IMSI-Catcher and Man-in-the-Middle attacks

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Outline

Scenario

- Wireless medium: Air
- Cryptography is used to ensure confidentiality and authenticity
- Attacks which circumvent cryptography all together are available

Threats and attacks

- Tracking of mobile services' users
- Eavesdropping/Tapping
- Man-in-the-Middle
- Law enforcement may be more or less warranted
- (Organized) Crime has an interest as well!
- Internet threats apply: Spoofing, phishing, fraud, malware

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Defense

- Authentication ensures the communication parties of their peers identities and of the message integrity
- Encryption ensures confidentiality

IMSI and SIM cards

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  - 1-10 digit Mobile Subscriber Identification Number (MSIN)
- MCC and MNC together form the Home Network Identifier (HNI)
  - which identifies the subscriber's home network
  - in Germany: allocated by the Bundesnetzagentur
  - may allow provider identification

Tracking

Requirements

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Countermeasures

- IMSI is transmitted as rarely as possible
- Temporary Mobile Subscriber Identity (TMSI)
  - is used instead to identify the user temporarily
  - is randomly assigned
  - is allocated after first location update
  - is local to the area of the cell
  - is changed peridocially by the network
  - is changed on location changes

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- to place the attacker as a man-in-the-middle
  - user establishes a connection with the fake base station.
  - IMSI-Catcher establishes another connection to a real base station, to forward communication

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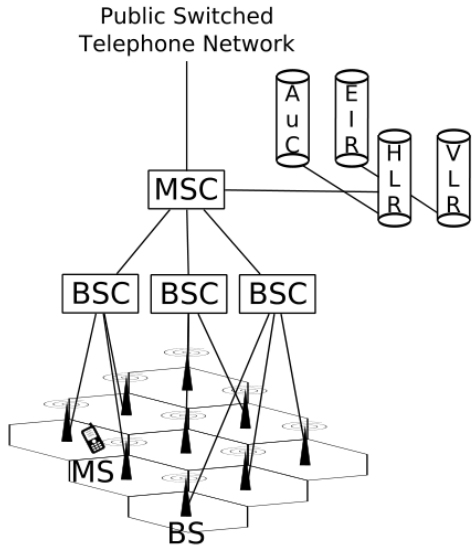
- user equipment has to support several protocols, which gives rise to more cases which have to be considered and analyzed

Network structure



Mobile Stations (MS) - mobile phones, etc.

- share IMSI with the Home Location Register (HLR) database
- share IMEI with the Equipment Identity Register (EIR) database

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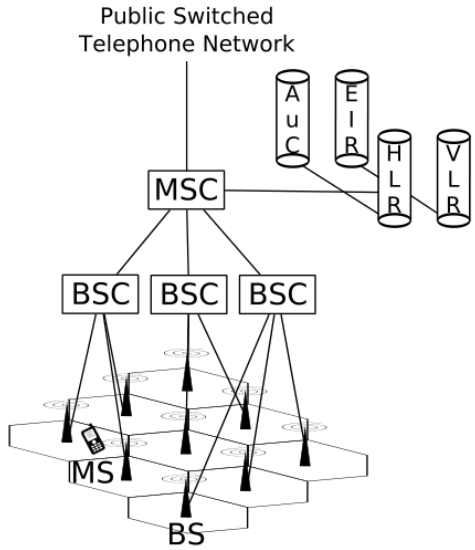

Base Stations (BS)

- connect mobile stations to Mobile switching centers
- area covered by a base station is called a cell
- handle encryption and decryption of data transmitted between user and network

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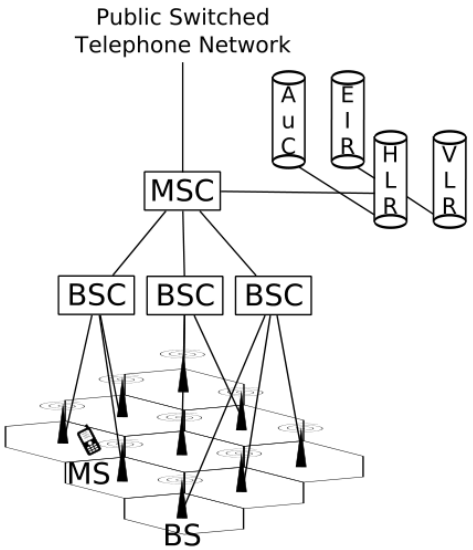
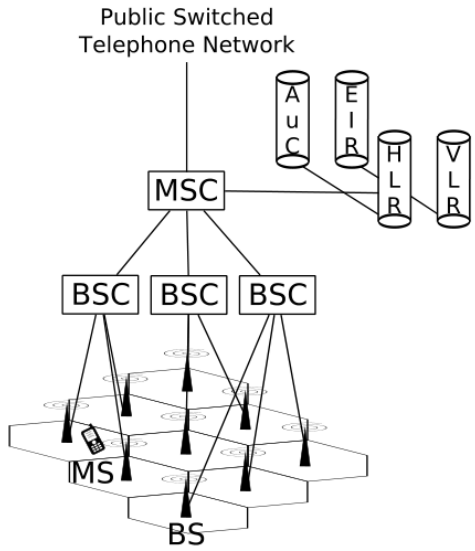


Base Station Controllers (BSC)

- coordinate base stations
- may handle handovers

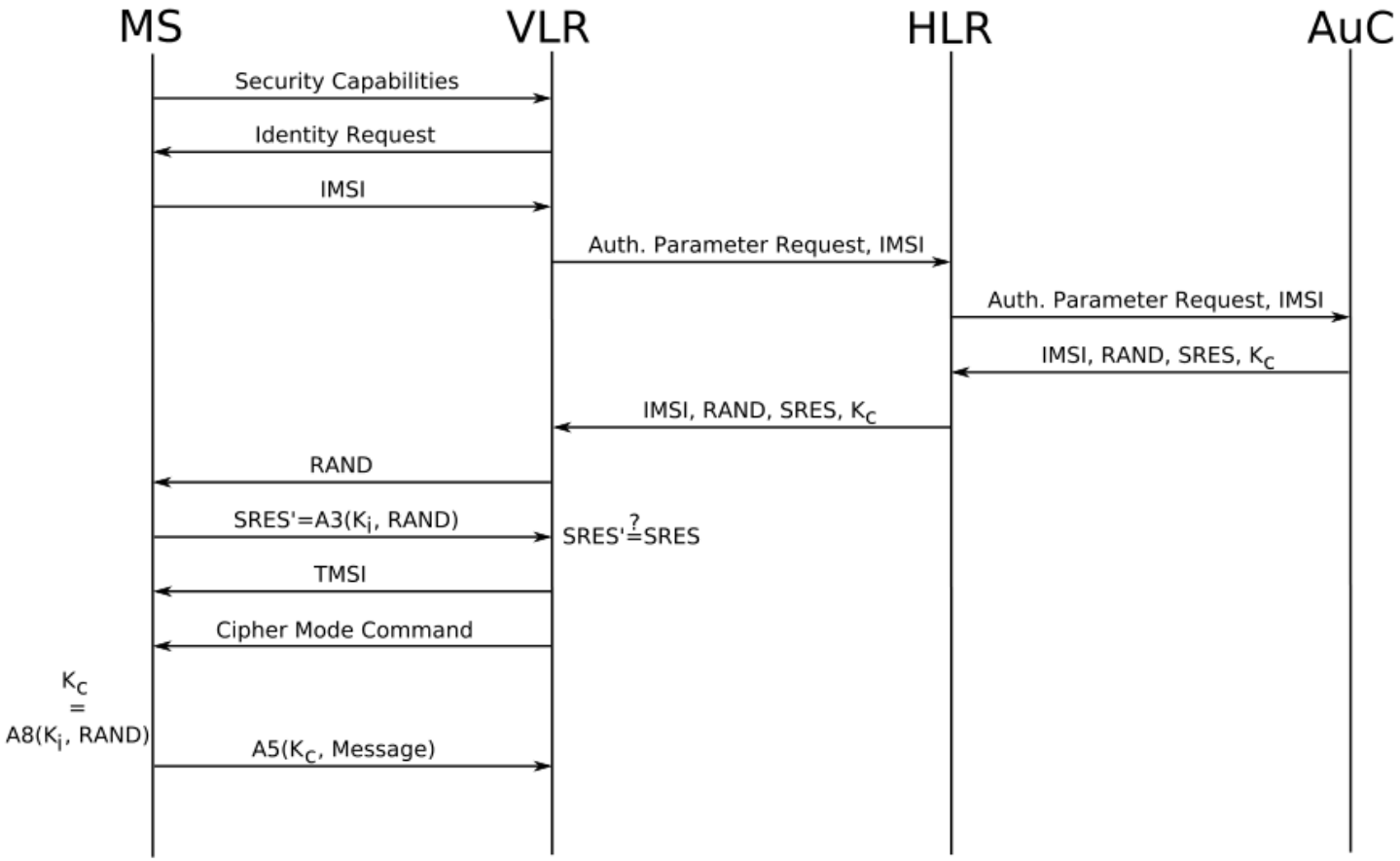
Network structure



Mobile Switching Centers (MSC)

- access Authentication Center (AuC) to handle authentication of mobile stations
- access EIR to detect stolen mobile station equipment
- maintain Visitor Location Register (VLR), which stores TMSI and data obtained from HLR
- route data between networks
- handover between base station controllers

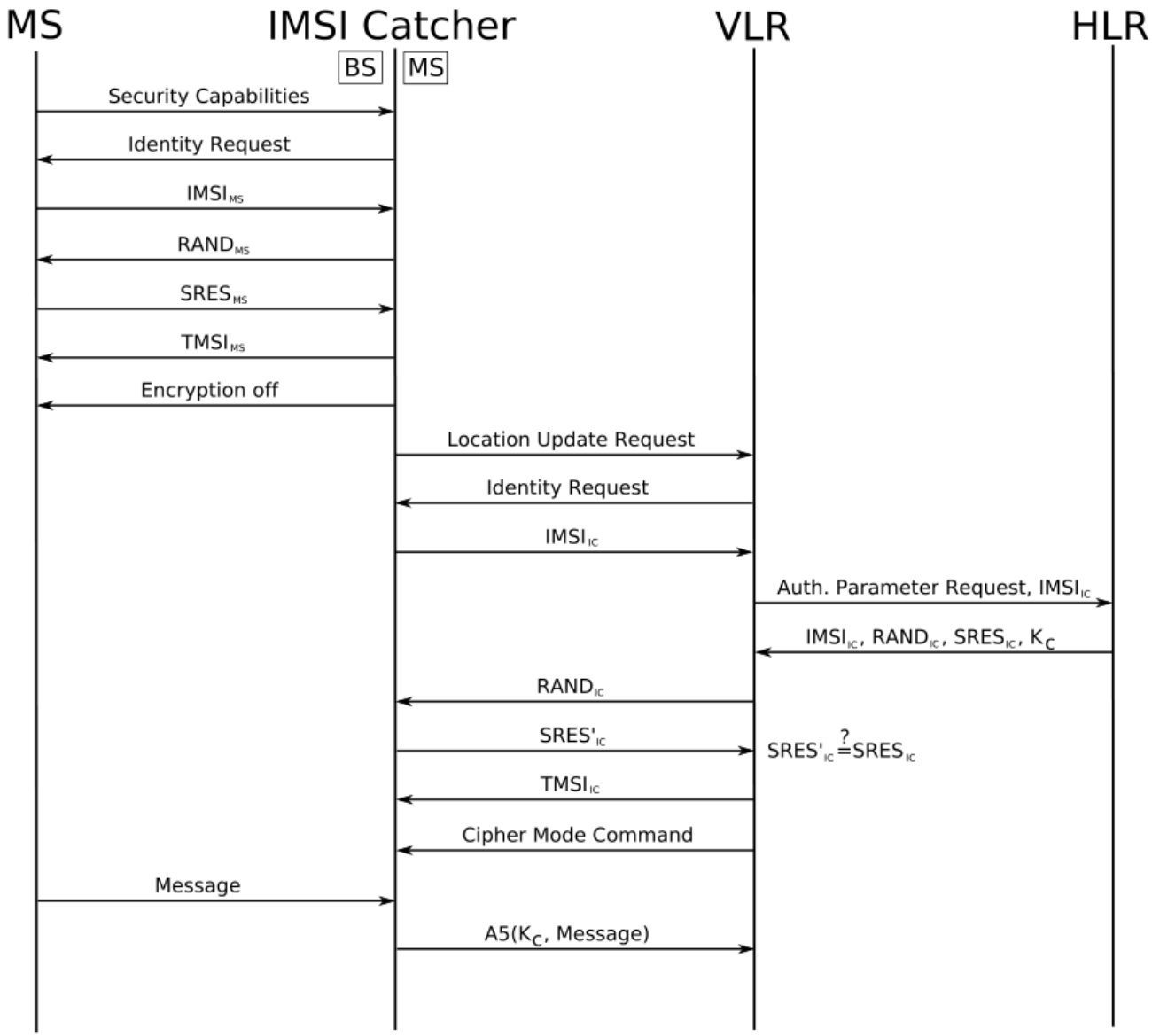
Authentication Protocol



Weaknesses

- No base station authentication
- Encryption algorithms, A5 family, basically broken
- A5/0 - No Encryption algorithm is a valid choice

The attack


MS
IMSI Catcher
BS
MS
VLR
HLR
Security Capabilities
Identity Request
IMSI_MS
RAND_MS
SRES_MS
TMSI_MS
Encryption off
Location Update Request
Identity Request
IMSI_IC
Auth. Parameter Request, IMSI_IC
IMSI_IC, RAND_IC, SRES_IC, K_C
RAND_IC
SRES'_IC
SRES'_IC ?= SRES_IC
TMSI_IC
Cipher Mode Command
Message
A5(K_C, Message)

UMTS

- Universal Mobile Telecommunications Standard - 3rd generation protocol
- Low coverage compared to GSM, as new base stations are required
- Interoperation with GSM possible

Changes compared to GSM

- Some architecture parts have been combined, renamed, etc.
  - Home Environment (HE) takes the role of MSC and HLR
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- Security capabilities of the mobile station included in final message

Interoperation with GSM

- GSM keys are computed from UMTS key material
- cipher mode command is last message - no security capabilities included

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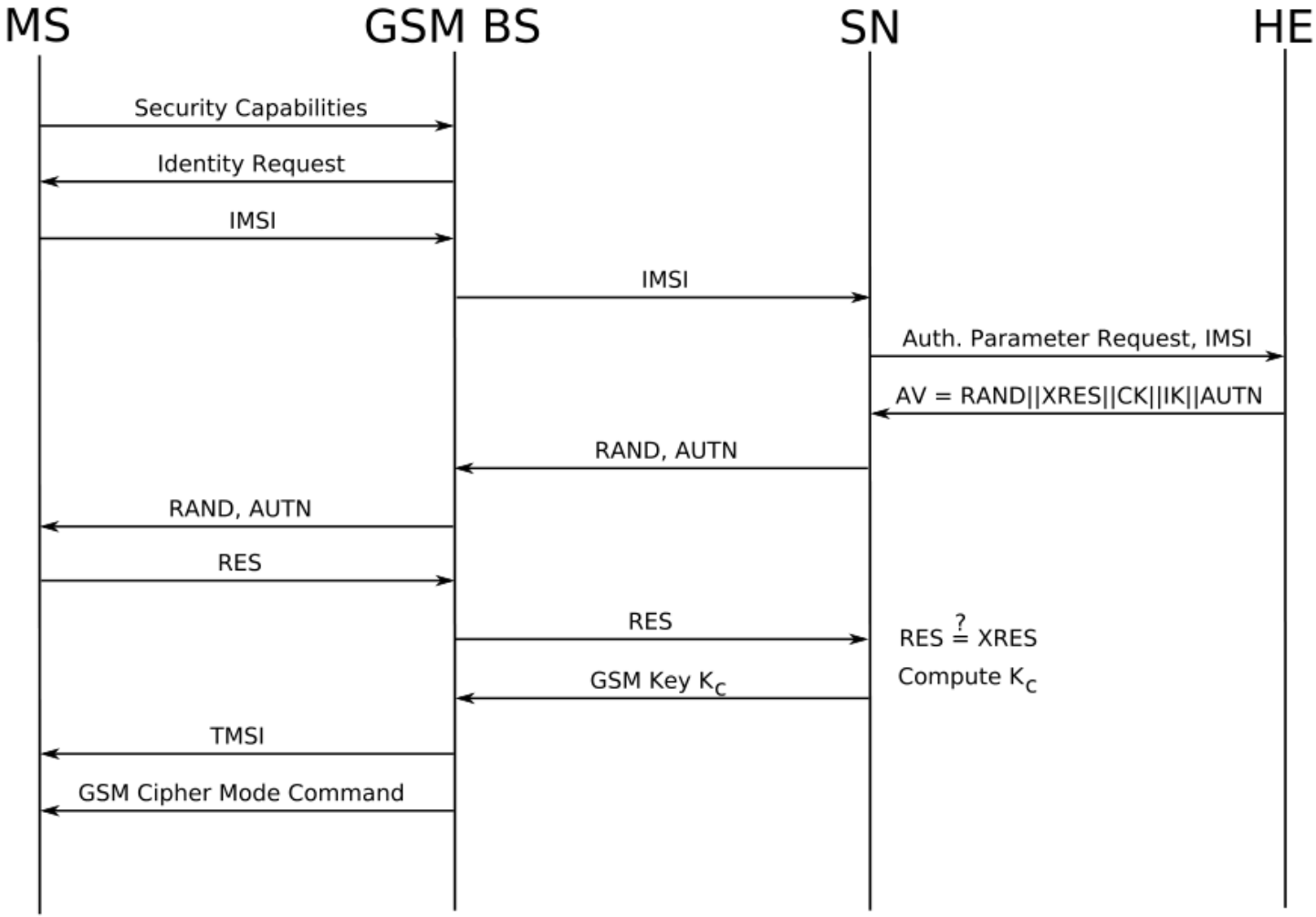
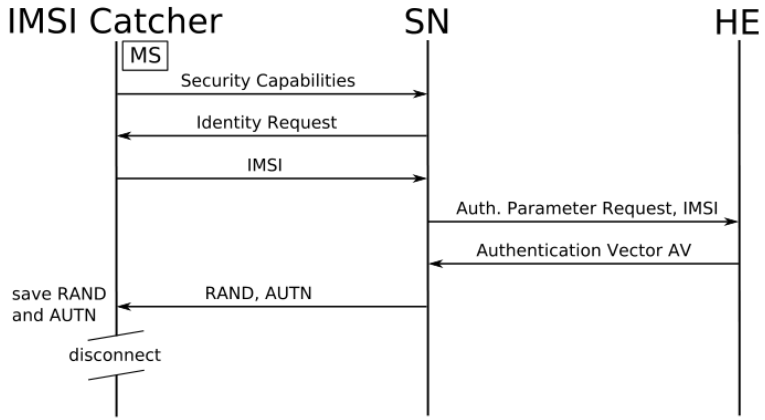


The attack

Step 1



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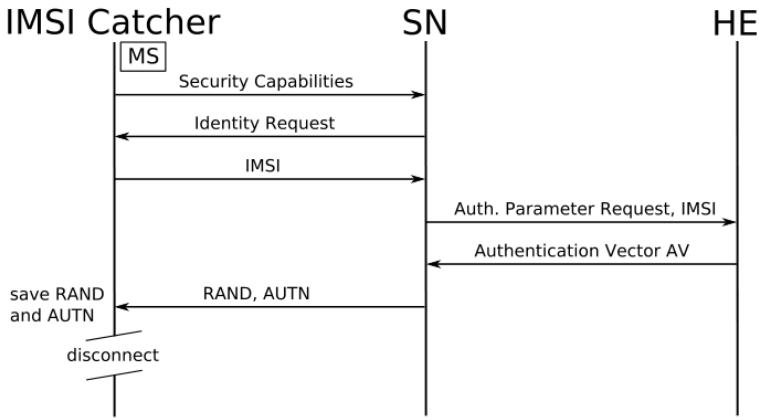
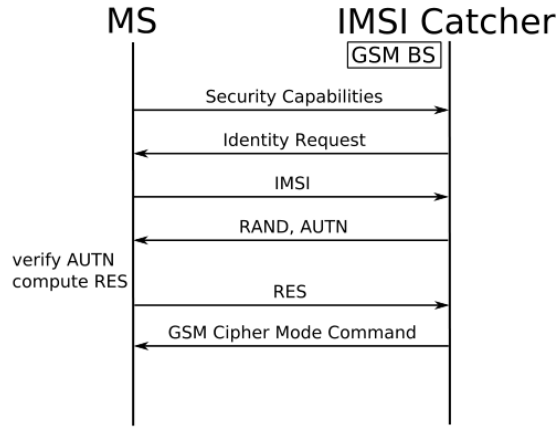


Step 2



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- Victim may change her SIM card regularly, or even the phone

Countermeasures

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- Generate cipher mode command in the Service Network, to be able to authenticate it, and include mobile station's original security capabilities

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- Socio-economic factors make this hard to fulfill
- Adapting protocols without introducing new problems or security flaws is not trivial
- Welcome to the future, welcome to the past!

Credit where credit is due

- Seminar on IMSI Catcher, Daehyun Strobel
  `http://www.crypto.rub.de/imperia/md/content/seminare/itsss07/imsi_catcher.pdf`
- Ulrike Meyer and Susanne Wetzel
- The authors of LaTeX and the excellent "beamer" class

Questions?