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Date: Tue, 25 Jan 2022 10:24:56 +0100
From: Matthias Gerstner <ngerstner@openwall.com>
To: oss-security@openwall.com
Subject: Multiple vulnerabilities in connman's dnspoxy component

Hello list,

while researching CVE-2021-33833 [1] in Connman's [2] dnspoxy component I found further (less severe) security issues in the dnspoxy codebase. Our SUSE colleague and upstream Connman maintainer Daniel Wagner published fixes for the issues just now [3].

[1]: <https://www.openwall.com/lists/oss-security/2021/06/09/1>
[2]: <https://git.kernel.org/pub/scm/network/connman/connman.git>
[3]: <https://lore.kernel.org/connman/20220125090026.5108-3-wagi@monom.org/T/#m81ef1e357b6b2d3efd53f86d1cdcbfe9a37d8b3f>

For the review I have been looking into the upstream version tag 1.40. I found a couple of invalid memory read accesses that could possibly lead to remote DoS, remote information leaks or otherwise undefined behaviour. Furthermore I found a way to trigger a 100 % CPU loop. The following sections explain the findings in detail. All of these affect the processing of DNS server replies, i.e. they can be triggered by malicious remote DNS servers, similar to CVE-2021-33833.

1) Possibly invalid memory reference in 'strlen()' call in 'forward_dns_reply()' (CVE-2022-23097)

In 'forward_dns_reply()' in 'dnspoxy.c:2004' the following 'strlen' invocation occurs:

```
...
host_len = *ptr;
if (host_len > 0)
    domain_len = strlen(ptr + 1 + host_len,
        reply_len - header_len);
...
```

This function does not actually check whether there are enough 'reply_len' bytes at all to even retrieve a valid 'host_len' from where 'ptr' is pointing to.

The maximum size calculation 'reply_len - header_len' is not correct. If 'reply_len' is smaller than 'header_len', which can be the case for the TCP case (see issue 2), then 'reply_len - header_len' can even become negative i.e. an underflow wrap occurs.

'host_len' can be up to 255 and is attacker controlled. This means even for the UDP case, where the calling function does make sure that at least 'header_len' bytes are available, the 'ptr + 1 + host_len' expression can point to up to 257 bytes outside of valid packet data.

For the UDP case this means that data present in the stack based buffer in function 'udp_server_event()' in 'dnspoxy.c:2243' will be accessed that could contain data from previous DNS replies or stack management data.

For the TCP case, where a heap based buffer of the exact receive size is used (see 'dnspoxy.c:2417') it means that a heap out of bounds read access is performed that could even crash Connman. In my exploit tests I did not manage to cause a crash but this depends strongly on the heap allocator and optimization levels etc.

So the possible effects of this vulnerability are:

- undefined behaviour of the domain name uncompress / recompress handling based on undefined data.
- remote denial of service especially in the TCP case
- an information leak, especially in the UDP case where a stack based buffer is used. If an attacker controls both the DNS server and the DNS client (or the DNS client and can spoof DNS replies on the network), then that attacker could receive stack management data on the client side. This is because the 'forward_dns_reply()' function has large degrees of freedom in the dns name uncompress / recompress handling and will forward even undefined data to the DNS client.

The attached Patch 0001 adds and fixes some checks for sufficient input data to avoid this issue.

2) TCP Receive Path does not Check for Presence of Sufficient Header Data (CVE-2022-23096)

In the UDP server reply code path a literal size check is performed to make sure that at least a complete DNS header has been received ('dnspoxy.c:2257'). This check is missing in the TCP server reply code path as can be seen in:

- dnspoxy.c:2417: here a heap buffer of the exact claimed packet size is allocated.
- dnspoxy.c:2444: here the now completely received packet is passed on to 'forward_dns_reply()' without any further minimum package size checks.

This means that a malicious DNS server can send a minimum reply message consisting of four bytes (claiming a TCP message of two bytes size, and then supplying the correct request ID in the next two bytes). 'forward_dns_reply()' will then be called with the 'reply_len' parameter being set to 4. There are no further input size checks in 'forward_dns_reply()':

```
...
int dns_id, sk, err, offset = protocol_offset(protocol);
if (offset < 0)
    return offset;
hdr = (void *) (reply + offset);
...
```

'offset' will be 2 for the TCP case. Thus 'hdr' will point to the two valid DNS ID bytes at the end of the heap allocated buffer. All further protocol processing code in this function will operate on undefined out of bounds heap data.

From here on the characteristics of this vulnerability are similar to issue 1). There can be undefined behaviour and a possibility for a remote DoS, a heap based information leak maybe.

A sample run of connmand in 'valgrind' acting against a malicious DNS server showed output like this:

```
Invalid read of size 2
at 0x487311: forward_dns_reply.isra.0 (dnspoxy.c:2153)
by 0x487EBD: tcp_server_event (dnspoxy.c:2447)
by 0x48C0D9E: g_main_context_dispatch (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x48C1127: ??? (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x48C1412: g_main_loop_run (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x41217B: main (main.c:932)
Address 0x587c88c is 2 bytes after a block of size 10 alloc'd
at 0x48437B5: malloc (in /usr/libexec/valgrind/vgpreload_memcheck-amd64-linux.so)
```

```
by 0x48C719F: g_try_malloc (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x4881A9: tcp_server_event (dnstproxy.c:2420)
by 0x48C0D9E: g_main_context_dispatch (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x48C1127: ??? (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x48C1412: g_main_loop_run (in /usr/lib64/libglib-2.0.so.0.7000.2)
by 0x41217B: main (main.c:932)
```

The attached patch 0001 also checks for presence of sufficient header data and thus fixes this issue.

3) TCP Receive Path Triggers 100 % CPU loop if DNS server does not Send Back Data (CVE-2022-23098)

In the TCP server reply case, if the server simply does not send back any data at all, but keeps the socket connection open, Connman enters a 100 % CPU loop. This is related to the event watch configuration in 'dnstproxy.c:2523', where 'G_IO_OUT' is set. This is done to react to the asynchronous (non-blocking) TCP connect result. After the connection is established the event watch is not adjusted, however, meaning that the event loop will wake up when data can be written to the TCP connection, which is true all the time.

Although there is a 30 second timeout configured in 'tcp_idle_timeout()', the 100 % CPU loop does not stop after that time. The reason is that, after the TCP connection succeeded, the timeout is removed again in 'dnstproxy.c:2342'.

The attached patch 0003 adjusts the IO watch after the connection succeeded to prevent the 100 % CPU loop. Furthermore the attached patch 0004 causes the timeout not to be removed even after the connection is established. This way the timeout covers not only the connection establishment but also the server reply.

4) TCP DNS Operation is Broken due to Bad TCP Length Header

This is only a functional issue. It seems the TCP based DNS operation never really worked, because in 'forward_dns_reply()' the message content is possibly modified due to the domain name uncompress logic. However, the TCP length header is never adjusted to reflect this. The original DNS header received from the server is plainly copied in 'dnstproxy.c:2125' and never adjusted after this.

This means that either, if the modified DNS message is shorter than the one supplied by the server, that the DNS header length will be larger than what is actually forwarded to the DNS client. The DNS client will wait for more data that will never be supplied. Or, should the modified DNS message become larger, then the DNS client will receive only a truncated message that will be incomplete / corrupted. I tested this simply using 'host -T' as a simple TCP based DNS client.

The attached patch 0002 adjusts the TCP message length before forwarding the message to the client to fix this.

Generally Worrying Code Quality / Suggestion to Refactor dnstproxy

Generally the code quality of the dnstproxy component in Connman is lacking. There are inconsistencies in data types, redundant code portions and overly complex functions that could benefit from a refactoring. The upstream maintainer agrees and we will attempt to find a way to contribute improvements in this area in the future.

Timeline

2021-12-30: I contacted the current Connman maintainer Daniel Wagner, a SUSE colleague, and shared the findings with him, offering coordinated disclosure.
2022-01-10: After getting confirmation from Daniel I requested CVEs for the three security issues from Mitre.
2022-01-19 until today: I helped Daniel reviewing, writing and testing the patches.

Cheers

Matthias

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Matthias Gerstner <matthias.gerstner@...e.de>
Security Engineer
<https://www.suse.com/security>
GPG Key ID: 0x14C405C971923553

SUSE Software Solutions Germany GmbH
HRB 36809, AG Nürnberg
Geschäftsführer: Ivo Totev

View attachment "0001-dnstproxy-Validate-input-data-before-using-them.patch" of type "text/x-diff" (3513 bytes)

View attachment "0002-dnstproxy-Update-TCP-length-header.patch" of type "text/x-diff" (850 bytes)

View attachment "0003-dnstproxy-Avoid-100-busy-loop-in-TCP-server-case.patch" of type "text/x-diff" (1370 bytes)

View attachment "0004-dnstproxy-Keep-timeout-in-TCP-case-even-after-connect.patch" of type "text/x-diff" (1108 bytes)

Download attachment "signature.asc" of type "application/pgp-signature" (834 bytes)

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