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.

```
[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
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C lets us do too much with memory.

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

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==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
```

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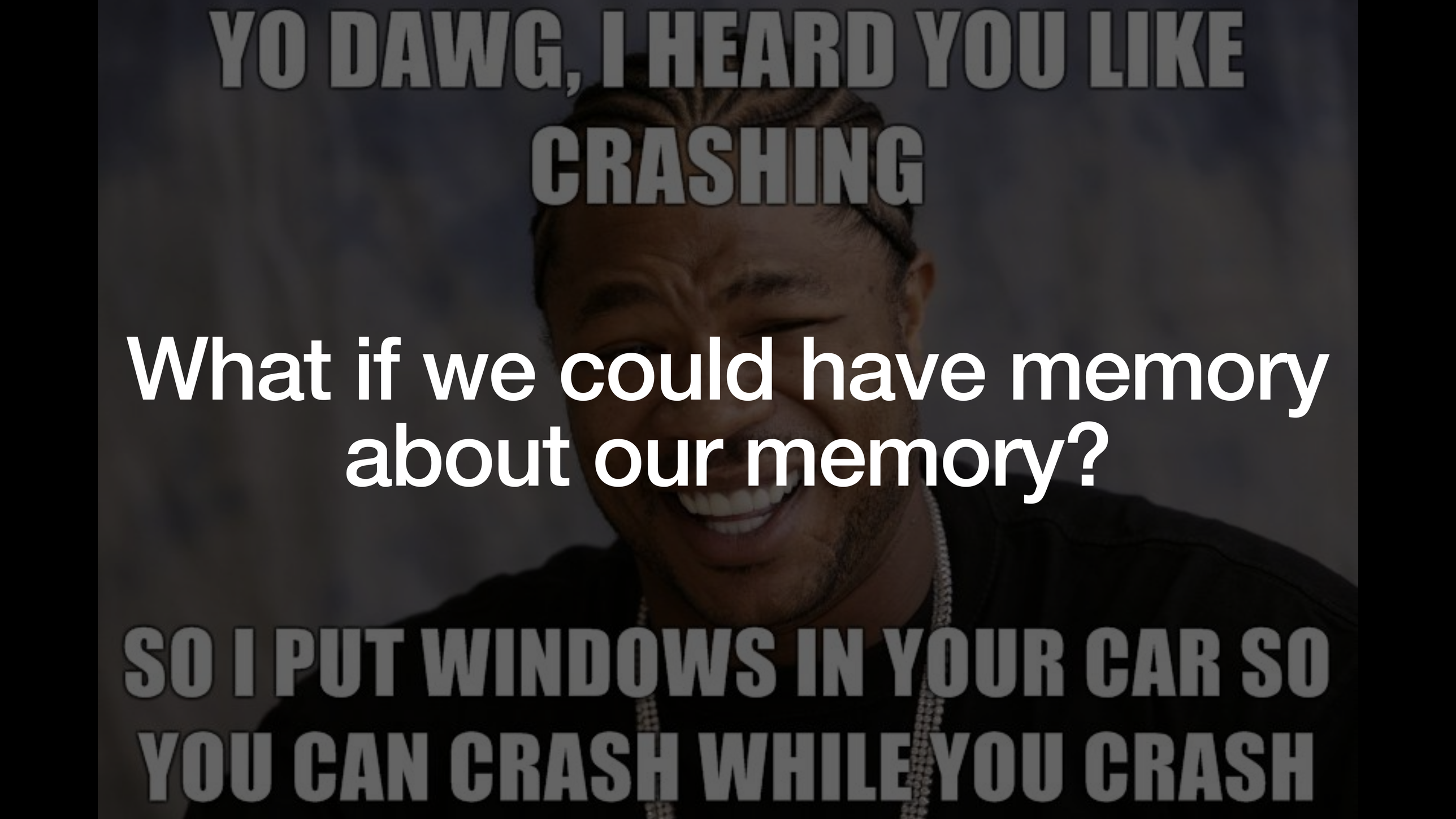
  - Less Intrusive - fewer dependencies on language
- Accurate?
  - Well, still no false positives.

The Approach


redzone1
mem1
redzone2
mem2
redzone3

How ASan lays out memory:

What if we could have memory about our memory?



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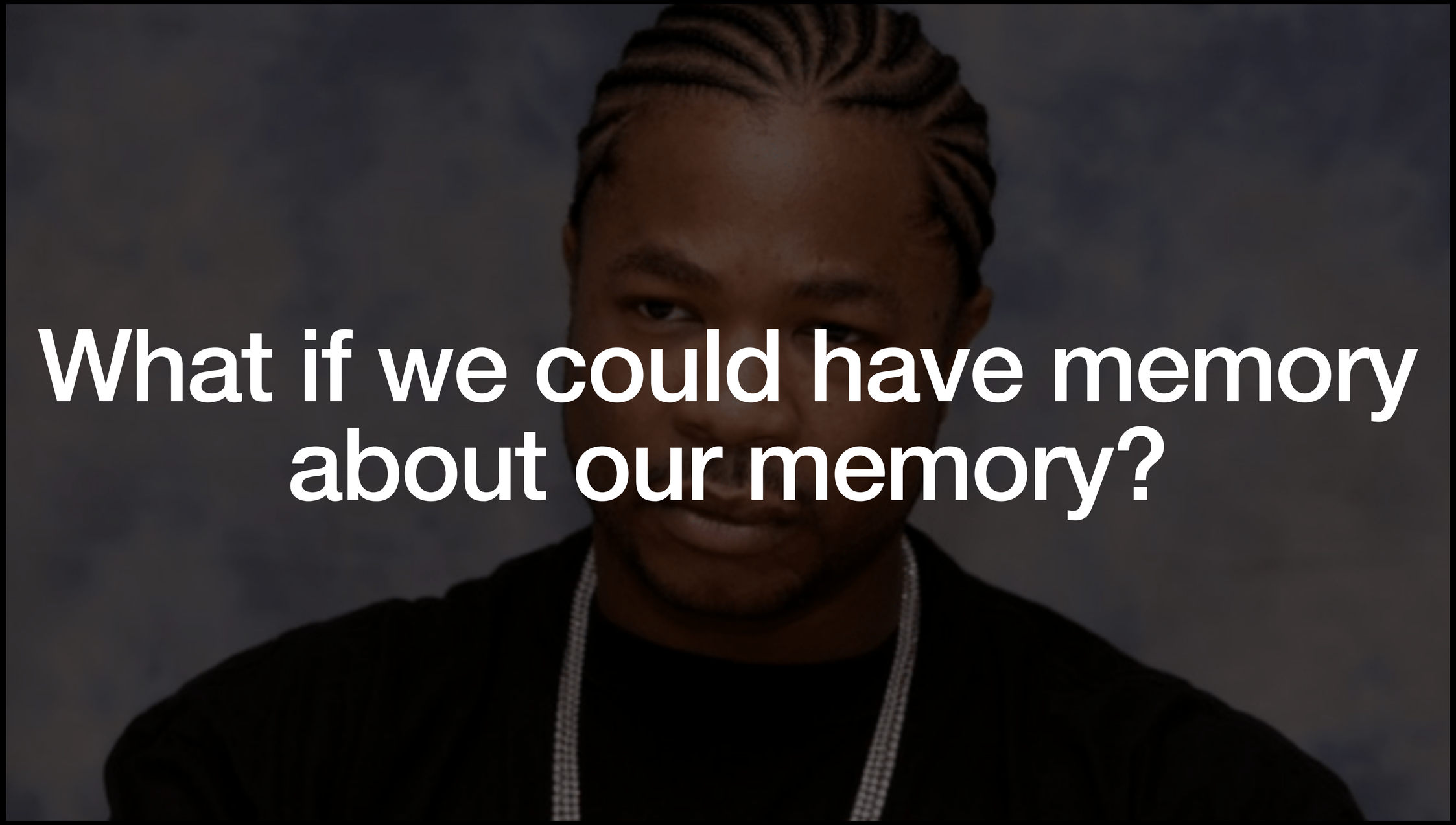

What if we could have memory about our memory?

The Shadow Mapping

Address of shadow byte =

(Address of normal byte >> 3) + Offset

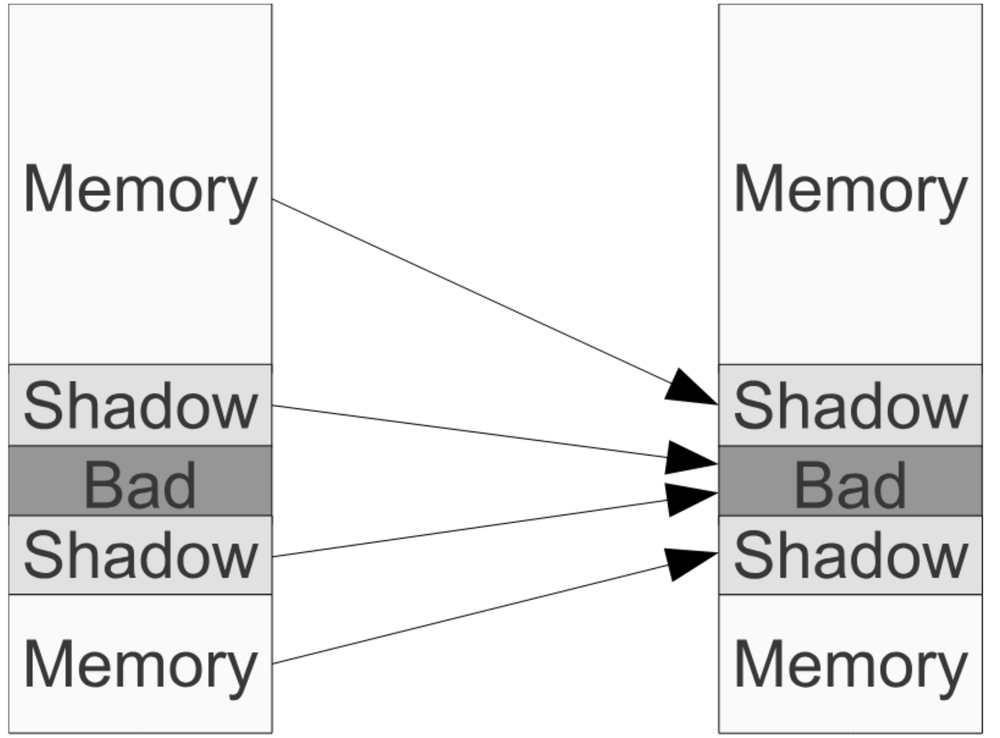
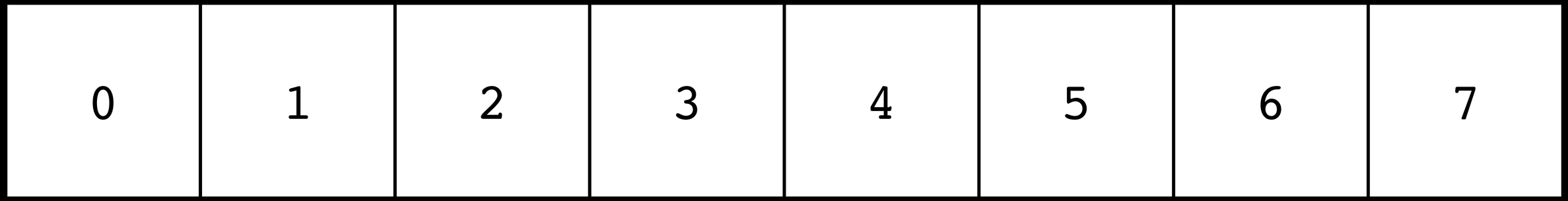


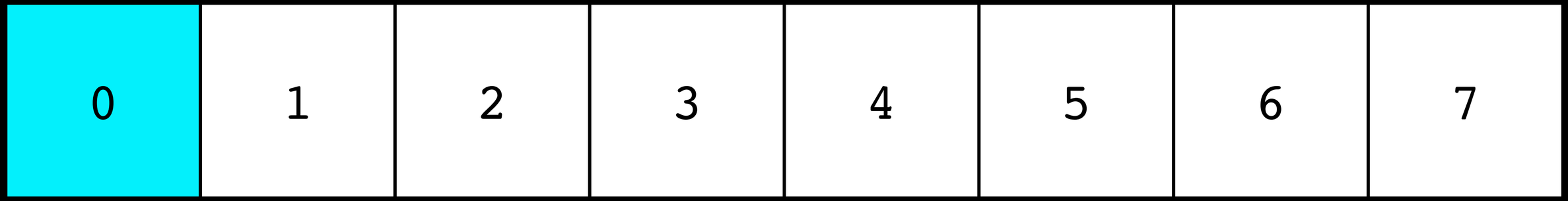
Figure 1: AddressSanitizer memory mapping.

A chunk of 8 bytes, 8-byte aligned



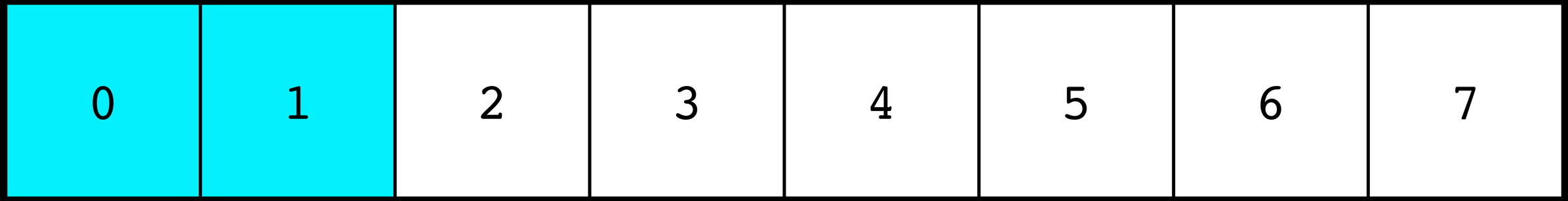
0 allocated bytes

A chunk of 8 bytes, 8-byte aligned



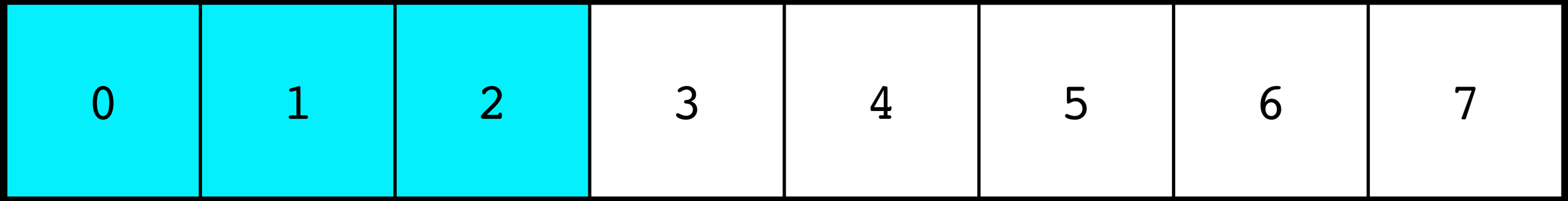
1 allocated byte

A chunk of 8 bytes, 8-byte aligned



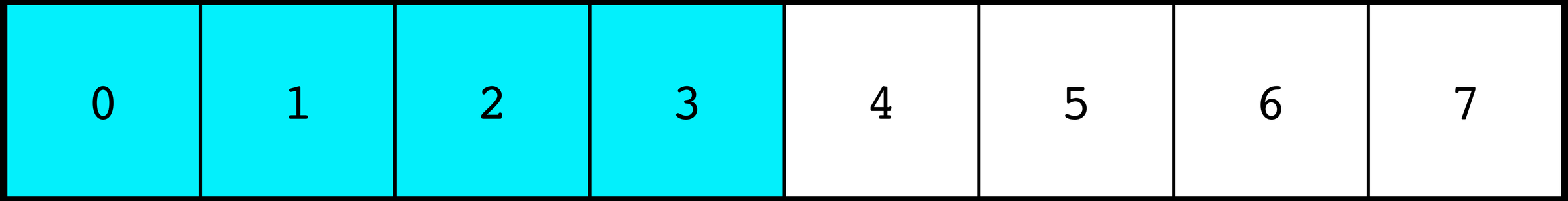
2 allocated bytes

A chunk of 8 bytes, 8-byte aligned



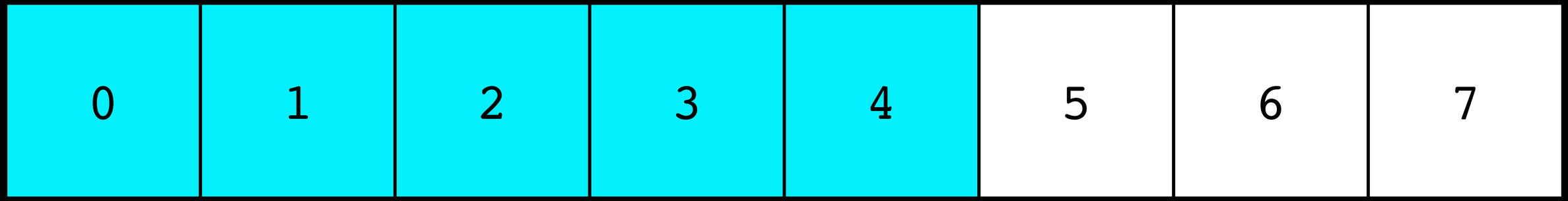
3 allocated bytes

A chunk of 8 bytes, 8-byte aligned



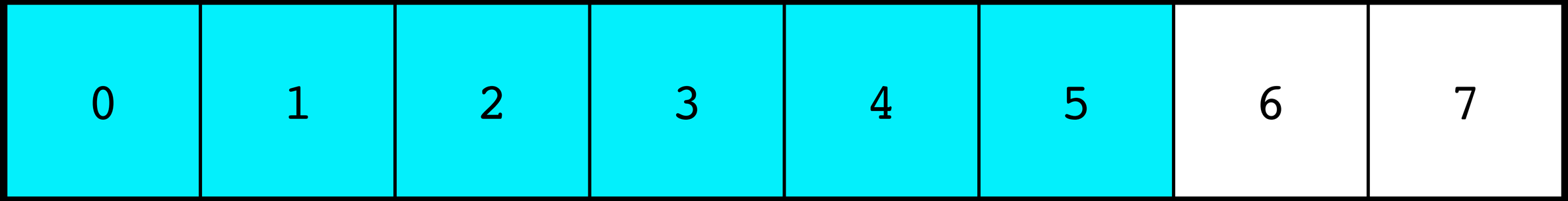
4 allocated bytes

A chunk of 8 bytes, 8-byte aligned



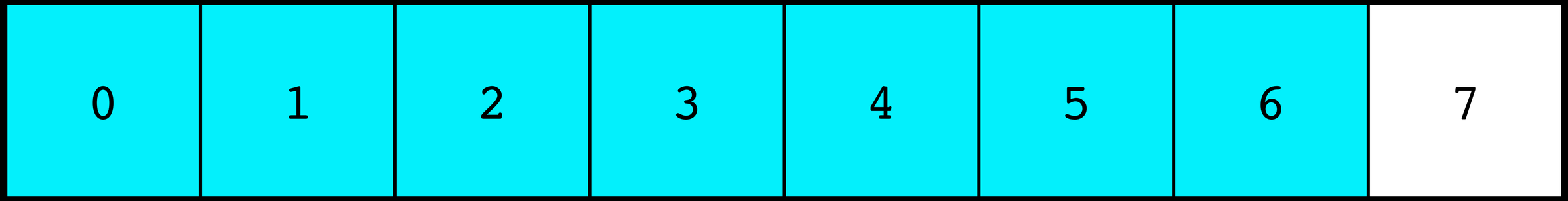
5 allocated bytes

A chunk of 8 bytes, 8-byte aligned



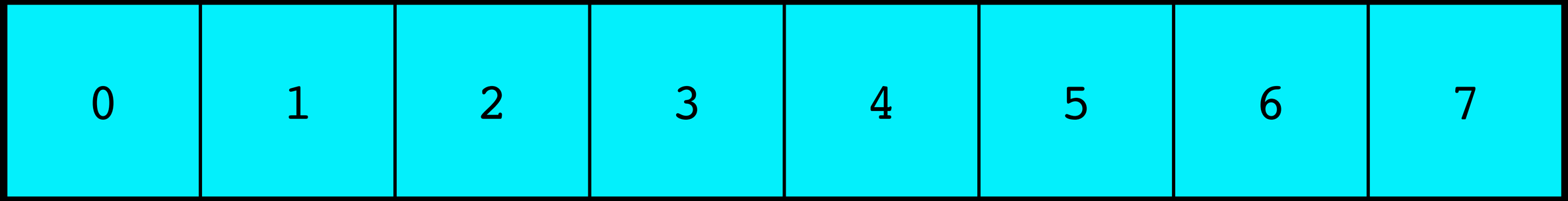
6 allocated bytes

A chunk of 8 bytes, 8-byte aligned



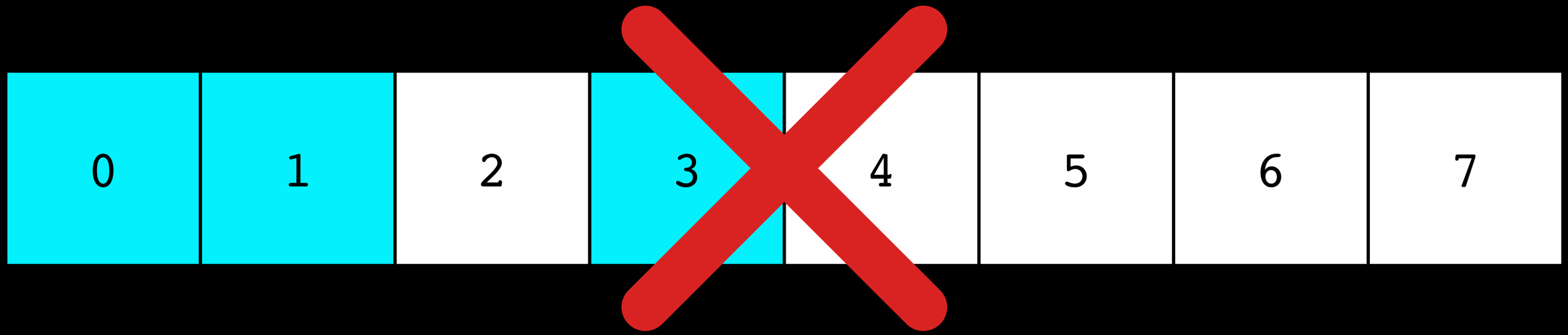
7 allocated bytes

A chunk of 8 bytes, 8-byte aligned



8 allocated bytes

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



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

Every Memory Load/Store Gets This Before it?

```
ShadowAddr = (Addr >> 3) + Offset;
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```

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

What We Looked At + Feedback

https://forms.gle/cj5FfdcnacixxAb37