The Road to the New VFS

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Road to a modern VFS for SMB2+

The Road to a modern VFS for SMB2+

The effort to modernize Samba's VFS interface has reached a major milestone with the release of Samba 4.14:

- This is an ongoing effort since a few years
- Initially driven by Jeremy Allison
  - standardizing path based filesystem syscalls on `*at()` variants
  - eg `openat()` instead of `open()`

We recently changed the fileserver code to use file handles instead of paths as often as possible

- eg `fstat()` instead of `stat()`

How did we get there?

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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
  - one of the core function `unix_convert()` had more then 800 lines (before we refactored it last year)
  - plus several thousand lines of code in callees

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

- Charset conversion
- Mangling non-Windows compatible paths to Windows compatible
- DFS paths
- Previous version paths (with "@GMT-..." tokens in the path)
- Case insensitive semantics
- Named streams support
- *Yuck!*

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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

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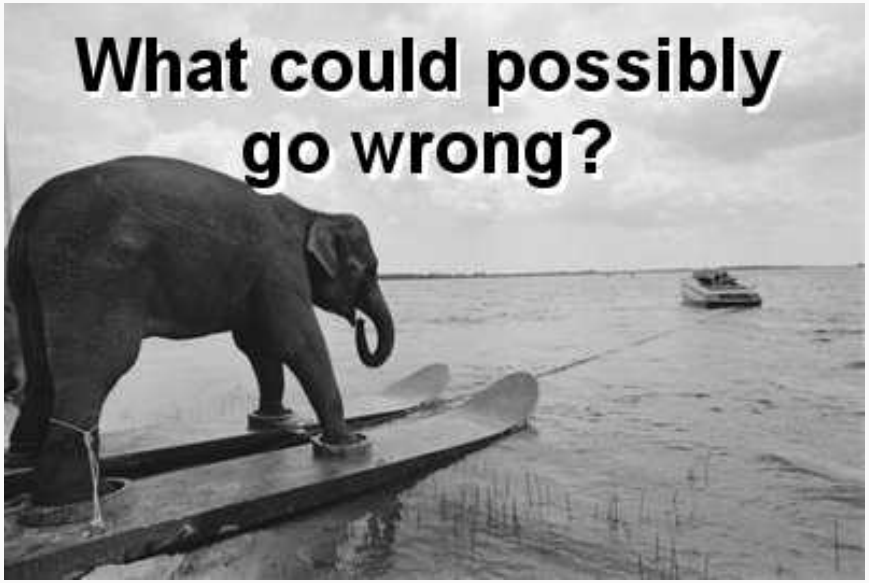
The Idea

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

- Streamline the VFS interface to be (mostly) handle-based
- No more `SMB_VFS_STAT()`, only `SMB_VFS_FSTAT()`
  - or `SMB_VFS_FGETXATTR()`, not `SMB_VFS_GETXATTR()`
  - or `SMB_VFS_FGET_DOS_ATTRIBUTES()`, not `SMB_VFS_GET_DOS_ATTRIBUTES()`
  - or `SMB_VFS_FGET_NT_ACL`, not `SMB_VFS_GET_NT_ACL()`
  - . . . and so on
- Perfect match for the SMB2+ protocol



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VFS Functions by Category

VFS Function Categories	Number
Path based	21
Path based namespace changing (create, delete, . . .)	8
Handle based	50
DFS-related	3
Disk operations	9
Pure path to path translation	4
Special cases (eg FileIDs)	6
Sum	101

Table 1: VFS interface functions grouped by category

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The Design Squad

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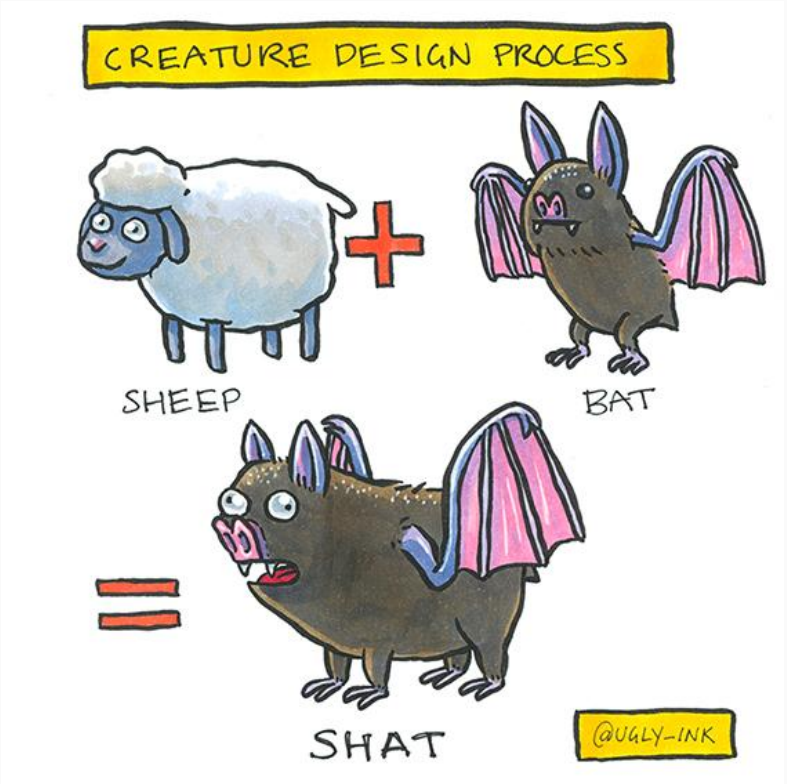

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Challenge: Permissions

Opening a file handle requires at least `O_RDONLY`

- If you want a file handle on Linux, you call `open[at](file, mode)`
- You request an access mode of either `O_RDONLY`, `O_WRONLY` or `O_RDWR`
- path based `stat("file")` only needs only `"x"` on parent directory, but ...
- `fd = open("file", O_RDONLY)` in oder to `fstat(fd)` needs `"r"` on `"file"`
- Currently if the client only requests `READ_ATTRIBUTES` access
  - which is the access right corresponding to reading a file's metadata (ie `stat()`)
  - then Samba doesn't open a file handle but uses path based syscall (ie `stat()`)

Kernel oplocks

- `O_RDONLY` triggers a kernel oplock break

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Uh-oh!

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Oh path, oh path!

The fix: Linux `open()` flag `O_PATH`

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

Limitted number of syscalls are allowed

- the important one from Samba's perspective: `fstat()`
- Can read the inode metadata but not modify it
- 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

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Oh path, oh path! Cont.

But wait, 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 (somehow_figure_out_fd_is_opath_fd(fd)) {
        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

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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 a few 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

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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 file handle

We added new helper function `openat_pathref_fsp()` which skips the NTFS emulation logic and calls `SMB_VFS_OPENAT()` with `O_PATH`

- I called the resulting fsp's pathref fsps
- pathref fsps can be upgraded to "full" fsps
  - fd is reopened
  - NTFS Windows emulation code is run
  - This happens when passing a pathref fsp to `SMB_VFS_CREATE_FILE()`
    - embedded in the filename that gets passed to `SMB_VFS_CREATE_FILE()` (see next slide)

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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.
- Which allows converting the whole codebase to use handle based VFS functions in a piecemeal fashion.

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VFS Functions by Category, todo

VFS Function Categories	Number	Todo
Path based	21	Use `O_PATH` pathrefs
Path based namespace changing (create, delete, ...)	8	-
Handle based but not allowed on `O_PATH` fds	8	Use /proc/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 2: VFS interface functions by category needing changes

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The Construction Squad

Construction Squad

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VFS Conversion Status

Status

VFS Function Category	Done	Todo
Path based	6	15
Handle based but not allowed on O_PATH	8	0

Table 3: VFS Conversion Status

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Links

- https://wiki.samba.org/index.php/The_New_VFS
- The New VFS, long version of this presentation in the Samba sources

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Q&A

Thank you!
Questions?

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