Developer's Guide to smbd

Ralph Böhme, Samba Team, SerNet

2020-05-27

Outline

SerNet

Fileserver Overview

SMB fileserver

- `smbd` process, parent and childs
- Forking architecture: forks a child process per connection
  - parent listens for SMB connections on port 445
  - `accept()` TCP connections and calls `fork()`
  - from then on child handles the connection

`smbd` child

- SMB frontend: network IO, SMB packet processing
- Windows NTFS semantics to POSIX translator
  (which contributes much of the code in smbd)
- Local filesystem access via VFS abstraction
- `smbd` is not just a fileserver:
  - database for user accounts and groups in a Windows fashion
    (SAM, Security Account Manager)
  - can be queried over the network with RPC

SerNet

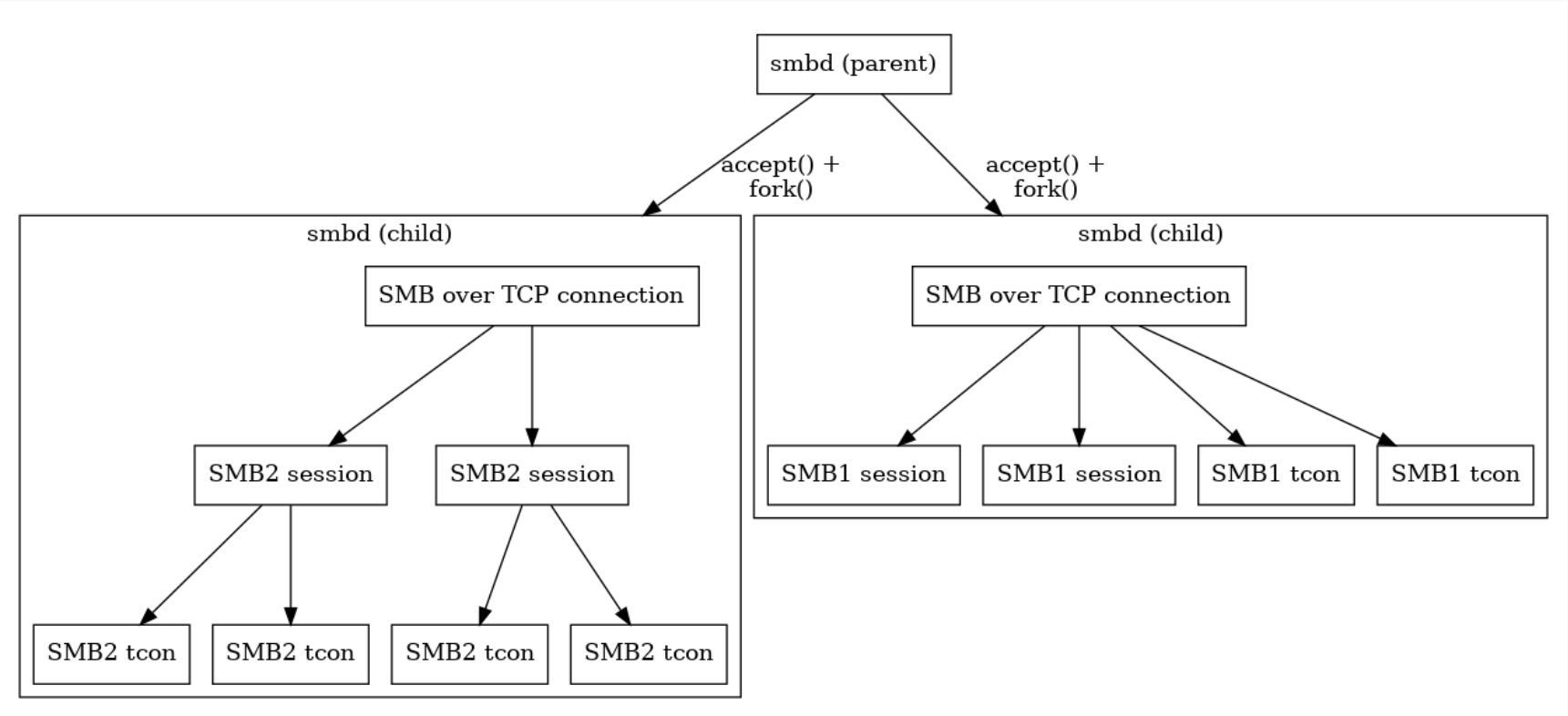
Why `fork()` ?

One smbd process per connection

- security: let the OS do all the permission checking by switching uid (and gid, gids)
- reliability: if one process crashes others are unaffected
- scalibilty: a lot of sync processing which gets nicely parallelized by having one process per connection

SerNet

smbd: processes, sessions, tcons



(Without multi-channel)

SerNet

winbindd

- nsswitch module
  - nsswitch is the plugin mechanism in UNIX to use different sources for defining users and groups
  - allows users and groups from Windows domains appear as OS users/groups
- Domain authentication proxy
  - `smbd` forwards authentication requests to `winbindd`
- Identifier mapping:
  - Windows SIDs to/from POSIX ids (idmapping)
  - SIDs to/from names
- Caching
  - only talk to DCs is something is not in the cache

SerNet

Authentication Aftermath: the Big Picture

After a user has been authenticated we need to fill in a valid UNIX account.

What do we need?

- A name for the UNIX account
- At least `struct passwd` home-directory
- uids and gids to impersonate the user at the UNIX level

What do we get?

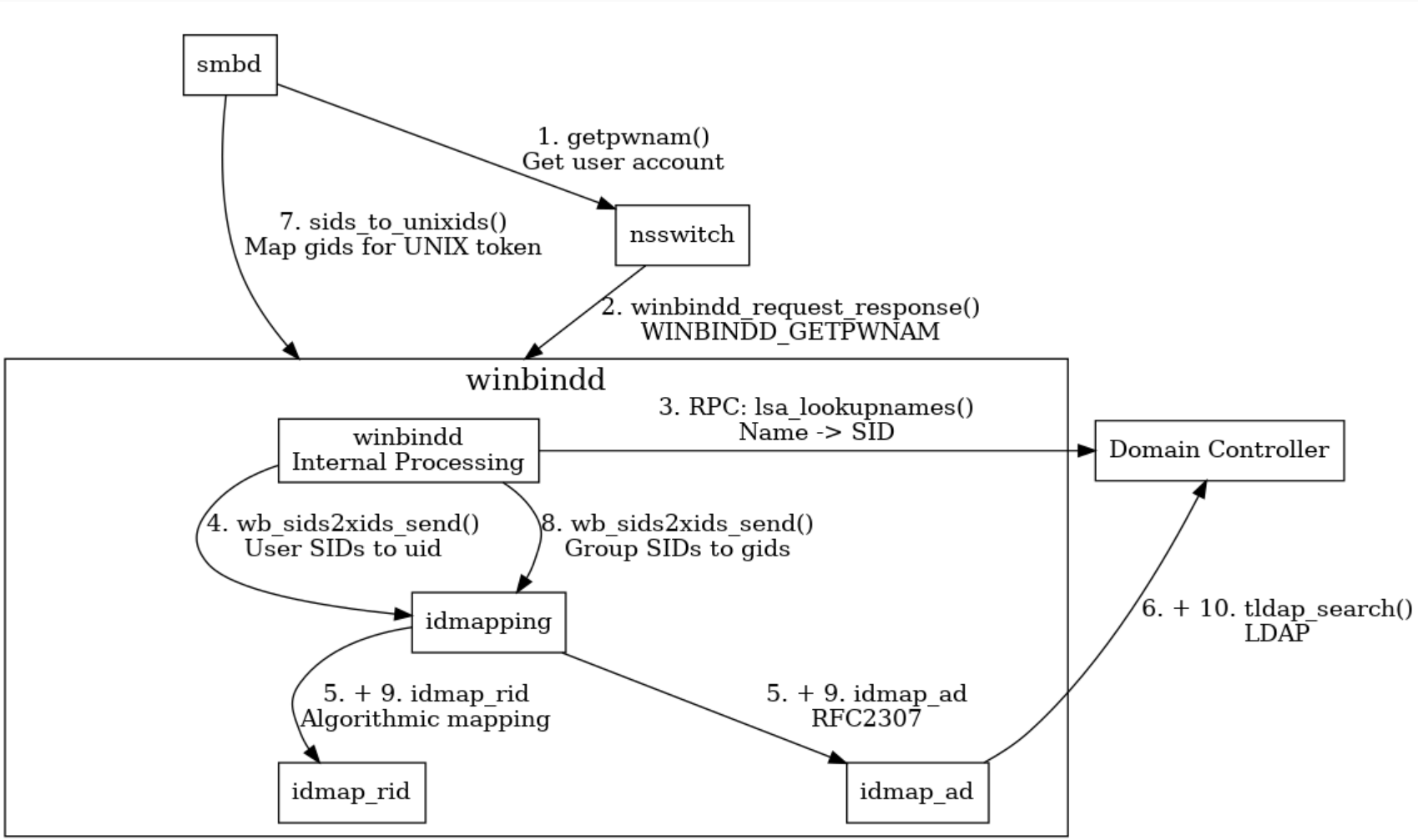
- Names: the domain and username from the authentication process
- SIDs: User SID and auxilliary group SIDs from the PAC

What do we do?

- See next slide . . .

SerNet

Authentication Aftermath: Building a Useraccount



Tour de smbd: Libraries and Subsystems

Important libraries

Main important libraries

- event handling and async processing abstraction: tevent
- hierarchical memory allocator: talloc
- key/value store: tdb, typically used via the dbwrap API
- Async socket programming: tsocket
- sources of all four in `lib/`

Tutorials:

- https://talloc.samba.org/talloc/doc/html/libtalloc__tutorial.html
- https://tevent.samba.org/tevent_tutorial.html
- lib/tsocket/tsocket_guide.txt

SerNet

VFS: abstract filesystem interface

- Abstract interface for POSIX filesystem functions
- Plus bunch of other higher level functions
- Loadable and configurable modules implement (parts of) interface
- Much like FUSE for the kernel
- VFS module vfs_default maps to POSIX calls
- VFS module that looks into SQL database is possible
- Tutorial: Writing a Samba VFS Module

`source3/modules/`

SerNet

IPC: messaging based on UNIX datagram sockets

- Mainly for communication between processes
- Support sending to self

```
/* Sending messages */
NTSTATUS messaging_send(struct messaging_context *msg_ctx, ...);
void messaging_send_all(struct messaging_context *msg_ctx, ...);

/* Listening for messages */
struct tevent_req *messaging_filtered_read_send(...);
struct tevent_req *messaging_read_send(...);
```

SerNet

dbwrap: abstract database interface

- Samba uses TDB databases to store various internal bits
- TDB is not clustered, so for clustering ctdb was invented
- API to abstract away locking details and non-clustered vs clustered usecase
- voilà: dbwrap, an API with backends
  (TDB, ctdb, in-memory Red-Black-Tree, . . .)

SerNet

Important subystems, cont.

Authentication components (madness lies here. . .)

- gensec: Generic Security Framework
  - provides authentication, authorisation and data integrity
  - implements SASL, GSSAPI, SPNEGO and NTLMSSP protocols

  `auth/`
- Low level crypto routines for NTLM, DES, netlogon and schannel

  `libcli/auth/`
- smbd authentication support

  `source3/auth/`
- gensec Kerberos backend for smbd

  `source3/liprpc/crypto/`

SerNet

Important subystems, cont.

Others...

- RPC server and RPC services

  `source3/rpc_server/`

- pidl: Perl IDL Compiler

  `pidl/`

- loadparm: processing smb.conf

  `lib/param/` **and** `source3/param/`

- passdb/groupdb: local SAM with users and groups

  `source3/{passdb|groupdb}/`

SerNet

Dive into the smbd sources: from main() to SMB2_CREATE processing

Set the ball rolling

source3/smbd/server.c

```
main()
`-> open_sockets_smbd()
|   `-> smbd_open_one_socket()
|       `-> fd = socket() + listen()
|       `-> tevent_add_fd(fd, smbd_accept_connection)
`-> smbd_parent_loop()
```

To be continued in `smbd_accept_connection()` ...

SerNet

Accept client TCP connection

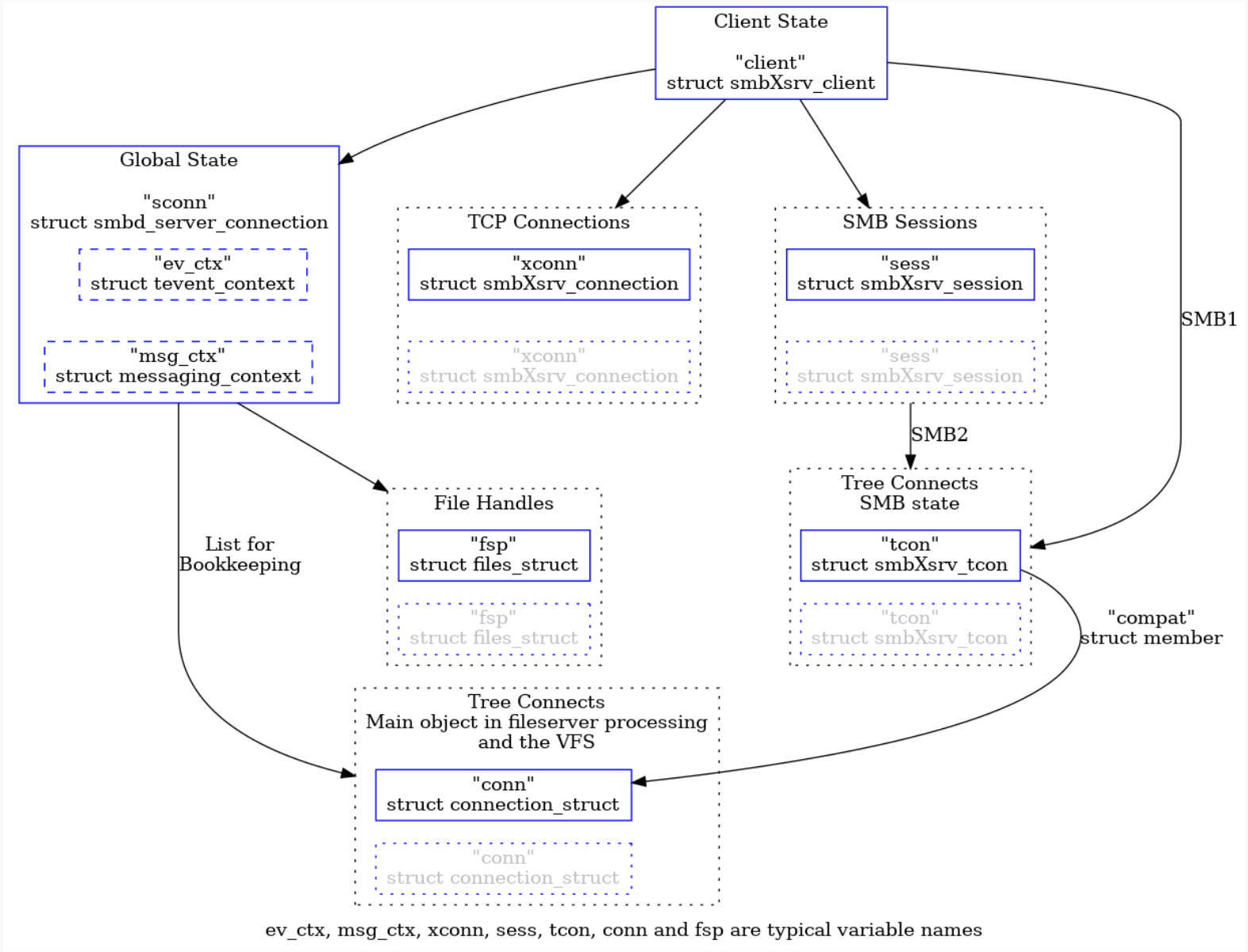
source3/smbd/server.c

```
smbd_accept_connection()
`-> accept() + fork()
`-> smbd_process() (in source3/smbd/process.c)
    `-> client = smbXsrv_client_create()
    `-> sconn = talloc_zero(client, struct smbd_server_connection)
    `-> xconn = smbd_add_connection(client, fd, ...)
        `-> fde = tevent_add_fd(fd, smbd_server_connection_handler, ...)
    `-> tevent_loop_wait()
```

To be continued in `smbd_server_connection_handler()` ...

SerNet

Core C state objects in smbd



SerNet

Process first SMB2 packet (SMB2_NEGPROT)

First source3/smbd/process.c, then source3/smbd/smb2_server.c

```
smbd_server_connection_handler(..., private_data)
`-> xconn = talloc_get_type_abort(private_data, ...)
`-> smbd_server_connection_read_handler(xconn)
    `-> receive_smb_talloc()
    `-> process_smb(xconn)
        `-> smbd_smb2_process_negprot(xconn) (in source3/smbd/smb2_server.c)
            `-> smbd_initialize_smb2(xconn, ...)
            |   `-> TALLOC_FREE(xconn->transport.fde)
            |   `-> xconn->transport.fde = tevent_add_fd(
            |                fd, smbd_smb2_connection_handler, ...)
            `-> smbd_smb2_request_dispatch(req)
```

To be continued in smbd_smb2_connection_handler() ...

SerNet

Processing of all subsequent SMB2 packets

source3/smbd/smb2_server.c

```
smbd_smb2_connection_handler(..., private_data)
`-> xconn = talloc_get_type_abort(private_data, ...)
`-> smbd_smb2_io_handler(xconn)
    `-> req = "prepare new SMB2 request object"
    `-> smbd_smb2_request_dispatch(req)
```

SerNet

Processing SMB2_CREATE

`smbd_smb2_request_dispatch()` **an** `SMB2_CREATE`

- calls `smbd_smb2_request_process_create()`
- this is the SMB2 frontend function and parses the SMB2 packet
- calls `smbd_smb2_create_send()`

`smbd_smb2_create_send()`

- process the `SMB2_CREATE`-context blobs
- process SMB2 features like Durable Handles and Create Replay
- pathname processing: `filename_convert()`
  - deals with Windows case-insensitive semantics
  - ... and with wildcards
- finally: call `SMB_VFS_CREATE_FILE()`

SerNet

Windows NTFS semantics on top of POSIX

This is where all the fun is

- Windows win32 API `CreateFileW()` function:

  `https://docs.microsoft.com/en-us/windows/win32/api/fileapi/nf-fileapi-createfilew`

- `CreateFileW()` returns a file-handle like POSIX `open()`

Additional semantics compared to POSIX `open()`

- Sharing modes: READ, WRITE and DELETE
- Caching: SMB1 oplocks / SMB2 leases
- NTFS behavioural differences:
  - Delete-on-close
  - Byterange locks
  - Timestamps (writetime)
- NTFS metadata: DOS Attributes, named streams

SerNet

Inside the VFS

`SMB_VFS_CREATE_FILE()`

- calls into the loaded VFS module stack
- every module that implements the VFS function is called in order
- `SMB_VFS_CREATE_FILE()` is typically only implemented by `vfs_default`
- `vfs_default` is the default VFS module, often the only one
- `vfs_default` calls `create_file_default()` in `source3/smbd/open.c`

SerNet

Inside `create_file_default()`

`create_file_default()`

- Quota support (fake-files)
- SMB2 POSIX WIP support for POSIX mode
- calls `create_file_unixpath()`

`create_file_unixpath()`

- calls `lease_match()`, protects against a subtle leases implementation problem
- calls `open_streams_for_delete()` to prevent deleting a file if any of its streams is open that doesn't allow deletion
- `SEC_FLAG_SYSTEM_SECURITY` access check. Related to SACLs (auditting support) which is not really implemented.
- Names streams support: if open is for a named stream, recurse into `create_file_unixpath()` to open the "base"-file

SerNet

Inside `create_file_unixpath()` cont.

The big divide:

- for directories call `open_directory()`
- for files call `open_file_ntcreate()`
- afterwards some postprocessing:
  - set initial EAs: `set_ea()`
  - allocate disk space if requested: `vfs_allocate_file_space()`
  - ACL: set requested ACL or inherit parent dir ACL

SerNet

Inside `open_file_ntcreate()`

`open_file_ntcreate()`

- Support for async `CREATE`: call `get_deferred_open_message_state()`
- Call the low level open routine: `open_file()`
  - `open_file()` ultimately calls into the VFS with ~~`SMB_VFS_OPEN()`~~ `SMB_VFS_OPENAT()`
- Deal with errors from opens that suggest a retry: `setup_poll_open()` or `schedule_async_open()`

Implement NTFS stuff (still `open_file_ntcreate()`)

- call `lock = get_share_mode_lock()` to fetch record from locking.tdb
- locking.tdb: our central store for filehandle information
- Delete-on-close semantics: `has_delete_on_close(lock, ...)`
- Implement sharing mode and oplock/lease: `handle_share_mode_lease(lock, ...)`, `set_share_mode(lock, ...)`
- DOS Attributes: `dos_mode()` and `file_set_dosmode()`
- more...

SerNet

locking.tdb

- locking.tdb is our central open-file database
- Of course we use dbwrap API to access it
- One record per file with open filehandles:
  - record has fixed size header with `struct share_mode_data`
  - record data then contains `struct share_mode_entry[]` array with opens per file
- How does it look like?

SerNet

locking.tdb record format

locking.tdb struct share_mode_data

```
typedef [public] struct {
        hyper sequence_number;
        share_mode_flags flags;
        [string,charset(UTF8)] char *servicepath;
        [string,charset(UTF8)] char *base_name;
        [string,charset(UTF8)] char *stream_name;
        uint32 num_delete_tokens;
        [size_is(num_delete_tokens)] delete_token delete_tokens[];
        NTTIME old_write_time;
        NTTIME changed_write_time;
        [skip] boolean8 fresh;
        [skip] boolean8 modified;
        [skip] boolean8 have_share_modes;
        [ignore] file_id id; /* In memory key used to lookup cache. */
} share_mode_data;
```

SerNet

locking.tdb record format, cont.

locking.tdb struct share_mode_entry

```
typedef [public] struct {
        server_id       pid;
        hyper           op_mid;
        uint16          op_type;
        GUID            client_guid;
        smb2_lease_key  lease_key;
        uint32          access_mask;
        uint32          share_access;
        uint32          private_options;
        timeval         time;
        udlong          share_file_id;
        uint32          uid;
        uint16          flags;
        uint32          name_hash;
        [skip] boolean8 stale;
}
```

SerNet

Reference: Sourcecode-Tree Overview

source3/ subdirectories, part 1

```
auth/ ........... Authentication stack
client/ ......... Home of smbclient
groupdb/ ......... Local SAM (passdb and groupdb)
include/ ......... Well, includes :)
lib/ ............ Kitchensink for various utility functions
libads/ ......... Kerberos, LDAP and SASL client wrappers
libgpo/ ......... GPO client extensions
libnet/ ......... libraray for automated join, remote SAM syncing
librpc/ ......... RPC server helpers
librpc/crypto/ ... gensec Kerberos backend
librpc/idl/ ...... IDLs for various SMB related structures
libsmb/ ......... SMB client library
locking/ ......... Deal with storing Windows NTFS state in locking.tdb
modules/ ......... The home of the VFS modules
```

SerNet

source3/ subdirectories, part 2

```
param/ ........... source3 loadparm backend, smb.conf processing
passdb/ .......... Local SAM (passdb and groupdb)
pidl/ ............ Perl IDL Compiler
printing/ ........ Printserver implementation
profile/ ......... Fileserver profiling
registry/ ........ Implementation of a Windows registry
                   (optional smb.conf backend)
rpc_client/ ...... RPC client interfaces
rpcclient/ ....... RPC client CLI tool
rpc_server/ ...... RPC server and services implementations
selftest/ ........ source3/ CI test driver (file tests.py)
smbd/ ............ Home of the core fileserver
torture/ ......... Home of smbtorture3, part of CI
utils/ ........... Various CLI utilities
winbindd/ ........ Well, winbindd
```

SerNet

```
lib/crypto/ ..... Cryptography
lib/dbwrap/ ..... dbwrap: abstract DB interface
lib/messaging/ ... IPC: UNIX datagram messaging
lib/param/ ...... loadparm: smb.conf processing
lib/pthreadpool/ . threadpool implementation
lib/replace/ ..... Platform compatability layer
lib/tsocket/ ..... Async socket programming
libcli/auth/ ..... Low level auth support: NTLM, DES, netlogin, schannel
librpc/ ......... RPC core and IDLs
```

SerNet

Links

Links

- https://wiki.samba.org/index.php/Developer_Documentation
- https://talloc.samba.org/talloc/doc/html/libtalloc__tutorial.html
- https://tevent.samba.org/tevent_tutorial.html
- lib/tsocket/tsocket_guide.txt
- Writing a Samba VFS Module

SerNet

Q&A

Q&A

Thank you! Questions?

Ralph Böhme <slow@samba.org>

Samba Team, SerNet

SerNet