Dead ways in multithreaded programing

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Agenda

- Process life
- Signals
- Atfork handlers
- Memory access
- Sessions

Why

- Nine years ago I spent one month to develop multithreaded application and three months to hunt a bugs.
- In former company I spent 3 weeks to rewrote signal handling to work correctly.
- Now because 6842872, 6828366, 6823591, 6548350, 6276483, ...

Process life - I

- Before main() function compiler and linker add prologue which setup libraries.
- After main() compiler and linker add epilogue which call exit(2) from libc.
- Exit(2) function call all atexit handler and close all opened files. After that it calls _exit(2) syscall.
- _exit(2) syscall start to cleanup process and their threads.

Process life - II

- Prologue runs as single threaded and .init sections are processed in the main thread, but if library is dynamically opened by dlopen(3C), application can have more threads already.
- When exit(2) is invoked other threads are still active and running. Clean up (e.g. atexit handlers, .fini) usually causes fatal errors or crash.

Process life - III

- Do not except that .init section runs in single threaded process.
- Do not call exit(2) function when more threads are running.
- Dedicate one thread (usually main thread) which control worker threads and which is responsible for cleanup.

Signals - I

- Signal is asynchronous event used for inter process communication.
- When signal arrives and it is not blocked one thread is interrupted and the thread runs signal handler.
- Signal handler runs in parallel with other threads.
- Each thread has own signal mask which is inherited from parent thread.
- Because list of signal safe functions is limited dedicate one thread to signal processing is better.
- DO NOT use mutexes in signal handler.

Signals - II

```
void *sigint(void *arg)
{
   int     sig;
   for(;;)
   {
      sigwait ( &signalSet, &sig );
      if ( sig == SIGINT )
      {
         printf("Got signal SIGINT\n");
         return NULL;
      }
   }
}
```

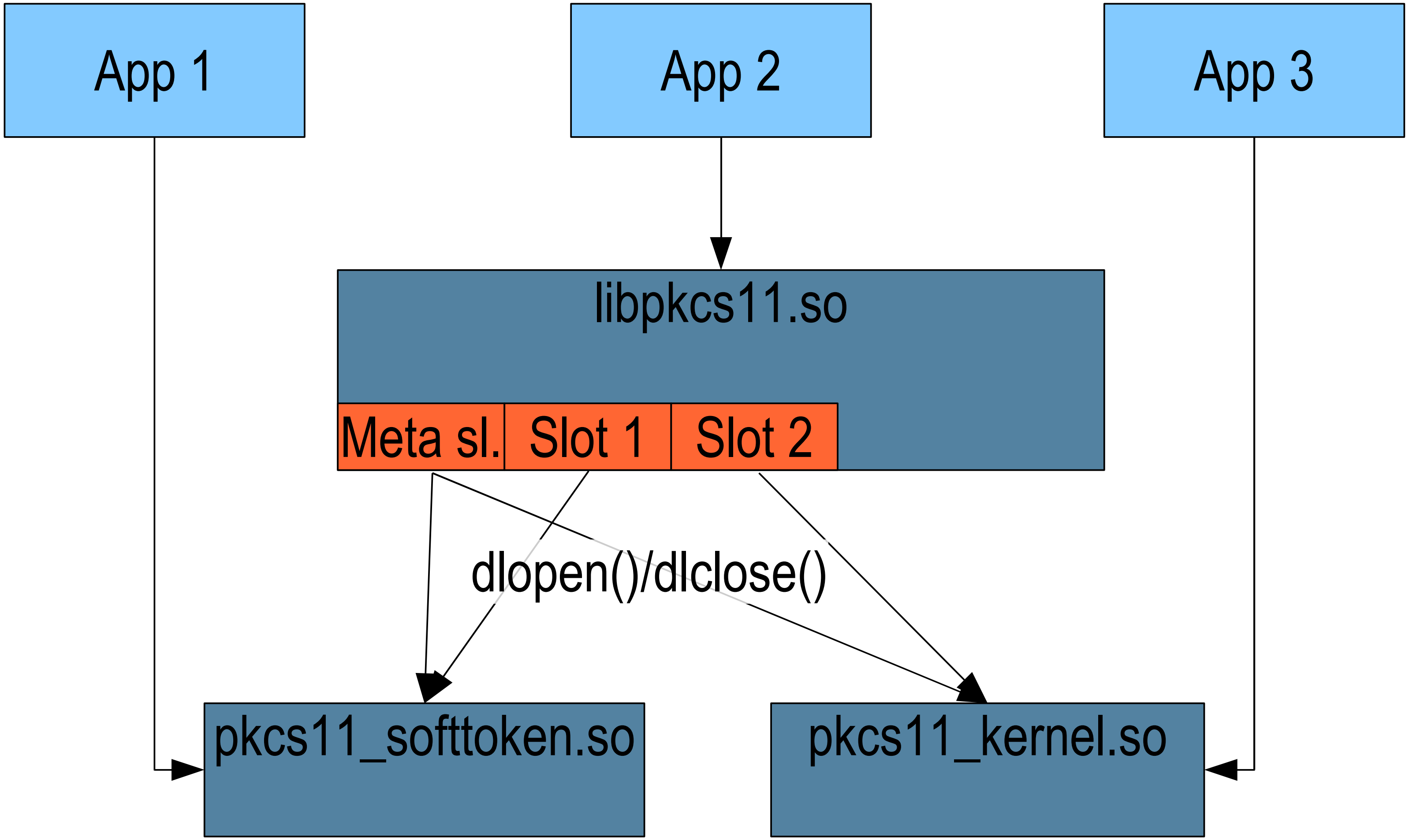
Atfork handlers I

- Fork(2) calls create children process which inherits only calling thread, but all mutexes, condvariables and so on stay in state before fork(2). For example some mutexes can be locked.
- It is important (especially for library) to handle it correctly.
- pthread_atfork(3C) allows to setup handlers which are called before and after fork. Handlers should acquire all mutexes before fork and released it after.
- Atfork handlers are processed in parallel with other threads.

Atfork handlers II

- Atfork handler have to be setup before any lock is acquired.
- Order of handlers registration is important. Wrong order can lead to deadlocks.
- Fork(2) and pthread_atfork(3C) use internally same mutex for atfork handler list access.

Atfork handler III



Note: Linking application directly against to pkcs11_softtoken and pkcs11_kernel is not recommended.

Atfork handler IV

Thread 1

```
C_Initialize(...)
    pthread_mutex_lock(&global)
    …
    pkcs11_slot_mapping(...)
      dlopen(softtoken)
        .init
          pthread_atfork(...)
            pthread_mutex_lock(&atfork_list)
```

Thread 2

```
...
fork()
  pthread_mutex_lock(&atfork_list)
    pkcs11_atfork_prepare()
      pthread_mutex_lock(&global)
```

Parallel memory access

- Access to shared memory has to be protected by lock. It is not necessary only in few cases.
- Locking is expensive and also critical section length has impact on performance and scalability.
- Using one giant lock is easy to implement, but application scalability is poor.
- Locking has to be designed at begging of development. Any future lock splitting is expensive and it is root cause of many bugs.
- Prefer pthread_rwlock for better scalability.

atomic.h

- Solaris offer bunch of atomic operations in atomic.h (atomic_ops(3C), membar_ops(3C))
- It is good when we need simple data structure modifications.
- Unfortunately, functions are not portable.
- Membar_ops are generic memory barriers which are dedicated to guaranties read/write memory order.

Thread Local Storage (TLS)

- Thread local storage is method how to store thread specific data.
- POSIX defines pthread_key_defines, pthread_setspecific, pthread_getspecific function.
- Compilers offer syntactic sugar. For example:

```
  __thread int localint;
```

Sessions

- Sessions are used to keep state information of communication between client and server or application and libraries.
- One session should not be used in different threads. Parallel usage causes usually crash or strange behavior.
- Session pooling is used for resource reduction in some cases, but usually it has limitations.

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