THE PROBLEM OF PRIVATE IDENTIFICATION PROTOCOLS

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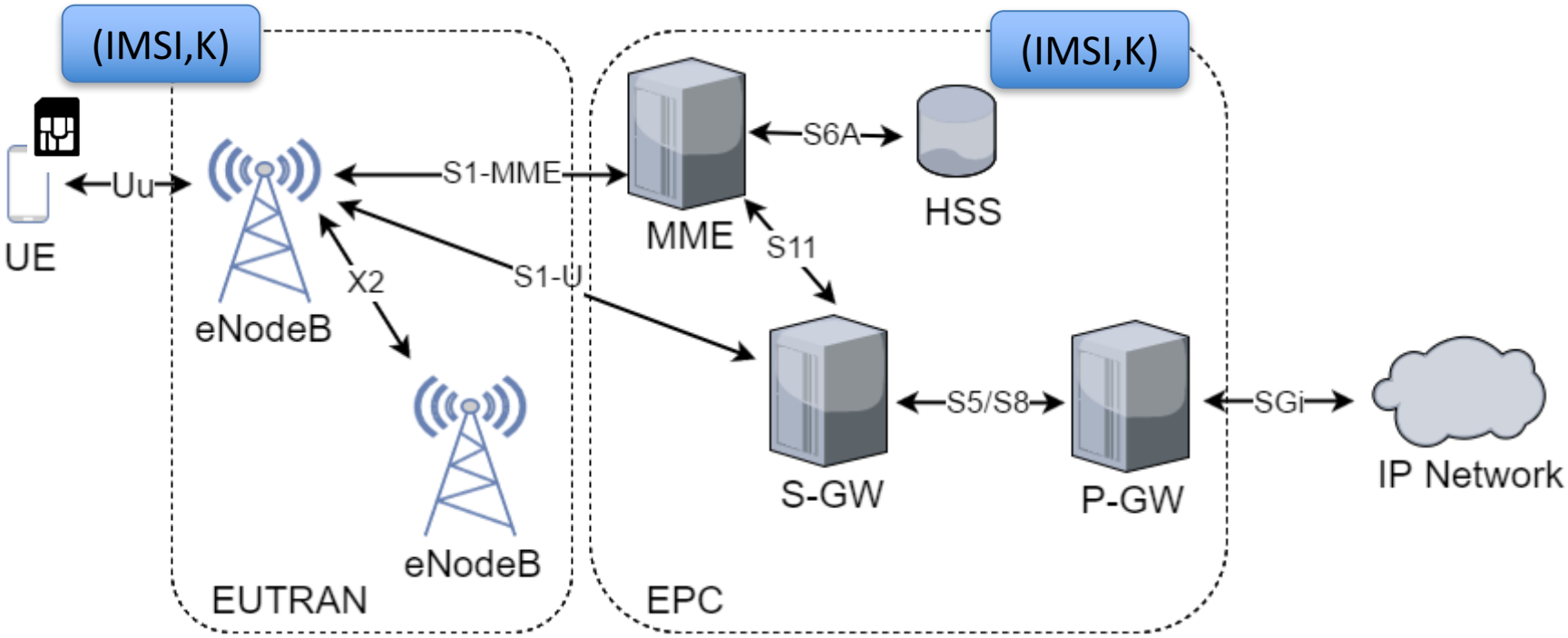
Motivation - LTE

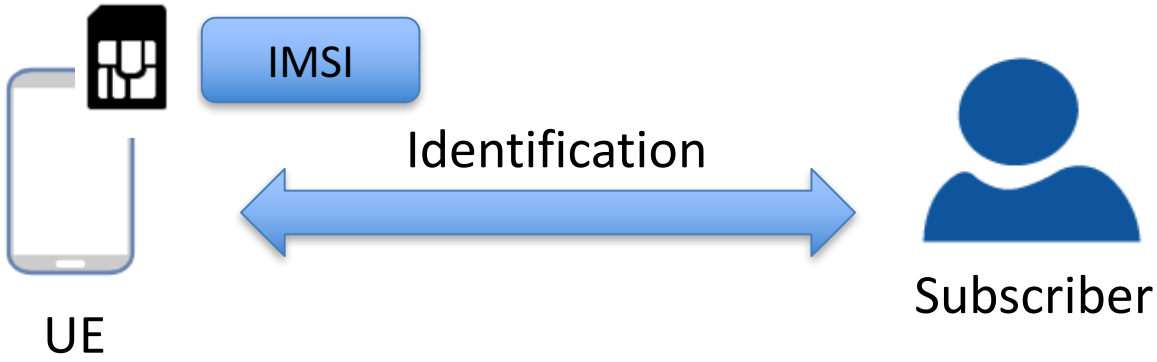
LTE - Subscriber's Identification

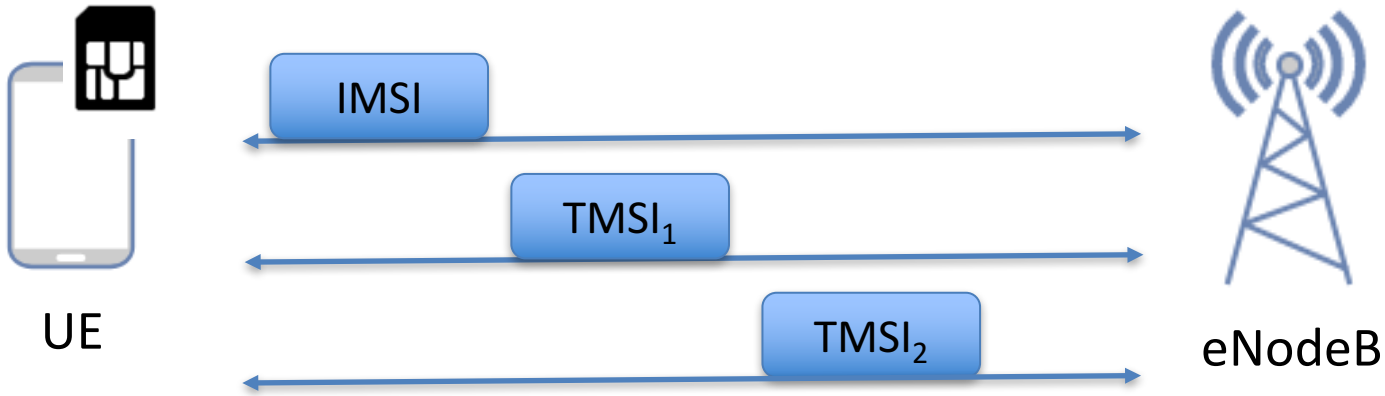


IMSI (International Mobile Subscriber Identity)

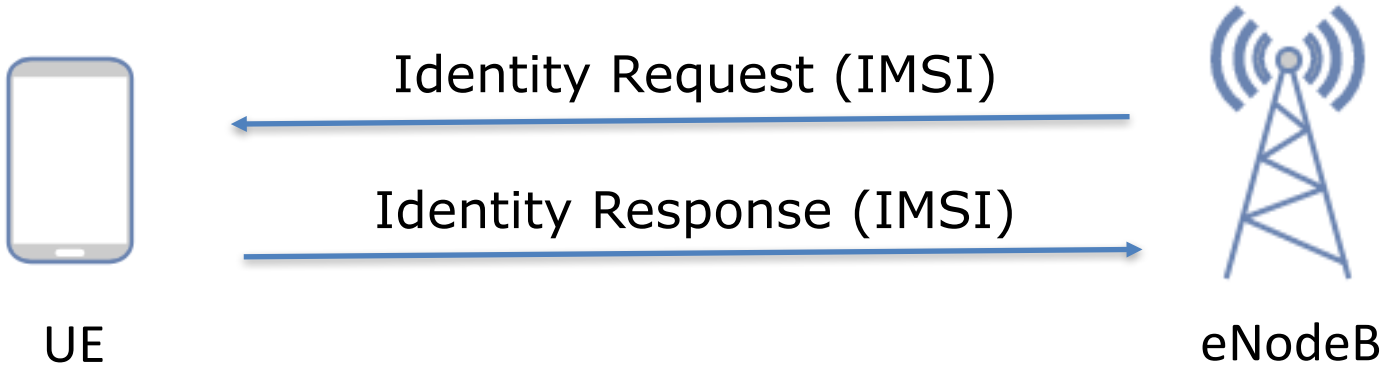
MCC (Mobile Country Code)	**MNC** (Mobile Network Code)	**MSIN** (Mobile Subscriber Identification Number)

LTE - Subscriber's Identification





LTE - Privacy Breach



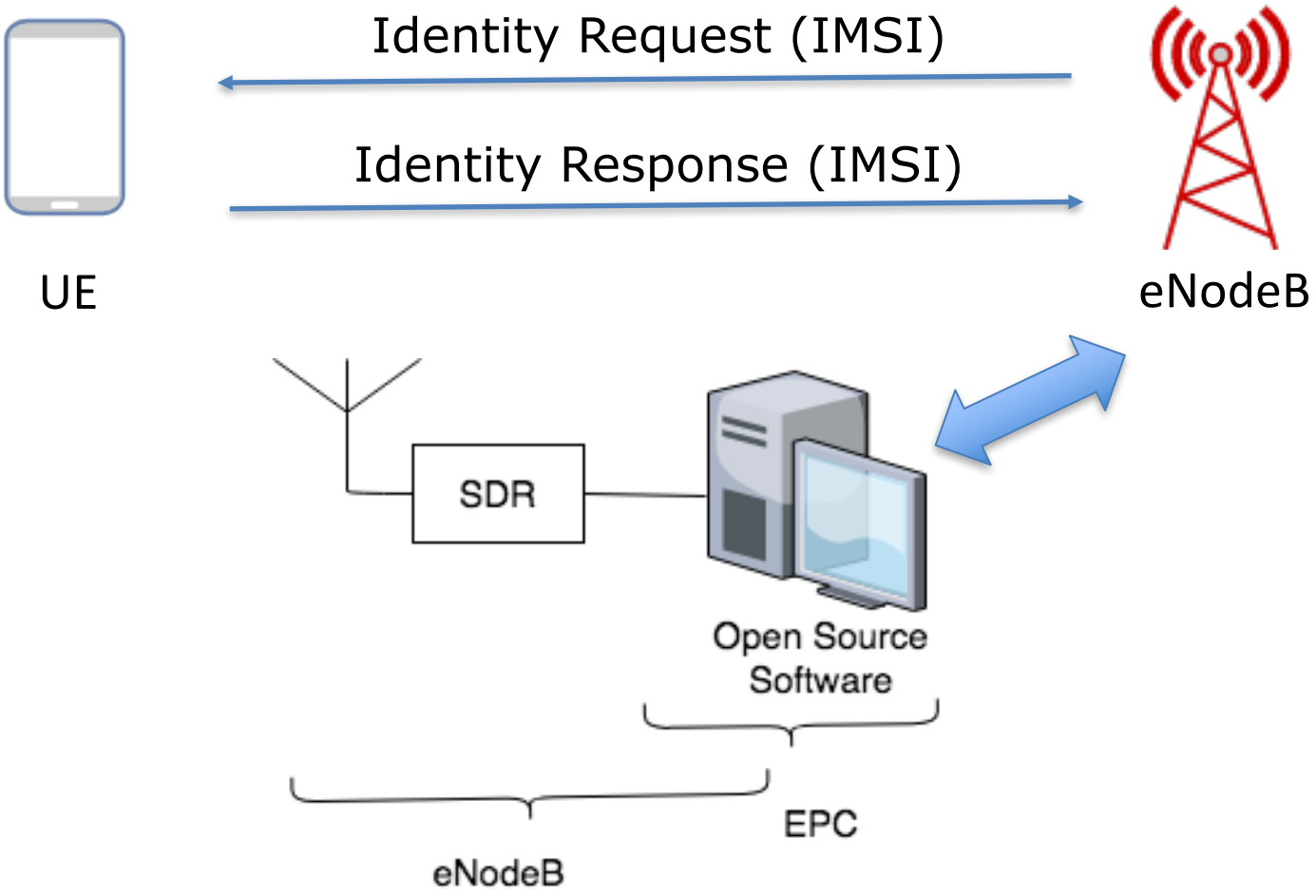
[. . .] requests the user to send its permanent identity. The user's response contains the IMSI in cleartext. This represents ***a breach in the provision of user identity confidentiality****.*

[ETSI TS 133 401 V14.4.0 (2017-10)]

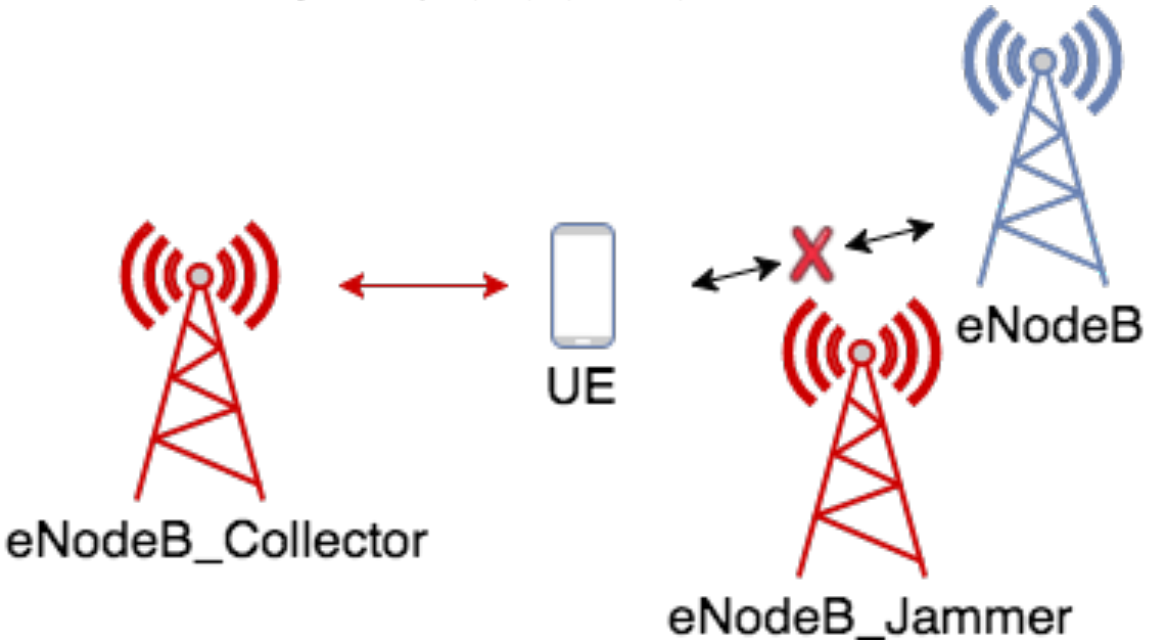
Experimental Work

- S.F.Mjølsnes, R.F.Olimid: *Easy 4G/LTE IMSI Catchers for Non-Programmers,* MMM-ACNS 2017
- S.F.Mjølsnes, R.F.Olimid: *Experimental Assessment of Private Information Disclosure in LTE Mobile Networks,* Secrypt 2017

Experimental Work

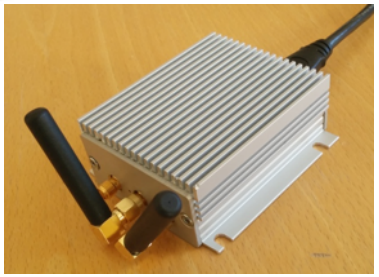


Our LTE IMSI Catcher



- `eNodeB_Jammer:` causes the UE to detach from the serving cell it camps on
- `eNodeB_Collector:` masquerades as an authorized eNodeB running on the (second) highest **priority frequency**, but with higher signal power, causing the UE to try reselection and expose the IMSI

Tools: **Hardware**

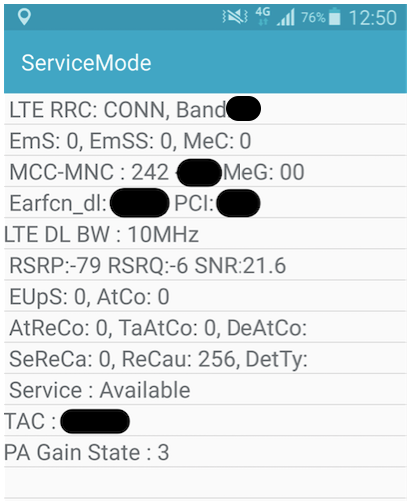


- Software radio peripherals (USRPs)
  - Ettus B200mini + antennas
    [https://www.ettus.com/product/details/USRP-B200mini]
- Computers (access and core network)
  - Standard desktops or laptops: Intel NUC D54250WYK (i5-4250U CPU@1,30GHz), Lenovo ThinkPad T460s (i7-6600U CPU@2,30GHz)

- Mobile terminals:
  - Samsung Galaxy S4 device, used to find the LTE channels and TACs used in the targeted area
  - Two LG Nexus 5X phones running Android v6, used to test our IMSI Catcher
- SIM cards

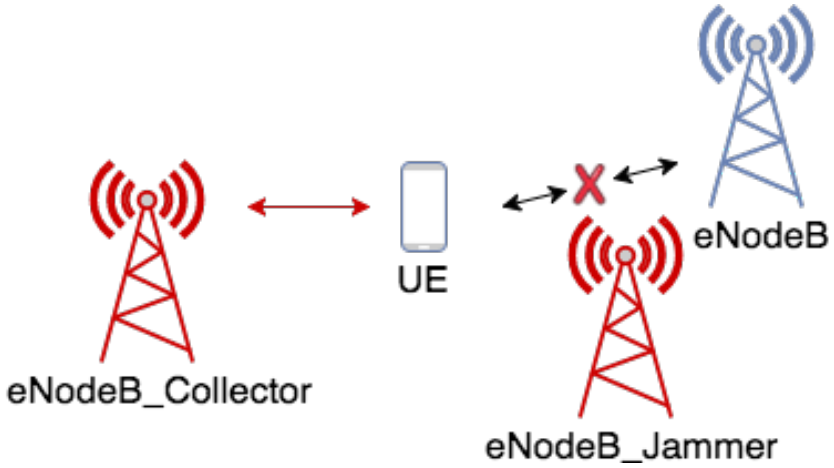
Tools: **Software**

- LTE Emulator:
  - **Open Air Interface (OAI),** an open source software that provides a (partially) standard compliant implementation of LTE



- Service Mode:
  - Dial *#0011# on Samsung Galaxy S4 device
  - Read configuration of the commercial network: EARFCN DL, TAC, MCC, MNC, Cell ID

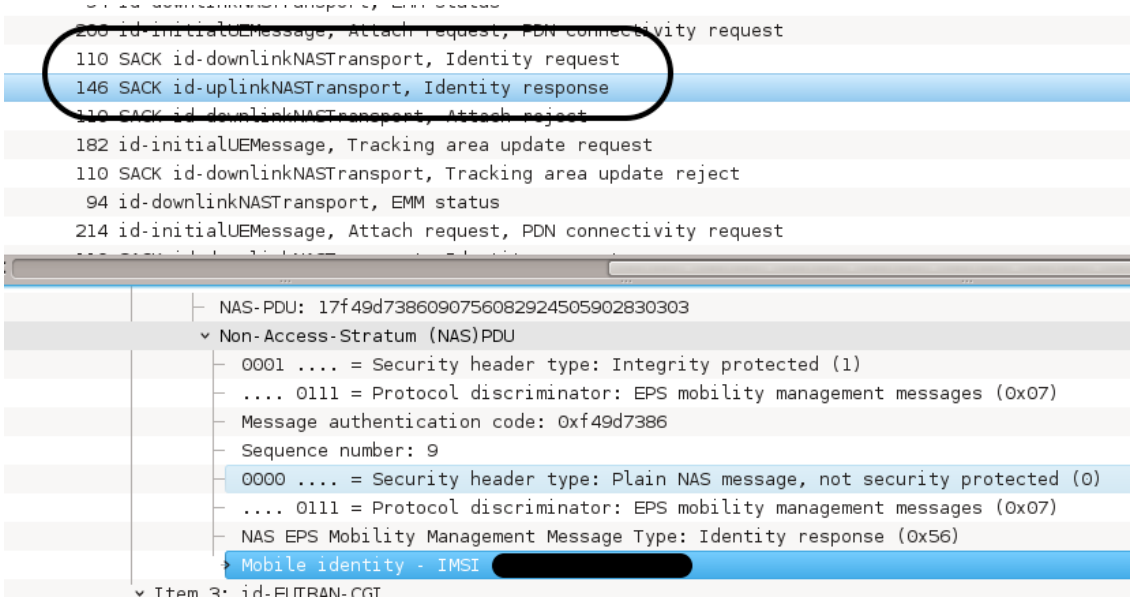
Construction



- **Phase 1. Gather the configuration parameters:**
  - Find the EARFCN DL and TAC (using the Samsung device)
  - Run `eNodeB_Jammer` using MCC, MNC and the EARFCN DL of the commercial cell
  - Read new EARFCN DL after reselection
- **Phase 2. Configure and run the LTE IMSI Catcher:**
  - Run `eNodeB_Collector` using MCC, MNC and the new EARFCN DL after reselection in the commercial network, but a different TAC
  - Run `eNodeB_Jammer` configured as in Phase 1

Results

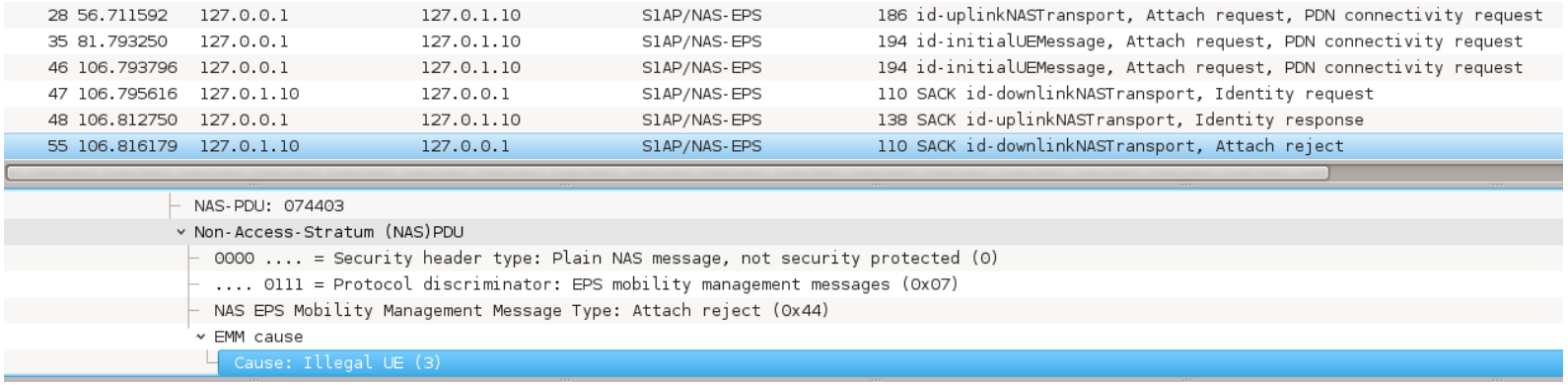
- Low-cost **IMSI Catcher** (< 3000 EUR):
  - COTS hardware and readily available software only
  - No (or very basic) changes in the source code




```
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] visited_plmn 242.[redacted] re_sync 0
83 [MESSAGE] 13 -> 8 0 0103:9921110 S6A_AUTH_INFO_ANS imsi 242[redacted] DIAMETER_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_PARAM_FAIL
```

Results

- Behaviour:
  - Denial-of-Service (DoS) until reboot - *cause 3* (`Illegal UE`)
  - Downgrade to non-LTE services - *cause 7* (`EPS services not allowed`)
  - Reconnection to the commercial network - *cause 15* (`No suitable cells in tracking area`)



Similar Work

Practical Attacks Against Privacy and Availability in 4G/LTE Mobile Communication Systems

Altaf Shaik*, Ravishankar Borgaonkar†, N. Asokan‡, Valtteri Niemi§ and Jean-Pierre Seifert*
*Technische Universität Berlin and Telekom Innovation Laboratories
Email: (altaf329, jpseifert) @sec.t-labs.tu-berlin.de
†Aalto University
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[NDSS 2016]

LTE security, protocol exploits and location tracking experimentation with low-cost software radio

Roger Piqueras Jover
Bloomberg LP, New York, NY
rpiquerasjov@bloomberg.net

International Conference on Mathematical Methods, Models, and Architectures for Computer Network Security
MMM-ACNS 2017: Computer Network Security pp 235-246

Easy 4G/LTE IMSI Catchers for Non-Programmers

Authors | Authors and affiliations

Stig F. Mjølsnes, Ruxandra F. Olimid

Experimental Assessment of Private Information Disclosure in LTE Mobile Networks

Topics: Security and Privacy in Mobile Systems

In **Proceedings of the 14th International Joint Conference on e-Business and Telecommunications - Volume 6: SECRYPT,** 507-512, 2017, Madrid, Spain

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NTNU

IMSI Catchers in the Real World

”Real World” IMSI Catchers

[Aftenposten, Dec.16 2014]

”Real World” IMSI Catchers

Piranha - 2G, 3G, and 4G IMSI Catcher

Piranha is a 2G, 3G and 4G (LTE) IMSI Catcher System that enables gathering mobile phone identities in the area of the system.

[http://www.rayzoneg.com/en.piranha.html]

”Real World” IMSI Catchers

[https://theintercept.com/2016/09/12/long-secret-stingray-manuals-detail-how-police-can-spy-on-phones/]

The Intercept_

54

Photo: U.S. Patent and Trade Office

LONG-SECRET STINGRAY MANUALS DETAIL HOW POLICE CAN SPY ON PHONES

Sam Biddle

September 12 2016, 9:33 p.m.

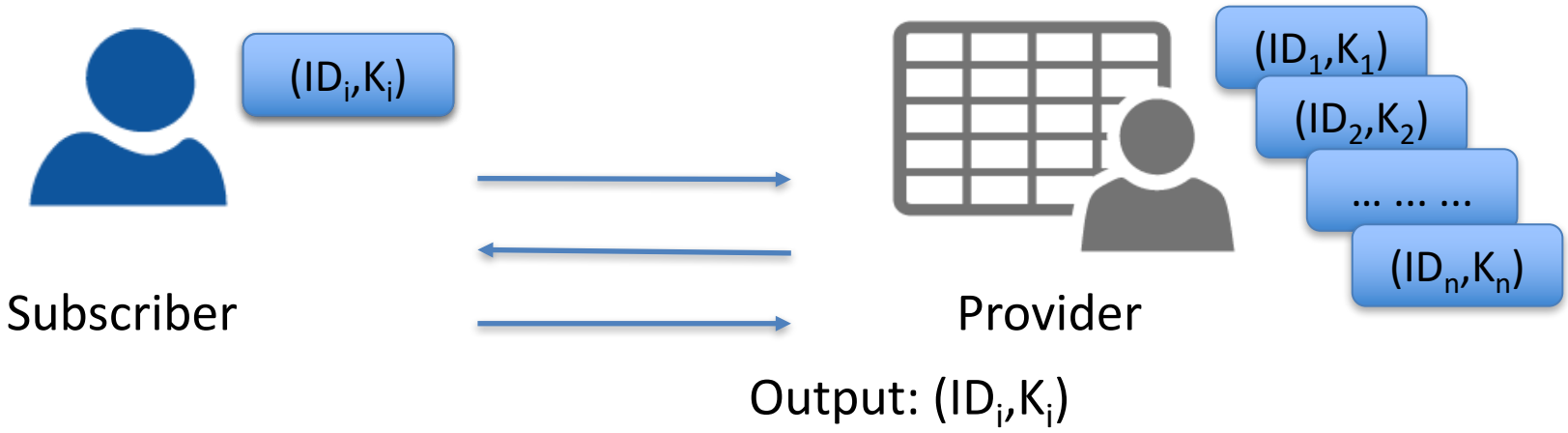
NTNU

The cryptographic problem

- S.F.Mjølsnes, R.F.Olimid: *The challenge of private identification, iNetSec 2017* (to appear)

The Problem

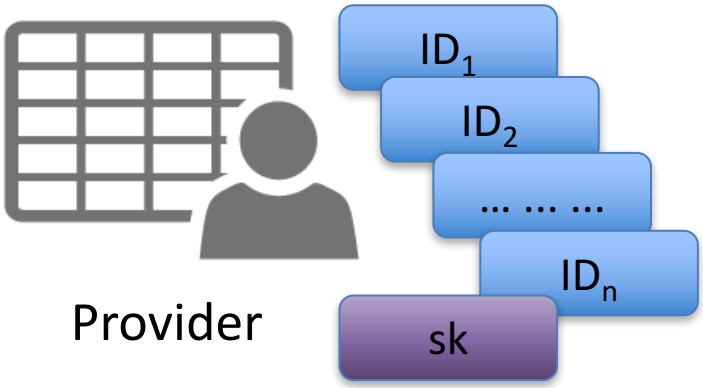
(*How) Can we construct efficient and scalable secure identification mechanisms in (mobile) communication systems?*



We **decouple** the protocol from *registration* and *authentication*, to gain independence in design and analysis - the private identification challenge becomes a *general standalone problem*

Public Key - Trivial Solution

Subscriber



Provider

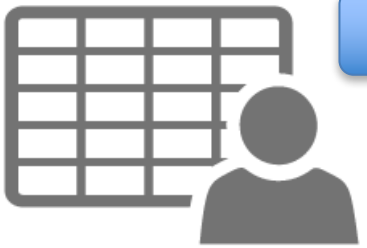
$Enc_{pk}(ID_i)$

No PubKey

$Dec_{sk}(Enc_{pk}(ID_i)) = ID_i$

Key Search - Linear Solution

(ID_i,K_i)



(ID_1,K_1)

(ID_2,K_2)

… … …

(ID_n,K_n)

Subscriber

Provider

$r_j \leftarrow^R \mathcal{R}$

*key-indistinguishable MAC

$r_j, Enc_{Ki}(r_j)$

Linear time

Try all $\{K_i\}$ until successfully decryption of r_j

Output: (ID_i,K_i)

[Weis, Sarma, Rivest, Engels - Security and Pervasive Computing'03]

[Alwen, Hirt, Maurer, Patra, Raykov - Anonymous Authentication with Shared Secrets'14]

Related Work

- Models and definitions:
  - Mobile Networks, include authentication [Alwen et al.'14, Abadi & Fournet'15]
  - RFIDs [Vaudenay'07], [Canard et al.'10], [Hermans et al.'14], [Yang et al.'17]
- Mobile networks (LTE):
  - Several IMSIs for each USIM [Kahn & Mitchel'15]
  - New temporary identifiers: *DMSI* (Dynamic Mobile Subscriber Identities) [Choudhury et al.'12], *PMSI* (Pseudo Mobile Subscriber Identities) [Broek et al.'15], *CMSI* (Changing Mobile Subscriber Identities) [Muthana &Saeed.'17]
  - Public-key solutions [Arapinis et al.'12], [Hermans et al.'14], [Chandrasekaran et al.'17]
- RFID:
  - Linear complexity in the number of subscribers [Weis et al.'03],
  - Surveys [Jules'06], [Langheinrich.'09], [Song et al.'09], [Song et al.'11], [Yang et al.'17]

Summary

- 4G/LTE IMSI-catchers
  - ***is IMSI-catching a bug or a feature?***
  - this problem should be considered for 5G and beyond

- Drawbacks of existing proposals:
  - architectural changes
  - significant modifications to the protocols and/or the exchanged messages
  - high computational costs and difficult management caused by public key cryptography
  - particularity to specific scenarios

- Private Identification Problem:
  - introduced as a **general standalone problem**, being decoupled from authorization (and registration)
  - ***existing efficient and scalable solutions in private key settings ?***

Thank you!