Chromium's Out-of-Memory Killer

or

Allocators Gonna Allocate

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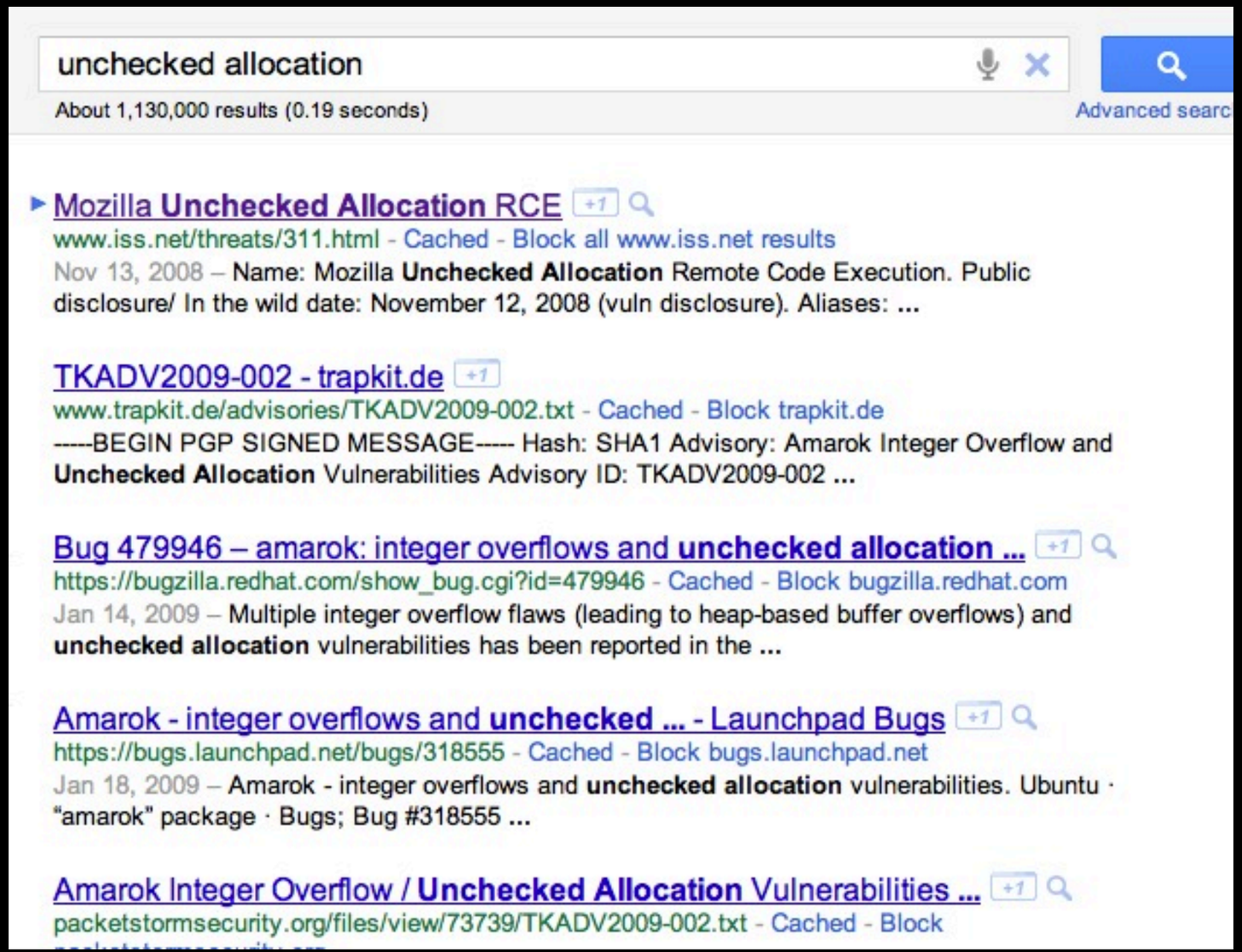
An unchecked allocation is an unfortunately popular security hole. Untrustworthy data can specify buffer sizes that cannot be allocated, and if the processing code doesn't handle a null return from a memory allocator, that null pointer can be abused for things like remote code execution.

Unchecked Allocations



From Mozilla Firefox,
netwerk\streamconv\converters\nsDirIndexParser.cpp
lines 203-204:

```
mFormat = new int[num+1];
mFormat[num] = -1;
```

From https://bugzilla.mozilla.org/show_bug.cgi?id=443299:

[...] If the fragmentation is successful this will result in a failed allocation of nsDirIndexParser::mFormat and the value 0xFFFFFFFF being written to the nsHTMLTags::sMaxTagNameLength at address 0xB45AD0. [...]

From https://bugzilla.mozilla.org/show_bug.cgi?id=443299:

[...] This stage contains a malformed HTML tag to write beyond the bounds of the static variable buf (address 0xB45CA8) in nsHTMLTags::LookupTag(). The exploit buffer overwrites several function pointers and replaces them with a pointer to the shellcode stub. [...]

Coders should always null-check allocations.

And I want a pony. And some ice cream.
With sprinkles.

malloc() **failure is fatal.**

How many ways can you allocate?

- malloc
  - calloc, valloc, realloc, posix_memalign
- operator new
- +[NSObject alloc], +[NSObject allocWithZone:]
- CFAllocator

How?

- APIs we can use
- APIs we can abuse
- SPIs we can use
- Raw memory mangling

APIs we can use

```
void oom_killer_new() {
  debug::BreakDebugger();
}

void EnableTerminationOnOutOfMemory() {
  // ...
  std::set_new_handler(oom_killer_new);
  // ...
}
```

```
typedef id (*allocWithZone_t)(id, SEL, NSZone*);
allocWithZone_t g_old_allocWithZone;

id oom_killer_allocWithZone(id self, SEL _cmd, NSZone* zone) {
  id result = g_old_allocWithZone(self, _cmd, zone);
  if (!result)
    debug::BreakDebugger();
  return result;
}
```

```
void EnableTerminationOnOutOfMemory() {
  // ...
  Method orig_method =
    class_getClassMethod(
      [NSObject class], @selector(allocWithZone:));
  g_old_allocWithZone =
    reinterpret_cast<allocWithZone_t>(
      method_getImplementation(orig_method));
  method_setImplementation(
    orig_method,
    reinterpret_cast<IMP>(oom_killer_allocWithZone));
  // ...
}
```

APIs we can abuse

#include <malloc/malloc.h>:

```
typedef struct _malloc_zone_t {
  // ...
  void *(*malloc)(struct _malloc_zone_t *zone, size_t size);
  void *(*calloc)(struct _malloc_zone_t *zone, size_t num_items, size_t
size);
  // ...
} malloc_zone_t;

malloc_zone_t *malloc_default_zone(void);
void malloc_zone_register(malloc_zone_t *zone);

void *malloc_zone_malloc(malloc_zone_t *zone, size_t size);
```

```
typedef void* (*malloc_type)
  (struct _malloc_zone_t* zone, size_t size);
malloc_type g_old_malloc;

void* oom_killer_malloc(
    struct _malloc_zone_t* zone, size_t size) {
  void* result = g_old_malloc(zone, size);
  if (!result && size)
    debug::BreakDebugger();
  return result;
}
```

```
malloc_zone_t* default_zone = malloc_default_zone();

g_old_malloc = default_zone->malloc;
g_old_calloc = default_zone->calloc;
g_old_valloc = default_zone->valloc;
g_old_realloc = default_zone->realloc;

default_zone->malloc = oom_killer_malloc;
default_zone->calloc = oom_killer_calloc;
default_zone->valloc = oom_killer_valloc;
default_zone->realloc = oom_killer_realloc;
```

Raw memory mangling

Allocators Gonna Allocate

- void* CFAllocatorAllocate (
  CFAllocatorRef allocator,
  CFIndex size,
  CFOptionFlags hint
  );
- **But what's a** CFAllocator**, really?**

#include <CoreFoundation/CFBase.h>:

```
struct CFAllocatorContext {
    CFIndex version;
    void *info;
    CFAllocatorRetainCallBack retain;
    CFAllocatorReleaseCallBack release;
    CFAllocatorCopyDescriptionCallBack copyDescription;
    CFAllocatorAllocateCallBack allocate;
    CFAllocatorReallocateCallBack reallocate;
    CFAllocatorDeallocateCallBack deallocate;
    CFAllocatorPreferredSizeCallBack preferredSize;
};
```

```
CFAllocatorAllocateCallBack g_old_cfallocator_system_default;

void* oom_killer_cfallocator_system_default(
    CFIndex alloc_size, CFOptionFlags hint, void* info) {
  void* result = g_old_cfallocator_system_default(alloc_size, hint, info);
  if (!result)
    debug::BreakDebugger();
  return result;
}
```

```
void EnableTerminationOnOutOfMemory() {
  // ...
  CFAllocatorContext context;
  CFAllocatorGetContext(kCFAllocatorSystemDefault, &context);
  g_old_cfallocator_system_default = context.allocate;
  context.allocate = oom_killer_cfallocator_system_default;
  // ...
}
```

```
$ ./base_unittests --gtest_filter=OutOfMemoryDeathTest.CFAllocatorSystemDefault
Note: Google Test filter = OutOfMemoryDeathTest.CFAllocatorSystemDefault
[==========] Running 1 test from 1 test case.
[----------] Global test environment set-up.
[----------] 1 test from OutOfMemoryDeathTest
[ RUN      ] OutOfMemoryDeathTest.CFAllocatorSystemDefault
/Users/avi/Source/chrome-git/src/base/process_util_unittest.cc:920: Failure
Death test: { SetUpInDeathAssert(); while ((value_ = base::AllocateViaCFAllocatorSystemDefault(signed_test_size_)))
{} }
    Result: failed to die.
 Error msg:
[  DEATH   ] base_unittests(2942) malloc: *** mmap(size=2147483648) failed (error code=12)
[  DEATH   ] *** error: can't allocate region
[  DEATH   ] *** set a breakpoint in malloc_error_break to debug
[  DEATH   ]
[  FAILED  ] OutOfMemoryDeathTest.CFAllocatorSystemDefault (3 ms)
[----------] 1 test from OutOfMemoryDeathTest (3 ms total)

[----------] Global test environment tear-down
[==========] 1 test from 1 test case ran. (5 ms total)
[  PASSED  ] 0 tests.
[  FAILED  ] 1 test, listed below:
[  FAILED  ] OutOfMemoryDeathTest.CFAllocatorSystemDefault

 1 FAILED TEST
```

http://www.opensource.apple.com/source/CF/CF-635/CFBase.c:

```
void CFAllocatorGetContext(
    CFAllocatorRef allocator, CFAllocatorContext *context) {
  // ...
  context->allocate = allocator->_context->allocate;
  context->reallocate = allocator->_context->reallocate;
  context->deallocate = allocator->_context->deallocate;
  context->preferredSize = allocator->_context->preferredSize;
  // ...
}
```

#include <CoreFoundation/CFBase.h>:

typedef const struct __CFAllocator * CFAllocatorRef;

http://www.opensource.apple.com/source/CF/CF-635/CFBase.c:

```
struct __CFAllocator {
  // ...
  void *(*malloc)(struct _malloc_zone_t *zone, size_t size);
  void *(*calloc)(struct _malloc_zone_t *zone, size_t num_items, size_t
size);
  // ...
  CFAllocatorRef _allocator;
  CFAllocatorContext _context;
};
```

```
CFAllocatorContext* ContextForCFAllocator(CFAllocatorRef allocator) {
  if (base::mac::IsOSLeopard() || base::mac::IsOSSnowLeopard()) {
    ChromeCFAllocatorLeopards* our_allocator =
        const_cast<ChromeCFAllocatorLeopards*>(
            reinterpret_cast<const ChromeCFAllocatorLeopards*>(allocator));
    return &our_allocator->_context;
  } else if (base::mac::IsOSLion()) {
    ChromeCFAllocatorLion* our_allocator =
        const_cast<ChromeCFAllocatorLion*>(
            reinterpret_cast<const ChromeCFAllocatorLion*>(allocator));
    return &our_allocator->_context;
  } else {
    return NULL;
  }
}
```

```
void EnableTerminationOnOutOfMemory() {
  // ...
  CFAllocatorContext* context =
      ContextForCFAllocator(kCFAllocatorSystemDefault);
  g_old_cfallocator_system_default = context->allocate;
  context->allocate = oom_killer_cfallocator_system_default;
  // ...
}
```

of course, it's not quite that easy...

Subtleties

(break to examine the code)

Q&A