Hacking Cellular Networks

Security Research with Open Source Cellular Network Projects

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Hiteam

Agenda

- Who we are & why we are giving this talk

- Security testing of LTE
  - Specification vulnerabilities
  - Implementation flaws: network & terminals
  - Testing setup

Who we are

- Huang Lin
  - Wireless security researcher from Qihoo 360
  - Worded in Orange from 2005~2014
  - SDR expert, use OAI since 2011

- Zou Xiaodong (aka Seeker)
  - Founder & CEO, HiTeam Group, a higher education + IT company
  - 30+ year coding & hacking
  - Angel investor & entrepreneurship mentor

Hackers – A Big Group of SDR Users

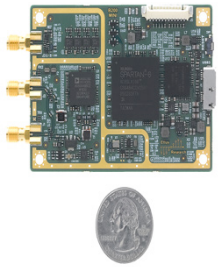
Using wideband SDR tools to analyze many kinds of wireless systems

- Short distance: Bluetooth, RFID, NFC
- Wifi, Zigbee, 315/433MHz
- Cellular: 2G/3G/4G
- Satellite system: GPS, GlobalStar, DVB-S
- Private protocol: private network, links of drones
- Industry control system

ANALOG DEVICES
超越一切可能™

AD936x
60MHz ~ 6GHz

$4000



$750

$300

￥100

Lime microsystems

LMS600x/700x
100KHz ~ 3.8GHz

Video Demo: GPS Spoofing

Fake GSM Base Station in China

- Resulting in a wide range of hazards
  - Send spam SMS
  - Phishing fraud

When Bike-sharing Meets Fake BS

- For IoT devices
  - Lose network connection
  - Data link hijack

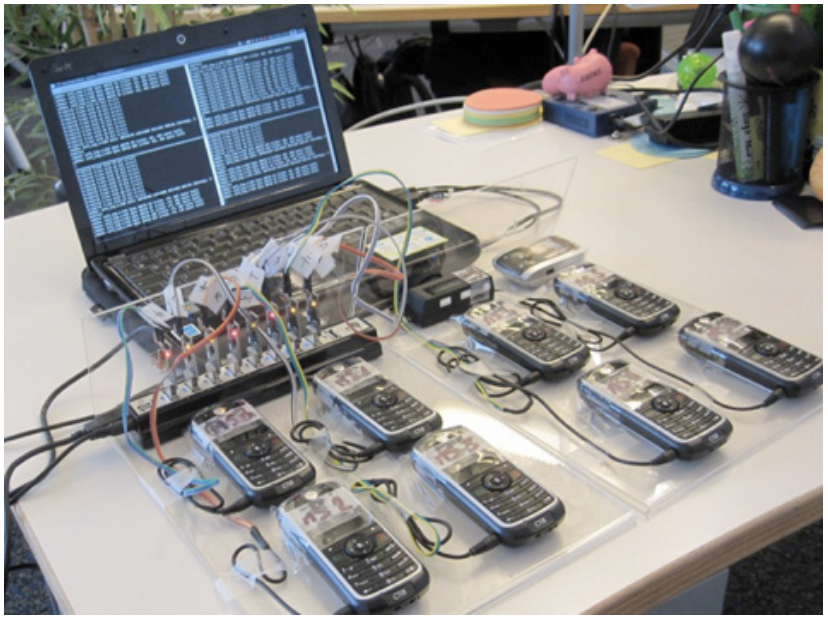
Most Fake BS Based on OpenBTS

- OpenBTS Project
  - Developed since 2009
  - First software based cellular base station
  - Had some real deployments

St. Pierre and Miquelon is a self-governing territorial overseas collective of France (COM) situated near Newfoundland, Canada.
An entrepreneur,GlobalTel, applied for wireless spectrum and deployed seven base stations, now actively serving a population of 6,000.

GSM Terminal Side: OsmocomBB

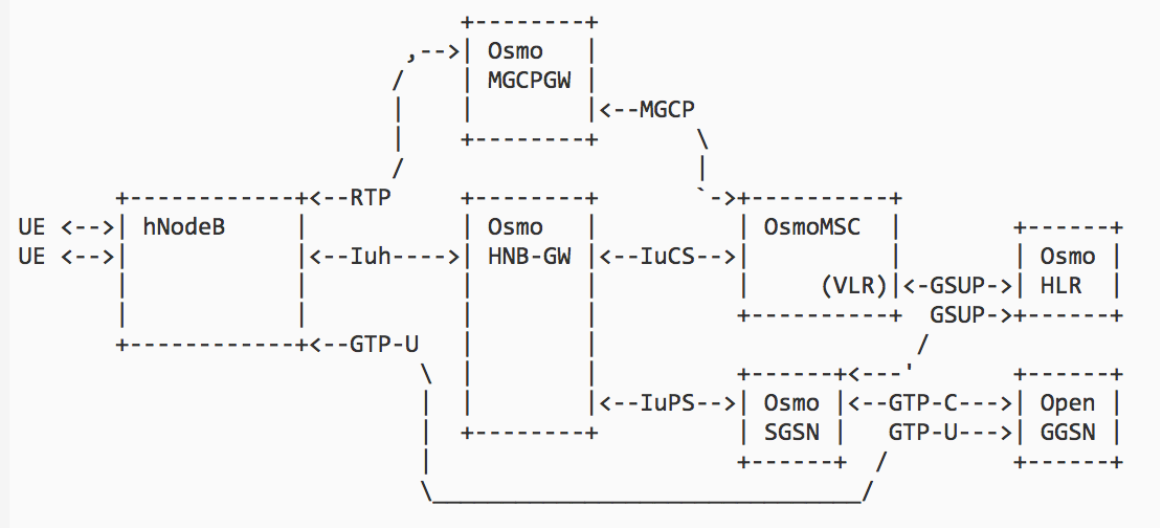
- OsmocomBB
  - GSM sniffer: OsmocomBB + C118
  - GSM man-in-the-middle attack: OsmocomBB + C118 + OpenBSC

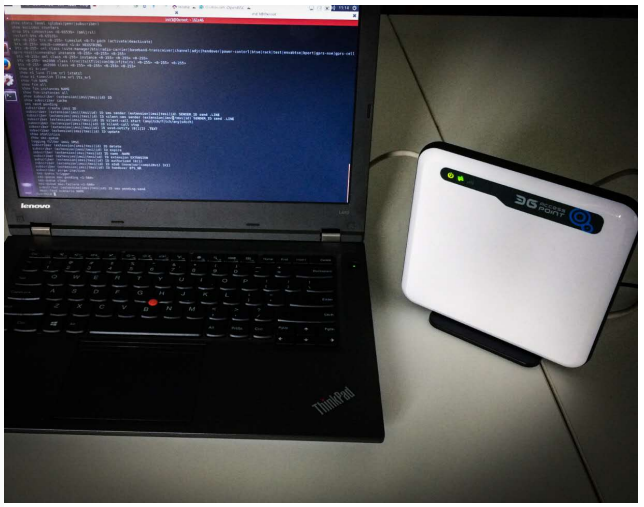


Multiple C118s listening the GSM channels simultaneously.

3G Base Station:
Osmocom Accelerate3g5 Project

- Femtocell + Open source CN
  - Femto: nano3G
  - CN: HNB-GW, SGSN, GGSN, VLR, HLR, PGW



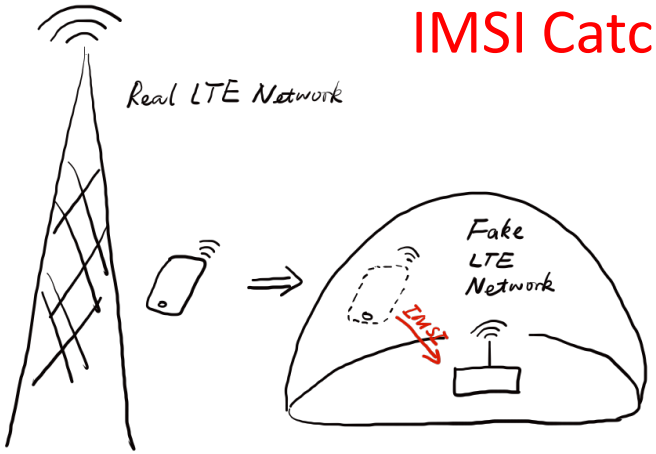


4G Security Research

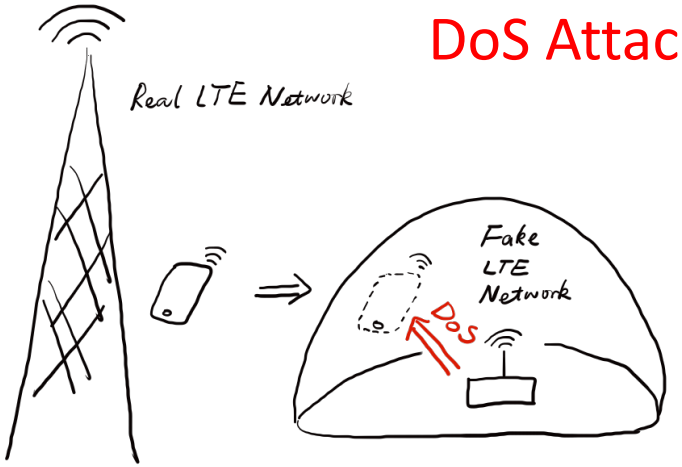
- Related works
  - Ravishankar Borgaonkar, Altaf Shaik, et.al., LTE and IMSI Catcher Myths, BlackHat Europe, 2015 (OpenLTE)
  - Roger Piqueras Jover, LTE Security and Protocol Exploits, ShmooCon 2016
  - Lin Huang, Forcing Targeted LTE Cellphone into Unsafe Network, HITB AMS Security Conference, 2016. (OpenLTE)
  - Xiaodong Zou, Advanced Fake Base Station Exploitations, KCon Hacking Conference, August 2016. (OAI)
  - Stig F. Mjølsnes, Ruxandra F. Olimid, Easy 4G/LTE IMSI Catchers for Non-Programmers, Feb. 2017. (OAI)

4G Exploitations

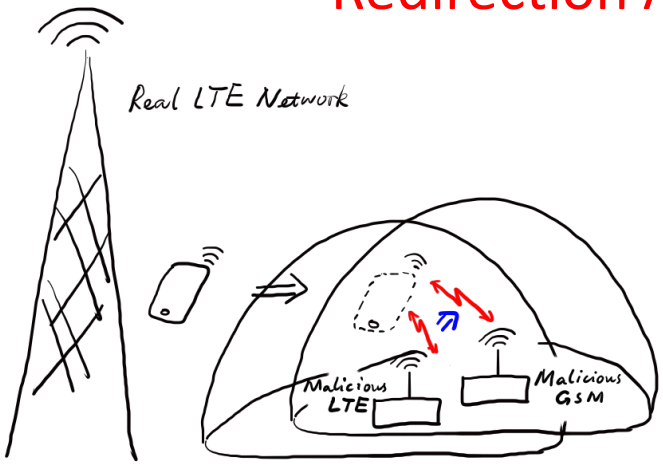
IMSI Catcher



DoS Attack



Redirection Attack



These exploitations are all related to 4G fake base station. There may be quite a lot IMSI catcher based on OAI.

Video Demo: Redirection Attack

Cellular Projects Summary

	2G	3G	4G
Network side	OpenBTS OpenBSC	OpenBTS-UMTS Osmocom Accelerate3g5	OAI OpenLTE/srsLTE
Terminal side	OsmocomBB	N/A	OAI UE srsUE

Expectation to 5G: Security Response Capability

- In IT/Internet area
  - Not every vulnerability needs to be fixed
  - Once exploitation appears, and widely known, the patch will be applied immediatly

- In mobile communication
  - Network side
    - Operators: update network equipment needs long tim
    - Vendors: Some old hardware cannot be updated.
  - Terminal side
    - Cellphone firmware is rarely updated
    - It’s difficult to patch IoT devices.

Programmable, Configurable and Patchable

- Network equipment becomes softer
  - Soft-CN: NFV, SDN etc, more mature
  - Soft-RAN: developing
- Terminal chipset becomes softer too
  - Programmable, especially for higher layers
  - Fix vulnerability and add new feature by updating firmware

FCC DA 16-1282 NOI document, mentions one requirement to 5G security: patch management

Security Testing of LTE/LTE-A

- Specification vulnerabilities
- UE implementation flaws
- Network:
  - Implementation flaws
  - Configuration issues

Specification Vulnerabilities

- RRC redirection
- RLF report

UE Implementation Flaws

- Network authentication
- Data encryption
- Security procedure of baseband OTA
- Robustness of baseband
- SMS sender spoofing
- VoLTE

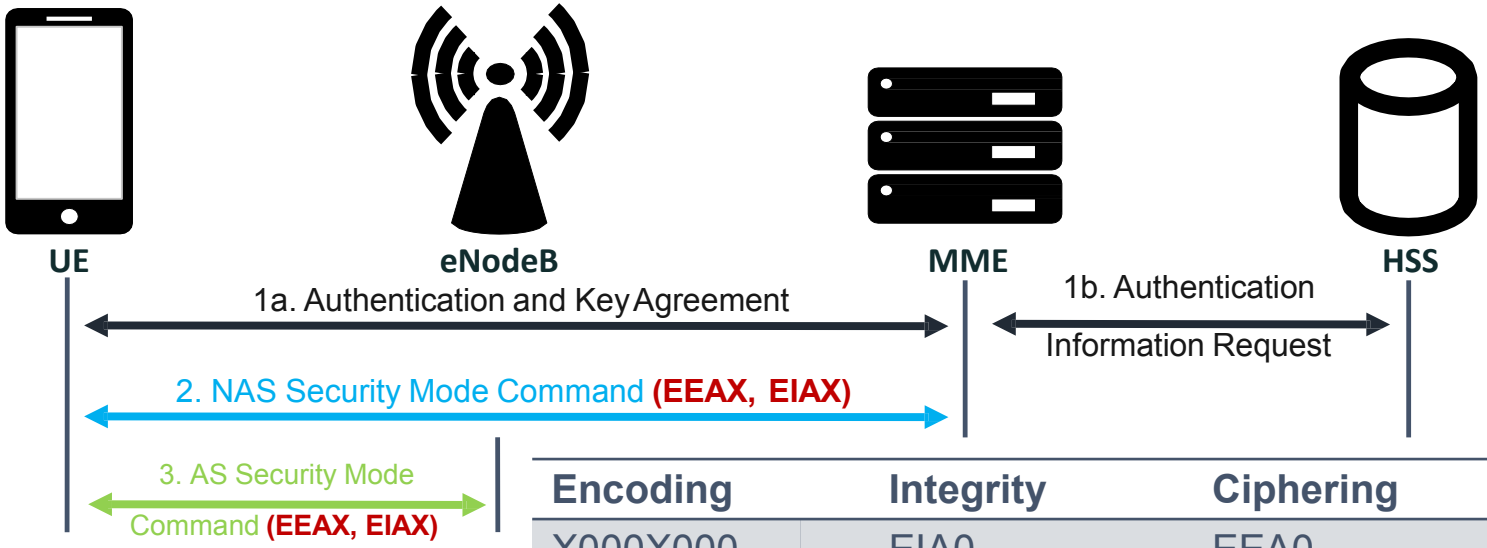
Network Authentication

- AUTN
- AS EIA0
- NAS EIA0
- MAC null
- Bypass?

Data Encryption

- AS EEA0
- NAS EEA0
- Unencryption?

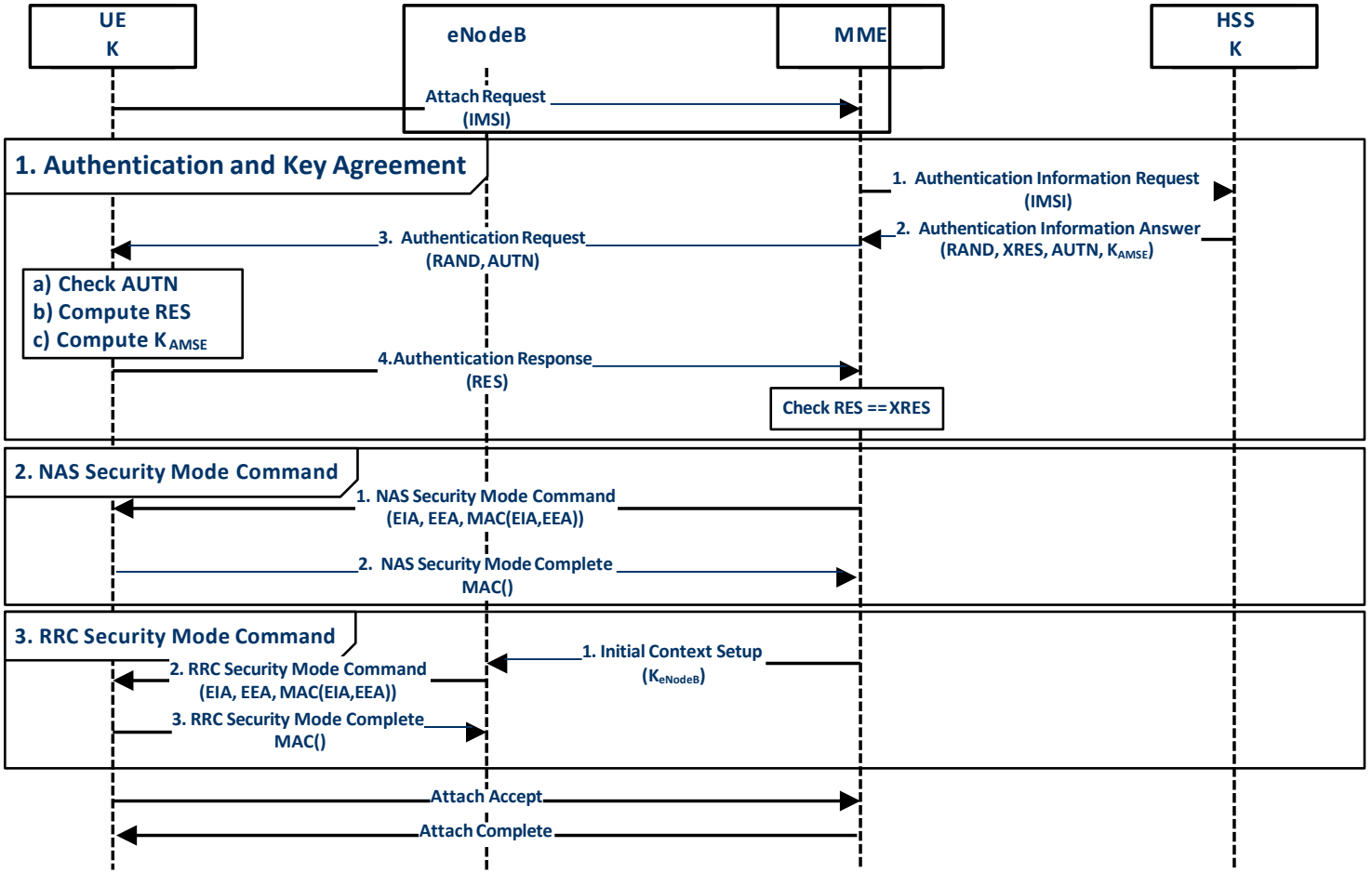
Security Algorithms



Security algorithms are selected by the provider

Encoding	Integrity	Ciphering	Algorithm
X000X000	EIA0	EEA0	NULL
X001X001	128-EIA1	128-EEA1	SNOW3G
X010X010	128-EIA2	128-EEA2	AES
X011X011	128-EIA3	128-EEA3	ZUC

Security Procedure



Network Configuration Issues

- Visibility of the back-end from UE
- Visibility of other UEs
- GTP over GTP?
- Ability to attack MME (signalling)

Network Implementation Flaws

- Robustness of stacks (eg SCTP)
  - Fuzzing
  - Sequence number generation
- Management interfaces
  - Web UI
  - SSH consoles
  - Proprietary protocols

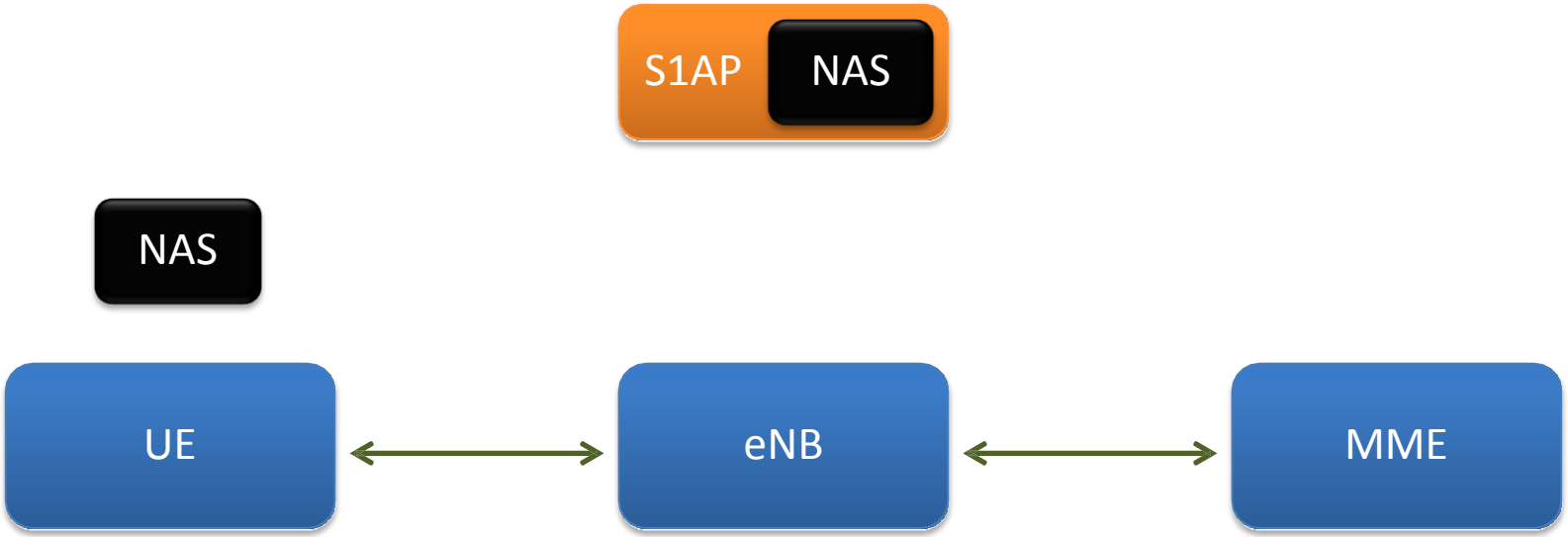
Key Protocols

S1AP Protocol

- By default no authentication to the service
- Contains eNodeB data and UE Signalling
- UE Signalling can make use of encryption and integrity checking
- If no UE encryption is used, attacks against connected handsets become possible

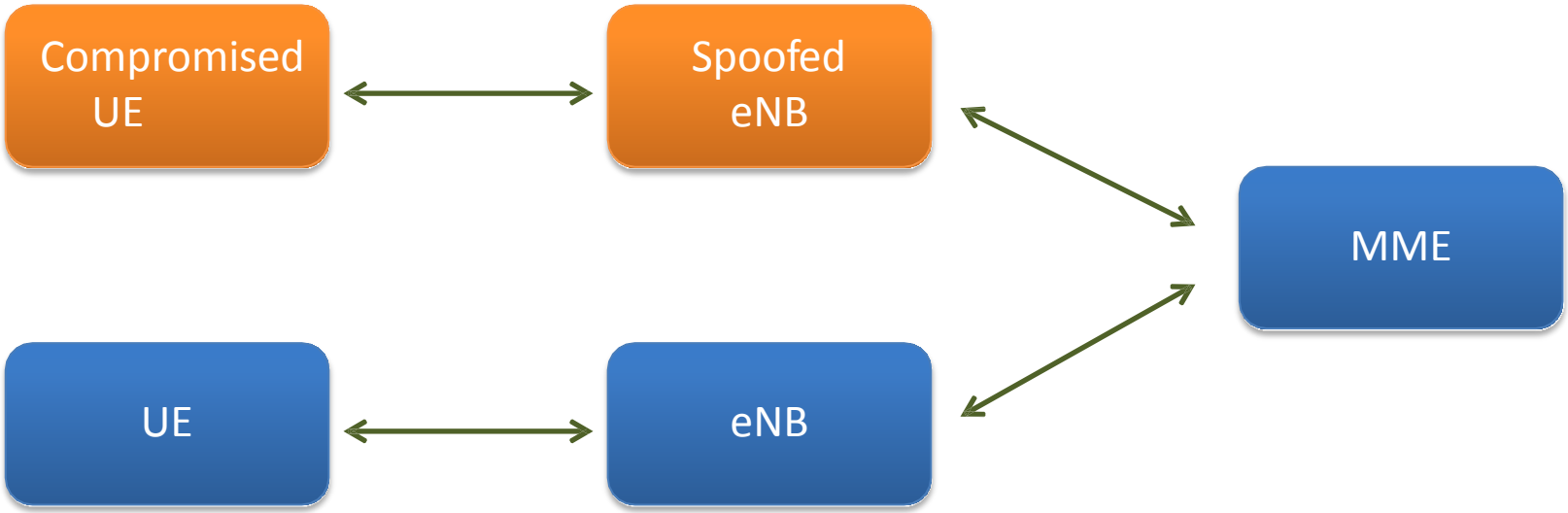
Key Protocols

S1AP and Signalling



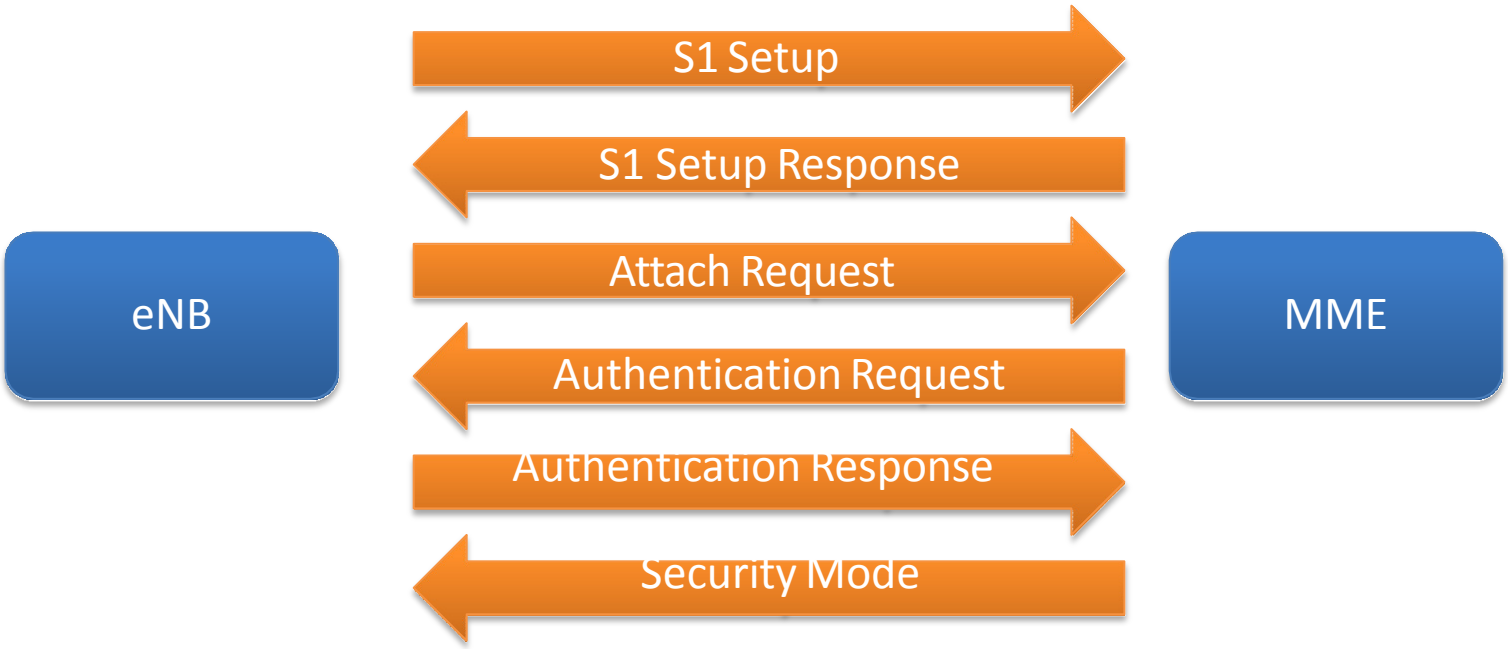
Key Protocols

S1AP and Signalling



Key Protocols

S1AP and Signalling



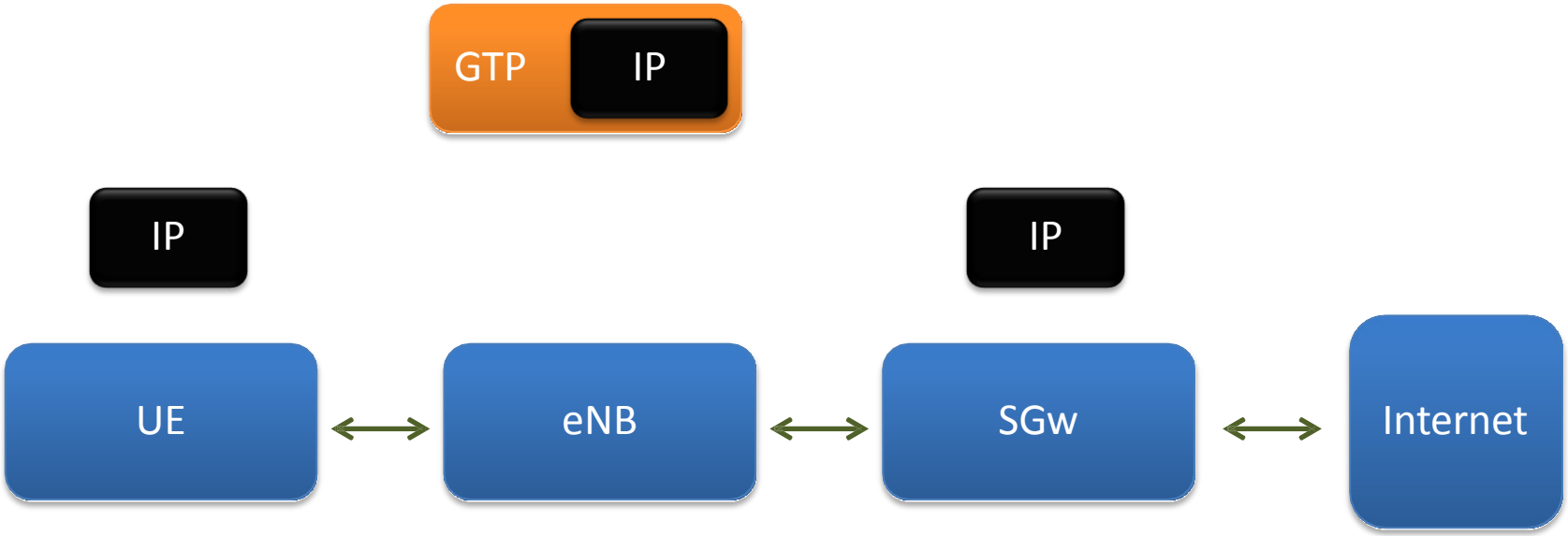
Key Protocols

GTP Protocol

- Gateway can handle multiple encapsulations
- It uses UDP so easy to have fun with
- The gateway needs to enforce a number of controls that stop attacks

Key Protocols

GTP and User Data



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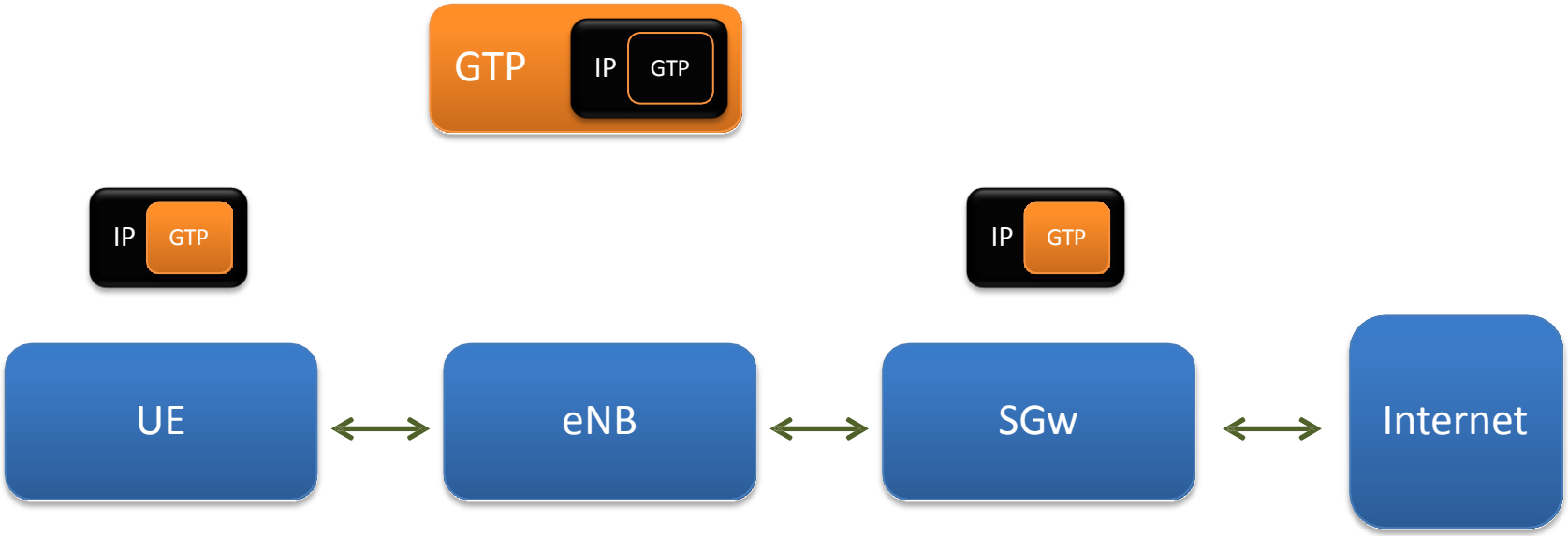
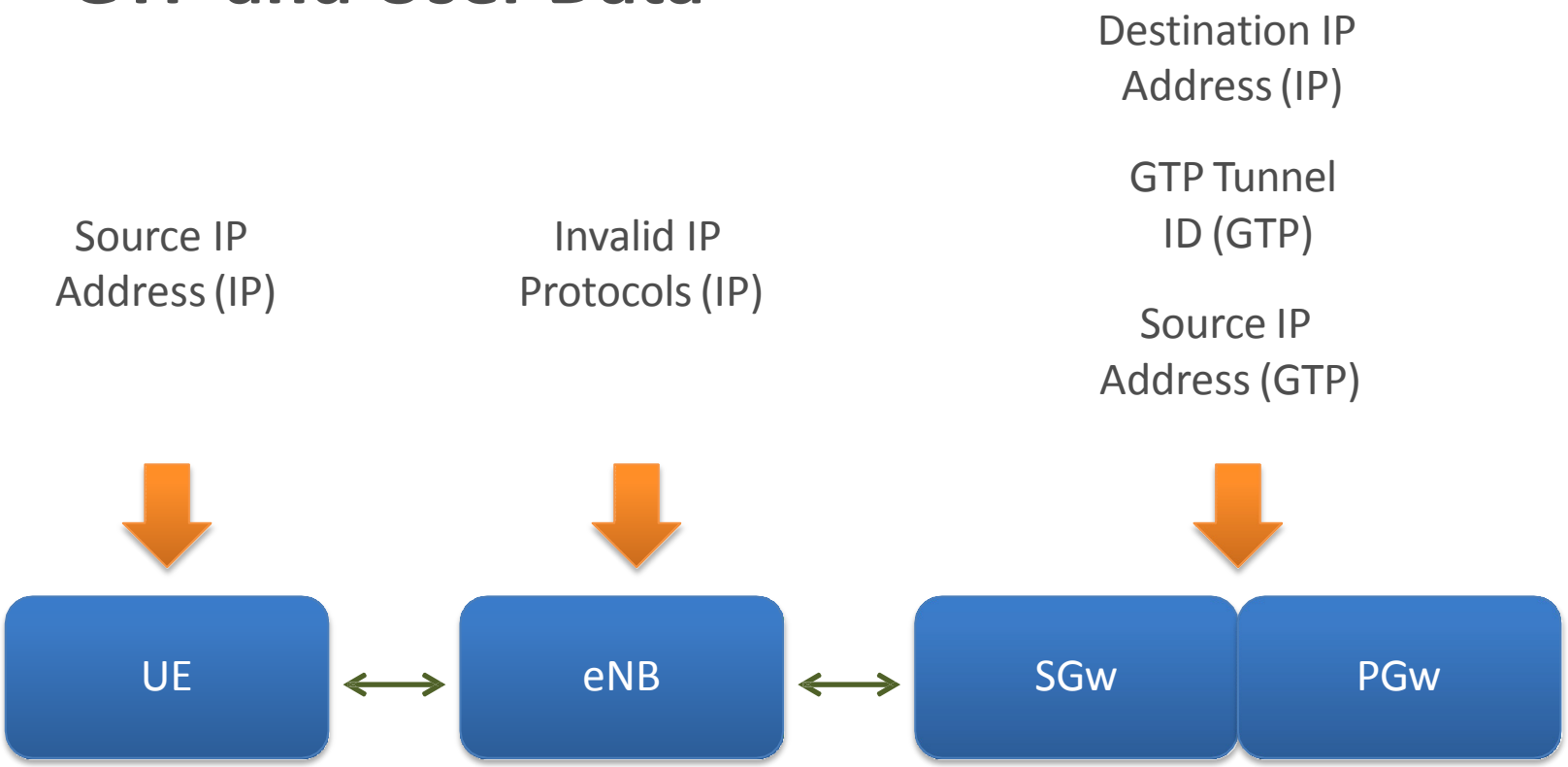


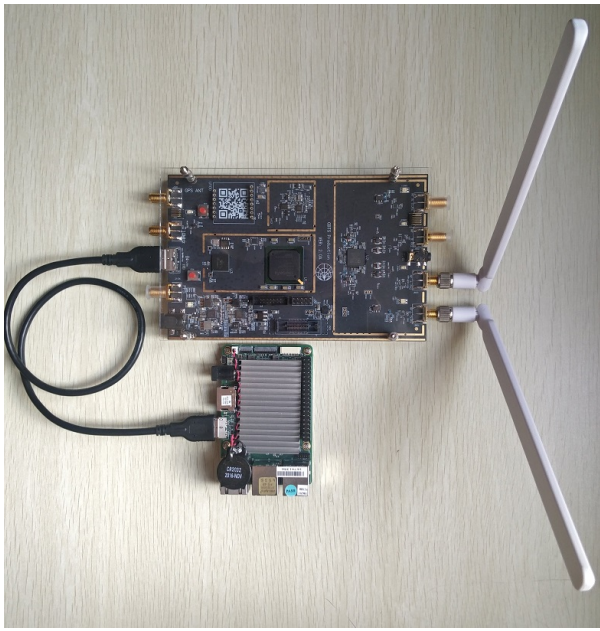
Key Protocols

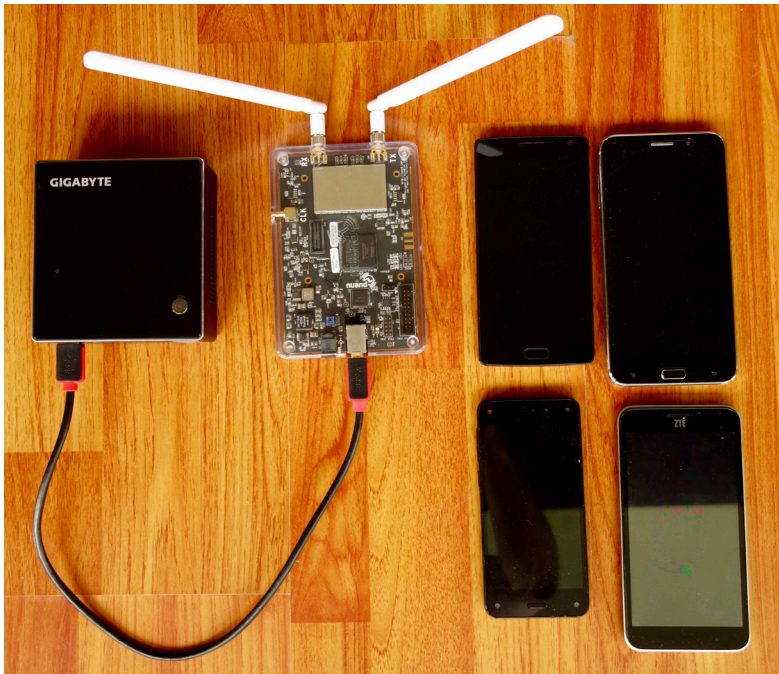
GTP and User Data



Testing Setup (Phase 1)

- EPC: Gigabyte Brix i7-5500, 16G RAM
- eNodeB/RRU:
  - UP Board + USRP B210/B200mini
  - ThinkPad T440s + bladeRF/LimeSDR
- UE: Samsung, iPhone, OnePlus, ZTE, etc.





Thank you!

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