

Easy 4G/LTE IMSI Catchers for Non-Programmers

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Abstract. IMSI Catchers are tracking devices that break the privacy of the subscribers of mobile access networks, with disruptive effects to both the communication services and the trust and credibility of mobile network operators. Recently, we verified that IMSI Catcher attacks are really practical for the state-of-the-art 4G/LTE mobile systems too. Our IMSI Catcher device acquires subscription identities (IMSI) within an area or location within a few seconds of operation and then denies access of subscribers to the commercial network. Moreover, we demonstrate that these attack devices can be easily built and operated using readily available tools and equipment, and without any programming. We describe our experiments and procedures that are based on commercially available hardware and unmodified open source software.

Keywords: 4G · LTE security · IMSI Catcher · Denial-of-Service

1 Introduction

1.1 IMSI Catchers

IMSI Catchers are active attack devices against the radio link protocols in mobile networks with the main goal of collecting IMSIs (International Mobile Subscriber Identities), the subscribers' identifiers used in the authentication and access control procedures. In particular, these attacks break one of the important security requirements set in the international specifications, namely the privacy and non-traceability of the subscriber. The malicious devices usually act as a man-in-the-middle to fulfil more advanced attacks. IMSI Catchers can be used for mass-surveillance of individuals in a geographical area, or link a real person to his/her identity in the network, trace a person with a known IMSI (check his/her presence in a building or area), eavesdrop on private conversations, all these being privacy issues concerns. IMSI disclosure is a direct consequence of the poor cryptographic mechanism used or its improper usage. On the other hand, DoS (Denial-of-Service) attacks introduce serious financial losses on a targeted operator, as the subscribers cannot access the mobile services; moreover, other services that use the mobile infrastructure are impacted by the network unavailability; these include emergency calls or SMSs containing one-time codes for two-way authentication mechanisms used in the bank sector.

1.2 Related Work

IMSI Catchers were first built for 2G/GSM, and later extended to 3G/UMTS protocols. Until recently LTE (Long Term Evolution) protocols were considered secure against these privacy attacks due to the stronger authentication and key exchange mechanisms. This claim has now been proved to be incorrect both by ourselves and others. Independently of our work, Shaik et al. showed that IMSI Catchers can be built for LTE mobile networks with similar consequences as for 2G and 3G networks [1]. The vulnerabilities in LTE protocols allow an adversary to trace the location of users with fine granularity, enable DoS attacks, or eavesdropping on the communication [1–5]. General techniques to set up attacks against LTE include traffic capture, jamming and downgrade to 2G. All these academic works implement IMSI Catchers by modifying the code of open-source software projects, such as OpenLTE [6], srsLTE [7,8] or gr-LTE [9]. Rupprecht et al. have very recently used Open Air Interface (OAI) [10] to test compliance of UE (User Equipment) with the LTE standard with respect to encryption and to exemplify a man-in-the-middle attack, but they assume that the UE tries to connect to the rogue base station [5]. Most of the works use OpenLTE code because, according to these researchers, the OpenLTE architecture is easier to modify. We use the unmodified OAI software here for the purpose of building an IMSI Catcher.

1.3 Summary of Results

Our main goal here is to demonstrate that it is easy to build a low-cost LTE IMSI Catcher that requires absolutely no programming skills, but only readily available standard equipment and tools. Although other related works show that an IMSI Catcher for LTE can be built, they all require modification to the source code. We are the first to build an LTE IMSI Catcher using existing “commercial off the shelf” hardware and readily available software only. This result demonstrates that anyone who has basic operational computer skills (installing and running software) can mount an IMSI Catcher attack; in particular, our attack set up requires no programming.

A second, but no less important, result is the ability of the adversary to perform a DoS attack, under the same conditions. The access to the authorised mobile network is controlled by the adversary in time and space: UEs are denied mobile services within the area of the rogue eNodeBs for the time they are active. Again, our attack set up requires no programming skills.

2 LTE Mobile Networks

2.1 LTE Architecture

LTE architecture (see Fig. 1) consists of two parts: EUTRAN (Evolved Universal Terrestrial Radio Access Network) and EPC (Evolved Packet Core), each of them being composed of several components that we briefly described next.

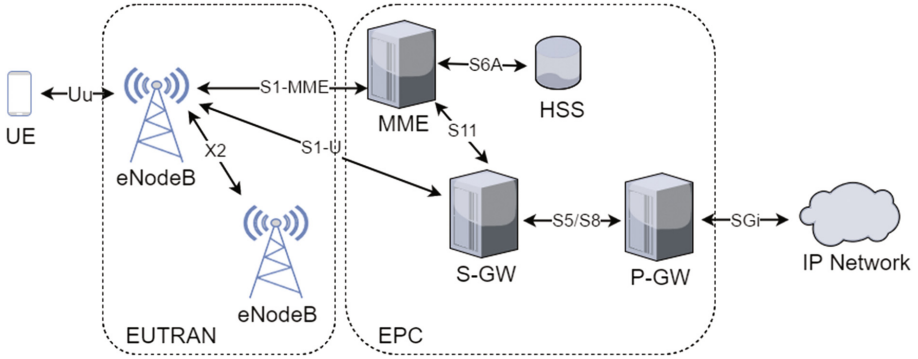


Fig. 1. LTE architecture

UE (User Equipment) refers to the mobile user terminal. It contains a USIM (Universal Subscriber Identity Module), which stores the IMSI (International Mobile Subscriber Identity) and the associated permanent secret key, used to derive temporary keys for authentication and encryption. IMSI is a permanent unique value that globally identifies the subscriber.

eNodeB (evolved NodeB) is the base station that communicates with UEs by radio links and represents the access point to the operator's network.

MME (Mobile Management Entity) is responsible for authentication and resources allocation to UEs. It manages the mobility of UEs in the network when eNodeBs cannot.

HSS (Home Subscriber Server) stores the authentication parameters, private keys and other details about the UEs.

S-GW (Serving Gateway) is an interconnection point between EUTRAN and EPC, being an anchor point for intra-LTE mobility.

P-GW (PDN Gateway) is a routing point to provide connectivity to the external PDN (Packet Data Network).

A mobile network is identified by MCC (Mobile Country Code) and MNC (Mobile Network Code). The MCC and MNC are publicly available online [11]. An eNodeB controls a set of cells running at a specific frequency in an LTE band, or equivalently, on an EARFCN (EUTRA Absolute Radio-Frequency Channel Number) [12, 13]. The frequency ranges allocated to the network operators are also public information [14]. Several cells in a geographically region form a TAC (Tracking Area Code), which is managed by a single MME. The eNodeB broadcasts information such as MCC, MNC or TAC via SIB (System Information Block) messages. This allows the UE to identify the operator. To attach to the network, UE then sends an ATTACH_REQUEST message to the eNodeB. If UE moves to a new area, it initiates a TAU_REQUEST and a TRACKING_AREA_UPDATE procedure is performed.

We skip other details here, but invite the reader to refer to the specifications for more details [15, 16].

2.2 LTE Cell Selection and Reselection

A mobile device that attempts to access the mobile network performs a *cell selection* procedure. This means that the UE searches for a suitable cell and chooses to camp on the one that provides the best service. If later on the UE finds a more suitable cell (according to some reselection criteria), then it performs *cell reselection* and camps onto the new cell. Cell selection and reselection in LTE mobile networks are complex processes involving several steps and different criteria [17, 18]. We do not describe the complete processes here, but only highlight the aspects that are further required for the understanding of our work.

When the UE is switched on, it camps on a cell within a PLMN (Public Land Mobile Network) selected accordingly to a list stored locally and some selection criteria. In practice, the selected PLMN corresponds to the last mobile network the UE had successfully connected to before switch off. Note that this is not always the home PLMN (the mobile network the USIM belongs to).

At reselection, the UE monitors intra-frequency, inter-frequency and inter-RAT (Radio Access Technology) cells indicated by the serving cell. In the following, we refer to inter-frequency reselection, as its understanding is a prerequisite for our results. The UE performs inter-frequency reselection when it camps on a cell that runs on a different frequency than the serving cell. First level criterion for reselection is the absolute priority list: the UE always monitors and tries to camp on cells that run on higher priority frequencies. The eNodeB of the serving cell broadcasts in clear the list of absolute priorities (along with other reselection parameters) in SIB messages. For each frequency that is listed, `cellReselectionPriority` field defines its absolute priority, where 0 indicates the lowest priority and 7 indicates the highest priority. Note that LTE reselection uses the radio link quality as second level criteria, so simply running a rogue eNodeB in the vicinity of the UE does not automatically trigger a reselection.

Operators use the absolute priority frequency criteria to gain robust coverage. They design the network such that within an area coexist multiple cells that run on distinct frequencies with associated priorities. In case of incidents or network congestion on the highest priority frequency, the UE will not lose connectivity, but reselect a cell that runs on the next priority frequency. Deciding the number of frequency levels that should coexist in an area and their associated priorities is a task of the design network engineer.

2.3 Security Requirements and the Adversarial Model

The main goals of the adversary are to collect IMSIs and to deny network availability. The adversary is constrained in both budget and technical skills, so it aims for a low-cost and simple attack that only requires basic computer knowledge. Our adversary will only use commercially available hardware and unmodified open source software.

Furthermore, the adversarial model follows the one of previous work [1, 3]. The attacker is active in the sense that it can build up a rogue eNodeB that interacts with the UEs. The model of a passive adversary (an adversary that can only

sniff LTE traffic, but cannot actively interfere) is inappropriate both for practical and theoretical reasons. On the practical side, active adversaries have been proved successful, so LTE mobile networks must protect against them, while on the theoretical side TMSIs (Temporary Mobile Subscriber Identities) have been introduced as a security measure starting with 2G. TMSIs are temporary values that replace the IMSIs in the process of subscribers' identification, minimising the transmission of IMSIs through the air and hence drastically decreasing the chances of a passive adversary to collect them.

3 Equipment and Tools

3.1 Hardware

Only Commercial Off-The-Shelf (COTS) devices have been used in our attack setup. The hardware components that we used for our experiments (excluding the mobile phones) are shown in Fig. 2.



Fig. 2. Experimental hardware (excluding UEs)

Computers. We used two different computers: one Intel NUC D54250WYK (i5-4250U CPU@1.30GHz) and one Lenovo ThinkPad T460s (i7-6600U CPU@2,30GHz). Both run 64-bit Kubuntu 14.04 kernel version 3.19.0-61-low latency and have USB3 ports, which are prerequisites for running the OAI software. The Intel NUC computer was attached with standard peripherals (display screen, mouse, keyboard).

USRPs. The B200mini is a USRP (Universal Software Radio Peripheral) from Ettus Research that can be programmed to operate over a wide radio-frequency range (70 MHz–6 GHz), communicating in full duplex. It can be used for all of the LTE frequency bands. The technical specifications of the B200mini are available at [19]. We used two USRP B200mini to set up the eNodeBs.

User Equipment. We used a Samsung Galaxy S4 device to find the LTE channels and TACs used in the targeted area. For testing the IMSI Catcher, we used

two LG Nexus 5X phones running Android v6. We used different USIMs from the two biggest Norwegian operators, and the two biggest Romanian operators (see Sect. 5).

The total hardware cost is less than 3000EUR. Any two OAI compatible computers and USRPs can be used to mount the experiments [20]. Also, a single mobile device is sufficient if it can provide the minimal information needed (EARFCN and TAC) for setting up the rogue eNodeBs. So, the minimal kit includes: two computers and two USRPs for the network side and one mobile device with a USIM from the targeted mobile operator for the client side. Keeping the configuration to minimum, cost might be decreased. Also, we expect the costs to be significantly lower in the near future.

3.2 Software

We used open-source freely available software that did not require any modification for our purposes to build and run the 4G/LTE IMSI Catcher.

Service and Testing Modes. Seen as a facility of the operating system and the privilege rights of the user, service or testing modes of mobile devices offer important information about the LTE network. We describe, for comparison, the information displayed by the two types of phones we used during the experiments.

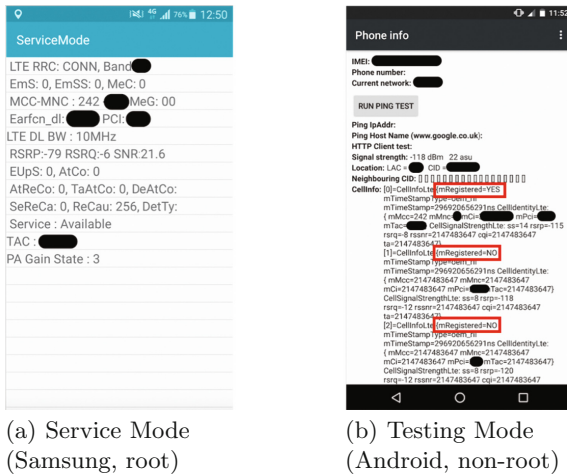


Fig. 3. Service and testing modes

Samsung phones offer LTE connection details by default [21]. To access Service Mode, call *#0011#. The most important pieces of information are the EARFCN_DL (downlink EARFCN) and the TAC. Other interesting information include the MCC, MNC and Cell ID. Refer to Fig. 3(a) for more details.

Android phones (including Samsung phones) access Testing Mode by calling `*##4636##*`. This is a feature available on all Android phones, which does not necessarily display EARFCN_DL by default (it is dependent of the Android version), but displays information about several LTE cells that coexist in the area on which the phone might downgrade to in case the actual cell becomes unavailable. Figure 3(b) shows the Testing Mode of a LG Nexus 5X display. The UE is registered to the first displayed cell (`mRegistered=YES`), while the others are showed to be accessible. However, last versions of Android or applications such as LTE G-Net Track Lite or NetCell Tracker [22, 23] (in root mode) can provide EARFCN_DL and other information in a user-friendly format.

OAI (Open Air Interface). OAI is open source software that implements both the core network (EPC) and access-network (EUTRAN) of 3GPP cellular networks [10, 24]. Currently, it provides a standard compliant implementation of Release 10 LTE and establishes generic interfaces with various hardware manufactures (including Ettus Research). Basically, the LTE network is emulated on a computer, and the USRP is used as the radio platform for the eNodeB implementation. It is recommended to run EPC and EUTRAN on different machines, but OAI accepts both on a single computer too. For our tests, keeping in mind the goal of a low-cost IMSI Catcher, we used two machines, one for each of the two rogue eNodeBs that must run concurrently.

OpenBTS. OpenBTS is an open source software development project for GSM mobile networks [25]. OpenRegistration in OpenBTS allows an IMSI that match a given regular expression to access the network. The one-sided authentication protocol of GSM permits the OpenBTS process to accept mobile terminals without proper mutual authentication. Note that we have used OpenBTS for testing purposes only, to make a roaming USIM connect to a masquerade home network, but this is not a prerequisite for setting up the LTE IMSI Catcher (see Sect. 5.4).

4 The LTE IMSI Catcher

We now describe how we built and operated our LTE IMSI Catcher. We ran two rogue eNodeBs using the OAI software, and set up with the proper configuration files. One rogue eNodeB (called `eNodeB_Jammer` from now on) causes the UE to detach from the serving cell that it is camped on, and to reselect to our rogue cell set up by the second eNodeB (called `eNodeB_Collector`), which masquerades as an authorized eNodeB but with higher signal power.

The `eNodeB_Collector` broadcasts the MCC and the MNC of the target network operator to impersonate the real network. The `eNodeB_Collector` signals a TAC value different from the commercial one, which brings the UE to initiate a TAU_REQUEST message. For simplicity, we configured it to the next available TAC (TAC of the commercial network + 1). We found that the TAC must not be changed for multiple runs of the experiment (assuming the commercial TAC is unchanged), therefore we kept this value constant. Besides the MCC-MNC of the target network, the `eNodeB_Collector` must run on the LTE EARFCN (the

absolute physical radio channel) which corresponds to the highest priority next to the jammed channel. This assures that the UE prefers the `eNodeB_Collector` prior to any other commercial `eNodeB` in the area. The `eNodeB_Jammer` is turned on, using the radio channel of the cell that the UE camps on. This jams the radio interface and decreases the signal of the commercial `eNodeB` under the specified threshold (see Sect. 2), causing the UE to trigger a new search for available `eNodeBs`. The UE tries to camp to the cell that runs on the next priority frequency and provides the best signal, namely the rogue `eNodeB`.

We divide the adversarial actions into two main phases:

Phase 1. Gather the configuration parameters (EARFCN and TAC):

1. Connect a mobile phone to the target network and read the `EARFCN_DL` and `TAC`;
2. Configure and run the `eNodeB_Jammer`, using the `MCC` and `MNC` of the target network and the `EARFCN_DL` from the previous step;
3. Read the new value of `EARFCN_DL`, after the UE performs reselection.

Phase 2. Configure and run the LTE IMSI Catcher:

1. Configure and run the `eNodeB_Collector`, using the `MCC` and `MNC` of the target network, a different `TAC` than the one in *Phase 1.1* and the `EARFCN_DL` set to the value in *Phase 1.3*;
2. Configure and run the `eNodeB_Jammer`, using the `MCC` and `MNC` of the target network and the `EARFCN_DL` set to the value in *Phase 1.1*.

The channel displayed in *Phase 1.1* is associated with the highest priority (unless the signal power is below the reselection threshold, see Sect. 2.2). The UE connects to it even if the signal power is not so strong. This can be easily seen by comparing the information displayed by the mobile device before and after the `eNodeB_Jammer` is turned on. The channel in *Phase 1.3* has either the same priority, but lower signal power, or lower priority, regardless the signal power. Once the `eNodeB_Jammer` is active, this triggers an `ATTACH_REQUEST` message from the UE to the `eNodeB_Collector`. Then the UE will reveal its `IMSI` as a response to an `IDENTITY_REQUEST` query from our `Collector` cell.

5 Experiments and Results

5.1 Introduction

All our experiments were run in our wireless security lab at the university. We intend our work to be a motivation for solving the problem of privacy attacks in mobile networks both in existing and emerging systems at the technical specification level, as well as for mobile network operators to use the already existing security mechanisms.


```

77 [MESSAGE] 6 -> 8 0 0103:9902850 NAS_UPLINK_DATA_IND ue_id 0x00000002 len 17
78 [MESSAGE] 8 -> 9 0 0103:9903210 EMMAS_DATA_IND ue_id 0x00000002 len 17 tai: plmn 242. [REDACTED] tac [REDACTED]
79 [EVENT] 9 0103:990822T3470 stopped UE 0x00000002
80 [MESSAGE] 9 -> 9 0 0103:990956EMMREG_COMMON_PROC_CNF ue_id 0x00000002
81 [EVENT] 9 0103:991075EMM state DEREGISTERED UE 0x00000002
82 [MESSAGE] 8 -> 13 0 0103:9911920 S6A_AUTH_INFO_REQ IMSI 242- [REDACTED] vis [REDACTED] ted_plmn 242. [REDACTED] re_sync 0
83 [MESSAGE] 13 -> 8 0 0103:9921110 S6A_AUTH_INFO_ANS imsi 242- [REDACTED] DIA HETER_AUTHENTICATION_DATA_UNAVAILABL
84 [EVENT] 7 0103:9921680 S6A_AUTH_INFO_ANS S6A Failure imsi 242- [REDACTED]
85 [MESSAGE] 8 -> 9 0 0103:9921820 EMMCN_AUTHENTICATION_PARA_FAIL

```

Fig. 4. IMSI Capture

28	56.711592	127.0.0.1	127.0.1.10	SIAP/NAS-EPS	186 id-uplinkNAStransport, Attach request, PDN connectivity request
35	81.793250	127.0.0.1	127.0.1.10	SIAP/NAS-EPS	194 id-initialUEMessage, Attach request, PDN connectivity request
46	106.793796	127.0.0.1	127.0.1.10	SIAP/NAS-EPS	194 id-initialUEMessage, Attach request, PDN connectivity request
47	106.795616	127.0.1.10	127.0.0.1	SIAP/NAS-EPS	110 SACK id-downlinkNAStransport, Identity request
48	106.812750	127.0.0.1	127.0.1.10	SIAP/NAS-EPS	138 SACK id-uplinkNAStransport, Identity response
55	106.816179	127.0.1.10	127.0.0.1	SIAP/NAS-EPS	110 SACK id-downlinkNAStransport, Attach reject


```

NAS-PDU: 074403
  Non-Access-Stratum (NAS)PDU
    0000 .... = Security header type: Plain NAS message, not security protected (0)
    .... 0111 = Protocol discriminator: EPS mobility management messages (0x07)
    NAS EPS Mobility Management Message Type: Attach reject (0x44)
      EMM cause
        cause: illegal UE (2)

```

Fig. 5. ATTACH_REJECT message

5.2 IMSI Catching

We successfully ran experiments with three subscriptions from two mobile operators in Norway, testing two, respectively one USIM card for each. For all, we used the same mobile device, the LG Nexus 5X. To respect privacy of other users, IMSI values were captured from our own USIM cards only.

All the three IMSIs used for tests were successfully captured by the eNodeB_Collector within a few seconds after the eNodeB_Jammer is switched on. Figure 4 shows a portion from the log file that contains a captured IMSI.

Experiments were repeated several times, with different values for Cell ID or eNodeB ID. They were all successful, so we conclude there is no protection mechanism in place (e.g. a list of accepted cells, TACs or timers).

5.3 Denial-of-Service

We observed that running the IMSI Catcher results in a DoS attack because authentication fails after the UE triggers the ATTACH_REQUEST and consequently sends its identity as a response to the IDENTITY_REQUEST. This is normal, as the IMSI is not recognised by the HSS as a valid subscriber and no handover procedures can be accomplished. The eNodeB_Collector responds to the UE with ATTACH_REJECT cause 3 (Illegal UE), making the UE to consider the network unavailable until reboot (Fig. 5) [16].¹

If the UE is powered off and on again while our rogue eNodeBs are still up, the UE keeps failing to camp on any cell. This turns into a controlled DoS attack against the target network in the area covered. This DoS mode remains active as long as the rogue eNodeBs are up.

¹ Depending on the exact software version of OAI being used, UE connectivity to the eRogueB fails in various ways, but all end up with DoS until the reboot of UE.

```

72 [MESSAGE] 8 -> 9 0 0370:7869980 EMMAS_DATA_IND ue_id 0x00000002 len 11 tai: plmn 226. visited_plmn 226. re_sync 0
73 [EVENT] 9 0370:787279T3470 stopped UE 0x00000002
74 [MESSAGE] 9 -> 9 0 0370:787345EMMREG_COMMON_PROC_CNF ue_id 0x00000002
75 [EVENT] 9 0370:787404EMM state DEREGISTERED UE 0x00000002
76 [MESSAGE] 8 -> 13 0 0370:7874860 S6A_AUTH_INFO_REQ IMSI 226. visited_plmn 226. re_sync 0
77 [MESSAGE] 13 -> 8 0 0370:7889220 S6A_AUTH_INFO_ANS imsi 226. DIAMETER_AUTHENTICATION_DATA_UNAVAILABLE
78 [EVENT] 7 0370:7889830 S6A_AUTH_INFO_ANS S6A Failure imsi 226.
79 [MESSAGE] 8 -> 9 0 0370:7889920 EMMCN_AUTHENTICATI
80 [EVENT] 9 0370:789185send ATTACH_REJECT to ue_id 0x00000002
81 [MESSAGE] 8 -> 6 0 0370:7893480 NAS_DOWNLINK_DATA_REQ ue_id 0x00000002 len 0
82 [MESSAGE] 7 -> 7 0 0370:7893890 DOWNLINK NAS TRANSPORT enb_ue_slap_id 0xF43950 ue_id 0x00000002
83 [MESSAGE] 6 -> 1 0 0370:7894640 downlinkNASTransport/initiatingMessage ue_id 0x00000002 mme_ue_slap_id 0x00000002

```

Fig. 6. IMSI capture in roaming

5.4 Roaming

An even simpler IMSI Catcher is available for USIMs in a roaming situation, in particular under restricted scenarios like airport arrivals. The adversary can now run a single rogue eNodeB with the MCC and MNC of the home network.

We distinguish 2 scenarios: (1) USIMs that are inactive in roaming (roaming was not activated or the user travels to a country without any roaming agreements with the home network) and (2) USIMs that are active in roaming, but did not connect to any network while in roaming. For both cases, the UE reveals its IMSI on power on, if the IMSI Catcher is up and running at that time.

USIMs inactive in roaming. A USIM for which roaming is disabled is directly susceptible to an LTE IMSI Catcher using the same MCC and MNC as the home network. Hence, to setup an IMSI Catcher in this scenario, an adversary simply configures the corresponding MNC and MCC, then runs OAI. The LTE frequency band, EARFCN or any other information are irrelevant in this scenario. If the IMSI Catcher is running when the UE is turned on, then the UE will try to camp on the cell that masquerades the HPLMN and hence, responds to the `IDENTITY_REQUEST` message with its IMSI.

We carried out this attack using an inactive LTE USIM card from one of the most known Romanian mobile operators. Figure 6 shows the IMSI, as captured by the IMSI Catcher as a response to an `IDENTITY_REQUEST` message.

USIM active in roaming. A USIM for which roaming is enabled is susceptible to an IMSI Catcher built as previously explained, when the UE is first powered on in roaming. Once connected in roaming, the UE will not search for its home network because in practice, regardless of the specifications, the UE will always try to connect to the most recent network for which the connection was successfully (this is an issue inherited from previous generations, as for example it exists in GPRS also [26]). The scenario could make sense on an airport: the user turns off its device (or equivalently, enable the fly mode) while connected to the home network and later turns it on (or equivalently, disables the fly mode) after landing, in the presence of a rogue eNodeB that simulates the home network. The UE will try to connect to the rogue eNodeB and hence, it will reveal its IMSI as a response to the `IDENTITY_REQUEST` message. Such an IMSI Catcher might be used by agencies that want to survey the presence of people arriving from specific countries to their own territory in a hidden manner (without revealing their intentions by asking official documents from the border authorities).

Independent work considers this scenario in theory and proposes correctness and completeness of location update trails and geographically plausibility of location updates to address this issue [27]. We have hereby certified this functionality.

We performed the experiment by using an active LTE USIM card belonging to another network operator in Romania. As the USIM had been already active in roaming, we simulated the test case by connecting it to a fictive 2G network that masquerades the home network. For this, we used OpenBTS in OpenRegistration mode. After the UE connected to the GSM network, we switched it to 4G and immediately turned it off. At power on, the UE tried to connect to the rogue eNodeB that simulated the home 4G network and then revealed its IMSI.

6 Conclusion

In conclusion, our experiments have verified, independently of other works, that IMSI-catching indeed can be done for the 4G/LTE system too. We claim that (1) IMSIs can be collected by the eNodeB.Collector, and (2) DoS (Denial-of-Service) is performed automatically after the UE receives an attach rejection message (with a specific cause). The 4G/LTE is vulnerable to active privacy attacks by IMSI Catcher, and we found that these attacks can be done quite easily and therefore can impact the confidence and reliability of commercial mobile networks. We showed that these attacks are not limited to clever programmers with special hardware. We hope that this report, and others, will make the 4G/LTE service providers aware of this threat, and lead to demands for improved privacy and security protocols in the mobile networks.

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