Integer Overflow Prevention BoF

LPC 24

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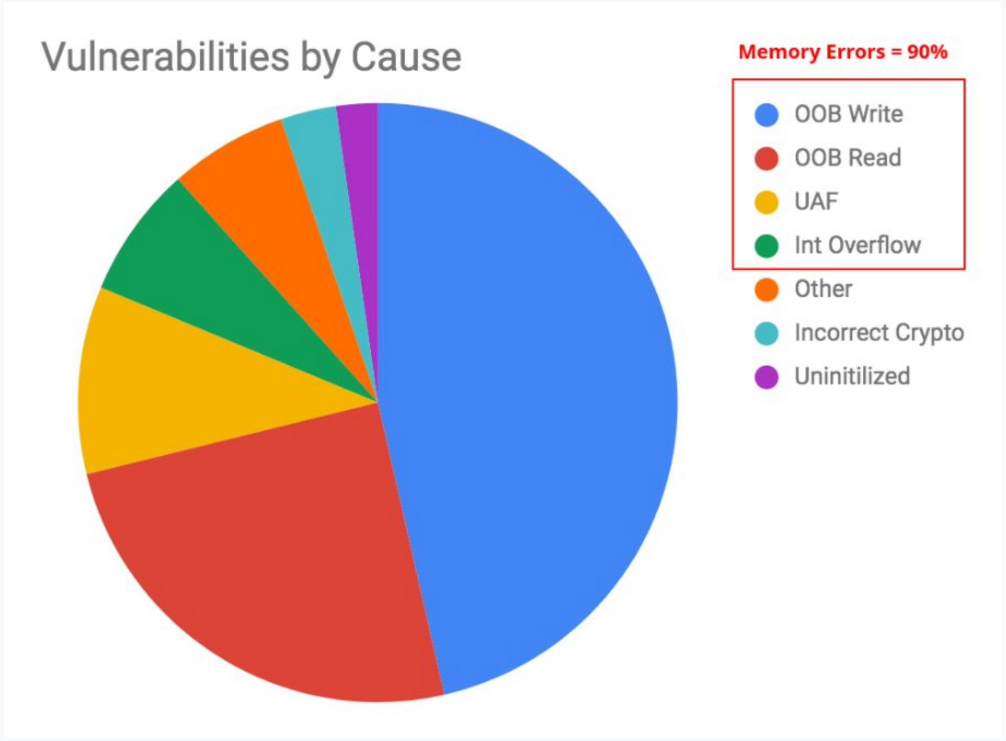
Prevalence of Integer Overflows



Integer overflows are seen as the 4th largest class of vulnerabilities, but they often go unrecognized as the root cause of Out-of-Bounds (OOB) reads and writes (e.g. buffer overflows), so their true prevalence is higher.

Example: Buffer overflow masking an integer overflow

```
u8 i = 0, num_elems = 0;
...
nla_for_each_nested(nl_elems, attrs, rem_elems)
    num_elems++; /* Truncates when >255 elements: an integer overflow */
elems = kzalloc(struct_size(elems, elem, num_elems), GFP_KERNEL);
...
nla_for_each_nested(nl_elems, attrs, rem_elems) {
    elems->elem[i++] = nla_data(nl_elems); /* Observed as OOB Write */
    ...
}
```

Fixed in 6311071a0562

Google

Types of Integer overflows (and truncations)

Necessary

Intentional

Unintentional but harmless

Buggy

Idiom Exclusions (Necessary overflows)

There exists some overflow-dependent code patterns that rely on the results of well-defined arithmetic wrap-around (even for pointers and signed types via `-fno-strict-overflow`).

- `if (a + b < a) ...`
- `while (i--)`
- `-1UL, -2UL, -{N}UL;`
- `end = start + length - 1;`

Intentional overflows

```
/* Align to pointer size and check for overflows */
tmp = ALIGN(data_size, sizeof(void *)) +
        ALIGN(offsets_size, sizeof(void *));
if (tmp < data_size || tmp < offsets_size)
        return 0;
```

or

```
crc += byte;
```

Unintentional overflows

```
p = xdr_inline_decode(xdr,
            rc_list->rcl_nrefcalls * 2 * sizeof(uint32_t));
....
rc_list->rcl_refcalls = kmalloc_array(rc_list->rcl_nrefcalls,
                        sizeof(*rc_list->rcl_refcalls),
                        GFP_KERNEL);
```

Implicit hidden code-flow choices

All arithmetic operations produce 2 potential code-flows:

- Path 1: no overflow has happened, carry on
- Path 2: overflow has happened! What do?

C does not provide a choice, and forces one path by default. (Some languages use exceptions to access other path – C must use the sanitizers to do that...)

x = a + b; // both paths exist – cannot be distinguished, forces Path 1.
x = -1UL; // Path 1 cannot exist, forces Path 2.
if (a + b < a) { /* path 2 */ } else { /* path 1 */ } // paths distinguished!

Silencing false positives

Wrappers?

```
x = overflows_ok(a + b);
```

Attributes?

```
size_t x __wraps;
x = a + b;

typedef unsigned long __nowraps size_t;
size_t y;
y = a + b;
```

ALIGN and round_up()

```
nctx_len = ALIGN(struct_size(nctx, ctx, val_len), sizeof(void *));
if (nctx_len > *uctx_len)
        return -E2BIG;

nctx = kzalloc(nctx_len, GFP_KERNEL);
```

PTR_ERR()

```
static inline long __must_check PTR_ERR(__force const void *ptr)
{
	return (long) ptr;
}

int function(...)
{
	...
	if (IS_ERR(result))
		return PTR_ERR(result); // negative long truncated to negative int
	...
}
```

But PTR_ERR_OR_ZERO() is actually an int return!