

Shadow bytes around the buggy address:

0x00016ddaab00:	00	00	00	00	00	00	00	00	00	00
0x00016ddaab80:	00	00	00	00	00	00	00	00	00	00
0x00016ddaac00:	00	00	00	00	00	00	00	00	00	00
0x00016ddaac80:	00	00	00	00	00	00	00	00	00	00
0x00016ddaad00:	00	00	f1	f1	f1	f1	00	00	00	00
=>0x00016ddaad80:	00	[f3]	f3	f3	f3	f3	f3	00	00	00
0x00016ddaae00:	00	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
```

C lets us do too much with memory.

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

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==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
```

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- Faster

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 - Less Intrusive - fewer dependencies on language

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

The Approach



How ASan lays out memory:

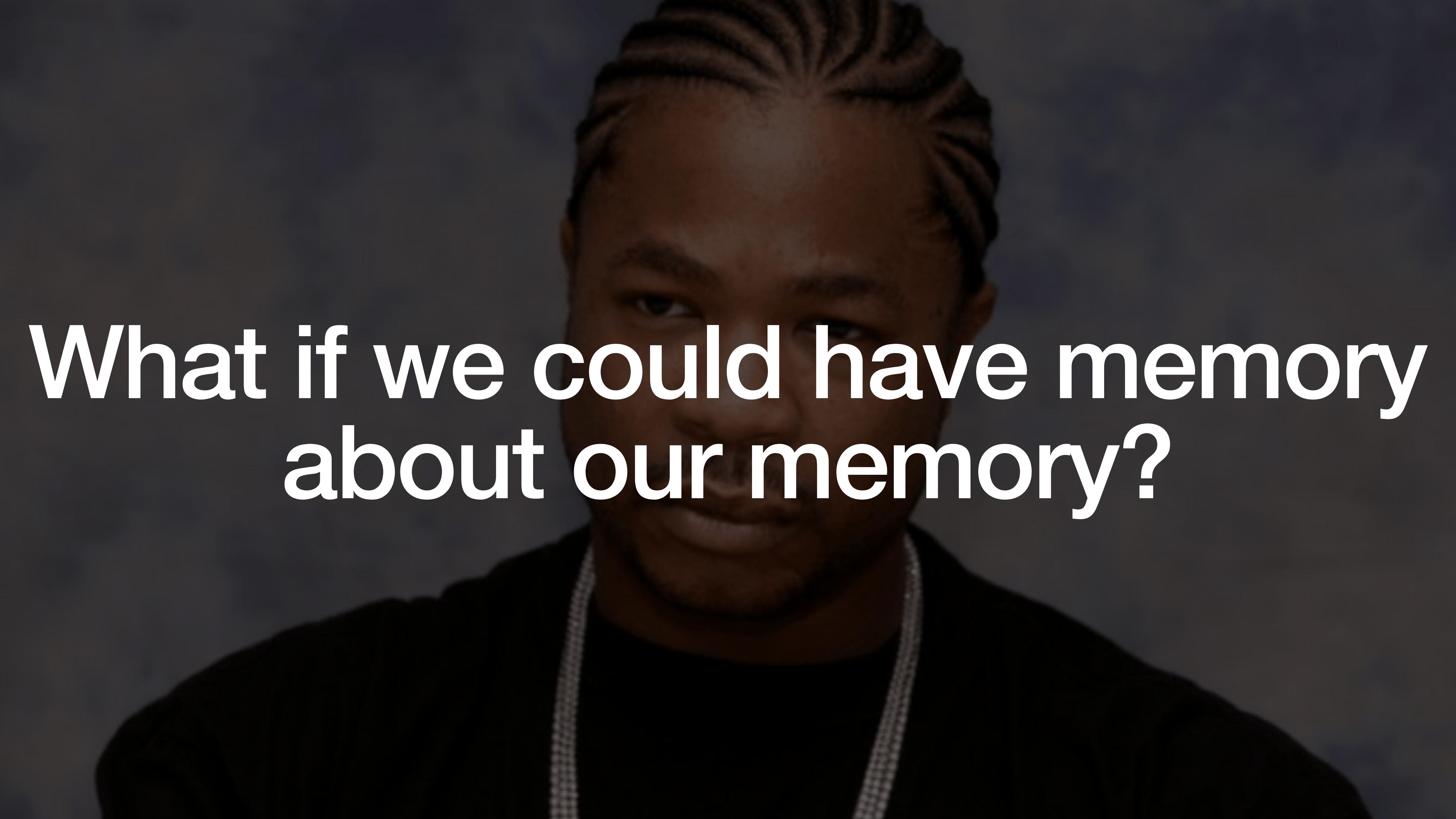


What if we could have memory
about our memory?

**YO DAWG, I HEARD YOU LIKE
CRASHING**

What if we could have memory
about our memory?

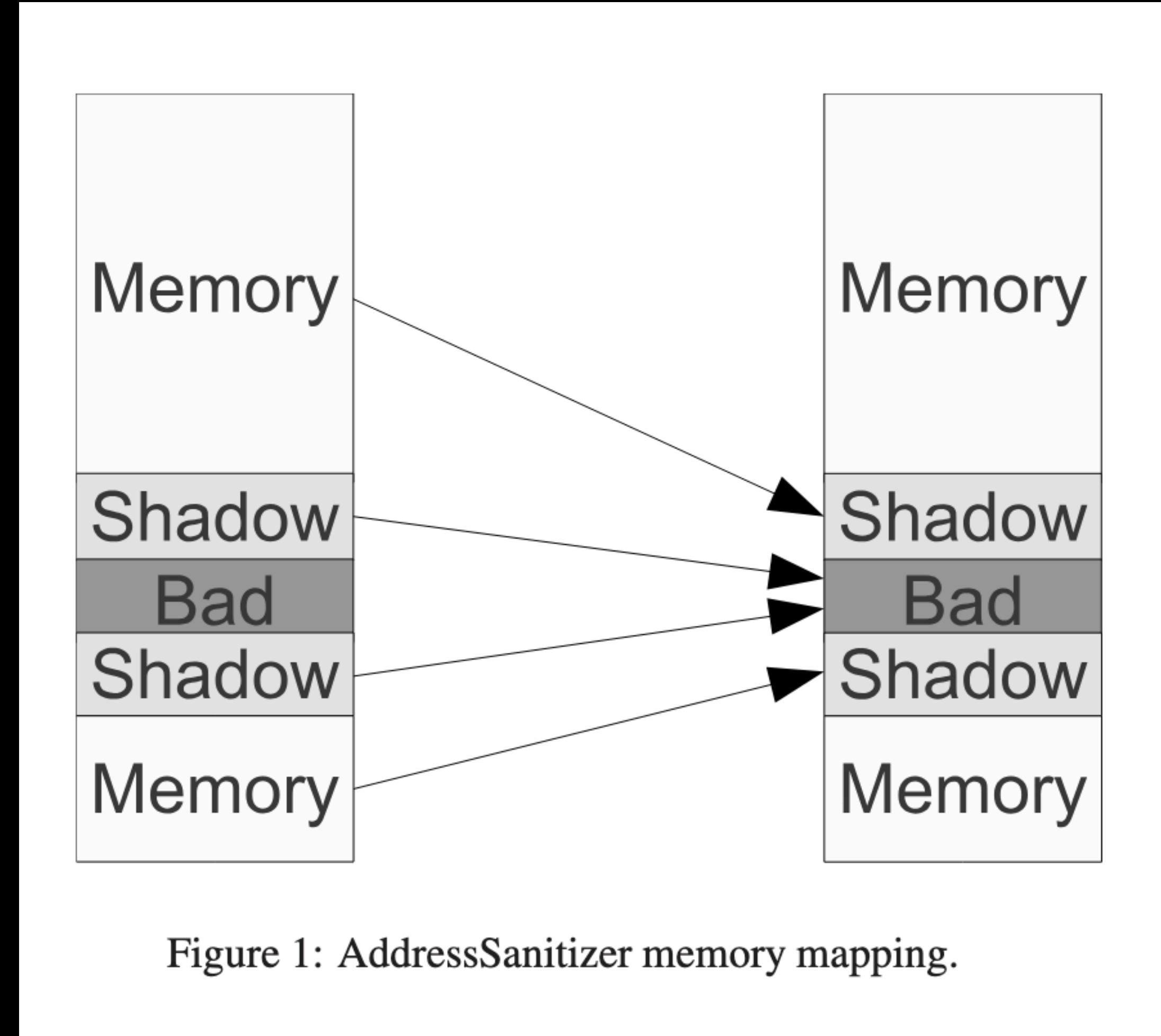
**SO I PUT WINDOWS IN YOUR CAR SO
YOU CAN CRASH WHILE YOU CRASH**

A close-up, low-key portrait of a man with dark skin and short, braided hair. He is looking directly at the camera with a neutral expression. The lighting is dramatic, casting deep shadows on one side of his face and highlighting the texture of his skin and hair. He appears to be wearing a dark zip-up hoodie. The background is a solid, dark grey.

What if we could have memory
about our memory?

The Shadow Mapping

Address of shadow byte =
 $(\text{Address of normal byte} \gg 3) + \text{Offset}$



0

1

2

3

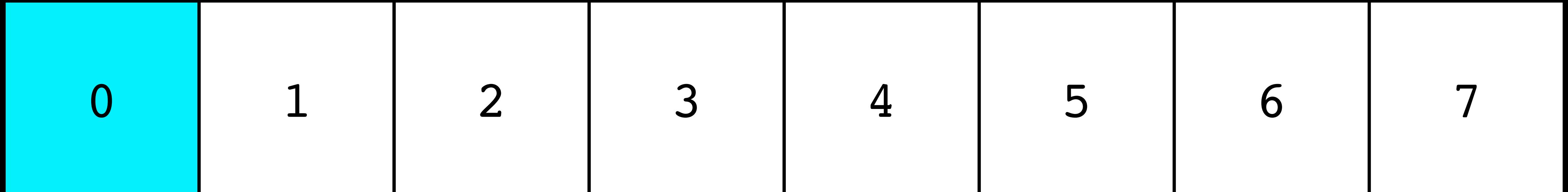
4

5

6

7

0 allocated bytes



0

1

2

3

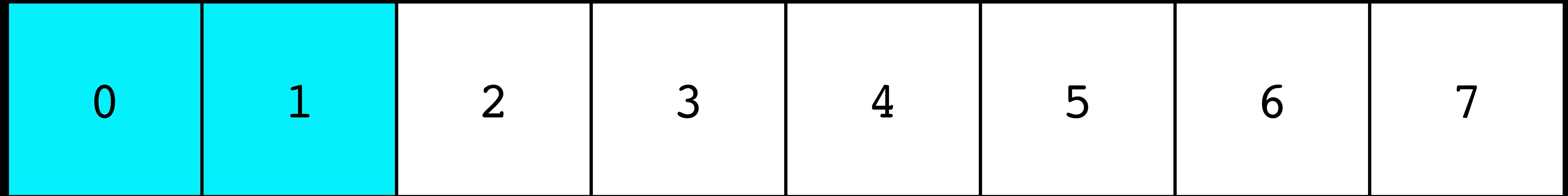
4

5

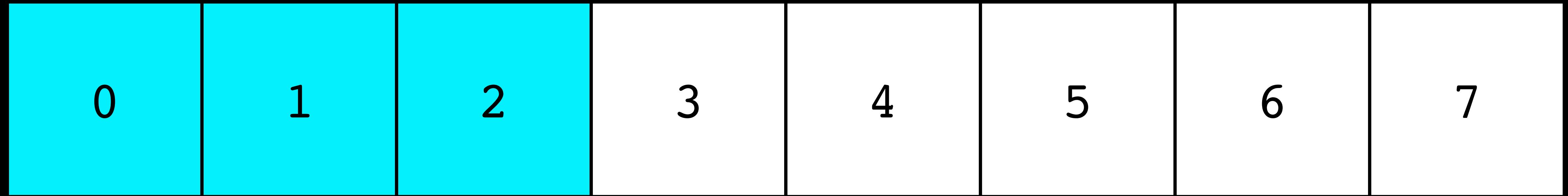
6

7

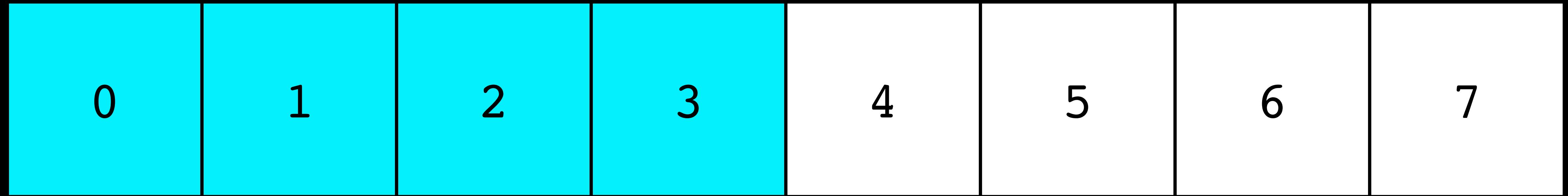
1 allocated byte



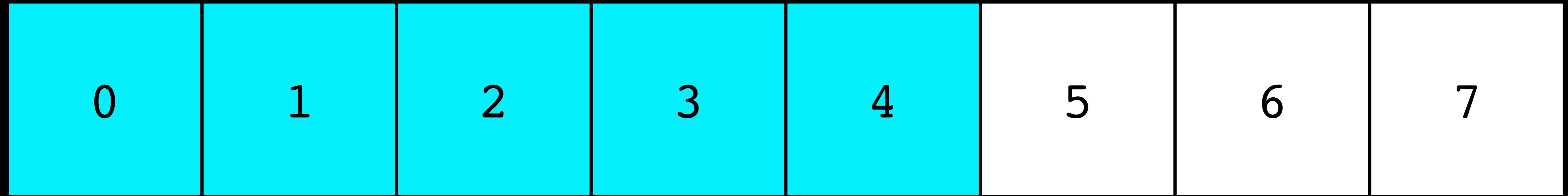
2 allocated bytes



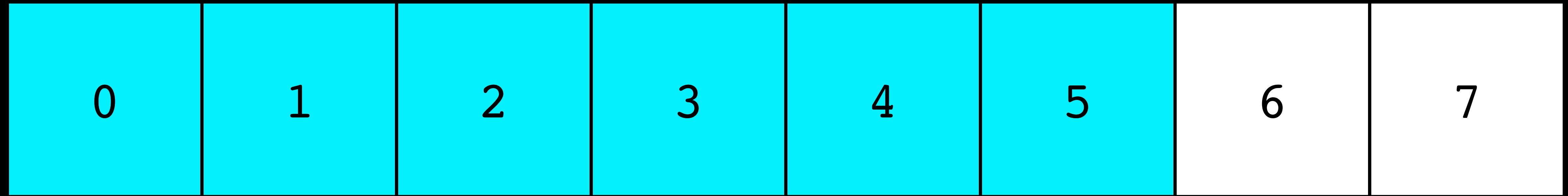
3 allocated bytes



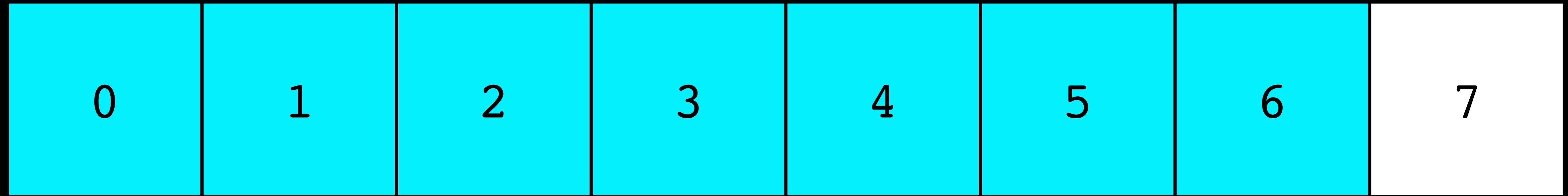
4 allocated bytes



5 allocated bytes

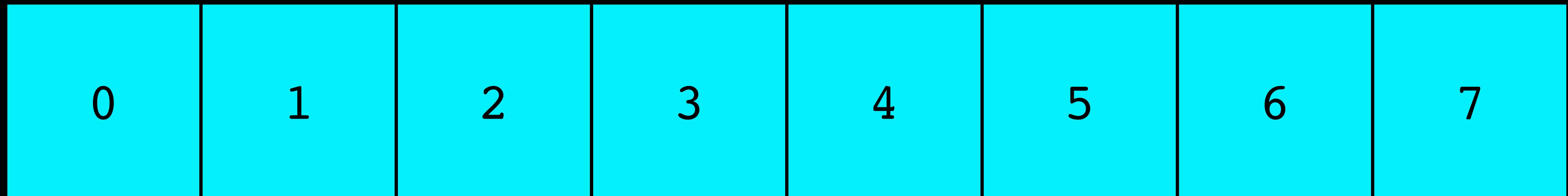


6 allocated bytes



7 allocated bytes

A chunk of 8 bytes, 8-byte aligned



8 allocated bytes

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

Every Memory Load Becomes:

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

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