

open5gs bug report2

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Open5gs - Malformatted UE initial message crashes AMF causing DoS

Recently, we discovered a vulnerability that may cause Open5gs AMF to crash during a code audit of Open5gs Ver2.4.11. The specific causes of the vulnerability are as follows:

Vulnerability description

When processing UE attachment, a memory leak in AMF `ngap-handler.c` from open5gs causing a DoS vulnerability.

ngap-handler

UE initial message is handled by function `ngap_handle_initial_ue_message` from `src/amf/ngap-handler.c`.

```
src/amf/ngap-handler.c
```

```
void ngap_handle_initial_ue_message(amf_gnb_t *gnb, ogs_ngap_message_t *message)
{
```

...

RAN_UE_NGAP_ID and UserLocationInformation is extracted from InitialUEMessage .

```
for (i = 0; i < InitialUEMessage->protocolIEs.list.count; i++) {
    ie = InitialUEMessage->protocolIEs.list.array[i];
    switch (ie->id) {
        case NGAP_ProtocolIE_ID_id_RAN_UE_NGAP_ID:
            RAN_UE_NGAP_ID = &ie->value.choice.RAN_UE_NGAP_ID;
            break;
        case NGAP_ProtocolIE_ID_id_NAS_PDU:
            NAS_PDU = &ie->value.choice.NAS_PDU;
            break;
        case NGAP_ProtocolIE_ID_id_UserLocationInformation:
            UserLocationInformation =
                &ie->value.choice.UserLocationInformation;
            break;
        ...
    }
}
```

ran_ue structure will be allocated and assigned after validating RAN_UE_NGAP_ID by calling ran_ue_add .

```
if (!RAN_UE_NGAP_ID) {
    ogs_error("No RAN_UE_NGAP_ID");
    ogs_assert(OGS_OK ==
        ngap_send_error_indication(gnb, NULL, NULL,
            NGAP_Cause_PR_protocol, NGAP_CauseProtocol_semantic_error));
    return;
}

ran_ue = ran_ue_find_by_ran_ue_ngap_id(gnb, *RAN_UE_NGAP_ID);
if (!ran_ue) {
    ran_ue = ran_ue_add(gnb, *RAN_UE_NGAP_ID);
    ogs_assert(ran_ue);
    ...
}
```

If UserLocationInformation is not present, the function will return and ran_ue_remove will never be called, here is the memory leak bug.

```
if (!UserLocationInformation) {
    ogs_error("No UserLocationInformation");
    ogs_assert(OGS_OK ==
        ngap_send_error_indication(gnb, &ran_ue->ran_ue_ngap_id, NULL,
```

```

        NGAP_Cause_PR_protocol, NGAP_CauseProtocol_semantic_error));
    return;
}
...
}

```

UE_ADD UE_POOL

Pool `ran_ue_pool` is initialed by `amf_context_init` from `src/amf/context.c` on line 61.

`src/amf/context.c`

```
ogs_pool_init(&ran_ue_pool, ogs_app()->max.ue);
```

When calling `ran_ue_add`, `ran_ue` will be allocated.

```

ran_ue_t *ran_ue_add(amf_gnb_t *gnb, uint32_t ran_ue_ngap_id)
{
    ran_ue_t *ran_ue = NULL;

    ogs_assert(gnb);

    ogs_pool_alloc(&ran_ue_pool, &ran_ue);
    ogs_assert(ran_ue);
    memset(ran_ue, 0, sizeof *ran_ue);
    ...

    ogs_list_add(&gnb->ran_ue_list, ran_ue);

    stats_add_ran_ue();

    return ran_ue;
}

```

One must call `ran_ue_remove` after `ue_add` to free the `ran_ue`.

```

void ran_ue_remove(ran_ue_t *ran_ue)
{
    ogs_assert(ran_ue);
    ogs_assert(ran_ue->gnb);

    ogs_list_remove(&ran_ue->gnb->ran_ue_list, ran_ue);
}

```

```

    ogs_assert(ran_ue->t_ng_holding);
    ogs_timer_delete(ran_ue->t_ng_holding);

    ogs_pool_free(&ran_ue_pool, ran_ue);

    stats_remove_ran_ue();
}

```

max.ue is defined 1024 as default.

lib/ogs-context.c

```

static void app_context_prepare(void)
{
    ...

#define MAX_NUM_OF_UE            1024    /* Num of UEs */
#define MAX_NUM_OF_PEER        64        /* Num of Peer */

    self.max.ue = MAX_NUM_OF_UE;
    ...
}

```

POC

To trigger this vulnerability, an `InitialUEMessage` without `UserLocationInformation` needs to be build.

```
[2022-09-19 03:16:03.232] [rrc] [info] RRC Setup for UE[1021]
[2022-09-19 03:16:03.232] [ngap] [debug] Initial NAS message received from UE[1021]
[2022-09-19 03:16:03.233] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:04.034] [rls] [debug] UE[1018] signal lost
[2022-09-19 03:16:04.250] [rrc] [debug] UE[1022] new signal detected
[2022-09-19 03:16:04.251] [rrc] [info] RRC Setup for UE[1022]
[2022-09-19 03:16:04.252] [ngap] [debug] Initial NAS message received from UE[1022]
[2022-09-19 03:16:04.253] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:05.053] [rls] [debug] UE[1019] signal lost
[2022-09-19 03:16:05.053] [rls] [debug] UE[1020] signal lost
[2022-09-19 03:16:05.267] [rrc] [debug] UE[1023] new signal detected
[2022-09-19 03:16:05.268] [rrc] [info] RRC Setup for UE[1023]
[2022-09-19 03:16:05.268] [ngap] [debug] Initial NAS message received from UE[1023]
[2022-09-19 03:16:05.269] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:06.290] [rrc] [debug] UE[1024] new signal detected
[2022-09-19 03:16:06.292] [rrc] [info] RRC Setup for UE[1024]
[2022-09-19 03:16:06.292] [ngap] [debug] Initial NAS message received from UE[1024]
[2022-09-19 03:16:06.293] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:07.094] [rls] [debug] UE[1021] signal lost
[2022-09-19 03:16:07.311] [rrc] [debug] UE[1025] new signal detected
[2022-09-19 03:16:07.313] [rrc] [info] RRC Setup for UE[1025]
[2022-09-19 03:16:07.313] [ngap] [debug] Initial NAS message received from UE[1025]
[2022-09-19 03:16:07.314] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:08.115] [rls] [debug] UE[1022] signal lost
[2022-09-19 03:16:08.333] [rrc] [debug] UE[1026] new signal detected
[2022-09-19 03:16:08.334] [rrc] [info] RRC Setup for UE[1026]
[2022-09-19 03:16:08.335] [ngap] [debug] Initial NAS message received from UE[1026]
[2022-09-19 03:16:08.336] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:09.136] [rls] [debug] UE[1023] signal lost
[2022-09-19 03:16:09.354] [rrc] [debug] UE[1027] new signal detected
[2022-09-19 03:16:09.355] [rrc] [info] RRC Setup for UE[1027]
[2022-09-19 03:16:09.356] [ngap] [debug] Initial NAS message received from UE[1027]
[2022-09-19 03:16:09.357] [ngap] [error] Error indication received. Cause: protocol/semantic-error
[2022-09-19 03:16:10.157] [rls] [debug] UE[1024] signal lost
[2022-09-19 03:16:10.375] [rrc] [debug] UE[1028] new signal detected
[2022-09-19 03:16:10.377] [rrc] [info] RRC Setup for UE[1028]
[2022-09-19 03:16:10.377] [ngap] [debug] Initial NAS message received from UE[1028]
[2022-09-19 03:16:10.601] [sctp] [debug] SCTP association shutdown (clientId: 2)
[2022-09-19 03:16:10.601] [sctp] [warning] Unhandled SCTP notification received
[2022-09-19 03:16:10.601] [ngap] [error] Association terminated for AMF[2]
[2022-09-19 03:16:10.601] [ngap] [debug] Removing AMF context[2]
[2022-09-19 03:16:11.179] [rls] [debug] UE[1025] signal lost
[2022-09-19 03:16:11.397] [rrc] [debug] UE[1029] new signal detected
[2022-09-19 03:16:11.399] [rrc] [info] RRC Setup for UE[1029]
[2022-09-19 03:16:11.399] [ngap] [debug] Initial NAS message received from UE[1029]
[2022-09-19 03:16:11.399] [ngap] [error] AMF selection for UE[1029] failed. Could not find a suitable AMF.
[2022-09-19 03:16:11.399] [ngap] [error] AMF context not found with id: 0
```

AMF will crash after 1024 malformed UE initial messages is reached.

```

amf | 09/19 03:16:00.172: [amf] INFO: [Added] Number of gNB-UEs is now 1015 (./src/amf/context.c:2132)
amf | 09/19 03:16:00.172: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:01.191: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:01.191: [amf] INFO: [Added] Number of gNB-UEs is now 1016 (./src/amf/context.c:2132)
amf | 09/19 03:16:01.191: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:02.212: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:02.212: [amf] INFO: [Added] Number of gNB-UEs is now 1017 (./src/amf/context.c:2132)
amf | 09/19 03:16:02.212: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:03.233: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:03.233: [amf] INFO: [Added] Number of gNB-UEs is now 1018 (./src/amf/context.c:2132)
amf | 09/19 03:16:03.233: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:04.253: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:04.253: [amf] INFO: [Added] Number of gNB-UEs is now 1019 (./src/amf/context.c:2132)
amf | 09/19 03:16:04.253: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:05.269: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:05.269: [amf] INFO: [Added] Number of gNB-UEs is now 1020 (./src/amf/context.c:2132)
amf | 09/19 03:16:05.269: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:06.293: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:06.293: [amf] INFO: [Added] Number of gNB-UEs is now 1021 (./src/amf/context.c:2132)
amf | 09/19 03:16:06.293: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:07.314: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:07.314: [amf] INFO: [Added] Number of gNB-UEs is now 1022 (./src/amf/context.c:2132)
amf | 09/19 03:16:07.314: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
osmohlr | 20220919031607400 DLINP <000b> input/rpa.c:412 connected read/write
osmohlr | 20220919031607407 DLINP <000b> input/rpa.c:368 172.22.0.31:40789 message received
amf | 09/19 03:16:08.335: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:08.335: [amf] INFO: [Added] Number of gNB-UEs is now 1023 (./src/amf/context.c:2132)
amf | 09/19 03:16:08.335: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
scscf | 5(36) DEBUG: ims_dialog [dlg_handlers.c:1923]: print_all_dlgcs(): ***** 5(36) DEBUG: ims_dialog [dlg_handl
scscf | 5(36) DEBUG: ims_dialog [dlg_handlers.c:1934]: print_all_dlgcs(): ***** 5(36) DEBUG: ims_auth [authorize.c
scscf | 5(36) DEBUG: ims_auth [authorize.c:232]: reg_await_timer(): [DONE] Looking for expired/useless at 100967002
amf | 09/19 03:16:09.356: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:09.356: [amf] INFO: [Added] Number of gNB-UEs is now 1024 (./src/amf/context.c:2132)
amf | 09/19 03:16:09.357: [amf] ERROR: No UserLocationInformation (./src/amf/ngap-handler.c:464)
amf | 09/19 03:16:10.378: [amf] INFO: InitialUEMessage (./src/amf/ngap-handler.c:361)
amf | 09/19 03:16:10.378: [amf] FATAL: ran_ue_add: Assertion 'ran_ue' failed. (./src/amf/context.c:973)
amf | 09/19 03:16:10.379: [core] FATAL: backtrace() returned 11 addresses (./lib/core/ogs-abort.c:37)
amf | ./open5gs-amfd(+0xee02) [0x5565d6098e02]
amf | ./open5gs-amfd(+0x4da27) [0x5565d60d7a27]
amf | ./open5gs-amfd(+0x1e7ee) [0x5565d60a87ee]
amf | ./open5gs/install/lib/x86_64-linux-gnu/libogscore.so.2(ogs_fsm_dispatch+0x113) [0x7f0a9f3a9417]
amf | ./open5gs-amfd(+0x2fe76) [0x5565d60b9e76]
amf | ./open5gs/install/lib/x86_64-linux-gnu/libogscore.so.2(ogs_fsm_dispatch+0x113) [0x7f0a9f3a9417]
amf | ./open5gs-amfd(+0x8f64) [0x5565d6092f64]
amf | ./open5gs/install/lib/x86_64-linux-gnu/libogscore.so.2(+0x117e5) [0x7f0a9f39a7e5]
amf | /lib/x86_64-linux-gnu/libpthread.so.0(+0x8609) [0x7f0a9eaf1609]
amf | /lib/x86_64-linux-gnu/libc.so.6(clone+0x43) [0x7f0a9ea16133]
amf | ./open5gs_init.sh: line 96: 13 Aborted (core dumped) ./open5gs-amfd
amf exited with code 134

```

Update

We have reported this vulnerability to the vendor through email at 19 Sep 2022, but this bug has not been fixed yet.

Acknowledgment

Credit to @ToughRunner,@HenryzhaoH,@leonW7 from Shanghai Jiao Tong University.

Releases

No releases published

Packages



No packages published