.
- You are cannot make a new full backup (that is, a backup without using lateLinks) when this new backup refers to a prior unfinished backup. This is simply because you cannot hard link to files which are not there.
- When using storeBackup.pl or storeBackupDel.pl, you cannot delete earlier backups to which an unfinished backup refers. (You could circumvent this using rm to delete, but that is inappropriate and not recommended.)

6.6 special files generated and used by storeBackup

Never change the files described below. They are absolutely important for storeBackup to work properly!

[11]see section 5.2, option otherBackupDirs to see how this can be configured

Inside a backup, the following entries are always created. Don't delete them. Also make sure you do not have these in the top level directory of your source tree:

`.md5CheckSums.info` This file contains meta information about the backup. Example (I cut some lines for better readability):

```
version=1.3
date=2008.09.06 10.23.33
sourceDir='/home/hjc'
followLinks=0
compress='bzip2'
uncompress='bzip2' '-d'
postfix='.bz2'
exceptSuffix='\.bz2' '\.gif' '\.gpg' '\.gz' '\.jpg' '\.mp3' '\.mpeg' '\.mpg' '\.ogg'
exceptDirs='/home/hjc/Mail' '/home/hjc/Maildir' '/home/hjc/nosave' '/home/hjc/tmp'
includeDirs=
exceptRule='$size > &::SIZE("100M")'
includeRule=
exceptTypes=
preservePerms=yes
lateLinks=yes
lateCompress=yes
cpIsGnu=yes
```

`.md5CheckSums[.bz2]` This file contains all information about the files, directories, ... in the backup. A few lines selected as an example:

```
# contents/md5 compr dev-inode inodeBackup ctime mtime atime size uid
gid mode filename
dir 0 2097-386 0 1169342164 1094800914 1200948038 0 1049 100 493 c++
063e5feb114a82059e7f44c5fb0e548c c 2097-1834 1372638 1169343033 1078512595 1125554314 489786 1049 1001 384 mbox
symlink 0 2097-31105 0 1169350675 1169350675 1169350675 0 1049 0 0 .Xresources
```

The permissions (mode) are stored as decimal values (not octal)!

`.storeBackupLinks` A directory which is empty if all links are set.

These files may be in the root of your backup directory:

`.md5CheckSums.notFinished` The existence of this file indicates, that this backup was not properly finished.

`.storeBackup.log[.bz2]` The log file of storeBackup.pl. This is the default name, which you can change using the options of storeBackup.pl. (Options logInBackupDir and compressLogInBackupDir)

`.storeBackup.notSaved.bz2` If you exclude files with rules, you can generate a list of files (via option writeExcludeLog of storeBackup.pl) which are *not* stored in the backup.

The following file only exist if you use option lateLinks, see section 6.5. After a successful run of storeBackupUpdateBackup.pl, see section 5.3, these files are deleted:

`.storeBackupLinks/linkFile.bz2` Contains (parts) of the information what has to be done by storeBackupUpdateBackup.pl (beside file `.md5CheckSums[.bz2]`).

`.storeBackupLinks/linkTo` Contains relative paths to the backups where `linkFile.bz2` refers to, eg:

```
../2008.09.05_16.07.23
../../lotte/2008.09.06_02.00.04
```

Here you see a relative path to a previous backup and a link to a backup in another backup series.

`.storeBackupLinks/linkFrom<number>` Each file contains relative paths *from* backups to the actual one. Example:

```
../2008.09.06_10.23.33
```

6.7 configuring NFS

Let's assume, that your server, where you want to write your backup via NFS is called 'nfsserver' and the path to the backup is /storeBackup. You then can use the following entry in `/etc/exports` on `nfsserver` (example with GNU/Linux, can differ on other Unix like operating systems):

```
/storeBackup 192.168.1.0/24(async,rw,no_root_squash)
```

`192.168.1.0/24` means, that access from any ip address beginning with `192.168.1` is allowed.
You should run
`# exportfs -a`
to make your entry visible to NFS. With
`# exportfs -v`
you can see how NFS is configured.
You probably have to change the ip address and the mask to your needs. Using `no_root_squash` is important for the client root user to have root permissions on the mounted file system. Use `async` to get a much better write performance (see `man mount` for further explanations).
In /etc/fstab on the NFS client (where you run storeBackup) you should configure a line like

```
nfsserver:/storeBackup /backup nfs user,exec,async,noatime 1 1
```

This will mount the file system `/storeBackup` of `nfsserver` to `/backup` on your client. This will occur if you boot or if you type:
`# mount /backup`
on the NFS client.
There are my other option with NFS. This short description only tries to give some helpful hints, not to explain NFS.

read or write access?

You probably want write access for storeBackup.pl but only read access for the users. There are at least to ways to achieve this:

1. Mount the specific NFS directory for the backup (eg. `/backup` read only. In the configuration file for storeBackup, use:

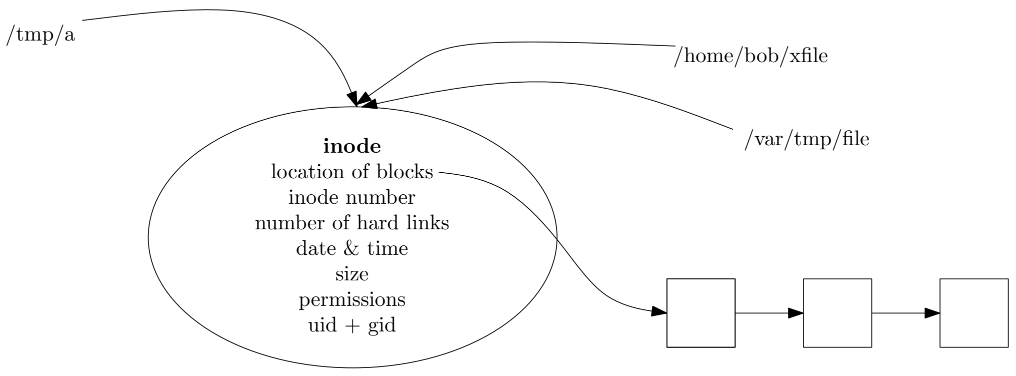
   ```
   precommand = mount /backup -o remount,rw
   postcommand = mount /backup -o remount,ro
   ```

   This will give storeBackup.pl write access (rw = read write) during the backup. Naturally, you can also wrap a script around storeBackup.pl what does the same.

2. Simply arrange two mount points to the NFS server: one rw and one ro. Limit access to the read only (ro) mount to root. You can also mount the mount points for storeBackup.pl only for the time during the backup. You can use storeBackupMount.pl, see section 5.9 for this.

6.8 what's an inode

In Unix like system, the central element of a file system entry is an inode (index node):



This inode contains several meta information and the location of that file on the disk (that part of the picture does absolutely not reflect the real situation).
In the figure above, you see three hard links ("file names") for this inode, so the number of hard links to this inode would be 3. We can see this with `ls -li`:

```
$ ls -li /tmp/a /home/bob/xfile /var/tmp/file
114693 -rw-r--r-- 3 hjc hjc 5 Sep 6 13:55 /tmp/a
114693 -rw-r--r-- 3 hjc hjc 5 Sep 6 13:55 /home/bob/xfile
114693 -rw-r--r-- 3 hjc hjc 5 Sep 6 13:55 /var/tmp/file
```

The first digits form the inode number.
Naturally, all hard links to an inode must be in the same file systems. If the different directories in the example above are not in the same file system on your computer, than you cannot configure exactly that example. To create a hard link, on the shell you have to use the command `ln`.
All these entries for that inode have the same permissions, gid and uid. See section 6.10, Limitations to understand what this means for storeBackup.

Btw., you cannot set a hard link to a directory because this could result in infinite loops. Nevertheless, a directory entries also use the feature of having multiple names for one inode: Take a look at the directory "name", "." and ".." (the last perhaps multiple times)!

6.9 Statistical Output of storeBackup.pl

After creating a new backup and possibly deleting old ones, storeBackup will write some statistical output:

`directories` Number of directories storeBackup found in the data source and created in the backup

`files` Number of files (more exactly number of links) storeBackup found in the data source. This includes all types of files storeBackup is able (or configured) to process.

`symbolic links` Number of symbolic links storeBackup found in the data source

`name pipes` Number of named pipes storeBackup found in the data source

`new internal linked files` Number of files with the same contents storeBackup found in the actual backup (not in an old backup) (this is checked first)

`old linked files` Number of files which exists in the previous backup with the same name, same size, same ctime and same mtime

`unchanged files` Number of files with the same contents storeBackup found in the old backup(s)

`copied files` Files with a new contents, copied to the backup directory

`compressed files` Files with a new contents, compressed into the backup directory

`excluded files because pattern` Files excluded because of option 'exceptPattern'

`included files because pattern` Files included because of option 'includePattern'

`max size of copy queue` Maximum size of copy queue during the backup

`max size of compress queue` Maximum size of compress queue during the backup

`calculated md5 sums` Number of files for which an md5 sum was calculated.

`forks total` Total number of forks (number of forks md5 + forks compress + forks copy + forks named pipes)

`forks md5` Number of forks for program md5sum.

`forks copy` Number of forks for program cp

`forks <compress>` Number of forks for program ¡compress¿

`sum of source` Size in bytes of all files in the source directory `sum of target all` Size in bytes of all files in the target directory

`sum of target new` Size in bytes of new copied or compressed files in the target directory

`sum of md5ed files` Size in bytes of all files for which an md5 sum was processed

`sum internal linked (copy)` Size of bytes of all files which were internal linked (see: new internal linked files). These files were linked to files which were copied into the backup.

`sum internal linked (compr)` Size in bytes of all files which were internal linked (see: new internal linked files). These files were linked to files which were stored compressed into the backup.

`sum old linked (copy)` Size in bytes of all files which were linked to older backups (see: old linked files). These files were linked to files which were copied into the backup.

`sum old linked (compr)` Size in bytes of all files which were linked to older backups (see: old linked files). These files were linked to files which were stored compressed into the backup.

`sum unchanged (copy)` Size in bytes of all files which existed with the same name, mtime and atime in the previous backup. These files were linked to files which were copied into the old backup.

`sum unchanged (compr)` Size in bytes of all files which existed with the same name, mtime and atime in the previous backup. These files were linked to files which were stored compressed into the old backup.

`sum new (copy)` Size in bytes of all files which were copied into the backup

`sum new (compr)` Size in bytes of all files which were stored compressed into the backup

`sum new (compr), orig size` Size in bytes in the source directory of the above files

`sum new / orig` Percentage of new files in the backup to their original size in the source directory

`size of md5CheckSum file` Size of the file ¡backupDir¿/.md5CheckSums[.bz2]

`size of temporary db files` Size of the db files generated during the backup in tmpdir

`deleted old backups` Number of old backups which were deleted.

`deleted directories` Number of directories deleted in old backups.

`deleted files` Number of files truly deleted in old backups (last link removed)

`(only) removed links` Number of links removed in old backups (files not deleted)

`freed space in old directories` Freed space in old directories, does not include meta information.

`add. used space in files` Additionally used space for this backup: difference between new allocated space and freed space in old backups.

`backup duration` Backup duration: time for precommand, backup, postcommand and deletion of old backups.

`over all files/sec (real time)` number of files divided by real time

`over all files/sec (CPU time)` number of files divided by (user and system time)

`CPU usage` average cpu time for the time period of "backup duration"

`PROGRESS 2009.05.09 10:16:43 22774 5000 files processed (324M, 152M) (340234099, 159903981)` storeBackup read 5000 files so far. The first number (324M or 340234099 bytes) is the total size of new files found on the source. The second number (152M or 159903981 bytes) is the space consumed in the backup destination by those new files. This size represents the files actually copied, the effects of compression to reduce the size, and the effects of linking to identical files already in the backup (so that additional spaced used is essentially near 0).

6.10 Limitations

- storeBackup can backup normal files, directories, symbolic links and named pipes. You can backup other file types only with option cpIsGnu (and if gnu cp is installed on your system).
- The permissions in the backup tree(s) are equal to the permissions in the original directory. Under special rare conditions it is possible, that a user cannot read one ore more of own his/her files in the backup because files are shared using hard links. With the restore tool – storeBackupRecover.pl – everything is restored with the original permissions.
- storeBackup uses hard links to save disk space. GNU/Linux with ext2 file system supports up to 32000, reiserfs up to 64535 hard links when you use a 32 bit operating system. If storeBackup needs more hard links, it will store a new (compressed) copy of the file. If you use ext2 for the backup, you have to reserve enough (static) inodes! (You will need one inode for each different file in the backup, *not* for every single hard link.)
- Changing the compression program is not supported up to now. In a backup ("backupDir") you should use the same compression program.

7 How to use storeBackup (Examples)

7.1 Some Information in the Beginning

Before explaining some examples, it's not too bad if you know what you are doing. Here are some important aspects about how storeBackup works: (The following explains the principle mechanisms, for performance reasons it's implemented a little bit different. There are several waiting queues, parallelisms and a tiny scheduler inside which are not described here.)

storeBackup uses at least two internal flat files in each generated backup:

`.md5CheckSums.info`	– general information about the backup
`.md5CheckSums[.bz2]`	– information about every file (dir, etc.) saved

When starting storeBackup.pl, it will basically do (beside some other things):

1. read the contents of the previous `.md5CheckSums[.bz2]` file and store it in two dbm databases: dbm(md5sum) and dbm(filename) (dbm(md5sum) means, that md5sum is the key). Default is to store these databases in memory.
2. read the contents of other `.md5CheckSums[.bz2]` files (otherBackupDirs) and store it to dbm(md5sum). Always store the last copied file in the dbm file if two different files (e.g. from different backup series) are identical. This assures, that multiple versions of the same file in different backups are unified in future backups.

- This item describes how storeBackup.pl works without sharing files from another backup series (simple backup), see example 1, section 7.2 and example 2, section 7.3.
  In a loop over all files to backup it will do:
  1. look into dbm(filename) — which contains all files from the previous backup — if the exact same file exists and has not changed. In this case, the needed information are the values of dbm(filename).
     If it existed in the previous backup(s), make a hard link and go to 3.)
  2. calculate the md5 sum of the file to backup look into dbm(md5sum) for that md5 sum
     if it exists there, make a hard link
     if it doesn't exist, copy or compress the file
  3. write the information of the new file to the corresponding .md5CheckSums[.bz2] file
- This item describes how storeBackup works with sharing of files from another backup series, see example 3, section 7.4 and example 4, section 7.5.
  In a loop over all files to backup it will do:

   1. look into dbm(filename) — which contains all files from the previous backup — if the exact same file exists and has not changed. In this case, the needed information are the values of dbm(filename).
      (Now, because there are independent backups, it is possible, that a file with the same contents exists in another backup series. So storeBackup.pl has to look into the dbm(md5sum) to ensure linking to the same file from all different backup series.)
   2. calculate the md5 sum of the file to backup if not known from step 1)
      look into dbm(md5sum) for that md5 sum
      if it exists there, make a hard link
      if it doesn't exist, copy or compress the file
   3. write the information of the new file to the corresponding .md5CheckSums[.bz2] file

- This item describes the usage of Option lateLinks, example 6, section 7.7 below
  If you save your backup via NFS to a server, then most of the time will be spent for setting hard links. Setting a hard link is very fast, but if you have many thousands of them it takes some time. You can avoid waiting for hard linking if you use the option lateLinks:

   1. make a backup with storeBackup and set `--lateLinks` (or set `lateLinks = yes`) in the configuration file. Then storeBackup will not generate any hard links, only a file will be written with the information what has to be linked.
   2. In a separate step, call storeBackupUpdateBackup to set all the required hard links to make full backups out of these incomplete backups. Please also see section 6.5, using option lateLinks for a more detailed explanation.

Conclusions:

1. Do not delete a backup to which the hard links are not yet generated. Use storeBackupUpdateBackup.pl to set the hard links and check consistency. It's a good idea to only use storeBackup.pl or storeBackupDel.pl for the deletion of old backups.
2. All sharing of data in the backups is done via hard links. This means:
   - A backup series cannot be split over different partitions.
   - If you want to share data between different backup series, all backups must reside on the same partition.
3. Every information of a backup in the .md5CheckSums is stored with relative paths. It does not matter if you change the absolute path to the backup or backup with a different machine (server makes backup from client via NFS — client makes backup to server via NFS).
   Unresolved hard links to to other backup series (via option lateLinks) are also stored with relative paths. This means: You can move backupDir around as you like, but you should never change the relative paths between backup series before resolving all the links with storeBackupUpdateBackup.pl.

If you have additional ideas or any questions, feel free to contact me (hjclaes(at)web.de).

It is a good idea to use a configuration file instead of command line options. Simply call:

```
# storeBackup.pl --generate <configFile>
```

Edit the configuration file and call storeBackup in the following way:

```
# storeBackup.pl -f <configFile>
```

You can override settings in the configuration file on the command line (see Example 6).

7.2 Example 1, very simple backup

This is a simple configuration with storeBackup using only the two required parameters (the source directory and the backup destination) and a single optional parameter, the name of a log file. This configuration will backup source tree `/home/jim` to `/backup`:

```
# storeBackup.pl --sourceDir /home/jim --backupDir /backup/jim --logFile /tmp/storeBackup.log
```

Option `--logFile` is optional and tells storeBackup to log into the file /tmp/storeBackup.log. Otherwise it would log to stdout.

The option "backupDir" is the destination – the external USB drive or other place your copied files will reside when the backup is finished. For more info, have a look at section 3, Quick Start. If you still have questions, review subsubsection 5.2.1, storeBackup.pl Options and specifically look at the –backupDir option.

7.3 Example 2, backup of multiple directories

For historical reasons, storeBackup.pl can only handle one source directory. But this drawback transforms to a feature when using option followLinks, because everything then becomes very easy and flexible.
You can also use the well known mechanism of includeDirs and exceptDirs well-established from other programs. But that is by way of comparison uncomfortable and nasty to handle.
To use lateLinks, execute the following steps (I assume, you will backup `/home/greg/important`, `/home/jim` and `/etc` to `/backup/stbu`. You can very easily change this later.). First of all, you make a special directory, eg. `/opt/stbu`. Let's also assume that you stored storeBackup at `/opt/storeBackup`:

```
# mkdir /opt/stbu
# cd /opt/stbu
# ln -s /opt/storeBackup storeBackup
# ln -s /home/jim home_jim
# ln -s /etc etc
# ln -s /home/greg/important home_greg_important
# ln -s . backup
```

With the first symbolic link we make sure, that storeBackup itself is part of the backup. So it's possible to restore it later with cp and then use storeBackupRecover.pl for the rest.
The last symbolic link is a trick to get an exact copy of `/opt/stbu` in the backup.
Now you should write a short script to start storeBackup.pl. Store it at `/opt/stbu/backup.sh`:

```
/opt/storeBackup/bin/storeBackup.pl -s /opt/stbu -b /backup/stbu \
    -S . -l /tmp/storeBackup.log --followLinks 1
```

Option `--followsLinks 1` tells storeBackup to use *the first level* of symbolic links exactly like directories. Therefore, you will find `home_jim` as a directory entry in your backup.
Finally, set the permissions of the script:

```
chmod 700 /opt/backup/backup.sh
```

Whenever you start this script, you will backup the wanted directories and your short script. You need to be root to have the required permissions to read the directories in this example. And naturally you need write permissions in `/backup/stbu`.
Now, you can simply change the directories to save or not to save by deleting or creating symbolic links in this directory.

7.4 Example 3, make a big backup once a week, a small every day

Now you will configure a big backup of the whole machine with exceptDirs and the small one of some special directories with option follow links. Naturally, you can also configure it the other way around, only use followLinks for both or use includeDirs.
Let's assume, you want to do:

1. your machine mounts from other servers directory `/net` which you don't want to backup

2. you also don't want to save `/tmp` and `/var/tmp`.

3. you want to backup the whole machine once a week to `/net/server/backup/weekly`
4. you want to backup `/home/jim` and `/home/tom/texts` to `/net/server/backup/daily` more quickly after you finished your work.
5. naturally, you want to share files between the two backup series
6. If you start both scripts at the same time, then new files will not be shared between these two. But over time, this will come together. But you should not start both backups at the same time when you start them for the very first time! In this case, all your files will *not* be shared!
7. You do not want to use option lateLinks, which would speed up your backups massively, because you cannot run scripts on the nfs server (or for whatever other reason).

To prepare the steps described above, you need to do the following:
For the daily backup, make a special directory (we use followLinks) like described in example 2 (you also stored storeBackup in `/opt/storeBackup` in this example):

```
# mkdir /opt/small-backup
# cd /opt/small-backup
# ln -s . small-backup
# ln -s /home/jim home_jim
# ln -s /home/tom/texts home_tom_texts
```

and write a backup script `byBackup.sh`:

```
#! /bin/sh
/opt/storeBackup/bin/storeBackup.pl -s /opt/small-backup
    -b /net/server/backup \
    -S daily -l /tmp/storeBackup.log --followLinks 1 0:weekly
```

Then write a script for the weekly backup:

```
#! /bin/sh
/opt/storeBackup/bin/storeBackup.pl -s / -b /net/server/backup -S weekly \
    -l /tmp/storeBackup.log --exceptDirs /net -e /tmp -e /var/tmp \
    -e /proc -e /sys -e /dev 0:daily
```

The "0" before the paths (like `0:daily`) means to take the last backup of the other backup series to check for identical files.
And — naturally — the directories `weekly` and `daily` must exist inside of `/net/server/backup` on the NFS server.
As you can see, using command line options begin to be a little bit confusing. When configuring such examples, you should try to generate a configuration file with `storeBackup.pl -g` *configFile* and to use that instead.

7.5 Example 4, backup from different machines, share data

This example shows how to make backups from different machines (not coordinated) and to share the data with hard links.
Imagine, you have defined the following boundary conditions:

1. you have a server called "server" with a separate disk which is mounted at `/disk1` to `/disk1/server`
2. you want to backup machine "client1" which mounts disk1 of the server at `/net/server/disk1` to `/net/server/disk1` and shall save to `client1` in that directory.
3. you want to backup machine "client2" which mounts disk1 of the server at `/net/server/disk1` to `/net/server/disk1` and shall save to `client2` in that directory.
4. the backup of the server runs nightly, independent of the other backups
5. the backups of the clients run uncoordinated, that means perhaps at the same time
6. you want to share all the data in the backup

7. you can also make small backups of parts of the source (with data sharing), but that's the same mechanism and not detailed in this example

8. If you have a client / server architecture like this, it's a good idea to use option lateLinks if you want to speed up. Example 6 explains how to use it.

Write the following script for the server:

```
#! /bin/sh
<PATH>storeBackup.pl -s / -b /disk1 -S server -l /tmp/storeBackup.log \
    -e /tmp -e /var/tmp -e /disk1 -e /sys -e /dev -e /proc 0:client1 0:client2
```

Write the following script for client 1:

```
#! /bin/sh
<PATH>/storeBackup.pl -s / -b /net/server/disk1 -S client1 \
    -l /tmp/storeBackup.log -e /tmp -e /var/tmp -e /disk1 -e /sys -e /dev \
    -e /proc 0:client1 0:client2
```

Write the following script for client 2:

```
#! /bin/sh
<PATH>/storeBackup.pl -s / -b /net/server/disk1 -S client2 \
    -l /tmp/storeBackup.log -e /tmp -e /var/tmp -e /disk1 -e /sys -e /dev \
    -e /proc  0:server 0:client1
```

7.6 Example 5, different keepTimes for some directories

You can do this very easy and obvious with the following (from the previous examples) known trick. Lets say you want to keep your backup for 60 days and all files in the directory “notimportant” for only 7 days.
Simply make two backups, one with `--keepAll 60d` and exclude directory “notimportant”. Make the second backup with `--keepAll 7d` for the missing directory. Like described in Example 3, create a relationship between the backups. So, if you move or copy a file between “notimportant”’ and the rest of your saved directories, you will not use additional space for the file.

7.7 Example 6, using lateLinks

After reading the previous example, it should not be a problem for you to understand how to configure multiple source directories (see example 2) and how to configure cross linking between to backup (see examples 3 and 4). I now assume, that you generate a configuration file with

```
# storeBackup.pl -g stbu.conf
```

- Configure storeBackup to make a backup to you backup directory via NFS. You configure all options in the configuration file `stbu.conf` and you set among others:

  ```
  lateLinks = yes
  lateCompress = yes
  doNotDelete = yes
  ```

  If you have a high bandwidth, there is no need to set lateCompress to `yes`. Because of `doNotDelete = yes` you will not have to wait for the deletion of old backups.

- Make your backup(s). (Like always, the very first backup will be slow.) You do not have to do anything more from your client (NFS client) side.

- Start (via cron) on the server (NFS server = backup server):

  ```
  storeBackupUpdateBackup.pl -f stbu.conf -b <backupDirDir> \
         -l /tmp/stbuUpdate.log
  ```

Where you have to set `backupDirDir` in the command above to the same *location* you specified in the configuration file of storeBackup.pl. If it's the same path on the client and on the server, you don't have to overwrite it (you don't have to specify it on the command line of storeBackupUpdateBackup.pl). (You can read more about configuration files and command line options in section 6.1.)

- Start (via cron) on the server:

  ```
  storeBackupDel.pl -f <cf1> -b <backupDirDir> \
          --unset doNotDelete
  ```

  This will overwrite (unset) also the doNotDelete flag in the configuration file.

You can also make the very first backup with the lateLinks option set. Naturally, you have to run storeBackupUpdateBackup.pl to get a complete backup.

8 FAQ, Frequently asked Questions

1 I don't want to compress any file
2 Where is the GUI?
3 I do not need that lateLinks stuff
4 Making a remote Backup with SSH (no NFS)
5 I like this blocked file stuff and want to use it for all files bigger than 50 MB
6 How do I make a full backup of my GNU/Linux machine?

* * * * *

FAQ 1 I don't want to compress any file
I don't want to compress any file in the backup. How can I configure this?
When configuring storeBackup.pl, set option exceptSuffix to '.*', which is the pattern for "match everything".

* * * * *

FAQ 2 Where is the GUI?
Why doesn't storeBackup provide a GUI (graphical user interface)?
There are several reasons why storeBackup is command line driven:

- If it's possible, you should make your backups on a regular basis via an automatic mechanism, eg. via cron.
- If you run storeBackup on a server, there probably is no gui. Or think about the dependencies to different versions of gui libraries.
- If you want to restore data to a somehow corrupted system, perhaps the gui (if you had one running) does not start any more. Then it's fine to have a tool, which you can start from any command line or recovery CD. It also makes sense, to let storeBackup itself be part of the backup, see example 2.

* * * * *

FAQ 3 I do not need that lateLinks stuff
I only want to make my backup to an external usb drive and don't want to use this new option "lateLinks". How can I do this?
You don't have to concern yourself with this "highly sophisticated option" (or with storeBackupUpdateBackup.pl) if you do not use option lateLinks. Have a look at Example 1.

* * * * *

FAQ 4 Making a remote Backup with SSH (no NFS)
Under GNU/Linux, it is also possible to back up data over an SSH connection. This has the advantage that no separate network file system has to be configured (as it is the case for NFS).
In order to mount the target directory, the sshfs program has to be used. It is shipped with most distributions, but can also be obtained from http://fuse.sourceforge.net/sshfs.html[12].
The command to mount the remote directory /var/backup on the computer chronos as user "backup" to the target directory /mnt/target is:

```
# sshfs backup@chronos:/var/backup /mnt/target
```

Now storeBackup.pl only has to be configured to place the backup in `/mnt/target`. After the backup, the target directory can be unmounted with `fusermount -u /mnt/target`.

Speeding up a Remote Backup over SSHFS
sshfs uses an individual network request for each individual hardlink that has to be set and for each single file that has to be deleted. Since the latency for any network operation is generally several magnitudes larger than for any local operation, backing up to a remote system can therefore be very slow even if the network bandwith is as high as for a local harddisk.
For this reason, it is strongly recommended to use the lateLinks and doNotDelete options for remote backups. Their usage allows to perform the hardlinking and deletion operations on the remote system only and generally speeds up backups by a factor of 10 to 75, depending on the amount of changed data and the latency of the network.
The general procedure is as follows:

1. Mount remote system:

   ```
   # sshfs backup@chronos:/var/backup /mnt/target
   ```

2. Do the backup:

   ```
   # storeBackup.pl --backupDir /mnt/target --lateLinks \
        --doNotDelete [other options]
   ```

3. Unmount remote system:

   ```
   # fusermount -u /mnt/target
   ```

4. Set hardlinks on remote system:

   ```
   # ssh -T -l backup ebox.rath.org \
       'storeBackupUpdateBackup.pl --backupDir /var/backup'
   ```

5. Delete old backups on remote system:

   ```
   # ssh -T -l backup chronos \
       "storeBackupDel.pl --backupDir /var/backup [other options]"
   ```

Note that this requires that storeBackup is also installed on the remote system.

* * * * *

FAQ 5 I like this blocked file stuff and want to use it for all files bigger than 50 MB
To archive the desired result, simply set:

```
checkBlocksSuffix = .*
checkBlocksMinSize = 50M
```

This configuration will use blocked files for all file with a size of 50 megabyte or more. If you want another size than 50 megabyte, eg. 800 kilobyte, set the value of `checkBlocksMinSize` to 800k.

Explanation for the experts: storeBackup.pl will generate an internal rule from the configuration above:

[12] http://fuse.sourceforge.net/sshfs.html

```
'$file =~ /.*$/' and '$size >= 52428800'
```

You can also directly use the following rule:

```
'$size >= &::SIZE("50M")'
```

to get the same result.

* * * * *

FAQ 6 How do I make a full backup of my GNU/Linux machine?

First of all, generate a configuration file:

```
storeBackup.pl -g completeLinux.conf
```

Open the configuration file with an editor of your choice and edit the following parameters:

```
sourceDir = /
```

Set `sourceDir` to `/`, so the whole file system will be saved.

```
backupDir=/media/drive
```

Here, I assume your attached hard disk for the backup uses path `/media/drive`. You have to change this if it's mounted elsewhere. Naturally, you also can save your backups eg. on an nfs mount. If you do so, you can find an explanation how to a remote file system via nfs in section 6.7. If you make a backup via nfs, you should read section 6.5.

Next, configure the directories you do not want to backup. We have to include `backupDir` in this list to avoid recursion.

```
exceptDirs= tmp var/tmp proc sys media
```

If there a other directories you do not want to save (eg. nfs mounted home directories), include them into this list.

Now let's say you also want to exclude the contents of all other directories called `tmp` or `temp` (upper or lower case) anywhere in the file system. So add:

```
exceptRule= '$file =~ m#/te?mp/#i'
```

To avoid cached files, add all directories with `cache` in their names (upper or lower case) to that list. Change the line above to:

```
exceptRule= '$file =~ m#/te?mp/#i' or '$file =~ m#cache.*/#i'
```

But now there have the risk, that perhaps some important files are not saved because the are stored in a directory called `/tmp/`, `/temp/` or a directory with eg. `Cache` in its name.
So write all files excluded because of rule `exceptRule` in a file to check these names after the backup:

```
writeExcludeLog=yes
```

In every backup, there will be a file called `.storeBackup.notSaved.bz2` listing all these files.
To copy all file types, expecially block and character devices in `/dev`, set:

```
cpIsGnu=yes
```

For making a full backup, you also have to store the boot sector. The following script assumes your system boots from drive sda. You may need to change this value to match your system. Make the directory `/backup` and locate the following script (`pre.sh`) in that directory:

```
#! /bin/sh

rm -f /backup/MBR.prior
mv /backup/MBR.copy /backup/MBR.prior
# copy the boot loader
dd if=/dev/sda of=/backup/MBR.copy bs=512 count=1 > /dev/null 2>&1

# copy back with:
# dd if=/backup/MBR.copy of=/dev/sda bs=512 count=1
```

Set the permissions:

```
chmod 755 /backup/pre.sh
```

To call the script, set `precommand` in the configuration file:

```
precommand = /backup/pre.sh
```

To see that something is happening during the backup, set:

```
progressReport = 2000
printDepth = yes
```

Look at the `keep*` option and set the appropriate values and set `logFile` to a useful value for you.
Also set the other options to values that fit to your need.

As always, the first backup will take some time because of calculating all the md5 sums and especially because of file compression. The next backups will be much faster.
After making your backup, you should control which files were *not* in the backup because of option `exceptRule`.

9 Contributors

Thanks to all people who shared their ideas with me, sent me bug reports and were patient enough to evolve storeBackup to what it is.
I like to list especially

- Francesco Potorti who helped a lot in bug fixing in parts of version 1.x
- Arthur Korn for lots of discussions and his support in Debian.
- Nikolaus Rath (Nikolaus at rath.org) who made substantial contributions to version 2 and rewoke my interest in continuing the development storeBackup
- W. David Shields, ViewMachine Corporation, Florida, USA, (dave at viewmachine.com) who enhanced the documentation and found many bugs during the testing phases of version 3.

This should not neglect all the others who helped me.

10 Change Log

```
----------------------------
version 1.0
first official release

----------------------------
version 1.1      2002.05.18
statistical output 'over all files/sec' was unclear
changed to:
over all files/sec (real time) =
 over all files/sec (CPU time) =
                     CPU usage =

versions are now (overall checksum):
storeBackup.pl -V         => 1.3461
storeBackupls.pl -V       => 1.2583
storeBackupVersions.pl -V => 1.4313
storeBackupRecover.pl -V  => 1.4992

----------------------------
version 1.2      2002.05.19
storeBackup.pl:
with option --exceptDirs you can also use wildcards
```

```
added option --contExceptDirsErr

storeBackupRecover.pl:
if you extract a directory (eg. abc) and there exists another
directory with a name with the same beginning (eg. abcd), this
one will also be extracted -> corrected

versions are now (overall checksum):
storeBackup.pl -V         => 1.3471
storeBackupls.pl -V       => 1.2583
storeBackupVersions.pl -V => 1.4313
storeBackupRecover.pl -V  => 1.5145

----------------------------
version 1.3      2002.05.22
all programs:
the usage of the programms with sensless list parameters
(like *.h) was ignored -- now an error message is produced

storeBackupVersions.pl:
improved performance, checks same inodes before calculating
md5 sums

storeBackup.pl:
when the time for backup was < 1 sec, a division by zero could happen
(thanks to Joerg Paysen for the report)
added --keepMinNumberAfterLastOfDay (instead of replacing --keepMinNumber)

versions are now (overall checksum):
storeBackup.pl -V         => 1.3491
storeBackupls.pl -V       => 1.2583
storeBackupVersions.pl -V => 1.4483
storeBackupRecover.pl -V  => 1.5159

----------------------------
version 1.4      2002.05.27
all programs:
support recovering of hard links in the source tree of storeBackup.pl

storeBackupRecover.pl
fixed some little bugs introduced in version 1.2

storeBackupConvertBackup.pl
new program to convert old backup directories (target) to the new
format of .md5CheckSums[.bz2]
YOU HAVE TO CALL IT, IF YOU WANT TO USE VERSION 1.4 WITH OLD BACKUPS!

versions are now (overall checksum):
storeBackup.pl -V              => 1.3568
storeBackupls.pl -V            => 1.2583
storeBackupVersions.pl -V      => 1.4775
storeBackupRecover.pl -V       => 1.4073
storeBackupConvertBackup.pl -V => 1.9776

----------------------------
version 1.5      2002.05.28
storeBackup.pl
better statistics about freed/used space on disk

versions are now (overall checksum):
storeBackup.pl -V              => 1.3606
storeBackupls.pl -V            => 1.2583
```

```
storeBackupVersions.pl -V      => 1.4775
storeBackupRecover.pl -V       => 1.4073
storeBackupConvertBackup.pl -V => 1.9776

----------------------------
version 1.6      2002.06.10
storeBackupVersions.pl
added flags:
--showAll (same as all below)
--size (shows size of found files)
--uid (show also uid of source file)
--gid (show also gid of source file)
--mode (show also mode of source file)
--ctime (show also creation time of source file)
--mtime (show also modify time of source file)
storeBackup.pl
added weekday to INFO output in log file when deleting old dir
via parameter --keepOnlyLastOfDay
ROADMAP is actualized

versions are now (overall checksum):
storeBackup.pl -V              => 1.3617
storeBackupls.pl -V            => 1.2583
storeBackupVersions.pl -V      => 1.4401
storeBackupRecover.pl -V       => 1.4073
storeBackupConvertBackup.pl -V => 1.9776

----------------------------
version 1.7      2002.07.2
storeBackup.pl
added flag --ignoreReadError
added flags --file, --generate, --print: you can now use a
configuration file instead of putting all in command line options

versions are now (overall checksum):
storeBackup.pl -V              => 1.2871
storeBackupls.pl -V            => 1.2972
storeBackupVersions.pl -V      => 1.3795
storeBackupRecover.pl -V       => 1.3280
storeBackupConvertBackup.pl -V => 2.0308

----------------------------
version 1.8      2002.08.17
storeBackupConvertBackup.pl
updated program to convert old backup directories (target) to the new
format of .md5CheckSums[.bz2] and .md5CheckSums.info
YOU HAVE TO CALL IT, IF YOU WANT TO USE VERSION 1.7 WITH OLD BACKUPS!
see file bin/_ATTENTION_ for detailed information

storeBackupls.pl
added option -v for verbose information

storeBackup.pl
- correction of minor errors
- added list parameter(s) otherBackupDirs
  allows you to hard link to older trees from the same backup
  allows you to hard link to backup trees of another backup series
  This gives you the possiblity to share data via hard link between
  independent backups. See README file for more information (search
  for 'otherBackupDirs').

storeBackupVersion.pl + storeBackupRecover.pl
```

```
- compatible with new file format

----------------------------
version 1.8.1    2002.08.19
Error fixing:
storeBackup.pl
- didn't build dbm(filename) correctly when first backup with
  otherBackupDirs
- pattern for recognizing of relative part of backup path did not
  work with some strange path names, pattern replaced with substr
  and length
- if the directory to backup was empty, then no .md5CheckSum.bz2
  was created

----------------------------
version 1.9      2002.08.26
storeBackup.pl
- new option --chmodMD5File
- total internal replacement for handling --onlyMD5Check
  is now handled in ::buildDBMs -> nearly as fast as without
  --onlyMD5Check
- new option --printDepth
- options --onlyMD5Check and --onlyMD5CheckOn are now only needed
  if hard linking with other backups (see otherBackupDirs)

----------------------------
version 1.9.1    2002.08.31
storeBackup.pl
- performance improvement when copying small files (< 100KB)
- error fix: --onlyMD5Check was not as fast as described in v1.9
  du to an error when making the package (but fortunately the
  correct version was in my backup)

versions are now (overall checksum):
storeBackup.pl -V              => 1.3138
storeBackupls.pl -V            => 1.2626
storeBackupVersions.pl -V      => 1.4091
storeBackupRecover.pl -V       => 1.3454
storeBackupConvertBackup.pl -V => 2.0844

----------------------------
version 1.10  2002.10.20
storeBackup.pl
- options --onlyMD5Check and --onlyMD5CheckOn are now obsolete
  storeBackup decides itself, if the functionality is needed
- you do not have to worry when using 'otherBackupDirs' if it's not
  yet ready. this is recognized automatically
- added options --withUserGroupStat --userGroupStatFile

versions are now (overall checksum):
storeBackup.pl -V              => 1.3325
storeBackupls.pl -V            => 1.2966
storeBackupVersions.pl -V      => 1.4295
storeBackupRecover.pl -V       => 1.3709
storeBackupConvertBackup.pl -V => 2.0844

----------------------------
version 1.10.1  2002.10.27
storeBackup.pl + storeBackupRecover.pl
- replaced syscall lchown with fork-exec chown
  because of error messages with perl 5.8 (SuSE 8.1)
```

```
versions are now (overall checksum):
storeBackup.pl -V              => 1.3334
storeBackupls.pl -V            => 1.2966
storeBackupVersions.pl -V      => 1.4295
storeBackupRecover.pl -V       => 1.3722
storeBackupConvertBackup.pl -V => 2.0844

----------------------------
version 1.11  2003.03.05
storeBackup.pl
- --exceptSuffix: removed '.bmp', added '.pgp'
- changed default of parameter --logFile
- new parameters:
  --plusLogStdout, --saveLogs, --compressWith,
  --logInBackupDir, --compressLogInBackupDir,
  --logInBackupDirFileName
- if called with parameter -f ... --print then
  evaluation of wildcards is performed
- correction of litte faults

versions are now (overall checksum):
storeBackup.pl -V              => 1.3435
storeBackupls.pl -V            => 1.3152
storeBackupVersions.pl -V      => 1.4406
storeBackupRecover.pl -V       => 1.3862
storeBackupConvertBackup.pl -V => 2.0844

----------------------------
version 1.12  2003.04.16
storeBackup.pl
- exception list was not taken into account when checking
  collisions from options of -t and -s
- added parameter --copyBWLimit (uses rsync for copying)
- in some cases internal linkage of duplicated files did not
  work properly
- added parameter --postcommand
- added statistical output for used length of queues

versions are now (overall checksum):
storeBackup.pl -V              => 1.3537
storeBackupls.pl -V            => 1.3322
storeBackupVersions.pl -V      => 1.4518
storeBackupRecover.pl -V       => 1.4001
storeBackupConvertBackup.pl -V => 2.0844
llt -V                         => 1.4294
multitail.pl -V                => 1.4555

----------------------------
version 1.12.1  2003.05.01
storeBackup.pl
- When copying files < 100 KB into the backup, owner and permissions
  were not set correctly. When hard linking in the next backup, this
  was corrected. -> Error fixed
- When problems with forking cp or the compression program occured,
  this was not handled correctly.

versions are now (overall checksum):
storeBackup.pl -V              => 1.3545
storeBackupls.pl -V            => 1.3322
storeBackupVersions.pl -V      => 1.4518
storeBackupRecover.pl -V       => 1.4001
storeBackupConvertBackup.pl -V => 2.0844
```

```
llt -V                         => 1.4294
multitail.pl -V                => 1.4555

----------------------------
version 1.12.2  2003.05.18
storeBackup.pl
- When copying files < 100 KB into the backup, sometimes the
  storeBackup internal scheduler slows down the backup -> fixed
- Files with size zero where not handled correctly -> fixed
- Some complicated if cases where not covered -> fixed
- better internal documentation
- granularity of the internal scheduler is now finer, prog should be
  about 5% faster
- added /etc/cron.daily/storebackup from Arthur Korn for Debian users

versions are now (overall checksum):
storeBackup.pl -V              => 1.3554
storeBackupls.pl -V            => 1.3322
storeBackupVersions.pl -V      => 1.4518
storeBackupRecover.pl -V       => 1.4001
storeBackupConvertBackup.pl -V => 2.0844
llt -V                         => 1.4294
multitail.pl -V                => 1.4555

----------------------------
version 1.13  2003.07.28
        - BSD is now supported
storeBackup.pl
- Many new options for managing old backups. New/changed parameters:
  --noDelete changed to --doNotDelete
  --keepAll can now handle the 'archive flag'
  --keepWeekDay can now handle the 'archive flag'
  --keepFirstOfYear is new
  --keepLastOfYear is new
  --keepFirstOfMonth is new
  --keepLastOfMonth is new
  --firstDayOfWeek is new
  --keepFirstOfWeek is new
  --keepLastOfWeek is new
  --keepOnlyLastOfDay changed to --keepDuplicate
  --keepMaxNumber is new
  --keepMinNumberAfterLastOfDay has gone
- Correct error message if you do not have permission to read a
  file (not being root).
- Option --exceptDirs only worked correct when storeBackup was
  started in the source directory (sourceDir)
storeBackupDel.pl
- new programm to only delete old backups with the flags described
  above at storeBackup.pl

versions are now (overall checksum):
storeBackup.pl -V              => 1.3664
storeBackupls.pl -V            => 1.3509
storeBackupVersions.pl -V      => 1.3765
storeBackupRecover.pl -V       => 1.4154
storeBackupConvertBackup.pl -V => 2.0844
storeBackupDel.pl -V           => 1.3606
llt -V                         => 1.2222
multitail.pl -V                => 1.4555

----------------------------
version 1.14  2003.08.26
```

```
storeBackup.pl
- most parts of the statistical output were twice when one ore more
  old backups were deleted
- now runs on AIX
- checks, if series has write permissions (better error message)
- replace statistic message:
  additional used space
  with
  add. used space in files
storeBackupDel.pl
- can use the config file of storeBackup.pl to operate
storeBackupls.pl
- can use the config file of storeBackup.pl to show analysis of
  livetime of old backups

versions are now (overall checksum):
storeBackup.pl -V              => 1.2993
storeBackupls.pl -V            => 1.2102
storeBackupVersions.pl -V      => 1.2949
storeBackupRecover.pl -V       => 1.3134
storeBackupConvertBackup.pl -V => 2.0844
storeBackupDel.pl -V           => 1.2795
llt -V                         => 1.2222
multitail.pl -V                => 1.4555

----------------------------
version 1.14.1  2003.10.25
storeBackup.pl (fixed)
- in some cases, setuid and setgid were not stored in the backup
- depending on the kernel version, permissions in the backup were
  not set correctly
storeBackupRecover.pl (fixed)
- depending on the kernel version, permissions in the backup were
  not set correctly

versions are now (overall checksum):
storeBackup.pl -V              => 1.3001
storeBackupls.pl -V            => 1.2102
storeBackupVersions.pl -V      => 1.2949
storeBackupRecover.pl -V       => 1.3147
storeBackupConvertBackup.pl -V => 2.0844
storeBackupDel.pl -V           => 1.2795
llt -V                         => 1.2222
multitail.pl -V                => 1.4555

----------------------------
version 1.15    2004.02.06
storeBackup.pl
- otherBackupDirs now understands 'from-to' and 'all'
--includeDirs is new
--exceptPattern is new
--includePattern is new
--resetAtime (in the source directory) is new
  - sets atime and mtime in the backup to the same values as in
    the source directory

deleting of old backups (storeBackup.pl, storeBackupls.pl,
                         storeBackupDel.pl)
- fixed bug with options --keepMinNumber and --keepMaxNumber
- set default value of --keepDuplicate to 7d
- result of checking old log files is now write to logfile
  inside of backup (if wanted)
```

```
storeBackupRecover.pl
- restores atime and mtime when restoring backups

llt
- output now in format yyyy.mm.dd, no longer in german format

configuration file syntax
- allows now the use of single quotes

storeBackupMount.pl
- pings server, mounts file systems, calls storeBackup and
  umounts filesystems

versions are now (overall checksum):
(these values have changed dramatically because I switched from cvs to svn)
storeBackup.pl -V              => 157.8243
storeBackupls.pl -V            => 96.8069
storeBackupVersions.pl -V      => 138.2092
storeBackupRecover.pl -V       => 171.4032
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 153.4117
storeBackupMount.pl -V         => 129.1638
llt -V                         => 103.7589
multitail.pl -V                => 62.3245

----------------------------
version 1.15.1   2004.02.08
storeBackup.pl
- fixed a bug when reading the config file
  (affecting exceptPattern, includePattern)
- fixed a bug when using 'sourceDir = /' and exceptPattern
  or includePattern

versions are now (overall checksum):
storeBackup.pl -V              => 183.5295
storeBackupls.pl -V            => 143.9218
storeBackupVersions.pl -V      => 171.1896
storeBackupRecover.pl -V       => 212.6288
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 183.3940
storeBackupMount.pl -V         => 170.2637
llt -V                         => 104.0773
multitail.pl -V                => 116.9386

----------------------------
version 1.16      2004.02.25
storeBackup.pl
- added parameter --exceptTypes
- store data in dbm files with pack / unpack
- better handling if maximum number of hard links is exceeded
- precommand and postcommand now understand single quotes nested
  in double quotes in the commandline (like ...Pattern)
- storeBackup didn't store the uncompress command correctly since
  version 1.15. This means, that storeBackupRecover could not
  restore the original version. This is because of the missing
  option '-d' in file .md5CheckSums.info. Wrong version:
     uncompress=bzip2
  but must be
     uncompress=bzip2 -d
  Change this line with an editor or use the script correct.sh
```

```
storeBackupRecover.pl
- storeBackupConvertBackup.pl had a bug, so that storeBackupRecover
  did not work any more. storeBackupRecover is now able to
  handle converted backups (again).

versions are now (overall checksum):
storeBackup.pl -V              => 183.9252
storeBackupls.pl -V            => 144.0733
storeBackupVersions.pl -V      => 171.5950
storeBackupRecover.pl -V       => 213.5498
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 183.7625
storeBackupMount.pl -V         => 170.9166
llt -V                         => 104.0773
multitail.pl -V                => 116.9386

----------------------------
version 1.16.1    2004.03.07
storeBackup.pl
- better explanations in the configuration file
  and for command line options
- better error messages
- option --print did not work for some values
- fixed a bug in the module for reading the
  configuration file with keepWeekday
- when printing to a log file and to stdout
  simultaneously, a possible error message with exit
  is now also printed to stdout
- option verbose now has the same effekt as debug=1

versions are now (overall checksum):
storeBackup.pl -V              => 184.4928
storeBackupls.pl -V            => 144.6597
storeBackupVersions.pl -V      => 172.0055
storeBackupRecover.pl -V       => 214.0630
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 184.5203
storeBackupMount.pl -V         => 171.2973
llt -V                         => 104.0773
multitail.pl -V                => 117.4461

----------------------------
version 1.16.2    2004.04.04
storeBackup.pl
- exit status is now correct (0) when running successfully
- option --verbose now prints some additionally verbose messages
  it is not similar any more to --debug 1
- the log file written into the backup now contains the
  "delete old backupevaluation"
- unsupported file type didn't generate an error message
  instead, the blew up the backup -> corrected
- integer overrun in the statistical output when saving large
  amounts of data is corrected
storeBackup_du.pl added to the package
versions are now (overall checksum):
storeBackup.pl -V              => 184.6565
storeBackupls.pl -V            => 144.2247
storeBackupVersions.pl -V      => 172.0004
storeBackupRecover.pl -V       => 214.0566
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 184.5157
storeBackupMount.pl -V         => 171.2909
```

```
llt -V                          => 104.0773
multitail.pl -V                 => 116.9386

----------------------------
version 1.17      2004.09.04
storeBackup.pl
- reduced size of temporary berkeley db files
  this results in better caching (and therefore better performance
  for backups with many files)
- also print size of the berkely db files into the statistical output
- new option --unlockBeforeDel
- various little bug fixes (corrected comments and print outputs)
storeBackupMount.pl
- better exit status, distinguishes between errors in
  storeBackup und storeBackupMount
versions are now (overall checksum):
storeBackup.pl -V               => 184.9850
storeBackupls.pl -V             => 144.6790
storeBackupVersions.pl -V       => 173.1101
storeBackupRecover.pl -V        => 214.4541
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V            => 184.8048
storeBackupMount.pl -V          => 171.8483
storeBackup_du.pl -V            =>  73.0682
llt -V                          => 104.0773
multitail.pl -V                 => 118.2667

----------------------------
version 1.18      2004.06.03
storeBackup.pl
- minor corrections to statistical output
- fixed a bug with options --includePattern and --exceptPattern:
  There had to be brackets around a logical expression.
storeBackupRecover.pl
- restoring of directories with a round bracket in the name did not
  work sometimes, fixed
versions are now (overall checksum):
storeBackup.pl -V               => 185.0688
storeBackupls.pl -V             => 144.6790
storeBackupVersions.pl -V       => 173.1101
storeBackupRecover.pl -V        => 215.1446
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V            => 184.8048
storeBackupMount.pl -V          => 171.8483
storeBackup_du.pl -V            =>  73.0682
llt -V                          => 104.0773
multitail.pl -V                 => 118.2667

----------------------------
version 1.18.1    2004.06.08
storeBackup.pl
- fixed a silly bug which occured one did not use option progressReport
versions are now (overall checksum):
storeBackup.pl -V               => 185.1527
storeBackupls.pl -V             => 144.6790
storeBackupVersions.pl -V       => 173.1101
storeBackupRecover.pl -V        => 215.1446
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V            => 184.8048
storeBackupMount.pl -V          => 171.8483
storeBackup_du.pl -V            =>  73.0682
llt -V                          => 104.0773
```

```
multitail.pl -V                => 118.2667

----------------------------
version 1.18.2    2004.06.26
storeBackup.pl
- storeBackup calculated too much md5 sums, corrected
- storeBackup had a dependency with perl versions >= 5.8,
  now it does not depend on this new version any more
versions are now (overall checksum):
storeBackup.pl -V              => 185.4812
storeBackupls.pl -V            => 145.1333
storeBackupVersions.pl -V      => 173.1101
storeBackupRecover.pl -V       => 215.5421
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 185.0938
storeBackupMount.pl -V         => 171.8483
storeBackup_du.pl -V           =>  73.0682
llt -V                         => 104.0773
multitail.pl -V                => 118.2667

----------------------------
version 1.18.3    2004.07.06
storeBackup.pl
- much better performance when used with exceptPattern or
  includePattern
storeBackupls.pl
- if used with option -f, default is to read the the location
  of the backup from the configuration file
  this default can be overwritten (if you have different mount
  points)
versions are now (overall checksum):
storeBackup.pl -V              => 185.8650
storeBackupls.pl -V            => 173.5429
storeBackupVersions.pl -V      => 173.9271
storeBackupRecover.pl -V       => 216.1658
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 185.5475
storeBackupMount.pl -V         => 172.4720
storeBackup_du.pl -V           =>  73.0682
llt -V                         => 104.0773
multitail.pl -V                => 118.2667

----------------------------
version 1.18.4    2004.07.11
storeBackup.pl
- (much) better performance because of reducing the number of
  md5sum calls when using otherBackupDirs
- the very first backup of a backup series did not hard link
  to another backup series defined with otherBackupDirs
- some temporary files were not deleted
versions are now (overall checksum):
storeBackup.pl -V              => 186.1958
storeBackupls.pl -V            => 173.9472
storeBackupVersions.pl -V      => 174.1391
storeBackupRecover.pl -V       => 216.4308
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 185.7402
storeBackupMount.pl -V         => 172.4720
storeBackup_du.pl -V           =>  73.0682
llt -V                         => 104.0773
multitail.pl -V                => 118.2667
```

```
----------------------------
version 1.19 2005.08.05
storeBackup.pl
- in some rare cases filenames were stored with a leading slash
  in .md5CheckSum. I could not be simulated by me. But the bug
  should be fixed.
- some fixes in handling of directory paths
- uid and gid were not set correctly for symbolic links in the
  backups (in the files, not the description of the files)
- formatting of file sizes with human readable number (eg. 3.5k)
  didn't work properly in all cases
- check for symbolic links before opening temporary files
- set permissions of backup root directory to 0755
  (independent of umask)
storeBackupRecover.pl
- could not restore directory '.' with option -r
- uid and gid were not set correctly for symbolic links when
  restoring, instead they were changed in the file where the
  symlink pointed to
versions are now (overall checksum):
storeBackup.pl -V              => 186.1958
storeBackupls.pl -V            => 173.9472
storeBackupVersions.pl -V      => 174.1391
storeBackupRecover.pl -V       => 216.4308
storeBackupConvertBackup.pl -V => 178.6868
storeBackupDel.pl -V           => 185.7402
storeBackupMount.pl -V         => 172.4720
storeBackup_du.pl -V           =>  73.0682
llt -V                         => 107.5789
multitail.pl -V                => 118.2667


- changed max args for GNU/Linux to 64*1024 because of
         possible problems when using multibyte character sets

----------------------------
version 1.19.1 2005.10.08
storeBackup.pl
- reduced the lenght of the command line because of problems
  with dual byte characters
- all temporary file names now have a 64 bit random number
  all (randomly generated) file names are checked for existence
  before used

----------------------------
version 1.19.2  2005.11.13
        storeBackup.pl
- when saving with --sourceDir / without using --includeDirs then
  storeBackup calculated useless md5sums

----------------------------
----------------------------
version 2.0  2008.11.09
        all programs:
- changed licence to gpl-3
- backup format is compatible to version 1.19,
  options *have changed*
- fixed several bugs
- introduction of lateLinks (this is the major change)
  - new options lateLinks, lateCompress
- new module for interpreting command line arguments and
  configuration file: a combination is now possible
```

```
- better support for files > 2GB on 64 bit operating systems
storeBackup.pl, storeBackupDel.pl:
- arguments in command line can overwrite configuration file
- new option keepRelative
- new option deleteNotFinishedDirs
storeBackup.pl:
- rewrite of core engine
- changed algorithm for linking with old backups
- directories specified with exceptDirs will now be created
  as empty directories
- new option ignorePerms
- new option cpIsGnu (support for special files)
- new option saveRAM (default is now to hold temp. DBs in RAM)
- removal of option exceptDirsSep
- renamed option withTime to suppressTime
- renamed option compressMD5File to doNotCompressMD5File
- exceptPattern has gone, now there is exceptRule (different syntax)
- includePattern has gone, now there is includeRule (different syntax)
- new option writeExcludeLog
- setting time on (absolute) symbolic link resulted in setting time
  in the original file -> corrected
storeBackupUpdateBackup.pl
- new program
- sets links asynchronously after running storeBackup with lateLinks
storeBackupSearch.pl
- new program
- allows searching in backups with a free definition depending on
  filename, size, uid, gid, ctime, mtime and file type

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version 3.0  2009.03.15
- support of ';' as comment sign in configuration files
  (additionally to '#' for better readability)
storeBackupCheckBackup.pl
- new program, checks consistency of a backup
storeBackupDel.pl:
- option keepLastOfWeek wasn't recognized when set in
  configuration file
storeBackup.pl:
- new options for saving files blocked:
  checkBlocksSuffix
  checkBlocksSuffixMinSize
  checkBlocksSuffixBS
  checkBlocksCompr
- new options for saving files blocked:
  checkBlocksRule (0-4)
  checkBlocksBS (0-4)
  checkBlocksCompr (0-4)
  checkBlocksRead (0-4)
- new options for saving devices blocked:
  checkDevices (0-4)
  checkDevicesDir (0-4)
  checkDevicesBS (0-4)
  checkDevicesCompr (0-4)
- new option to hard link symbolic links:
  linkSymlinks
- new option for defining which files to compress:
  comprRule

----------------------------
version 3.1  2009.05.24
```

```
storeBackup.pl
- storeBackup did not backup sockets, now it does
- for new files, the md5 sum is now calculated before *and*
  after copying / compressing for safety reasons. The file could
  have been changed during that time. So the md5 sum would not
  match the real one. A file with the firstly calculated
  md5 sum later could be hard linked to the changed file which
  means there is no backup of its content.
  If both md5 sums do not match, an warning is generated and
  the md5 sum is set to ggggg... which is a not possible value.
  This problem does not exist for blocked files in v3.0.
- improved statistic at the end of a run (sum of warnings
  and errors)
- added options checkBlocksParallel and checkDevicesParallel0
- added option linkToRecent
- name clashes because of compressing files (eg. add .bz2)
  were not handeld corretly - bug was introduced in 3.0
  corrected
- when making a backup with source=/ while not using
  includeDir then the md5 sums of all files were calculated
  also after the first backup
- corrected some issues with the statistical output
- option copyBWLimit is now deprecated because
  - of internal performance optimization
  - it is useless
- new option suppressWarning
storeBackupUpdateBackup.pl
- if sourceDir=/, for the very first backup with option
  lateLinks an empty 'linkFrom' file was generated which lead
  to (useless) error messages. corrected.
storeBackupCheckBackup.pl
- now also checks if files in the backup are not listed
  in .md5CheckSum
storeBackupRecover.pl
- the directories in the path to the restored files / directories
  were not set the original permissions, corrected
llt
- added option --epoch to calculate human readable dates from
  epoch based dates
man
- man pages for all programs (Thanks to Ryan Niebur)
all programs
- solved issues with single quotes in path and filenames
```

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