(n+1)G - Security

IMI 2019

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About Me

- Brian
  - @BadgeWizard
  - brian@security-bits.de
- Security Researcher / Hacker
  - Officially: “Incident Response”
  - Work for DB but not here as DB
- Hardware-, Embedded-, a bit of Telko-Security
  - Done a fair amount of research and security testing on cellular clients and backends

The Opening

- Option 1:
  - NanoBTS, 1800MHz, eBay, 100€-200€
  - 1800MHz Multiplexer, Sysmocom 120€
    - Cable setup
    - Because I currently do not have a license to actually transmit data over the air at this location
  - Cheap vehicle immobilizer, Amazon <40€
  - Complete OpenBSC Backend, Osmocom Project, Free

- **Option 2:**
  - Motorola C118
  - Running OsmocomBB
    - Open source operating system for certain mobile phones
  - Sniffing on a frequency belonging to ???
    - Legally sniffing is a very very grey area
    - Obviously this was just for research & demonstration purposes
  - Otherwise said, you've just seen a 12€ IMSI Catcher in action

State of Cellular Security

- Black Magic! & Best explained with a simple example
- Text on the right is just there for afterwards, don't read it :)

Dialog with a customer from a while ago: "We've received your device and can't get it to work" - "What's the problem?" - "It doesn't connect" - "What does the debug output say?" - "Everything ok" - "So it works!" - "No it doesn't connect to the backend" - "But it says ok, so it's fine. You're doing something wrong" - "Here's the PCAP of the failed connections" - "How did you get that PCAP, we've never seen that kind of traces!?" - "Well we sniffed it!" - "What?" - "The traffic on the cellular interface" - "But...How? You can't just do that"

2G - 2007: The GSM Scanner Project

- THC Group

- Using gammu & debug mode on Nokia 3310 for sniffing GSM traffic

Hackers start buying Nokia 3310

2G - 03.2008: Intercepting GSM traffic

- Black Hat DC: THC Group

- Sniffing GSM traffic with a Nokia 3310
- Stating broken A5/0, A5/1, A5/2
  - Using Rainbow tables, unpublished
- Sniffing location data in plaintext
- Sniffing IMSI

Hackers buy even more 3310

Ein Blick in die Zukunft

- Jeder Blick in diese Folien ist ein kleiner Blick in die Zukunft
  - Du, neugierig und gespannt, am suchen welch Kleinigkeit ich dir nun wieder hier versteckt habe
  - Ich, voller Freude in Gedanken, das Strahlen auf deinem sehend
- Viele, viele kleine Momente, die die Sorgen, Problemen und Herausforderungen des Alltags mit hellem Spaß überschatten
  - Und den Begriff “Alltag” verschwimmen lassen

Obgleich nicht auf den ersten Blick ersichtlich, verstecken sich selbst in einem 3km langen pech dunklen Lava Stollen spannende Anblicke

2G - 12.2009: Using OpenBSC for fuzzing of GSM handset

- 26C3: Harald Welte

- Running an own 2G network and utilizing it for fuzzing and attacking mobile phones

libsmpp

```
git clone git://git.osmocom.org/libsmpp34.git
cd libsmpp34
autoreconf -fi
./configure
make
sudo make install
sudo ldconfig
```

osmo-ggsn

```
git clone git://git.osmocom.org/osmo-ggsn/
cd osmo-ggsn
autoreconf -fi
./configure
make
sudo make install
sudo ldconfig
```

osmo-sgsn

```
git clone git://git.osmocom.org/osmo-sgsn/
cd osmo-sgsn
autoreconf -fi
./configure
make
sudo make install
sudo ldconfig
```

osmo-sip-connector

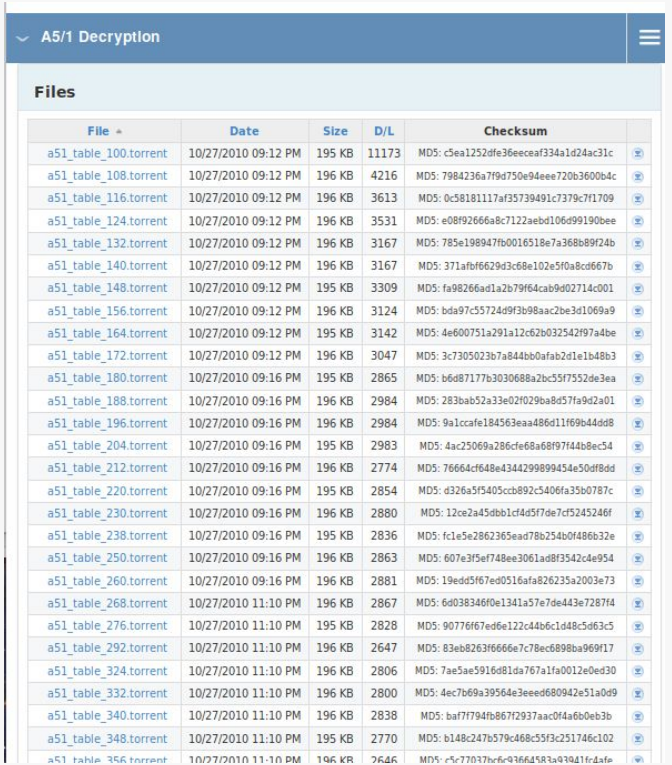
```
git clone git://git.osmocom.org/osmo-sip-connector
cd osmo-sip-connector
autoreconf -fi
./configure
make
sudo make install
```

:)

2G - 12.2009: GSM: SRSLY?

- 26C3: Chris Paget, Karsten Nohl

- Enabling cracking of A5/1 encryption with about 2TB of rainbow tables
- Published tools & rainbow tables for everyone to decrypt A5/1 encrypted communication



File	Date	Size	D/L	Checksum
a51_table_100.torrent	10/27/2010 09:12 PM	195 KB	11173	MD5: c5ea1252dfe36eeceaf334a1d24ac31c
a51_table_108.torrent	10/27/2010 09:12 PM	196 KB	4216	MD5: 7984236a7f9d750e94eee720b3600b4c
a51_table_116.torrent	10/27/2010 09:12 PM	196 KB	3613	MD5: 0c58181117af35739491c7379c7f1709
a51_table_124.torrent	10/27/2010 09:12 PM	196 KB	3531	MD5: e08f92666a8c7122aebd106d99190bee
a51_table_132.torrent	10/27/2010 09:12 PM	196 KB	3167	MD5: 785e198947fb0016518e7a368b89f24b
a51_table_140.torrent	10/27/2010 09:12 PM	196 KB	3167	MD5: 371afbf6629d3c68e102e5f0a8cd667b
a51_table_148.torrent	10/27/2010 09:12 PM	195 KB	3309	MD5: fa98266ad1a2b79f64cab9d02714c001
a51_table_156.torrent	10/27/2010 09:12 PM	196 KB	3124	MD5: bda97c55724d9f3b98aac2be3d1069a9
a51_table_164.torrent	10/27/2010 09:12 PM	195 KB	3142	MD5: 4e600751a291a12c62b032542f97a4be
a51_table_172.torrent	10/27/2010 09:12 PM	196 KB	3047	MD5: 3c7305023b7a844bb0afab2d1e1b48b3
a51_table_180.torrent	10/27/2010 09:16 PM	195 KB	2865	MD5: b6d87177b3030688a2bc55f7552de3ea
a51_table_188.torrent	10/27/2010 09:16 PM	196 KB	2984	MD5: 283bab52a33e02f029ba8d57fa9d2a01
a51_table_196.torrent	10/27/2010 09:16 PM	196 KB	2984	MD5: 9a1ccafe184563eaa486d11f69b44dd8
a51_table_204.torrent	10/27/2010 09:16 PM	195 KB	2983	MD5: 4ac25069a286cfe68a68f97f44b8ec54
a51_table_212.torrent	10/27/2010 09:16 PM	196 KB	2774	MD5: 76664cf648e43442998994 5a50df8dd
a51_table_220.torrent	10/27/2010 09:16 PM	195 KB	2854	MD5: d326a5f5405ccb892c5406fa35b0787c
a51_table_230.torrent	10/27/2010 09:16 PM	196 KB	2880	MD5: 12ce2a45dbb1cf4d5f7de7cf5245246f
a51_table_238.torrent	10/27/2010 09:16 PM	195 KB	2836	MD5: fc1e5e2862365ead78b254b0f486b32e
a51_table_250.torrent	10/27/2010 09:16 PM	196 KB	2863	MD5: 607e3f5ef748ee3061ad8f3542c4e954
a51_table_260.torrent	10/27/2010 09:16 PM	196 KB	2881	MD5: 19edd5f67ed0516afa826235a2003e73
a51_table_268.torrent	10/27/2010 11:10 PM	196 KB	2867	MD5: 6d038346f0e1341a57e7de443e7287f4
a51_table_276.torrent	10/27/2010 11:10 PM	195 KB	2828	MD5: 90776f67ed6e122c44b6c1d48c5d63c5
a51_table_292.torrent	10/27/2010 11:10 PM	196 KB	2647	MD5: 83eb8263f6666e7c78ec6898ba969f17
a51_table_324.torrent	10/27/2010 11:10 PM	196 KB	2806	MD5: 7ae5ae5916d81da767a1fa0012e0ed30
a51_table_332.torrent	10/27/2010 11:10 PM	196 KB	2800	MD5: 4ec7b69a39564e3eeed680942e51a0d9
a51_table_340.torrent	10/27/2010 11:10 PM	196 KB	2838	MD5: baf7f794fb867f2937aac0f4a6b0eb3b
a51_table_348.torrent	10/27/2010 11:10 PM	195 KB	2770	MD5: b148c247b579c468c55f3c2517 46c102
a51_table_356.torrent	10/27/2010 11:10 PM	196 KB	2646	MD5: c5c77037bc6c93664583a93941fc4afe

More and more networks enforce using A5/3

2G - 12.2010: SMS-o-Death

- 27C3: Nico Golde, Collin Mulliner

- Insight into SMS fuzzing
- DoS against various mobile phones by sending type 0 and other “funky” SMS

Mobile manufacturers start implementing measures

2G - 12.2010: Wideband GSM Sniffing

- 27C3: Karsten Nohl, Sylvain Munaut

- Using old Motorola phones and OsmocomBB to sniff 2G communication
- Direct output to wireshark

Hackers buy stacks of old Motorola phones

- Zu zweit allein, das wär ich gern mit dir
- Dich vergessen lassen
- Dich träumen lassen
- Dich genießen lassen
- Nur wir zwei allein

- Sehen wie du dich fallen lässt und versinkst und in meinen Armen untergehst
  - Und du spürst das du in jenem moment alles hast was du brauchst um glücklich zu sein

Auch wenn eine Fahrt in die Niagara Fälle trübe erscheint, ist die unglaubliche Erfahrung jeden tropfen Wasser in den Socken wert. Und sobald die Socken und die Kamera wieder trocken sind ist alle Reue vergessen

3G - 06.2011: Breaking into Vodafone UK 3G femto cells

- THC Group

- Access is possible via a serial interface on the device's PCB
- Allows tapping into phone calls of phones connected to the cell

Vodafone initially ignores the vulns, then decides to fix them
Researchers start buying the cells

2G - 03.2013: Let me answer that for you

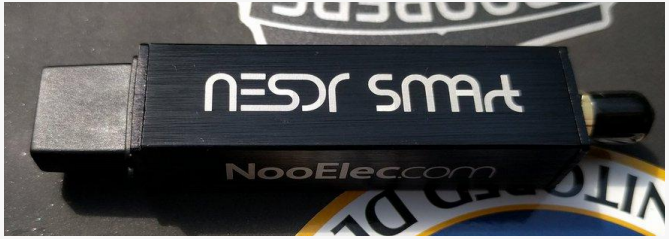
- TelcoSecDay: Nico Golde, Kevin Redon

- DoS attack against 2G networks by answering all paging requests in a certain area with a few mobile phones

:)

2G - 2014 GR-GSM

- Tool by Piotr Krysik

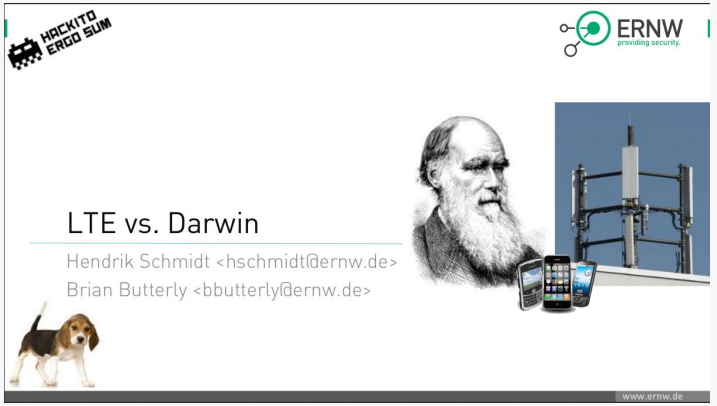


- Using software defined radio for sniffing GSM traffic
- Compatible with 20€ RTL SDR sticks
  - DVB-T Sticks that can be reused as a sniffer
- Direct output to wireshark

SDR sticks rise in price

4G - 01.2014: LTE vs. Darwin

- ShmooCon: Hendrik Schmidt, Brian Butterly



- Conceptual/design flaws and issues in 4G standards
- Theoretical attacks against LTE base stations

Invitation to share more details with GSMA

Freude & Genuss

- Das wichtigste an der Freude ist das Genießen, das wichtigste am Genießen ist Freude, die es bereitet
- Beides sind Gefühle, die gerne mit dir teilen möchte. Ich mit dir, du mit mir

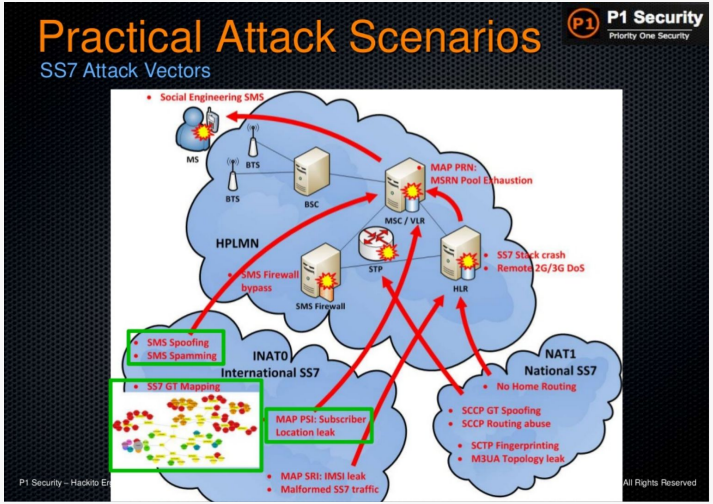
- Scheint ich genieße es riesig, dir eine Freude zu machen und habe Freude an deinem Genießen
  - Genieß die Freude, erfreu dich am Genuss und lass dich bei mir fallen. Dazu: Für dich ein *Kuss*

Diesen Rosenstrauch zeig ich dir auf einem unserer ersten längeren gemeinsamen Ausflüge

2G - 05.2014: Worldwide Attacks on SS7 Networks

- Hackito Ergo Sum: Pierre-Olivier Vauboin, Alexandre De Oliveira

- Rerouting calls and messages via direct access to the worldwide 2G backend network



Telcos start hardening SS7 infrastructure

2G - 05.2014: Hacking Telco equipment, The HLR/HSS

- Hackito Ergo Sum: Laurent Ghigonis

- Insight into security of cellular core networks
- Disclosure of various vulnerabilities and attack methods

:)

4G - 11.2015: LTE and IMSI catcher myths

- Black Hat EU: Ravishankar Borgaonkar, Altaf Shaik

- Flaws in authentication, convincing phone to connect to fake BTS, relying on vulns in device and network
- Downgrade attacks, force phone to leave “secure” 4G network and use 2G instead

Die Aufmunterung in der Mitte (nur für dich)

4G - 05.2016 IMSecure - Attacking VoLTE and other Stuff

- Area 41: Hendrik Schmidt, Brian Butterly

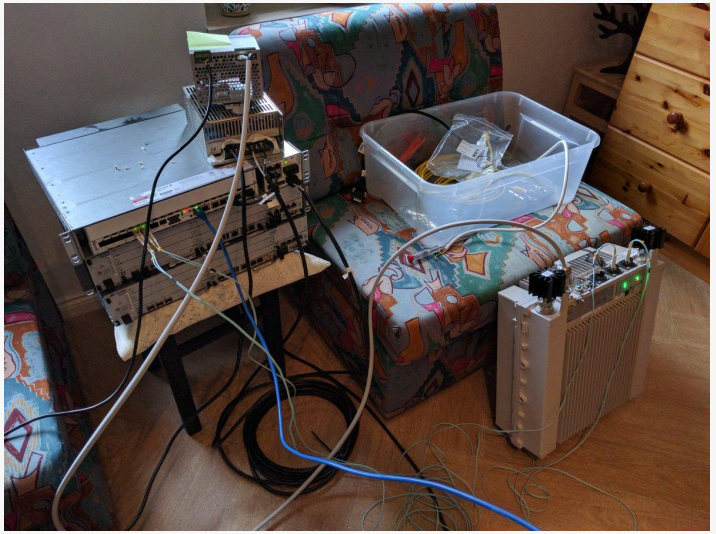
- Insight into security aspects of VoLTE
- Presentation of attack paths, vectors and flaws

Various VoIP security researchers also start looking at VoLTE

4G - 08.2016: Attacking BaseStations

- DefCon: Hendrik Schmidt, Brian Butterly

- Insight into the architecture and issues with 4G basestations
  - Also insight into how insecurely actual networks are configured
- Fully configure MetroPCS basestation acquired from eBay and taken to pieces
- Emulation of core backend components



Invitation to GSMA
Telcos understand the issues

4G - 07.2017: New Adventures in Spying 3G & 4G

- Black Hat: Ravishankar Borgaonkar

- Passively sniffing 3G & 4G networks to track phones
- Using fake SIM cards

:)

4G - 12.2017: Attacking NextGen Roaming Networks

- Black Hat EU: Hendrik Schmidt, Daniel Mende

- Insight into the 4G successor of SS7
- Transferring known vulnerabilities from SS7 to the new technology

Telcos started thinking about maybe changing things?

4G - 06.2019: Spoofing Emergency Alerts

- University of Colorado Boulder

- Project shows how easily Presidential Alert Messages can be spoofed
  - Partially motivated by the Hawaii missile alert
- Single transmitter sufficient to cover a complete football stadium

:)

Tracking, Sniffing, Spoofing

- Attack vectors have changed
- 4G has become more secure
- Still a lot of old issues have been re-implemented in 4G

5G - A New Hope

- Many features presented in 5G where actually concepted for 4G
  - But never implemented
- NB-IoT and LTE-M kind of failed during the 4G era
  - Consumer market was priority 1, protocols weren’t implemented in time, thus never used
- Security community has proposed many changes during 2G, 3G, 4G
  - Some have been accepted

5G - 08.2019: New Vulnerabilities in 5G Networks

- Black Hat: Altaf Shaik, Ravishankar Borgaonkar

- Tracking: Same protocol, same issues as in 4G
- Downgrade: Still possible
- NB IoT partially not encrypted
- Battery drain attacks by keeping IoT devices alive

Things are starting just as bad with 5G as with 4G
Issues are being addressed, but . .

:)

- Reden, Kuscheln, Küssen
- Die Welt neu entdecken
- Sachen kaputt machen
- Spaß haben…
- Wandern, Reisen, Tage & Nächte genießen
- Altes neu erleben
- …Lieben…

- Nur ein paar der Kleinigkeiten, die keine Reue zulassen

:)

- Ich hab dich lieb
- Fühl dich gedrückt
- Ich würde für dich und mit dir bis ans Ende der Welt gehen
  - Selbst bei dem Wissen, die Erde ist eine Kugel

- Und ich verspreche dir, wenn du mir deine Hand anvertraust, werde ich sie ewig halten
  - Und dir all deine Lasten abnehmen, mit der du und deine freie Hand zu kämpfen haben

Summary on a low budget

- Attackers can
  - Sniff 2G & crack, unless it's A5/3
  - Set up fake 2G basestations/networks and trick devices to connect
  - Force devices from 4G to downgrade to insecure 2G
- 2G Vulns still result in significant issues for 4G networks
  - And probably also 5G

Not everything is bad

- 2G: A5/3 is still ok
- 4G is comparably secure
  - If there wasn't the downgrade
- 5G seems to be starting as "secure" as 4G

- The IoT protocols are new and thus will be flawed
  - Experience....

Outlook

- Companies have to learn to never solely rely on transport networks
  - And telkos should be more transparent about this
- Always use some kind of application layer encryption
  - TLS FTW
- Maybe think about dropping 2G all together
- Think twice whether you really need RF

Thanks for your time

Questions?

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