Vulnerabilities in the proc component of the CAN BCM protocol in the Linux kernel

Analysis and vulnerabilities discovery

Anderson Nascimento, 307 Temporary Security Conference.

Agenda

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  - Out-of-bounds read in bcm_can_tx() (CVE-2025-38004)

About me

About me

- Anderson Nascimento
  - Director and Principal Security Researcher at Allele Security Intelligence
  - Linux and Android security researcher with more than 10 years of experience in vulnerability research.
  - Discovered and exploited several vulnerabilities in the past.
  - Instructor of Linux binary and kernel exploitation training.

Summary

- This presentation is about three vulnerabilities affecting the proc component of the CAN BCM networking protocol in the Linux kernel.
  - I wrote an exploit for the first one in 2020, and in 2023 I noticed there was another vulnerability in the same component. While working on a proof of concept for that second issue, I discovered the patch doesn't fix it. Besides being able to exploit it on the latest linux kernel version earlier this year, I also found a different vulnerability.
  - I will talk about the exploits and proofs of concept I wrote for them, a technique used to speed up one of the exploits and the experience of working with the developers to fix the vulnerabilities I discovered.

Introduction to the CAN BCM protocol in the Linux kernel

Introduction to the Linux CAN BCM protocol

- It’s a protocol I have been playing with for a while, but I still don’t understand its purpose or how to use it properly. My goal in working with it is just discovering and exploiting vulnerabilities. Don’t ask me much.
- It’s used mostly on vehicles and industrial systems, including defense and military applications. There are several protocols:
  - BCM
  - RAW
  - ISO-TP
  - GW
  - J1939

Vulnerabilities in the proc component of the CAN BCM protocol

First vulnerability

Race condition in bcm_connect() leading to use-after-free read

Race condition in bcm_connect() leading to use-after-free read

- Vulnerability patched in October 2016 in the Linux kernel upstream, discovered by Andrey Konovalov.
- The CAN BCM protocol was added to the Red Hat Enterprise Linux 7 in the 7.3 release on November 2016, but didn’t contain the patch that fixes the vulnerability.
- I noticed in the second semester of 2020 that RHEL 7 missed the patch and wrote an exploit that dumps the content of the file /etc/shadow and the hash of the root user of the MySQL/MariaDB databases.

Race condition in bcm_connect() leading to use-after-free read

Commit `deb507f`

hartkopp authored and **marckleinebudde** committed on Oct 31, 2016

```
can: bcm: fix warning in bcm_connect/proc_register

Andrey Konovalov reported an issue with proc_register in bcm.c.
As suggested by Cong Wang this patch adds a lock_sock() protection and
a check for unsuccessful proc_create_data() in bcm_connect().

Reference: http://marc.info/?l=linux-netdev&m=147732648731237

Reported-by: Andrey Konovalov <andreyknvl@google.com>
Suggested-by: Cong Wang <xiyou.wangcong@gmail.com>
Signed-off-by: Oliver Hartkopp <socketcan@hartkopp.net>
Acked-by: Cong Wang <xiyou.wangcong@gmail.com>
Tested-by: Andrey Konovalov <andreyknvl@google.com>
Cc: linux-stable <stable@vger.kernel.org>
Signed-off-by: Marc Kleine-Budde <mkl@pengutronix.de>
```

`master` · v6.18 ••• v4.9-rc6

Race condition in bcm_connect() leading to use-after-free read

- The protocol doesn’t protect against two threads executing the connect() system call on the same socket simultaneously.
  - The connect() system call is used to define the address of the destination, just as the bind() system call is used to define the local address.
  - While one of the threads succeeds and creates the entry on /proc/net/can-bcm/ENTRY, the other will fail because the entry has already been created. This results in the pointer in the socket bo->bcm_proc_read being set to NULL.
  - When the socket is closed and freed, due to bo->bcm_proc_read being NULL, the entry on the proc filesystem is not removed, allowing access to the freed object.

Race condition in bcm_connect() leading to use-after-free read

- As the freed object is part of a linked-list and used inside list_for_each_entry(), those characteristics make it a less interesting vulnerability. Too many conditions.
  - We would need to know the address of the list (head) and find an object that would have an interesting content at the offsets printed by bcm_proc_show() and still allowing to control the field obj->next.
  - But we can turn this vulnerability into an arbitrary read in an unclean way by abusing the oops handler and the fact that access to the kernel console is allowed to unprivileged users. It’s not worth it for a professional exploit, but might be useful in other scenarios.

Race condition in bcm_connect() leading to use-after-free read

- To abuse it, we still need a KASLR bypass. Otherwise, even if we can read any kernel address, we don’t know where the interesting content is located. Fortunately, there were plenty of kernel addresses leaked on Red Hat Enterprise Linux 7 and its derivatives. I implemented this one below in the exploit.
  - Create a process, put it to sleep and read /proc/PID/stat. The wchan value returned contains the address of a kernel function.

Exploiting a Linux Kernel Infoleak to bypass Linux KASLR
https://marcograss.github.io/security/linux/2016/01/24/exploiting-infoleak-linux-kaslr-bypass.html

Race condition in bcm_connect() leading to use-after-free read

- In fact, KASLR is naturally bypassable due to micro-architectural design and there was a leak of a kernel address since before the introduction of KASLR. It was fixed only in 2024.

  KASLR: An Exercise in Cargo Cult Security
  https://grsecurity.net/kaslr_an_exercise_in_cargo_cult_security

  Exploiting CVE-2022-42703 - Bringing back the stack attack
  https://googleprojectzero.blogspot.com/2022/12/exploiting-CVE-2022-42703-bringing-back-the-stack-attack.html

Commit deb507f

```
diff --git a/net/can/bcm.c b/net/can/bcm.c
index 8e999ffdf28b..8af9d25ff988 100644
--- a/net/can/bcm.c
+++ b/net/can/bcm.c
@@ -1549,24 +1549,31 @@ static int bcm_connect(struct socket *sock, struct sockaddr *uaddr, int len,
   struct sockaddr_can *addr = (struct sockaddr_can *)uaddr;
   struct sock *sk = sock->sk;
   struct bcm_sock *bo = bcm_sk(sk);
+ int ret = 0;
...
- if (bo->bound)
-    return -EISCONN;
+ lock_sock(sk);
+
+ if (bo->bound) {
+    ret = -EISCONN;
+    goto fail;
+ }
```

Commit deb507f

```
@@ -1577,17 +1584,24 @@ static int bcm_connect(struct socket *sock, struct sockaddr *uaddr, int len,
...
- bo->bound = 1;
-
...
     bo->bcm_proc_read = proc_create_data(bo->procname, 0644,
...
+    if (!bo->bcm_proc_read) {
+      ret = -ENOMEM;
+      goto fail;
+    }
...
- return 0;
+ bo->bound = 1;
+
+fail:
+ release_sock(sk);
+
+ return ret;
 }
```

Function bcm_proc_show()

```
list_for_each_entry(op, &bo->rx_ops, list) {
...
    if (op->flags & CAN_FD_FRAME)
        seq_printf(m, "(%u)", op->nframes);
    else
        seq_printf(m, "[%u]", op->nframes);
...
    if (op->kt_ival1.tv64)
        seq_printf(m, "timeo=%lld ",
        (long long)ktime_to_us(op->kt_ival1));

    if (op->kt_ival2.tv64)
        seq_printf(m, "thr=%lld ",
        (long long)ktime_to_us(op->kt_ival2));
...
}
```

How can we abuse it?

- We can successfully reallocate the freed object and populate it with arbitrary content.
- By defining the next pointer to an address we would like to read that is not a pointer and accessing the dangling proc entry, the content of the address will be interpreted as an object and the access results in an oops. The content of the address can be seen via the kernel console (dmesg).
- If the address we would like to read is a pointer, it’s possible to read it by making it an invalid address (e.g: adding and subtracting 1). This requires at least two accesses to read the content.

How can we abuse it?

```
$ sudo cat /proc/kallsyms | grep -w page_offset_base
ffffffff81c45c00 D page_offset_base
$
```

How can we abuse it?

```
(gdb) x/gx 0xffffffff81c45c00
0xffffffff81c45c00:0xffff880000000000
(gdb) x/gx 0xffffffff81c45c00 + 1
0xffffffff81c45c01:0x00ffff8800000000
(gdb) x/gx 0xffffffff81c45c00 - 1
0xffffffff81c45bff:0xff880000000000ff
(gdb)
```

How can we abuse it?

```
$ ./exploit
[*] PID: 2707
[*] KASLR disabled
[*] Socket address: 0xffff88006cce1080
[*] CAN BCM entry: 28650
[*] page_offset_base: 0xffff880000000000
```

```
[  112.500541] R13: ffff88007818d400 R14: 00ffff8800000000 R15: 0000000000000064
[  112.515984] R13: ffff88007818d400 R14: ff880000000000ff R15: 0000000000000064
```

How can we abuse it?

```
$ ./exploit
[*] PID: 2707
[*] KASLR disabled
[*] Socket address: 0xffff88006cce1080
[*] CAN BCM entry: 28650
[*] page_offset_base: 0xffff880000000000
[*] vmemmap_base: 0xffffea0000000000
```

```
[  112.535092] R13: ffff88007818d400 R14: 00ffffea00000000 R15: 0000000000000064
[  112.553935] R13: ffff88007818d400 R14: ffea000000000000 R15: 0000000000000064
```

Optimizing it

- We can read arbitrary content by abusing the default configuration that allows reading the kernel console, doesn’t set panic_on_oops by default and other settings.
  - But we would still need to trigger the vulnerability for any read we need to do. The race condition is easy to trigger, but it adds complexity.
  - It also has a side effect of creating many more entries on /proc/net/can-bcm/ than needed.

Optimizing it

- We can use a technique to speed up the exploit.
  - We need a kernel address that we can update at will. Then, when we want to read the next address, we just update the kernel address. But where can we find one?
  - TCP sockets!
  - I wrote an exploit in the past that I abused the address (interface address, not object address) of a TCP socket. The addresses (kernel address) of the TCP sockets were leaked on /proc/net/tcp.
  - Instead of than filling the freed object with the address we want to read, we fill the freed object up with the offset address of the TCP socket that holds the interface address. Then, when we want to read the next address, we bind the desired address on the TCP socket.

Optimizing it

- The optimization implemented allowed us to use only a dangling CAN BCM entry on /proc/net/can-bcm/ to read as many addresses we want.
- This also makes the exploit much faster, allowing it to dump the content of the /etc/shadow in less than 30 seconds.

Demonstration

Second vulnerability

Use-after-free read in bcm_proc_show() (CVE-2023-52922)

Use-after-free read in bcm_proc_show() (CVE-2023-52922)

- Vulnerability patched in July 2023 by YueHaibing (Huawei). The objects accessible via the /proc/net/can-bcm/ entry were being freed before the entry was removed, leading to use-after-free reads in the same bcm_proc_show() function.
- The function bcm_remove_op(), which is called when the socket is closed, frees the socket's objects before the function remove_proc_entry() is executed. If bcm_remove_op() is called while bcm_proc_show() executes, it can access a freed object.
- The patch changes the order of the functions.

Commit 55c3b96

YueHaibing authored and **marckleinebudde** committed on Jul 17, 2023

```
can: bcm: Fix UAF in bcm_proc_show()

BUG: KASAN: slab-use-after-free in bcm_proc_show+0x969/0xa80
Read of size 8 at addr ffff888155846230 by task cat/7862

CPU: 1 PID: 7862 Comm: cat Not tainted 6.5.0-rc1-00153-gc8746099c197 #230
Hardware name: QEMU Standard PC (i440FX + PIIX, 1996), BIOS 1.15.0-1 04/01/2014
Call Trace:
 <TASK>
 dump_stack_lvl+0xd5/0x150
 print_report+0xc1/0x5e0
 kasan_report+0xba/0xf0
 bcm_proc_show+0x969/0xa80
 seq_read_iter+0x4f6/0x1260
 seq_read+0x165/0x210
 proc_reg_read+0x227/0x300
 vfs_read+0x1d5/0x8d0
 ksys_read+0x11e/0x240
 do_syscall_64+0x35/0xb0
 entry_SYSCALL_64_after_hwframe+0x63/0xcd

Allocated by task 7846:
 kasan_save_stack+0x1e/0x40
 kasan_set_track+0x21/0x30
 __kasan_kmalloc+0x9e/0xa0
 bcm_sendmsg+0x264b/0x44e0
 sock_sendmsg+0xda/0x180
 ____sys_sendmsg+0x735/0x920
 ___sys_sendmsg+0x11d/0x1b0
 __sys_sendmsg+0xfa/0x1d0
 do_syscall_64+0x35/0xb0
 entry_SYSCALL_64_after_hwframe+0x63/0xcd

Freed by task 7846:
 kasan_save_stack+0x1e/0x40
 kasan_set_track+0x21/0x30
 kasan_save_free_info+0x27/0x40
 ____kasan_slab_free+0x161/0x1c0
 slab_free_freelist_hook+0x119/0x220
 __kmem_cache_free+0xb4/0x2e0
 rcu_core+0x809/0x1bd0

bcm_op is freed before procfs entry be removed in bcm_release(),
this lead to bcm_proc_show() may read the freed bcm_op.

Fixes: ffd980f ("[CAN]: Add broadcast manager (bcm) protocol")
Signed-off-by: YueHaibing <yuehaibing@huawei.com>
Reviewed-by: Oliver Hartkopp <socketcan@hartkopp.net>
Acked-by: Oliver Hartkopp <socketcan@hartkopp.net>
Link: https://lore.kernel.org/all/20230715092543.15548-1-yuehaibing@huawei.com
Cc: stable@vger.kernel.org
Signed-off-by: Marc Kleine-Budde <mkl@pengutronix.de>
```

master · v6.18 ··· v6.5-rc3

Commit 55c3b96

```
diff --git a/net/can/bcm.c b/net/can/bcm.c
index 32db244ba2c012..0a082726395af3 100644
--- a/net/can/bcm.c
+++ b/net/can/bcm.c
@@ -1572,6 +1572,12 @@ static int bcm_release(struct socket *sock)

  lock_sock(sk);

+#if IS_ENABLED(CONFIG_PROC_FS)
+ /* remove procfs entry */
+ if (net->can.bcmproc_dir && bo->bcm_proc_read)
+   remove_proc_entry(bo->procname, net->can.bcmproc_dir);
+#endif /* CONFIG_PROC_FS */
+
  list_for_each_entry_safe(op, next, &bo->tx_ops, list)
    bcm_remove_op(op);
```

Commit 55c3b96

```
@@ -1607,12 +1613,6 @@ static int bcm_release(struct socket *sock)
  list_for_each_entry_safe(op, next, &bo->rx_ops, list)
    bcm_remove_op(op);

-#if IS_ENABLED(CONFIG_PROC_FS)
- /* remove procfs entry */
- if (net->can.bcmproc_dir && bo->bcm_proc_read)
-   remove_proc_entry(bo->procname, net->can.bcmproc_dir);
-#endif /* CONFIG_PROC_FS */
-
  /* remove device reference */
  if (bo->bound) {
    bo->bound   = 0;
```

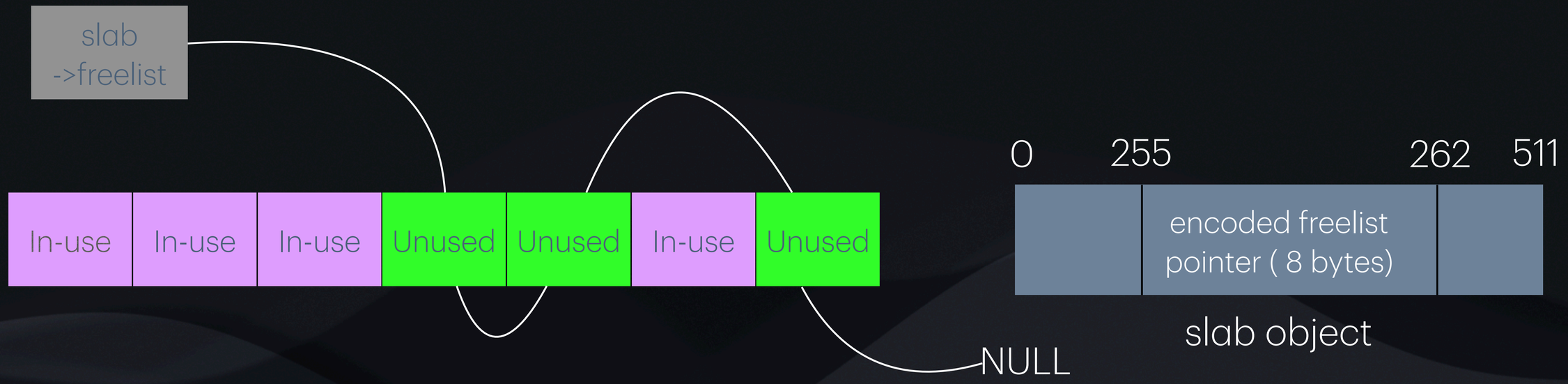
Abusing CVE-2023-52922

- This vulnerability was fixed on July, 2023. We reported it to Red Hat on July 2024 and it was finally fixed on March 2025.
- We wrote two proofs of concept for it.
  - The first one leaks the encoded freelist pointer.
    - This can help attackers to bypass a security mitigation
  - The second one dumps the addresses of a slab.
    - This can also help attackers to bypass a security mitigation

Leaking encoded freelist pointer

- The first result
  - In the Linux dynamic memory management, the unused objects are reused to store the addresses of the next unused objects. This is the freelist pointer.
  - In the past, the freelist pointer were placed at the beginning of the object, but it was easier for an out-of-bounds write to overwrite it. To mitigate this attack, the freelist was moved to the middle of the object. Also, it's encoded in modern Linux kernel to reduce the impact even when it's leaked.
  - Coincidentally, if the vulnerability is triggered and the freed object is not reclaimed, the object data leaked at the same than the offset for the encoded freelist pointer (the middle of the object). As the object data is not overwritten even after being freed, the ->next pointer still points to the head of the list, making the list_for_each_entry() on bcm_proc_show() to exit gracefully. This results in the vulnerability to be used to leak encoded freelist pointer in a reliable and clean way.

slab in-use and unused objects



Defeating the randomization of slabs objects

- The second result
  - Playing with the vulnerability, we noticed we can dump the encoded freelist pointer of all objects from a slab. We then tried to derive another attack.
  - We discovered if we XOR the encoded freelist pointer of the last object with the others encoded freelist pointers, we obtain a result that is very similar to the addresses of the objects being used in the operation.

Demonstration

That’s the question.

- A common pattern of vulnerabilities?
  - Even though the characteristics of the vulnerabilities were different, they were in the same component of the same protocol. I also noticed there were other patches fixing issues in the /proc component of the CAN BCM protocol, but I didn’t take time to analyze those ones.
  - We wrote a blog post detailing our results and mentioned in the post that looks like the CAN BCM protocol was having a common pattern of vulnerabilities affecting the proc component.

USE-AFTER-FREE VULNERABILITY IN THE CAN BCM SUBSYSTEM LEADING TO INFORMATION DISCLOSURE (CVE-2023-52922)
https://allelesecurity.com/uaf-can-bcm/

Third vulnerability

Use-after-free read in bcm_proc_show() due to missing rcu read protection.

Use-after-free read in bcm_proc_show() due to missing rcu read protection.

- After we had finished the work on the vulnerability CVE-2023-52922 and reviewing the blog post, I remembered there are other paths on the CAN BCM protocol that free the struct bcm_op objects, the commands: TX_DELETE and RX_DELETE.
- As the fix for CVE-2023-52922 focused on the struct bcm_op objects being freed when the socket is released, the function bcm_release(), I imagined it could still be triggered via the delete commands.
- I wrote a proof of concept and confirmed I had discovered a 0day vulnerability. We reported it upstream.

Use-after-free read in bcm_proc_show() due to missing rcu read protection.

- Besides the problem in the order of the operation during the release of the socket, the protocol implemented Read-Copy Update (RCU) locking, but it wasn’t being used properly.
  - RCU allows an object that is about to be freed to be used in a safe way. In simple terms, the reader notifies the system it is using the object and then the freeing of the object is delayed.
  - The reader of those objects needs to notify the kernel by using rcu_read_lock() and rcu_read_unlock(). Even though the objects were being freed via RCU, the reader weren’t using it.
  - To make things worse, the implementations using RCU need to have some properties that are enforced by the right API functions. This wasn’t happening with the CAN BCM protocol.
    - E.g: list_for_each_entry_rcu() rather than list_for_each_entry().

Commit dac5e62

hartkopp authored and **marckleinebudde** committed on May 19

```
can: bcm: add missing rcu read protection for procfs content

When the procfs content is generated for a bcm_op which is in the process
to be removed the procfs output might show unreliable data (UAF).

As the removal of bcm_op's is already implemented with rcu handling this
patch adds the missing rcu_read_lock() and makes sure the list entries
are properly removed under rcu protection.

Fixes: f1b4e32 ("can: bcm: use call_rcu() instead of costly synchronize_rcu()")
Reported-by: Anderson Nascimento <anderson@allelesecurity.com>
Suggested-by: Anderson Nascimento <anderson@allelesecurity.com>
Tested-by: Anderson Nascimento <anderson@allelesecurity.com>
Signed-off-by: Oliver Hartkopp <socketcan@hartkopp.net>
Link: https://patch.msgid.link/20250519125027.11900-2-socketcan@hartkopp.net
Cc: stable@vger.kernel.org # >= 5.4
Signed-off-by: Marc Kleine-Budde <mkl@pengutronix.de>
```

master · v6.18 ••• v6.15

Using the proper RCU functions

```
diff --git a/net/can/bcm.c b/net/can/bcm.c
index 871707dab7db..6bc1cc4c94c5 100644
--- a/net/can/bcm.c
+++ b/net/can/bcm.c
@@ -217,11 +217,13 @@ static int bcm_proc_show(struct seq_file *m, void *v)
...
- list_for_each_entry(op, &bo->rx_ops, list) {
+ rcu_read_lock();
+
+ list_for_each_entry_rcu(op, &bo->rx_ops, list) {
...
@@ -273,10 +275,13 @@ static int bcm_proc_show(struct seq_file *m, void *v)
...
+
+ rcu_read_unlock();
+
   return 0;
  }
```

Using the proper RCU functions

```
@@ -856,11 +861,11 @@ static int bcm_delete_rx_op(..., struct bcm_msg_head *mh,
...
-       list_del(&op->list);
+       list_del_rcu(&op->list);
        bcm_remove_op(op);
...
@@ -876,11 +881,11 @@ static int bcm_delete_tx_op(..., struct bcm_msg_head *mh,
  list_for_each_entry_safe(op, n, ops, list) {
...
-       list_del(&op->list);
+       list_del_rcu(&op->list);
        bcm_remove_op(op);
...
@@ -1294,11 +1299,11 @@ static int bcm_rx_setup(..., struct msghdr *msg,
...
-       list_del(&op->list);
+       list_del_rcu(&op->list);
        bcm_remove_op(op);
```

Trying a proper fix (let's hope so)

- One of the developers asked if only the RCU lock pair is enough, but after testing a patch, UAF didn't happen. There were other bugs. The function list_del() executing concurrently with list_for_each_entry(). After changing all the functions to their RCU equivalent functions, no issues happened even after testing the proof of concept for more than 30.000 times.
- Fortunately, I had time available to test their patch and elaborate my approach that fixed the problem. I wrote a reliable proof of concept that I could use to validate the patch.
- But this takes time! I had to maintain my own Linux kernel source based on the release candidate at the time, as the Linux kernel is actively being developed and changes so much and so fast. The patch needs to be developed based on the latest Linux kernel version available to avoid conflicts.

But then, I found another vulnerability.

Fourth vulnerability

Race condition in bcm_can_tx() leading to out-of-bounds read (CVE-2025-38004)

Race condition in bcm_can_tx() leading to out-of-bounds read (CVE-2025-38004)

- While working on CVE-2023-52922, I had to do heap grooming. I usually do that with the subsystem's own objects. So, I played with the sending and deleting operations of the CAN BCM protocol.
  - Through the delete operations I noticed a UAF on bcm_proc_show() could still be triggered, bypassing the patch for CVE-2023-52922.
  - Through the send operations (TX_SETUP) I learned some details of the protocol and noticed the function bcm_can_tx() uses a variable and increment it later on. That function doesn’t use lock mechanism, so it seemed suspicious.
    - It can be executed directly (at a user wishes) and via a scheduled timer. So, it could race making the second execution to read the variable beyond the value it should.

op->currframe unprotected accesses

```
static void bcm_can_tx(struct bcm_op *op)
{
...
  struct canfd_frame *cf = op->frames + op->cfsiz * op->currframe;
...
  skb_put_data(skb, cf, op->cfsiz);
...
  skb->dev = dev;
  can_skb_set_owner(skb, op->sk);
  err = can_send(skb, 1);
...
  op->currframe++;
...
  if (op->currframe >= op->nframes)
    op->currframe = 0;
...
```

Consequences and the protection

- An out-of-bounds is triggered and the data read is returned to the user.
- It’s possible to reach several different caches.
- It leaks struct pages, dynamic objects (heap de-randomization) and the vmlinux addresses, leading to KASLR bypass.
- The fix was to protect the race in the accesses of op->currframe in bcm_can_tx()
  - I suggested using spin_lock() to guard the variable access. The developers didn’t like it and decided a different approach, but it didn’t work and my suggestion was implemented in the end. Different from my suggestion, they implemented the lock per-object.

Commit c2aba69

hartkopp authored and **marckleinebudde** committed on May 19

```
can: bcm: add locking for bcm_op runtime updates

The CAN broadcast manager (CAN BCM) can send a sequence of CAN frames via
hrtimer. The content and also the length of the sequence can be changed
resp reduced at runtime where the 'currframe' counter is then set to zero.

Although this appeared to be a safe operation the updates of 'currframe'
can be triggered from user space and hrtimer context in bcm_can_tx().
Anderson Nascimento created a proof of concept that triggered a KASAN
slab-out-of-bounds read access which can be prevented with a spin_lock_bh.

At the rework of bcm_can_tx() the 'count' variable has been moved into
the protected section as this variable can be modified from both contexts
too.

Fixes: ffd980f ("[CAN]: Add broadcast manager (bcm) protocol")
Reported-by: Anderson Nascimento <anderson@allelesecurity.com>
Tested-by: Anderson Nascimento <anderson@allelesecurity.com>
Reviewed-by: Marc Kleine-Budde <mkl@pengutronix.de>
Signed-off-by: Oliver Hartkopp <socketcan@hartkopp.net>
Link: https://patch.msgid.link/20250519125027.11900-1-socketcan@hartkopp.net
Cc: stable@vger.kernel.org
Signed-off-by: Marc Kleine-Budde <mkl@pengutronix.de>
```

master · v6.18 ··· v6.15

Implementing lock per-object

```
@@ -122,6 +123,7 @@ struct bcm_op {
122  123      struct canfd_frame last_sframe;
123  124      struct sock *sk;
124  125      struct net_device *rx_reg_dev;
     126  +   spinlock_t bcm_tx_lock; /* protect currframe/count in runtime updates */
125  127    };
```

Guarding the variable accesses

net/can/bcm.c

```
@@ -285,13 +287,18 @@ static void bcm_can_tx(struct bcm_op *op)
285 287  {
286 288      struct sk_buff *skb;
287 289      struct net_device *dev;
288     -    struct canfd_frame *cf = op->frames + op->cfsiz * op->currframe;
    290 +    struct canfd_frame *cf;
289 291      int err;
290 292
291 293      /* no target device? => exit */
292 294      if (!op->ifindex)
293 295          return;
294 296
    297 +    /* read currframe under lock protection */
    298 +    spin_lock_bh(&op->bcm_tx_lock);
    299 +    cf = op->frames + op->cfsiz * op->currframe;
    300 +    spin_unlock_bh(&op->bcm_tx_lock);
    301 +
```

Guarding the variable accesses

net/can/bcm.c

```
                322 +
                323 +     /* update currframe and count under lock protection */
                324 +     spin_lock_bh(&op->bcm_tx_lock);
                325 +
315             326       if (!err)
316             327           op->frames_abs++;
317             328
318             329       op->currframe++;
319             330
320             331       /* reached last frame? */
321             332       if (op->currframe >= op->nframes)
322             333           op->currframe = 0;
                334 +
                335 +     if (op->count > 0)
                336 +         op->count--;
                337 +
                338 +     spin_unlock_bh(&op->bcm_tx_lock);
323             339   out:
324             340       dev_put(dev);
325             341   }
```

Leaking dynamic objects (0xffff8880...)

```
[root@almalinux95research tmp]# for ((i=0; i<1000; i++)); do ./exploit 3
2 0 0 0 0 1 0; done

[*] - Success!
can_id: 1
len: 0
__pad: 0
__res0: 0
len8_dlc: 0
data:

0x0 0x21 0x53 0xc 0x80 0x88 0xff 0xff
```

Leaking struct page objects (0xffffea...)

```
[root@almalinux95research tmp]# for ((i=0; i<1000; i++)); do ./exploit 2 0 0 0 0 1 0;
 done
[*] - Success!
can_id: 2465024
len: 0
__pad: 234
__res0: 255
len8_dlc: 255
data:

0x0 0x82 0x35 0x0 0x0 0xea 0xff 0xff
[*] - Success!
can_id: 2232320
len: 0
__pad: 234
__res0: 255
len8_dlc: 255
data:

0xc0 0xf5 0xd0 0x0 0x0 0xea 0xff 0xff
```

Leaking vmlinux addresses (0xffffffff8265....)

```
[root@almalinux95research tmp]# for ((i=0; i<1000; i++)); do ./exploit 32 0 0 0 0 1 0
; done
[*] - Success!
can_id: 32
len: 0
__pad: 0
__res0: 0
len8_dlc: 0
data:

0x6 0x24 0x41 0xed 0x0 0x0 0x0 0x0
[*] - Success!
can_id: 5
len: 0
__pad: 0
__res0: 0
len8_dlc: 0
data:

0xb3 0xc3 0x65 0x82 0xff 0xff 0xff 0xff
```

Conclusion

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- Some vulnerabilities are harder to fix.
- Use-after-free reads are also interesting.
- The security of the Linux ecosystem is messy.
- Auditing well-known subsystems might still be worth.
- There are still ancient vulnerabilities.

THANK YOU!
Questions?