Samuel Skean 2025-11-03

```
Shadow bytes around the buggy address:
  0x00016ddaab00: 00 00 00 00 00 00 00 00 00
  0x00016ddaab80: 00 00 00 00 00 00 00 00 00
  0x00016ddaac00: 00 00 00 00 00 00 00 00 00
  0x00016ddaac80: 00 00 00 00 00 00 00 00 00
  0x00016ddaad00: 00 00 f1 f1 f1 f1 00 00 00
=>0x00016ddaad80: 00[f3]f3 f3 f3 f3 f3 00 00
  0x00016ddaae00: 00 00 00 00 00 00 00 00 00
```

Address Sanitizer (ASan) Internals

Adapted from Serebryany et al. (2012)

Motivation

The problem: C lets us do too much with memory.

C lets us do too much with memory.

- Buffer overflow (/underflow)
  - Heap
  - Stack
  - Global
- Use-after-free
- Use after function return?

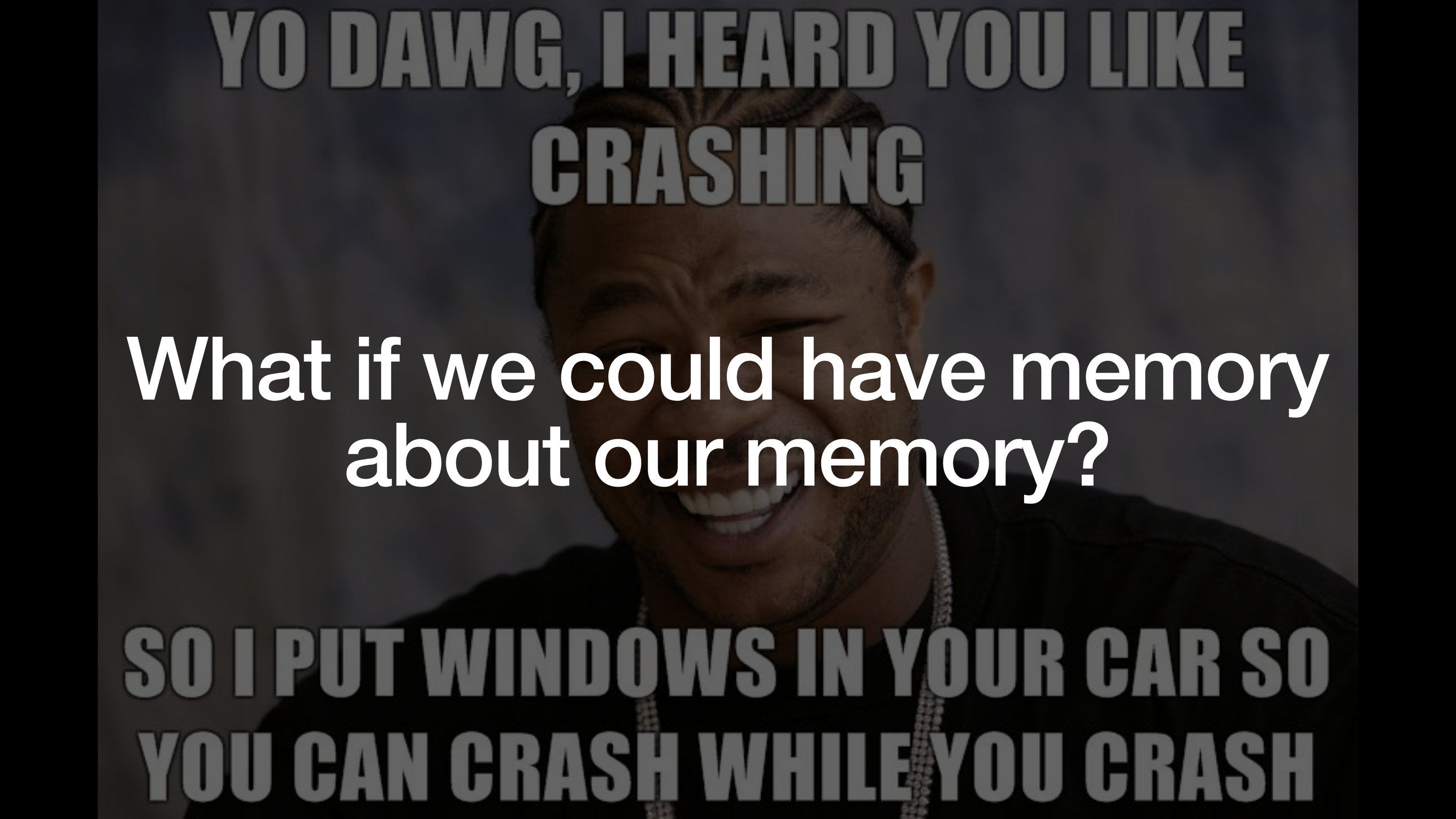
```
[samuel-skean@armDebianVM:~$ valgrind ./a.out
==2031== Memcheck, a memory error detector
==2031== Copyright (C) 2002-2024, and GNU GPL'd, by Julian Seward et al.
==2031== Using Valgrind-3.24.0 and LibVEX; rerun with -h for copyright info
==2031== Command: ./a.out
==2031==
Hi this is your number: 8
==2031== Invalid read of size 4
==2031==    at 0x108814: main (silly.c:14)
==2031==  Address 0x1fff0007bc is on thread 1's stack
==2031==  20 bytes below stack pointer
==2031==
Your number, sir: 8
==2031==
==2031== HEAP SUMMARY:
==2031==     in use at exit: 4 bytes in 1 blocks
==2031==   total heap usage: 2 allocs, 1 frees, 1,028 bytes allocated
==2031==
==2031== LEAK SUMMARY:
==2031==    definitely lost: 4 bytes in 1 blocks
```

We can do better than Valgrind.

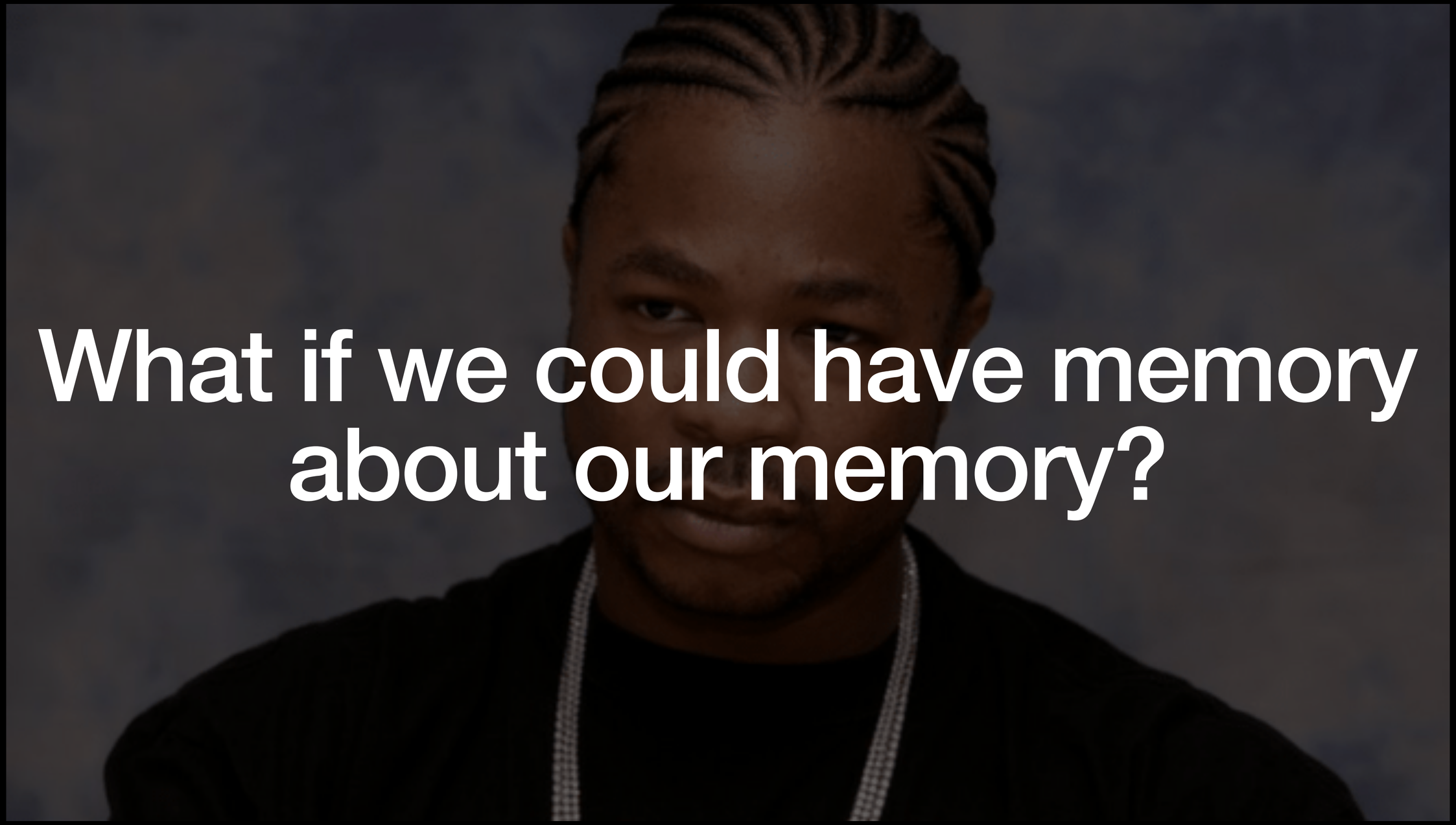
- Faster
  - Less Intrusive - fewer dependencies on language
- Accurate?
  - Well, still no false positives.

The Approach

How ASan lays out memory:



What if we could have memory about our memory?


What if we could have memory about our memory?

The Shadow Mapping

Address of shadow byte =

(Address of normal byte >> 3) + Offset

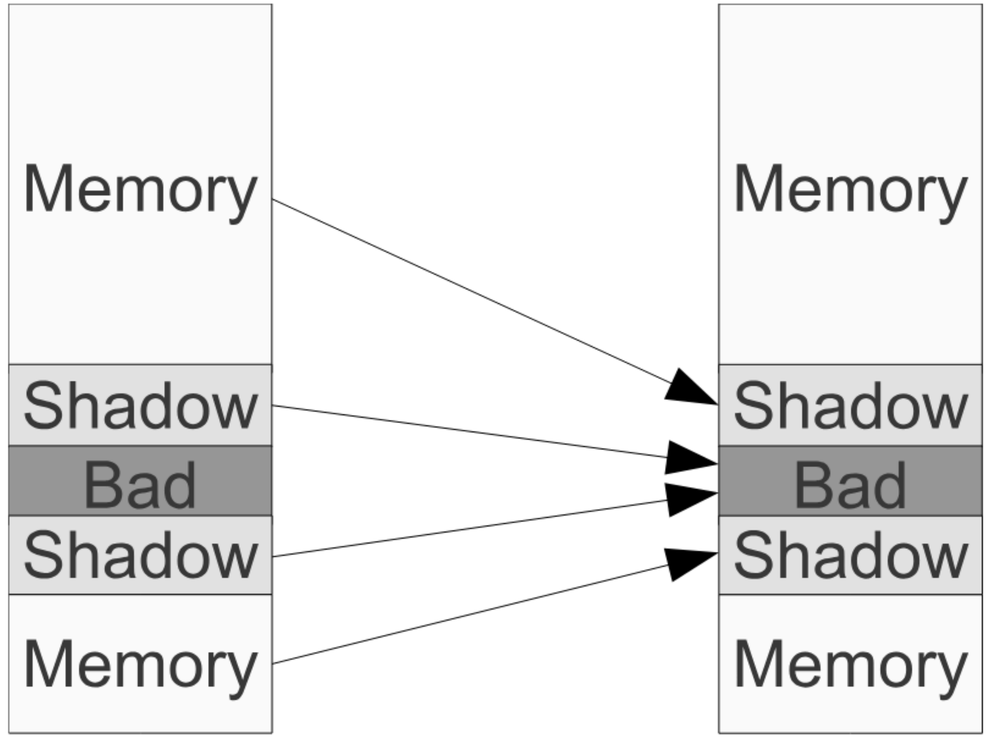
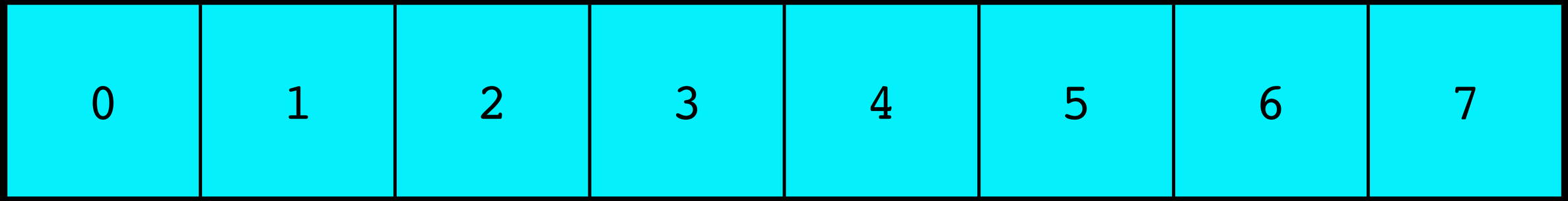


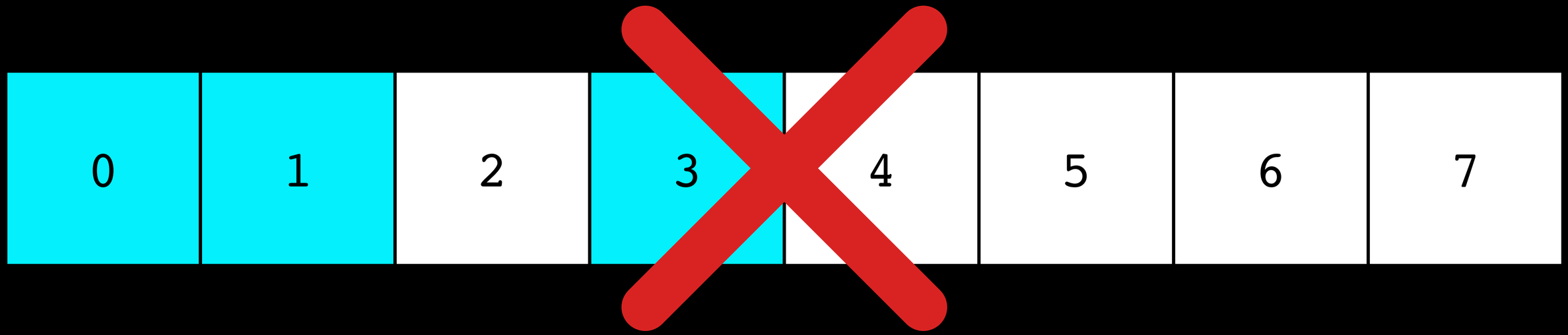
Figure 1: AddressSanitizer memory mapping.

A chunk of 8 bytes, 8-byte aligned



allocated bytes

A chunk of 8 bytes, *Not* 8-byte aligned



Every Memory Load Becomes:

```
ShadowAddr = (Addr >> 3) + Offset;
if (*ShadowAddr != 0)
  ReportAndCrash(Addr);
```

Every Memory Store Becomes:

```
ShadowAddr = (Addr >> 3) + Offset;
k = *ShadowAddr;
if (k != 0 && ((Addr & 7) + AccessSize > k))
    ReportAndCrash(Addr);
```

What We Looked At + Feedback

https://forms.gle/cj5FfdcnacixxAb37