accu conference 2024

# Advanced Usage of the C++23 Stacktrace Library

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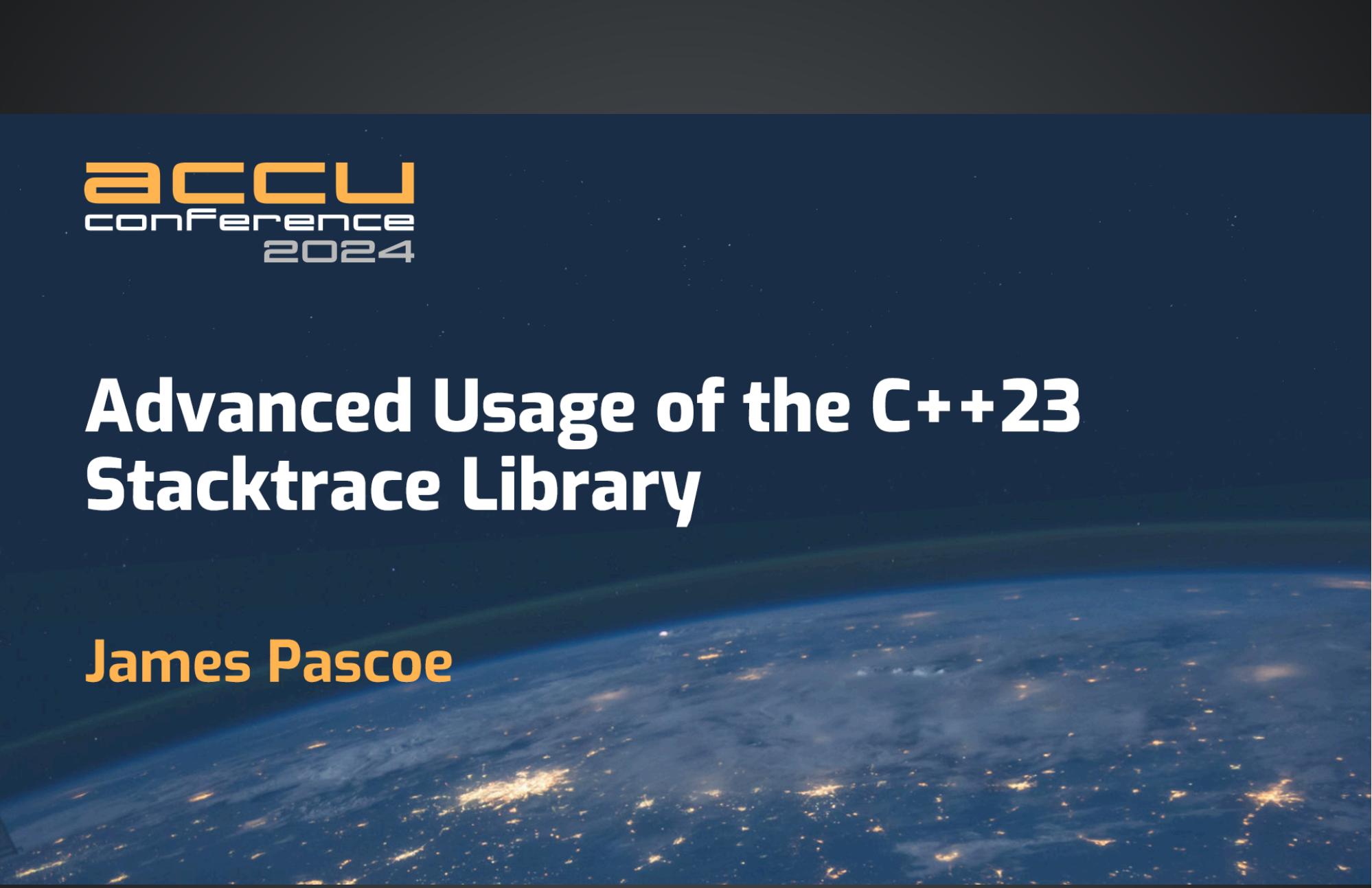

# ADVANCED USAGE OF THE C++23 STACKTRACE LIBRARY

## (STACKTRACES AND HOW TO USE THEM)

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http://jamespascoe.github.io/accu2024-stacktrace
https://github.com/jamespascoe/accu2024-example-code

ACCU Bristol and Bath Meetup Coordinator

# STACKTRACES, TRACEBACKS, CALL SEQUENCES

- Locate problems without a debugger
  - assertions, exceptions, unreachable code
- Introspection
  - object lifetimes e.g. RAII
  - useful with coroutines
- Signal tracing e.g. SEGV (but use with caution)

# STACKTRACES IN C++

- C++23 gives us standardised stacktraces
  - P0881R7: A Proposal to Add A Stacktrace Library
- Complementary libraries:
  - cpptrace: C++11, good treatment of signal-safety
  - backward-cpp: stack trace pretty printing
  - Boost::Stacktrace: mature, also some signal-safety

# FIBONACCI (WITH STACKTRACE)

```
1  #include <iostream>
2  #include <format>
3  #include <stacktrace>
4
5  class fib_with_stacktrace {
6
7    std::stacktrace::size_type max_depth = 0;
8    std::stacktrace max_trace;
9
10 public:
11
12   fib_with_stacktrace() = default;
13
14   // Return the nth number in the fibonaci sequence
15   unsigned int fib(unsigned int n)
16   {
17     auto trace = std::stacktrace::current();
18     auto depth = trace.size();
19     if (trace.size() > max_depth) {
20       max_trace = trace;
21       max_depth = depth;
```

# COMPILATION AND LINKING

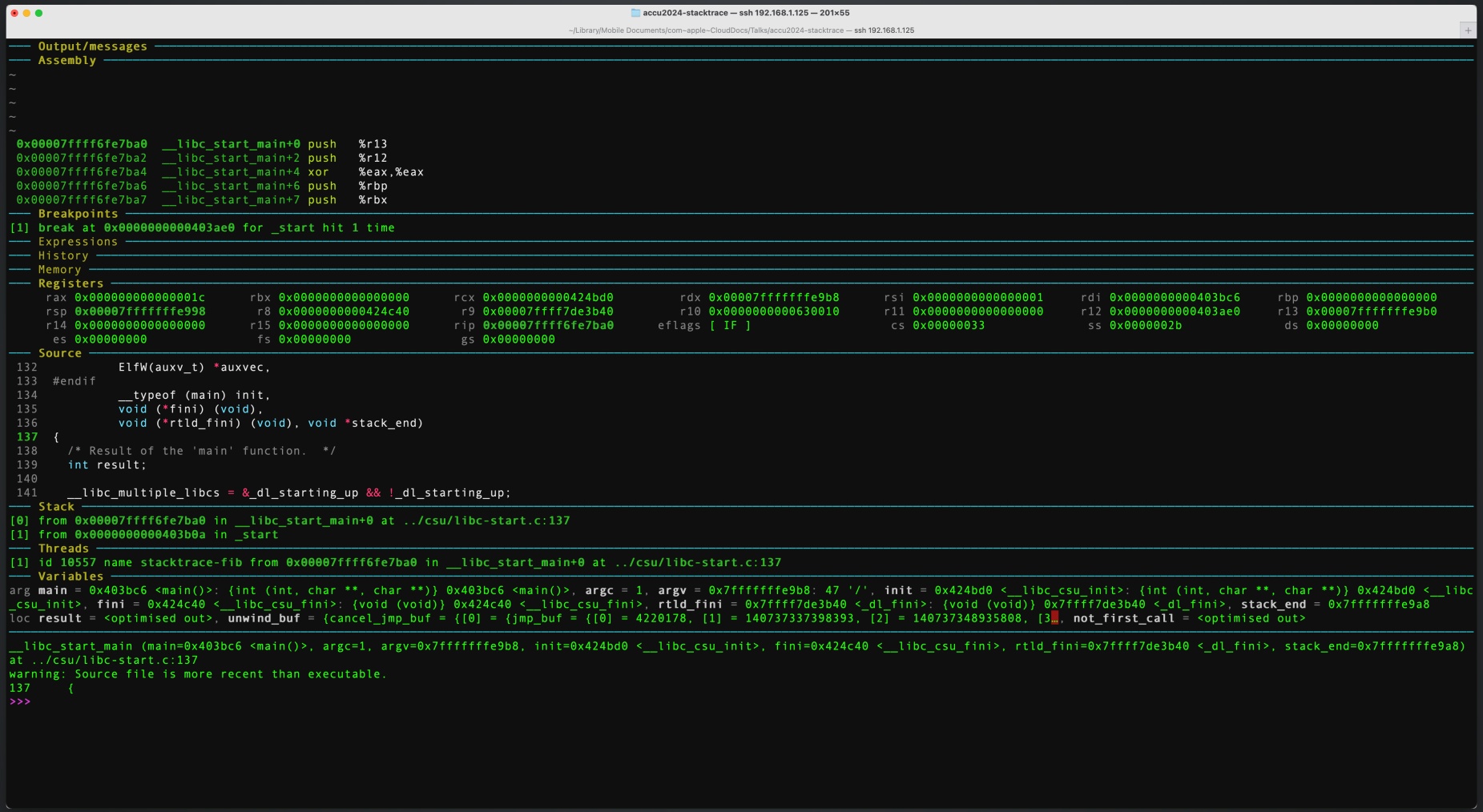
- GCC build must be enabled with:
  - --enable-libstdcxx-backtrace=yes
- 'libstdcxx-backtrace' is the implementation:
  - <gcc trunk>/libstdc++-v3/include/std/stacktrace
  - <gcc trunk>/libbacktrace
- Compiler options:
  - -g -lstdc++_libbacktrace

# FIBONACCI OUTPUT

```
 1 0 1 1 2 3 5 8 13 21 34
 2 Max stack depth was: 13
 3 stacktrace.cpp:17 fib_with_stacktrace::fib(unsigned int)
 4 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
 5 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
 6 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
 7 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
 8 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
 9 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
10 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
11 stacktrace.cpp:24 fib_with_stacktrace::fib(unsigned int)
12 stacktrace.cpp:38 main
13 :0 // __libc_start_main (<glibc trunk>/csu/libc-start.c:129)
14 :0 _start
15 :0
```

# OBSERVATIONS

- Attach information to stack frames via hash support
  - std::unordered_map<std::stacktrace_entry, T>
- GDB is great for exploring
  - Tip: Andrea Cardaci's GDB Dashboard
- Observer for implementation defined native handle
  - constexpr nh_type native_handle() const noexcept;


accu2024-stacktrace — ssh 192.168.1.125 — 201×55
~/Library/Mobile Documents/com~apple~CloudDocs/Talks/accu2024-stacktrace — ssh 192.168.1.125
Output/messages
Assembly
0x00007ffff6fe7ba0 __libc_start_main+0 push %r13
0x00007ffff6fe7ba2 __libc_start_main+2 push %r12
0x00007ffff6fe7ba4 __libc_start_main+4 xor %eax,%eax
0x00007ffff6fe7ba6 __libc_start_main+6 push %rbp
0x00007ffff6fe7ba7 __libc_start_main+7 push %rbx
Breakpoints
[1] break at 0x0000000000403ae0 for _start hit 1 time
Expressions
History
Memory
Registers
rax 0x000000000000001c rbx 0x0000000000000000 rcx 0x0000000000424bd0 rdx 0x00007fffffffe9b8 rsi 0x0000000000000001 rdi 0x0000000000403bc6 rbp 0x0000000000000000
rsp 0x00007fffffffe998 r8 0x0000000000424c40 r9 0x00007ffff7de3b40 r10 0x0000000000630010 r11 0x0000000000000000 r12 0x0000000000403ae0 r13 0x00007fffffffe9b0
r14 0x0000000000000000 r15 0x0000000000000000 rip 0x00007ffff6fe7ba0 eflags [ IF ] cs 0x00000033 ss 0x0000002b ds 0x00000000
es 0x00000000 fs 0x00000000 gs 0x00000000
Source
132 ElfW(auxv_t) *auxvec,
133 #endif
134 __typeof (main) init,
135 void (*fini) (void),
136 void (*rtld_fini) (void), void *stack_end)
137 {
138 /* Result of the 'main' function. */
139 int result;
140
141 __libc_multiple_libcs = &_dl_starting_up && !_dl_starting_up;
Stack
[0] from 0x00007ffff6fe7ba0 in __libc_start_main+0 at ../csu/libc-start.c:137
[1] from 0x0000000000403b0a in _start
Threads
[1] id 10557 name stacktrace-fib from 0x00007ffff6fe7ba0 in __libc_start_main+0 at ../csu/libc-start.c:137
Variables
arg main = 0x403bc6 <main()>: {int (int, char **, char **)} 0x403bc6 <main()>, argc = 1, argv = 0x7fffffffe9b8: 47 '/', init = 0x424bd0 <__libc_csu_init>: {int (int, char **, char **)} 0x424bd0 <__libc
_csu_init>, fini = 0x424c40 <__libc_csu_fini>: {void (void)} 0x424c40 <__libc_csu_fini>, rtld_fini = 0x7ffff7de3b40 <_dl_fini>: {void (void)} 0x7ffff7de3b40 <_dl_fini>, stack_end = 0x7fffffffe9a8
loc result = <optimised out>, unwind_buf = {cancel_jmp_buf = {[0] = {jmp_buf = {[0] = 4220178, [1] = 140737337398393, [2] = 140737348935808, [3
, not_first_call = <optimised out>
__libc_start_main (main=0x403bc6 <main()>, argc=1, argv=0x7fffffffe9b8, init=0x424bd0 <__libc_csu_init>, fini=0x424c40 <__libc_csu_fini>, rtld_fini=0x7ffff7de3b40 <_dl_fini>, stack_end=0x7fffffffe9a8)
at ../csu/libc-start.c:137
warning: Source file is more recent than executable.
137 {
>>>

# COROUTINE EXAMPLE

```
1  // This is based on the Boost.Beast HTTP coro server example.
2  // See the following for documentation and details:
3  //
4  // https://www.boost.org/doc/libs/1_84_0/libs/beast/doc/html/
5  // beast/examples.html#beast.examples.servers_advanced
6
7  #include <boost/asio/dispatch.hpp>
8  #include <boost/asio/spawn.hpp>
9  #include <boost/asio/strand.hpp>
10 #include <boost/beast/core.hpp>
11 #include <boost/beast/http.hpp>
12 #include <boost/beast/version.hpp>
13 #include <boost/config.hpp>
14
15 #include <iostream>
16 #include <memory>
17 #include <thread>
18 #include <vector>
19 #include <stacktrace>
20 #include <format>
21
```

# COROUTINE OUTPUT

```
/home/pascoej/accu2024-example-code/coro_http_server.cpp:58
  operator()
/home/pascoej/accu2024-example-code/coro_http_server.cpp:71
  do_session()
/usr/local/include/c++/13.0.1/bits/invoke.h:61
  void std::__invoke_impl()
/usr/local/include/c++/13.0.1/bits/invoke.h:96
  std::__invoke_result()
/usr/local/include/c++/13.0.1/functional:506
  void std::_Bind()
/usr/local/include/c++/13.0.1/functional:591
  void std::_Bind()
/usr/local/include/boost/asio/impl/spawn.hpp:1493
  boost::asio::detail::old_spawn_entry_point()
/usr/local/include/boost/asio/impl/spawn.hpp:1485
  boost::asio::detail::old_spawn_entry_point()
/usr/local/include/boost/asio/impl/spawn.hpp:158
  boost::asio::detail::spawned_coroutine_thread::entry_point()
/usr/local/include/boost/coroutine/detail/pull_coroutine_object.hpp:2
  boost::coroutines::detail::pull_coroutine_object()
/usr/local/include/boost/coroutine/detail/trampoline_pull.hpp:41
```

# ASYNCHRONOUS SIGNAL SAFETY

- How do I get a stacktrace in a signal handler?
- Tricky to implement safely
  - Collect minimal information in the handler
  - Resolve outside (or in another process)
- std::stacktrace is not (currently) signal safe
  - But could be in the future
- See: cpptrace and Boost safe_dump_to

# CONCLUSIONS

- Stacktraces are useful
  - Enrichment, introspection, object lifetimes
- Stack depth can be a useful proxy
  - Inexpensive to store - easy to chart
- Use with caution in signal handlers
- Be mindful of stacktrace output (extensive)
- Debugging starts in the design phase

# RESOURCES

- Episode 336: C++ Weekly (Jason Turner)
- Sandor Dargo's Blog
- Boost::Stacktrace Documentation
- Signal safety:
  - Theoretical Async Signal Safety (Boost)
  - Signal-Safe Tracing (cpptrace)
  - signal-safety (Linux man page)