SAMBA Opening Windows to a Wider World

Asynchronous Samba

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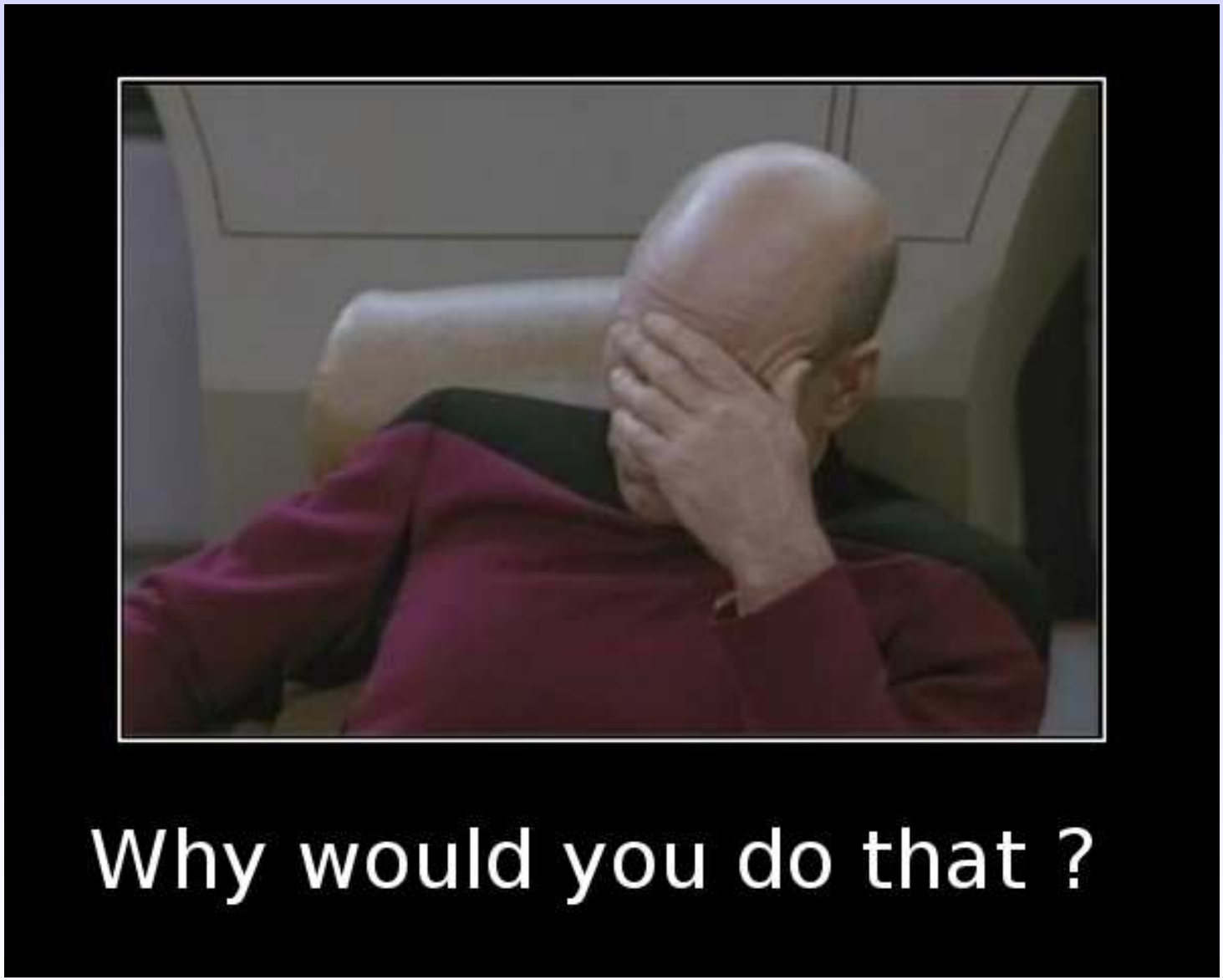
Tridge's view

"Threads are evil. Processes are ugly. State machines send you mad."

Andrew Tridgell, "Musings on Software Engineering" 2005.

So of course Samba utilizes all three simultaneously..



Using processes

- Historical reasons.
  - Earliest Samba architectural decision, one process per client (single connected TCP socket).
- Still (IMHO) a good decision.
  - Robustness.
  - Scalability (depending on underlying OS).
  - Allowed easy clustering separation.
  - Security separation.
    - Linux (and Windows I guess :-) still the only OS(es) where threads can have separate credentials.
- Still an ideal choice for programmers when dealing with code complexity.

Using processes

- Ideal choice when splitting off large areas of functionality.
  - Splitting out of processes to implement server end of names pipes is an ideal case (spoolssd).
  - Depends upon good inter-process communication (IPC).
    - Volker's recent work on our IPC layer (for Samba 4.2) has improved our scalability immensely.
- Little shared state by default (so long as you're careful after the fork() call).
  - winbindd code spins off separate processes for background DNS resolution.

Using processes - downsides

- Just too heavyweight.
  - Using a separate process for every required asynchronous event simply overwhelms machine resources.
  - Copy-on-write issues.
    - Any memory allocation / free that modifies the malloc pool can cause many copy on write issues as pages have to be duplicated.
- Cleanup issues.
  - Unless properly reaped, zombie children can pile up under a process.
- Heavyweight IPC mechanisms needed.

Using threads

- First use of threads within Samba (at least on Linux) was under the covers via a library.
  - Glibc POSIX aio uses threads to implement asynchronous IO (badly, see my 2012 talk..).
- Ideal way to ensure efficient use of all available cores.
  - Lightweight way of sharing kernel vm mappings for a process.
  - Modern Samba uses threads for some blocking system calls (pread, pwrite, open, fsync).
- Volker created two good abstraction layers for Samba (pthreadpool, asys) to make using threads easier.
  - pthreadpool even works without threads :-).

Using threads - downsides

- Monstrous complexity.
  - Shared-everything means all shared data (and there is a LOT in Samba) needs protecting by mutexes or reader-writer locks.
- Samba code was not designed this way.
  - Going fully threaded is a rewrite, not a retro-fit.
- A fully threaded server depends on either:
  - Per-thread credentials to protect file system access.
  - Careful coding as root to avoid race conditions (Ganesha, user space NFS does this – very tricky).
    - POSIX ACL evaluation becomes impossible.

Using state machines

- Tries to manage asynchronous complexity by breaking it up and linearizing it.
- As only one event is being processed at a time it removes the locking requirements of threaded code.
- Coupled with non-blocking sockets allows work to be done whilst waiting for I/O to complete.
- No dependence on impossible to debug race conditions.
- Depends upon an underlying event library.
  - Choices were libevent, libev or create our own..
  - In the grand Samba tradition, tevent was created :-).

The tevent solution

- Tevent integrates directly with talloc(), making it really easy to use within Samba.
  - https://tevent.samba.org/tevent_tutorial.html
- Tevent handles things libevent originally did not (POSIX real-time signals, used in the Linux kernel for leases).
- Allows for usage that libevent disallows.
  - Separate read and write events attached to the same file descriptor.
- Efficiently uses epoll() on Linux (similar versions for Solaris ports created, kqueue on FreeBSD in process).

How is tevent used ? (a variable called 'req')

- A client request ends up calling a XXXX_send() function, which calls tevent_req_create(), with associated state structure.
  - tevent_req_create() returns an opaque pointer which can be used to reference the outstanding event.
  - Completion callback is attached to this pointer - by convention XXXX_done().
  - Asynchronous operations scheduled (often using pthreadpool and asys).
- Control passes back to main loop.

How is tevent used (continued) ? (a variable called 'subreq')

- When async operation completes it calls tevent_req_done().
  - This calls the callback XXXX_done().
  - XXXX_done() calls XXXX_recv() to return the results of the operation.
  - Opaque pointer is talloc_free()'d and the operation is over (talloc destructors take care of cleanups).
- Multi-part events can be nested by being split into multiple requests (usually named 'subreq') and chained together.
  - As each event completes it calls back up the chain.

The tevent Swiss Army Knife (more variables called 'req')

- Many kinds of async events can be handled by tevent.
  - Timer functions.
  - Lossless signal handling (normal and real-time).
  - File descriptor I/O.
    - Including non-blocking IO with partial reads/writes.
  - Immediate events.
    - 'Run me next' kind of requests from low down in the event stack.
- Queueing API's built in.
  - Allows events to be buffered within the event main loop.

Tevent downsides (all variables called 'req')

- Currently only used inside Samba, sssd and ctdb.
  - Little sample code for new users to use as examples.
- Complex set of naming rules/conventions.
  - Easy to get wrong and get confused between tevent_req_done() / tevent_req_post() / tevent_req_error() etc.
- Complex API, lots of 'unwritten rules'.
  - Currently the best guide is looking at existing code.
  - Monstrous complexity, just not as bad as threads.
  - Hard to program – non natural code flow.

Integrating tevent with the Samba VFS

- pread_send() and pwrite_send() return tevent structures (req).
  - Older interfaces still exist, used by the SMB1 non-asynchronous code.
  - SMB2+ (and SMB1 aio code) natively use the tevent-based versions of the VFS calls.
- Much more work needs to be done.
  - Firstly, VFS interfaces need to have the tevent variants (XXXX_send / XXXX_recv) added.
  - Secondly, the main server code needs to be split into state-machine style of functions at every blocking point.

Who goes there ?

- Subtle but really important issue to consider.
  - User id of tevent request that may be deferred.
  - After async request finishes, and callback is re-scheduled the uid of the process may have changed.
    - Oh :-(. That's a “bad thing”.
- Currently this state has to be stored manually (full token list and then restored in the callback function.
  - Only current example of this is code inside async SMB2 logoff / tree disconnect code path.
  - But metze has plans (flamethrower for this code :-).

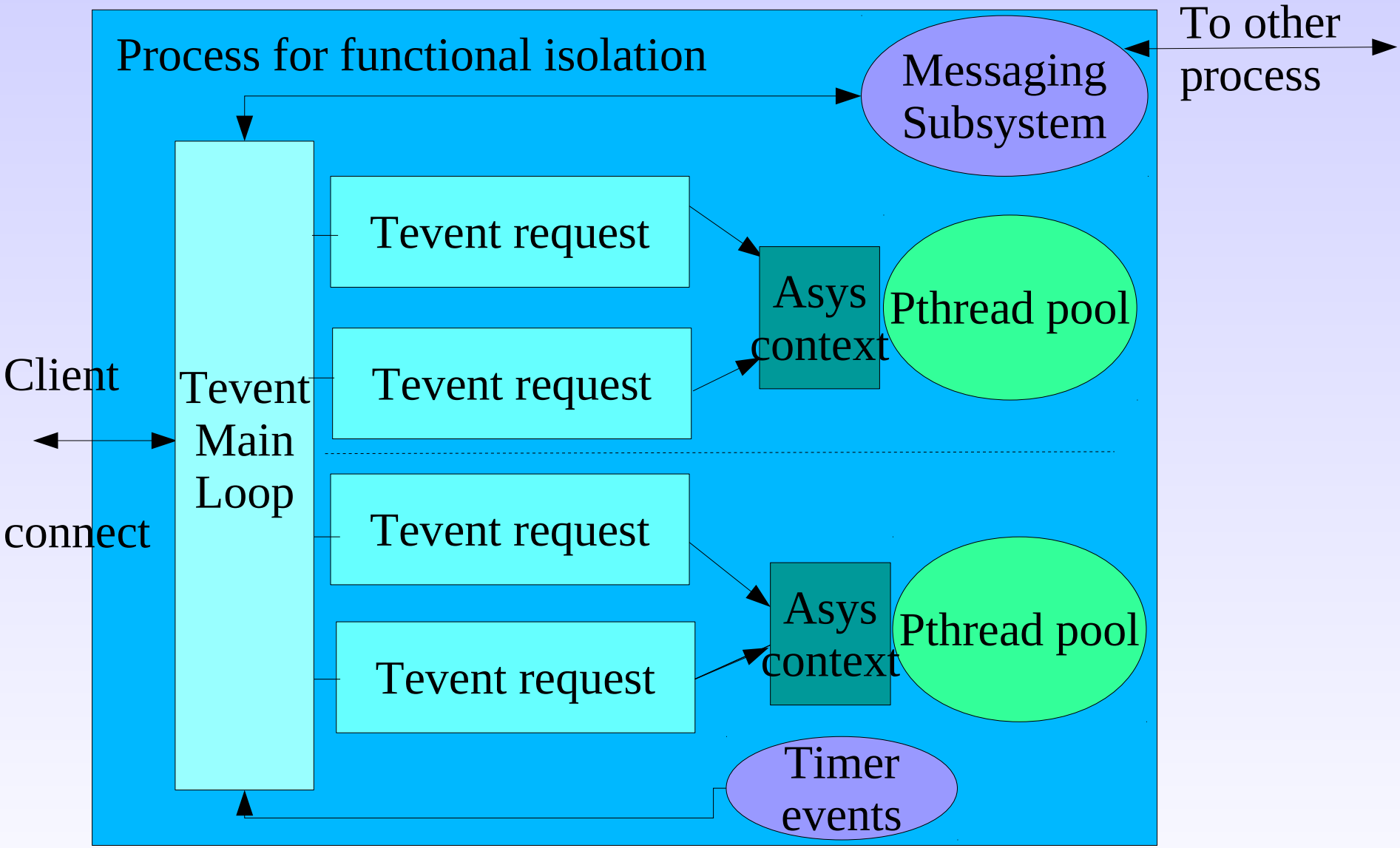
How not to do it..

- The SMB2 CreateFile() code path also uses tevent internally.
  - DO NOT USE THIS AS EXAMPLE CODE :-).
  - First integration of tevent into 'backend' file server code (as opposed to tevent use in 'front end' request serving code).
  - Mangled tevent semantics to match existing asynchronous interface created for SMB1 deferred opens.
- New code written for SMB2 read/write requests is a much cleaner sample.

Hierarchy

- At the lowest level, a tevent_req can spin off a pthreadpool (or use an asys asynchronous system call) to provide true parallelism and utilize multiple cores per proces.
- Within Samba:
  - Processes contain:
    - tevent requests which contain:
      - asys contexts which utilize:
        - pthreadpools to implement blocking system calls asynchronously.
      - Timed events.
      - File descriptor events.
      - Immediate events.
      - Signal events.

Why we did it 'that way'



Making it so..

- To be a proficient Samba programmer today, you MUST understand tevent semantics.
  - Like it or not, tevent is the way most asynchronous complexity is going to be handled in the Samba code going forward.
  - Unless nirvana (complete thread-safe code within all of Samba) is achieved, tevent is the best middle ground available.
  - The more code is converted, the easier converting the remaining code will become (experience and added boilerplate to use / copy from).

Questions and Comments ?

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Slides available at:

ftp://samba.org/pub/samba/slides/sambaxp-2014-async-samba.odp