Zephyr® Project

Developer Summit

Zephyr® Project
Developer Summit

Adding Coredumps To Your Debugging Toolkit

Eric Johnson, *Memfault*
@ejohnso49

#EMBEDDEDOSSUMMIT

Zephyr® Project
Developer Summit

About Me:

- Firmware Solutions Engineer @ Memfault
- Previously: Walgreens Health, Athos, Acuity Brands, Lexmark
- First encountered Zephyr at OSS 2018
- Met Tyler Hoffman at ZDS 2022
- Contributor of humble bug fixes to BLE, Kernel, Shell subsystems

Memfault

- Coredumps Overview
- Coredumps + Zephyr
  - Zephyr Asserts and Fault Handling
  - Subsystem Components
  - Host Tools
  - Scripting
- Demo!
- Future Work

Logging is great, until…

```
[61:55:52.180,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.280,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.380,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.480,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.580,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.680,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.780,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.880,000] <err> sensor: Could not insert data into ring buffer
[61:55:52.980,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.080,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.180,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.280,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.380,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.480,000] <err> sensor: Could not insert data into ring buffer
[61:55:53.580,000] <err> sensor: Could not insert data into ring buffer
```

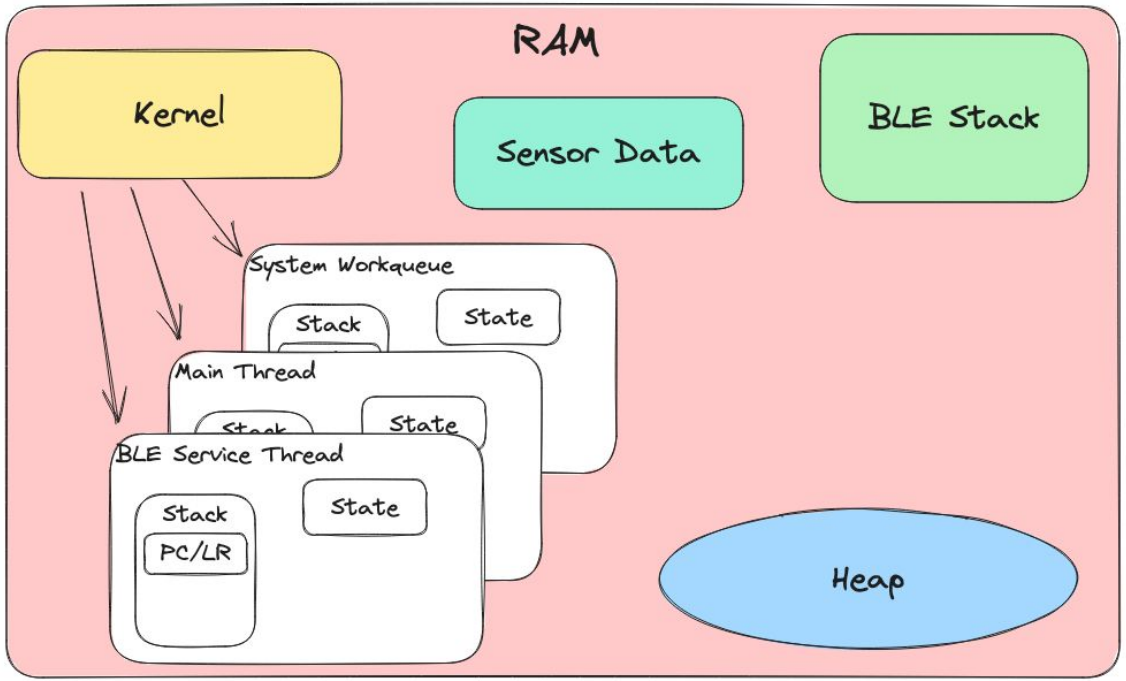
Panics are great, but only show 1 frame

```
[70:52:25.480,000] <err> sensor: Could not insert data into ring buffer
ASSERTION FAIL [ret != size] @ WEST_TOPDIR/eoss-app/src/sensor.c:16
[70:52:25.480,000] <err> os: r0/a1:  0x00000004  r1/a2:  0x00000010  r2/a3:  0x00000002
[70:52:25.480,000] <err> os: r3/a4:  0x20000200 r12/ip:  0x200029c0 r14/lr:  0x00000407
[70:52:25.480,000] <err> os:  xpsr:  0x4100000f
[70:52:25.480,000] <err> os: Faulting instruction address (r15/pc): 0x0000a13c
[70:52:25.480,000] <err> os: >>> ZEPHYR FATAL ERROR 4: Kernel panic on CPU 0
[70:52:25.480,000] <err> os: Fault during interrupt handling
```

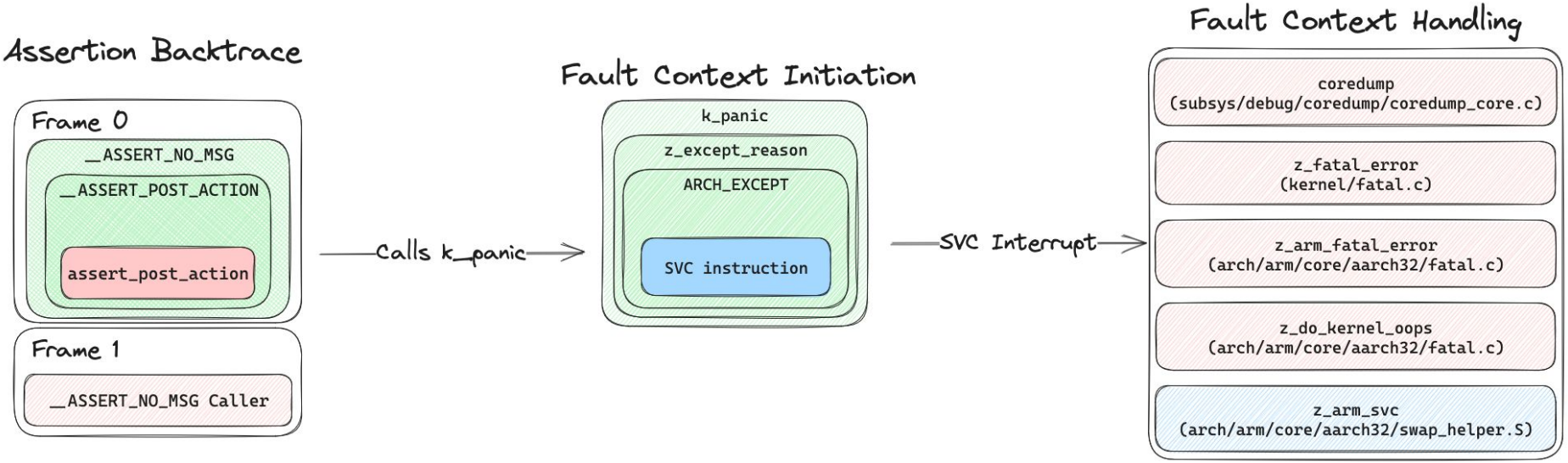
Coredumps

- Triggered by faults, kernel panics, asserts
- Captures registers and memory to allow for later analysis
- Data can be streamed out immediately or stored in non-volatile memory

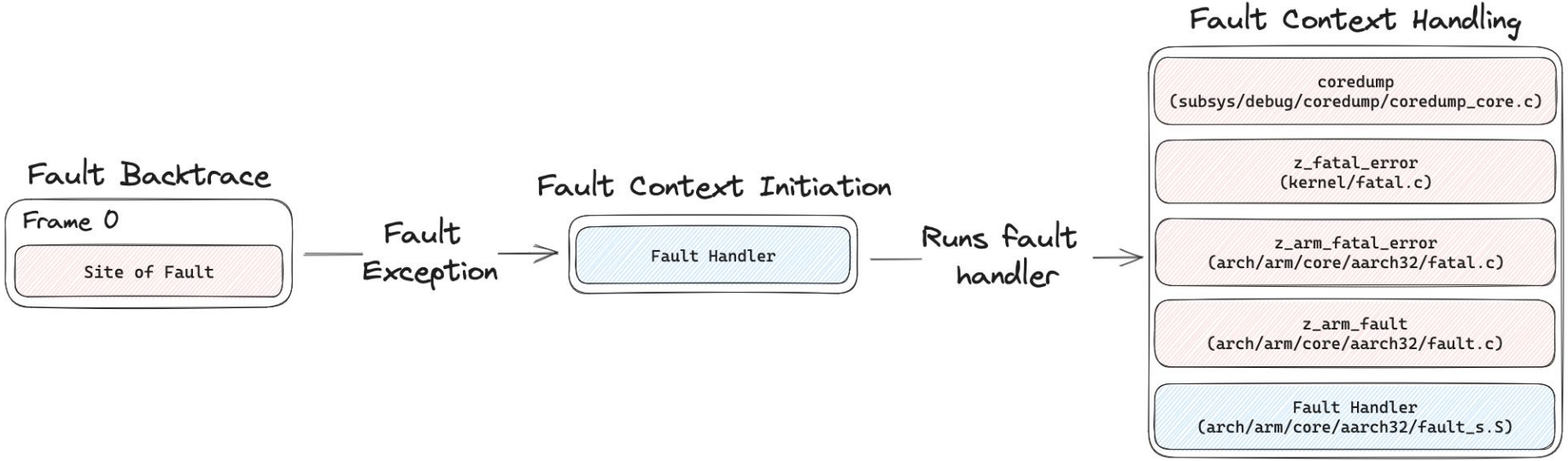
Coredump Components



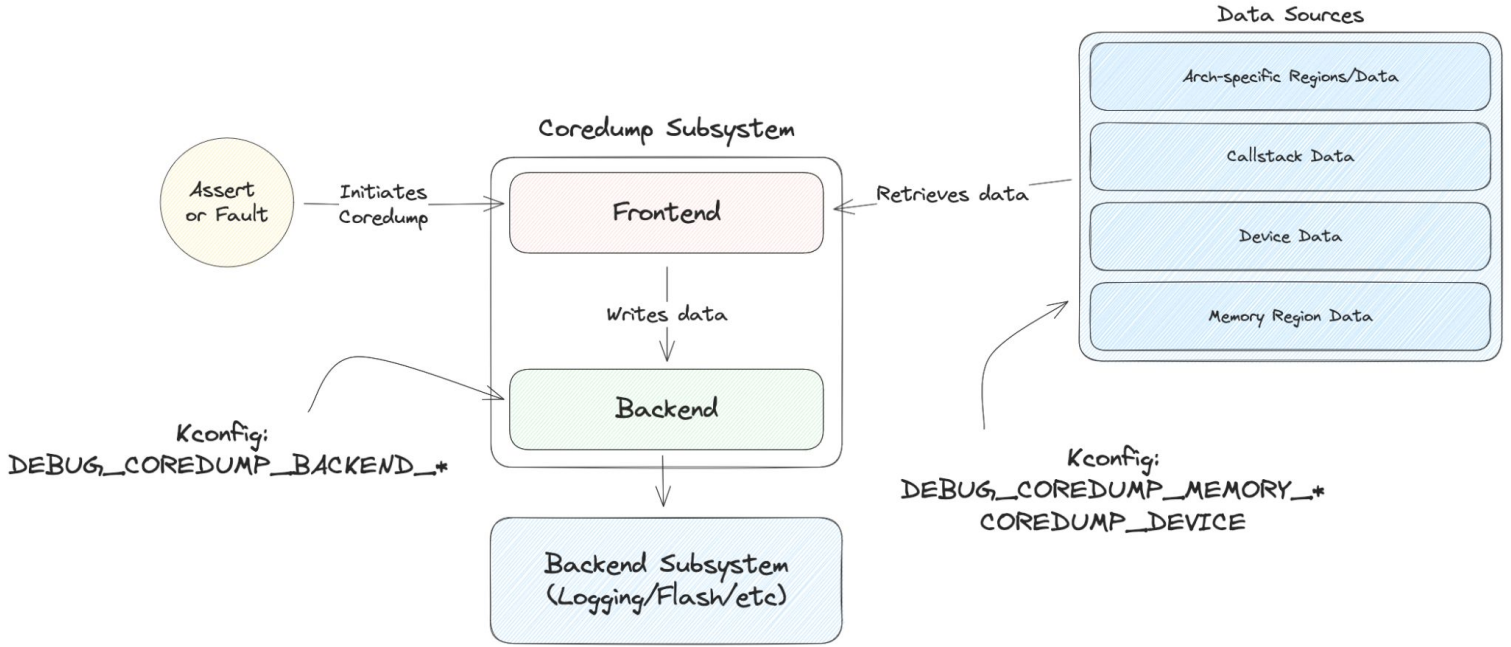
Zephyr Assertion Call Graph



Zephyr Fault Handling Call Graph



Coredump Subsystem



Device Region Example

```
/ {
    coredump_gpio: coredump-gpio {
        compatible = "zephyr,coredump";
        coredump-type = "COREDUMP_TYPE_MEMCPY";
        status = "okay";
        memory-regions = <0x40004000 0x1000>;
    };
};
```

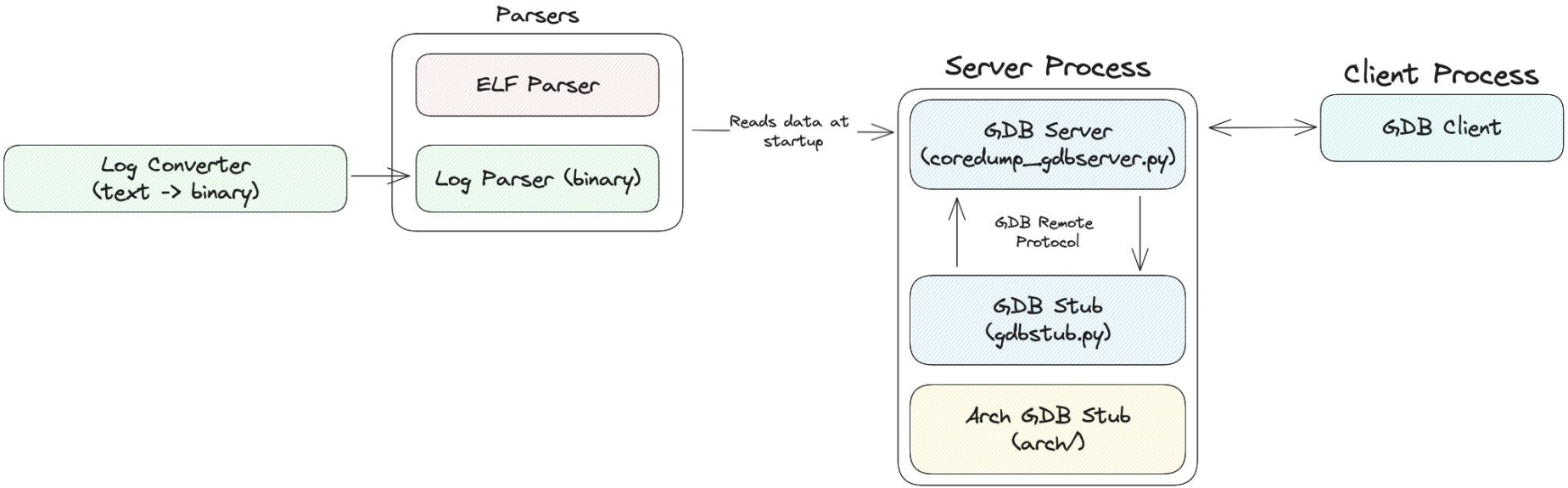
Zephyr® Project
Developer Summit

```
*** Booting Zephyr OS build v3.4.0 ***
uart:~$ sensor enable
[70:52:25.480,000] <err> sensor: Could not insert data into ring buffer
ASSERTION FAIL [ret != size] @ WEST_TOPDIR/eoss-app/src/sensor.c:16
[70:52:25.480,000] <err> os: r0/a1:  0x00000004  r1/a2:  0x00000010  r2/a3:  0x00000002
[70:52:25.480,000] <err> os: r3/a4:  0x20000200 r12/ip:  0x200029c0 r14/lr:  0x00000407
[70:52:25.480,000] <err> os:  xpsr:  0x4100000f
[70:52:25.480,000] <err> os: Faulting instruction address (r15/pc): 0x0000a13c
[70:52:25.480,000] <err> os: >>> ZEPHYR FATAL ERROR 4: Kernel panic on CPU 0
[70:52:25.480,000] <err> os: Fault during interrupt handling

[70:52:25.480,000] <err> os: Current thread: 0x200009e8 (idle)
[70:52:25.480,000] <err> coredump: #CD:BEGIN#
[70:52:25.480,000] <err> coredump: #CD:5a4501000300050004000000
[70:52:25.480,000] <err> coredump: #CD:4102004400
[70:52:25.480,000] <err> coredump: #CD:040000001000000002000000000020020c02900200704000003ca100000f000041
[70:52:25.480,000] <err> coredump: #CD:0000000000000000000000000000000000000000000000000000000000000000
[70:52:25.480,000] <err> coredump: #CD:00000000
[70:52:25.480,000] <err> coredump: #CD:4d01000000002088390020
[70:52:25.480,000] <err> coredump: #CD:a5b92dedc233c34c4035002004000000040000000000000000000000000000000
[70:52:25.480,000] <err> coredump: #CD:0000000000040000010000000100000000000000000000000000000005f40000
[70:52:25.480,000] <err> coredump: #CD:0100000001000000e9660000d7a3000000000000010000006800002040330020
[70:52:25.480,000] <err> coredump: #CD:4033002000000000403300201c0000001c0000000000000000000000000000000
[70:52:25.480,000] <err> coredump: #CD:0000000000200000cc8000074c800004039002000e0000000e00000000000000
[70:52:25.480,000] <err> coredump: #CD:0e0000000e000000000000040000000803900209400000094000000900000000
[70:52:25.480,000] <err> coredump: #CD:940000009400000090000000800000e9660000000000208839002000000000
[70:52:25.480,000] <err> coredump: #CD:00000000a1640000a9650000e5640000316400004564000000c2010000000000
[70:52:25.480,000] <err> coredump: #CD:0000000000c201000000000000000000d00040001bb700b3bd000000c20100
[70:52:25.480,000] <err> coredump: #CD:353a000074c80000b0010020c0060020300100203001002000000100010001000
[70:52:25.480,000] <err> coredump: #CD:c0000000c0000000c0000000c000000007000000000000000ffa3000099a30000
[70:52:25.480,000] <err> coredump: #CD:b8020020000100004e0000006c0100206c0100200100000010000007c010020
[70:52:25.480,000] <err> coredump: #CD:7c0100200000000001b0000001b0000001b0000001b0000001b0000001b000000
[70:52:25.480,000] <err> coredump: #CD:1b0000001b0000001b0000001b0000000c00600202801002061910000000000000
[70:52:25.480,000] <err> coredump: #CD:0a000000000000000c8010020c80100204f9e0000000000000a00000000000000
[70:52:25.480,000] <err> coredump: #CD:0100000000000000000200200002002000000000001000000f8010020f8010020
[70:52:25.480,000] <err> coredump: #CD:e8010020e8010020e801002000020e0000000000000000000000000000000000
[70:52:25.480,000] <err> coredump: #CD:0000000000000000000000000000000e8010020ffffffffffffffff00000000
[70:52:25.480,000] <err> coredump: #CD:fffffffffffffffe80100200000000d8190020000000058020020580200 20
```

#EMBEDDEDOSSUMMIT

Coredump Host Tools



Scripting Extensions

- GDB can be built with Python extension support
  - Zephyr toolchain defaults to no-py version
  - Use Python with “-py”
- Requires matching system Python install
- Use venv + gdbundle to manage packages

Zephyr® Project
Developer Summit

Demo!

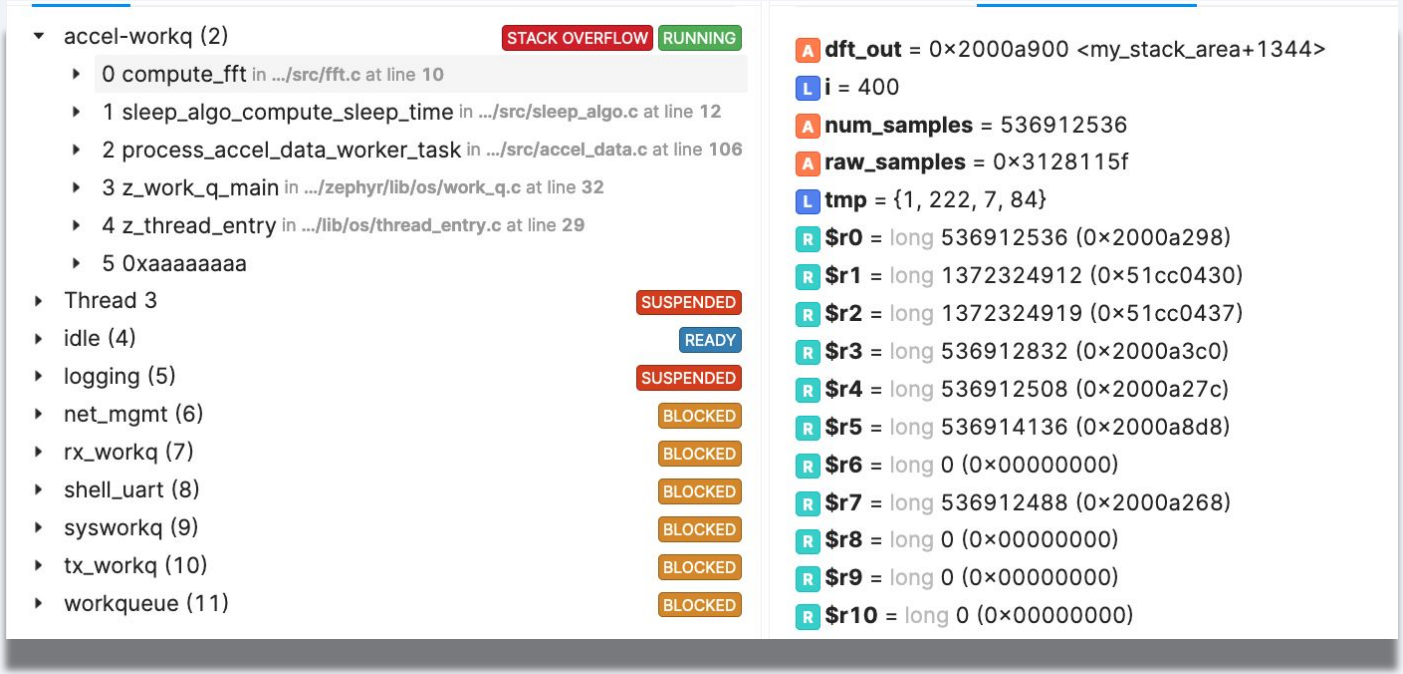
Future Work

- ISR-safe Flash backed: See issue
- Allow application to override linker memory region
- Encourage users to submit coredumps with bugs/issues
- Add example using flash simulation region for backend
- Extend west to convert log output and run coredump server

Where To Find Me

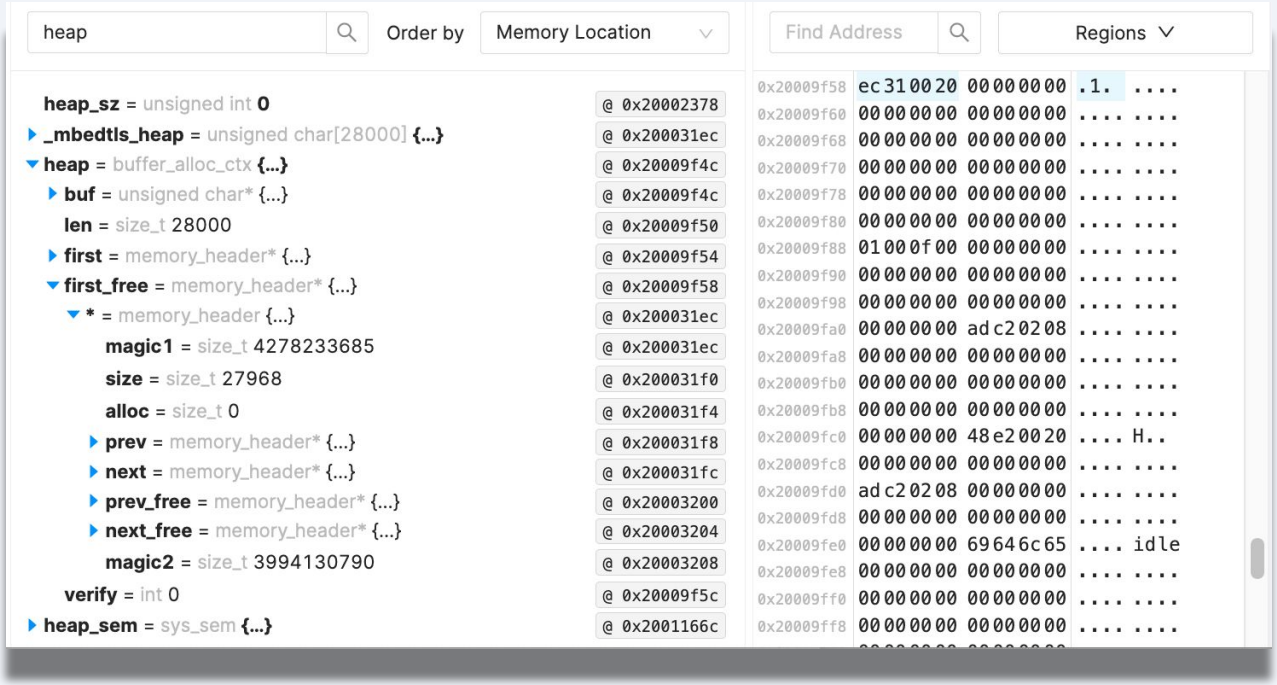
- linkedin.com/in/ejohnso49/
- Github: ejohnso49
- interrupt.memfault.com

Coredumps in Memfault



View tasks, stack traces, registers, and local variables

Coredumps in Memfault



View all global variables at time of coredump

Acknowledgements:

- Coredump subsystem maintainers and contributors
- Coredump: A brief introduction and demo by Daniel Leung

- https://github.com/memfault/gdbundle
- https://github.com/ejohnso49/gdbundle-gpio