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The Road to the New Samba VFS

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Road to a modern VFS for SMB2+

Samba 4.15

Samba 4.15.0 Release Notes

```
NEW FEATURES/CHANGES
====================

VFS
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The effort to modernize Samba's VFS interface is complete and
Samba 4.15.0 ships with a modernized VFS designed for the post
SMB1 world.
```

Woohoo! :)

The Road to a modern VFS for SMB2+

Samba 4.15 finishes the VFS modernisation

- Ongoing effort since a few years, initially driven by Jeremy Allison
- Standardizing path based filesystem syscalls on `at()` variants
    - eg `openat()` instead of `open()`
- use file handles instead of paths as often as possible
    - eg `fstat()` instead of `stat()`

Why did we do this?

How did we get there?

Some History

SMB1 Fallacies: Pervasive use of Paths

A path by any other name would smell as unpleasing.

Most metadata operation (get and set) in SMB1 can be done on paths:

- Path processing is complex and slow
  - the core function `unix_convert()` had more then 800 lines (before we refactored it last year)
  - plus several thousand lines of code in related helper function

So what's wrong with paths? Things to consider:

- Charset conversion
- Mangling Windows incompatible paths
- DFS paths
- SMB1 previous version paths (with `@GMT-...` tokens in the path)
- Case insensitive semantics
- Named streams support

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Enter SMB2

By contrast, SMB2+ is a purely handle based protocol

- `SMB2 Create` request takes a pathname
- Everything else operates on a handle returned by `SMB2 Create`
- . . . with a few exceptions:
  - `QueryInfo(NormalizedNameInformation)` returns a full pathname
  - `QueryDirectory()` returns relative pathnames
  - `SetInfo(File{Link,Rename}Information)` takes a full target pathname

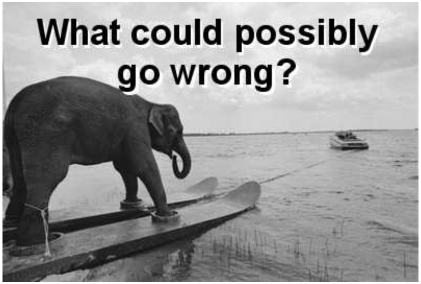
Deprecation of SMB1 in 4.11

- The world has moved away from SMB1
- So did we, SMB1 is now disabled by default
- Not yet removed completely: used in tests

The Idea

The idea: a (mostly) handle-based VFS for the SMB2+ World

- Streamline the VFS interface to be (mostly) handle-based
  - `SMB_VFS_FSTAT()` instead of `SMB_VFS_STAT()`
  - `SMB_VFS_FGETXATTR()` instead of `SMB_VFS_GETXATTR()`
  - `SMB_VFS_FGET_DOS_ATTRIBUTES()` instead of `SMB_VFS_GET_DOS_ATTRIBUTES()`
  - . . . and so on.
- Perfect match for the SMB2+ protocol



Samba VFS: Functions by Category, todo

VFS Function Categories	Number	Todo
Path based	21	Use `O_PATH` handles
Path based namespace changing (create, delete, . . .)	8	Use `*at()` calls
Handle based but not allowed on `O_PATH` fds	8	Use /proc/PID/fd/FD
Handle based	42	-
DFS-related	3	-
Disk operations	9	-
Pure path to path translation	4	-
Special cases (eg FileIDs)	6	-
Sum todo	29	

Table 1: VFS interface functions by category needing changes

Challenges: Permissions and Oplocks

Opening a file handle requires at least `O_RDONLY`

- Path based `stat("dir/file")`
  `"x"` access right on `"dir"` required
- To replace `stat()` with `fstat()` first we to open the file
  1. `fd = open("file", O_RDONLY)`
  2. `fstat(fd)`

  `"r"` access right on `"file"` required

Kernel oplocks

- `O_RDONLY` triggers a kernel oplock break

O_PATH to the rescue

O_PATH

The solution: Linux open() flag O_PATH

- Available since since Linux 2.6.39 (May 2011), in FreeBSD 14
- Returns a file handle that acts as a mere path "reference"
  - I coined the term pathref for referring to them in Samba
- Doesn't need "r" on object, only "x" on the parent directory

Limitted number of syscalls are allowed

- `fstat(fd, ...)`, `fchdir(fd, ...)`, `utimensat(fd, ..., AT_EMPTY_PATH)`
- Syscalls that work at the file-descriptor/inode level
- Can't be used for any sort of IO
- Can also be used as dirfd for `*at()` syscalls

Fallback to open-as-root if O_PATH is not available

- root-opened fds are "guarded", access only via accessor functions
  - `fsp_get_pathref_fd(fsp)`, `fsp_get_io_fd(fsp)`
  - `fsp_get_pathref_fd(fsp)` must be auditted

O_PATH Cont.

Samba needs more then fstat()

- Samba needs to read ACLs and xattrs
- But both can't be retrieved via O_PATH handles
- Use the /proc/self/fd/FD trick:
  - use path based version with path "/proc/self/fd/%d"
  - replacing %d with the O_PATH fd

Example Code: Fallback to getxattr

```
if (fsp->fsp_flags.is_pathref) {
        char buf[PATH_MAX];
        sprintf(buf, "/proc/self/fd/%d", fd);
        getxattr(buf, ...);
} else {
        fgetxattr(fd, ...);
}
```

Fine Print

- /proc/self/fd currently Linux only, elsewhere fallback to path based access
- Which is the same net result as in pre O_PATH Samba

Challenge: SMB1 Heritage

Due to paths being used heavily in the protocol we have pervasive use of paths in the Samba codebase

- we want to convert 21 path based VFS functions, ...
- that are used at several hundred places in the codebase and ...
- will we need a file handle in all those places

Samba high-level code "degrades" handles to path-based access in many places

- So in theory we have a handle (`fsp` in Samba parlance)
- But use path attached to `fsp` (`fsp->fsp_name`) with path based VFS function
- Or need to call a VFS function on the parent directory of `fsp->fsp_name`
- Sometimes paths get passed to functions, not a handle – even though we have one

SMB1 Heritage: Turning pathnames into pathrefs

How to get a file handle? The old way

Samba's internal file handle structure is of type `struct files_struct` and all variable pointing to objects of such type are typically called `fsp`'s.

- `fsp`'s are returned by `SMB_VFS_CREATE_FILE()`
- this is the 1000 pounds Gorilla of the VFS functions zoo
- calls on to `SMB_VFS_OPENAT()` to open the low-level fd
- then goes through Samba's NTFS Windows emulation (eg `locking.tdb`)

New, additional way to get a `O_PATH` file handle

New helper function `openat_pathref_fsp()`:

- skips the NTFS emulation logic
- just calls `SMB_VFS_OPENAT()` with `O_PATH`
- returns a pathref fsp
- pathref fsps can be upgraded to "full" fsps
  - fd is reopened via `/proc/PID/fd/FD`
  - NTFS Windows emulation code is run

SMB1 Heritage, Cont.

Client supplied paths are processed by the core function `filename_convert()`

- Returs a pointer to an object of type `struct smb_filename`.
    - Variables are typically called `smb_fname`.
- `filename_convert()` is updated to call `openat_pathref_fsp()`
- storing the resulting pathref `fsp` inside `struct smb_filename`
    - `smb_fname->fsp`
- As a result the whole codebase has immediate access to a file handle.

This allowed converting the large codebase to a handle based VFS in a piecemeal fashion.

The Design Squad

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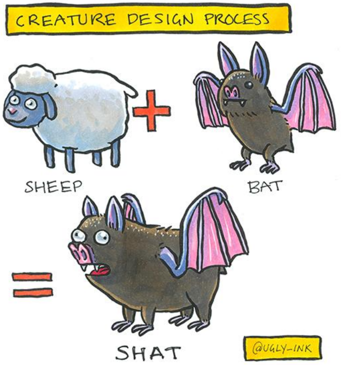
Volker Lendecke
Jeremy Allison
Ralph Böhme



The Construction Squad

Construction Squad

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The End

Thank you!

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Links

- https://wiki.samba.org/index.php/The_New_VFS