Intercoms Hacking
Call the Front Door and Install Your Back Door

Presented by Sébastien Dudek
About me

- Company: Synacktiv [http://www.synacktiv.com]
- Twitter: @fluxius
- Interests: radio-communications (Wi-Fi, RFID, GSM, PLC...), networking, web, Linux security... and intercoms!
- Do red team tests at Synacktiv:
  - spear phishing,
  - remote and physical intrusions
  - ...


Physical intrusions (1)

Why?:
- to plug a malicious device,
- dump computer memory,
- or let malicious USB keys indoor, ...
Main problem: we always need a way to enter to a building

How?:
- lockpicking,
- RF attacks,
- social engineering,
- or attacking Intercoms!
Red team tests

- Sometimes it works, but sometimes we get spotted...

Alert! Intruder!
Why intercoms could be interesting?

- **At night → entering premises like a ninja!**
- **But also:**
  - to spy on conversations in the street, when it’s possible
  - to make money
  - and have a lot of fun...
Warning

- This talk applies practical attacks on intercoms
- But other devices in the “IoT” ecosystem are also concerned...
Intercoms today

Features:

- Pass code
- RF tag access
- Call a resident:
  The resident can then open the door

When calling a resident, this intercoms uses the mobile network → that explains the (+33)6* prefix displayed on the resident’s phone

* Like +49<cell phone number> in Germany
Would it be possible to play with the intercom?

We tried to directly call the intercom

but the intercom doesn’t answer to the call

Dump and modify the flash

good option, but difficult to do without being spotted in the street…

A mobile attack → Better!

but we need to understand the functioning of these intercoms first!
Context

- Intercom / door phone / house intercom
- A voice communication device → within a building
- Numeric for our case → use the mobile network (SIM/USIM cards)
- Allows to call a resident to identify the visitor and open a door

Different types of intercoms exist
## Different types of intercoms

<table>
<thead>
<tr>
<th>Description</th>
<th>Conventional</th>
<th>Simplified</th>
<th>Numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used for medium sized buildings</td>
<td>/</td>
<td>Medium sized building, or private residents</td>
<td></td>
</tr>
<tr>
<td>4+n (2 for power, 2 for the door system and n → number of residents)</td>
<td>1 wire for power and door system + n → number of residents</td>
<td>Generally: no wires for each resident</td>
<td></td>
</tr>
</tbody>
</table>
Numeric intercoms

Wires replaced by:

- GSM, 3G, rarely in 4G
- or Wi-Fi...

⇒ Avoid complicated and cumbersome cables
⇒ Easy installation
Numeric intercoms: simplified architecture
Network architecture with M2M

Admin

Intercom centralized server

M2M Mobile network connection

BTS / (e)NodeB

Gateway

MSC/VLR, PSTN, ISDN, PSDPND, CSPDN, ...

Resident’s phone

Answer and open the door

Call/Intercept commands

Intercom

Open

Door
Different brands market

- 4 brands are well-known in France:
  - Comelit
  - Intratone
  - Norasly
  - Urmet Captiv… that cost ~2000€

- Cheaper alternatives:
  - Linkcom → commonly used by private residents
    → Our choice for our 1st analysis
How to recognize a mobile intercom

- Not easy… maybe spotting a nice LCD screen, new stainless steel case…
- Or...

Looks like a mobile module?
State Of the Art: intercoms

- Publications about intercoms are nearly nonexistent
- But research on mobile security can be applied to attack these devices...
State Of the Art: Mobile security

Many publications exist:

- **Attacks on GSM A5/1 algorithm with rainbow tables**
  (at 26c3, Chris Paget and Karsten Nohl)

- **OsmocomBB**
  (at 2010 at 27c3, Harald Welte and Steve Markgraf)

- **Hacking the Vodafone femtocell**
  (at BlackHat 2011, Ravishankar Borgaonkar, Nico Golde, and Kevin Redon)

- **An analysis of basebands security**
  (at SSTIC 2014, Benoit Michau)

- **Attacks on privacy and availability of 4G**
  (In October 2015, Altaf Shaik, Ravishankar Borgaonkar, N. Asokan, Valtteri Niemi and Jean-Pierre Seifert)

- **How to not break LTE crypto**
  (at SSTIC 2016, Christophe Devine and Benoit Michau)

- And many others...
State Of the Art: tools

- **Hardware**
  - USRP from 700 € (without daughter-boards and antennas)
  - SysmoBTS from 2,000 €
  - BladeRF from 370 € (without antennas)

- **Software**
  - Setup a mobile network
    - OpenBTS: GSM and GPRS network compatible with USRP and BladeRF
    - OpenUMTS: UMTS network compatible with some USRP
    - OpenLTE: LTE network compatible with BladeRF and USRP
    - OpenAir: LTE network compatible with some USRP
    - YateBTS: GSM and GPRS network compatible with USRP and BladeRF
  - Analyze traffic
    - libmich: Analyze and craft mobile packets captured with GSMTAP
    - Wireshark: Analyze GSMTAP captured packets
    - OsmocomBB: sniff and capture GSM packets
GSM and GPRS: authentication

- BTS: Base Transceiver Station
- BSC: Base Station Controller
- MSC: Mobile Switch Center
- VLR: Visitor Location Register
- HLR: Home Location Register
- AuC: Authentication Center

The diagram shows the process of authentication in GSM and GPRS networks. The SIM card generates Ki, which is used by the GSM network to create RAND, A3, and A8 (Output: Kc). The RES is generated by the HLR/AuC and compared with SRES. If SRES = RES, the authentication is successful; otherwise, it is rejected.
GSM and GPRS: Handover

A stronger signal will likely attract User Equipments → Useful for attackers

Source: article.sapub.org
GSM and GPRS: possible attacks

- No mutual authentication → Fake rogue BTS
- Reuse of Authentication triplet RAND, RES, $K_c$ many times
- Signaling channel not encrypted → open for attacks
- Attacks on the A5/1 algorithm

⇒ Interception is possible on GSM and GPRS
## 3G/4G: advantages

<table>
<thead>
<tr>
<th></th>
<th>GSM</th>
<th>3G</th>
<th>4G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client authentication</strong></td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Network authentication</strong></td>
<td>NO</td>
<td>Only if USIM is used (not SIM)</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Signaling integrity</strong></td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Encryption</strong></td>
<td>A5/1</td>
<td>KASUMI</td>
<td>SNOW-3G</td>
</tr>
</tbody>
</table>
Mobile interception: signal attraction

- A User Equipment connects to the closest Base Station

- 3G/4G downgrades to 2G via
  - protocol attacks → difficult
  - jamming attacks → a simple Gaussian noise in targeted channels
Jamming is generally basic...
The 3G module

- Found in a public documentation:

« Lorsque le réseau 3G est inexistant sur les lieux de l’installation, le bloc 3G cherchera le réseau GSM automatiquement et pourra résumer ses fonctionnalités dans ce mode :
- Appel Audio (sans Visio).
- Mise à jour en temps réel sur le réseau GSM et non plus 3G. »

= If 3G is unreachable → use 2G instead!
To jam a 3G channel

- We can buy a jammer + disable 2G Tx
- Or for each operator:
  - enumerate the list of close UARFCN (UTRA Absolute Radio Frequency Channel Number)
  - with UARFCN → translate into central frequencies to jam the channels
  - send Gaussian noise into each detected channel using SDR
How to enumerate UARFCN? (1)

- OsmocomBB only works for GSM =(
Baseband diag interfaces (1)

- Android phones with a XGold baseband → /dev/ttyACM0 → use xgoldmon tool
- UMTS RRC (Radio Resource Control) messages → get DL UARFCN
Baseband diag interfaces (2)

- Qualcomm baseband sometimes expose a `/dev/diag` interface that could be exploited
- But a universal (and dirty) method exists with Samsung mobiles
Cheap and dirty UARFCN enumerator with Samsung Mobiles

- When entering the ServiceMode (e.g. *#0011#) in Samsung and trying to register
  → the DL and UL UARFCN are logged in logcat

- We can parse the logcat output to get the UARFCN

```
[...]
LOG:>>[HIGH]oemtestmode.c,403,Idle: dl_uarfcn 10688
ul_uarfcn 9738<<
[...]
```
Downgrade 3G → 2G demo

- Targeted channel jamming
- Using a simple HackRF for ~300€
  → works also with a USRP (~700€), or a bladeRF (~400€)
GSM Lab setup: for interception

No full duplex with hackRF → we use a bladeRF instead!

- 1 BladeRF = 370 € minimum
- 2 Antennas = 15 € minimum each
- YateBTS software = FREE
- Total cost = 400 €
Intercom setup: configuration

- This intercom can be configured in 3 ways:
  - With a programming interface and the Link iDP manager software
  - With a SIM card reader/programmer
  - Via SMS messages

- The SIM card is used as a memory → contains all the settings

- A first administrator number “ADMIN1” has to be setup in the SIM card contacts
First impressions

- **Our goals:**
  - impersonate a number, or find a way to bypass it
  - then open a door, or send commands to the intercoms
  - …

- **A good indicator → after sending commands, an acknowledgment is performed by SMS**
Hypotheses as a potential attacker

- We don’t know the mobile operator
- We don’t know intercom’s number
- The commands could be found with public or leaked documentations, or by performing a firmware analysis
Attacker steps to open the door

1. Recognize intercom’s operator to trap it
2. Leak, or guess, numbers to impersonate
3. Register my phone with the leaked resident number on the fake BTS
4. Call myself
5. Open the door!
To trap the intercom

- Bruteforcing the 4 MCC/MNC (FR)
  - 15min~ waiting for each MCC/MNC
- Strong GSM signal
- Button push → calling intercepted → success!

Note: The used MCC/MNC but mostly the used channel can be discovered with jamming tests over the different channels.
What’s next? Let's leak numbers!

- Activate GSM tapping on YateBTS → Wireshark
- Then push on buttons → CC SETUP
What’s next? Let's open the door!

- Leaked number → affect it to your IMSI in *tmsidata.conf*

```
[tmsi]
last=007b0005
[ues]
20820<attacker’s IMSI>=007b0003,35547XXXXXXXXXXX,
<resident or admin number>,1460XXXXXX,
ybts/TMSI007b0003
# associating attacker IMSI with a resident number
[...]
```
What’s next? Let's backdoor it!

- **Leak the admin number:**
  - buttons (call, or alarm triggers, etc.)
  - social engineering

- **Find commands:**
  - public or leaked documentations
  - Passive channel monitoring → good luck!
  - or buy the same model in commercial web sites such as “leboncoin”, eBay, and so on.

- **In our case with Linkcom iDP:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>READ &lt;NAME&gt;</td>
<td>Read the number of a button, or an admin (ADMIN[1-9]).</td>
</tr>
<tr>
<td>WRITE &lt;NAME&gt; &lt;number&gt;</td>
<td>Add or update a number associated to a name.</td>
</tr>
<tr>
<td>CAL AT&lt;command suffix&gt;</td>
<td>Send an AT command to the baseband through SMS!</td>
</tr>
</tbody>
</table>
AT commands?

We can interact with Intercom’s baseband:

- retrieve SMS messages → \textit{AT+CMGL=\textit{"ALL"}}
- spying building door conversations with auto-answer feature (if not disabled) → \textit{ATS0=1}
- and so on.
Demo

- Trapping an intercom
- Impersonating a resident
Call premium rate numbers

- We can modify a contact → why not choose a premium number?
  - Allopass
  - Optelo
  - Hipay
  - and so on.

Solution de micro paiement sécurisé
Securised micro payment solution

Pour acheter ce contenu, insérez le code obtenu en cliquant sur le drapeau de votre pays
To buy this content, insert your access code obtained by clicking on your country flag

France

Pour obtenir votre code, appelez le :

08 99 78 05 05

La communication vous sera facturée :
1,34€/appel + 0,34 €/min. depuis une ligne fixe.
Obtention du code <1,30min, coût : 1,80€

Paiement par CB / CB Payment

Paiement par Neosurf

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Attacking 3G/4G intercoms
Intercoms using M2M SIM/USIM cards

- Provided with a M2M SIM/USIM card
  - more than 10 years subscription
  - the mobile operator provides a virtual network to manage the intercoms

- Use the UMTS network by default
  - GSM is used if UMTS is unreachable

- Intercoms → managed by a centralized server
  - It’s an interesting new vector of attacker, but there are many others...
Attack vectors with M2M Intercoms

Vulnerabilities in Services: Web, SIP, etc.

SIM/USIM → look for vulnerabilities in the virtual network

3G downgrade to 2G + GSM interception
Website vulnerabilities

- Websites → manage one or multiple intercoms thanks to their mobile number

- Vulnerabilities could be found:
  - account guessing + bruteforce → we’ve tested it on a product
  - authentication bypasses → could be identified crawling with Google!
  - SQL injections,
  - LFI,
  - and so on.
Our tests on “Product A”

- We’ve tested a 3G intercom that is provided with a M2M SIM Card
- Let’s call it “Product A”
Bruteforce accounts

- By default, “Product A” website doesn’t enforce a password to manage intercoms:

But we need a valid number…
Number enumeration (quick PoC)

```python
code_url = "http://<login page of product A>/<login page>"

prefixes = ["07", "08", "30", "70", "71", "72", "73", "74", [...]]
prefixes = reversed(sorted(prefixes))
init = 100000
numbers = []
for p in prefixes:
    init = 100000
    while init <= 999999:
        if init == 100000:
            numbers.append("06" + p + "000000")
            numbers.append("06" + p + str(init))
        init += 1
f = open("numbers.list", "a+")
for x in numbers:
    t = int(time.time())  # timestamp added for the POST query
    data = {"**CENSORED1**":x, "**CENSORED2**":t}
    r = requests.get(url, params=data, headers=headers)
    if r.url != u"http://<login page of product A>/<error page>":
        f.write(x+"\n")
```

Enumerated accounts

- The server doesn’t mitigate wrong tries
- So 90 numbers have been enumerated for 1 prefix (+33 6 77 ******) < 4 hours
- We are able to manage intercoms without the need of SDR tools!
Attack scenarios

Without the need of any SDR tool:

- Update all intercoms with a premium rate number =/
- open doors → but we need the locations...
How to get the location?

- In general, people add their home number first...
Reverse look-up directories

Reverse look-up directories → get the precise location
The M2M virtual network as a second attack vector

- Provided SIM/USIM cards could be plugged on other devices
  - we can scan the virtual network
- But product’s “A” SIM/USIM card has a PIN code… =/
  - not a problem for the SIMtrace tool!
SIMtrace setup and results

SIMtrace as a “proxy” between the SIM/USIM ↔ intercom:

Entering main loop
ATR APDU: 3b 9f 96 80 1f c7 80 31 e0 73 fe 21 1b 64 40 91 11 00 82 90 00 01
PPS(Fi=9/Di=6) APDU: 00 a4 00 04 02 3f 00 61 23
[...]
APDU: 00 20 00 01 08 ** ** ** ff ff ff 90 00
APDU: 00 2c 00 01 00 63 ca
[...]

PIN code typed by the “Product A” intercom itself
Connecting to the M2M network

- Put the SIM/USIM in your phone
- Optionally change the IMEI (possible with some Chinese phones)
- Setup the right APN (Access Point Name) of the M2M network → documented
- Tether the communication → use a computer

Changing the IMEI within the engineer mode
Traceroute in the M2M virtual network

Check the connection with a tethered computer:

```
$ traceroute 8.8.8.8
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
1 192.168.42.129 (192.168.42.129) 0.622 ms 0.643 ms 0.705 ms
2 10.***.***.250 (10.***.***.250) 105.629 ms 125.547 ms 185.628 ms
3 10.***.***.209 (10.***.***.209) 195.783 ms 195.900 ms 195.831 ms
[...]
14 google-public-dns-a.google.com (8.8.8.8) 50.771 ms 50.248 ms 51.016 ms
```

An attacker will now be able to:
1) scan the virtual network
2) search for vulnerable services
3) then exploit vulnerable services
4) and so on… or use the SIM/USIM to get a free internet access ^^
SIP as an attack surface

- “Product A” has a mobile application to provide Video calls
- Video calls use SIP
- To use this app a premium account is required =( 
- But let’s analyze it!
Application analysis: first results

- Mainly (very) bad/NULL SSL checks… → MITM is possible
- Also one SIP credential seems to be hardcoded:

```java
public static final String PASSWD = "E[*****D";
public static final String SENDER_ID = "97[*****7";
public static final String SETTINGS = "[*****].settings";
public static final String URL = "https://sip.[*****]/";
public static final String URL_TEST = "https://siptest.[*****]/";
public static final String USER = "user";
public static final String USERNAME_INTERPHONE_SIP = "1002";
```
Registering in the SIP server

- Using hardcoded credentials → success!

```
SIP/2.0 200 OK
Via: SIP/2.0/TCP 10.***.***.11:38703;alias;branch=z9hG4bK.rfZ5uXs1W;rport=38703;received=19**********2
From: <sip:user@sip.********>;tag=qmu7Mgc8t
To: sip:user@sip.********;tag="
CSeq: 21 REGISTER
```
Results on “product A” SIP vector

- Not satisfying =/
- We are able to contact simple users like:
  - “user”;
  - “root”, …
- But impossible to contact a known number
  → Maybe because the number needs be registered as a premium extension
- Actual question: how to find a valid extension (without flooding with “INVITE” requests)?
Security recommendations for M2M solutions

- Enforce a PIN code on SIM/USIM cards → like in “Product A”
- Whitelist IMEIs
- Audit/pentest regularly the management website against web vulnerabilities, but also other services
- Restrict actions and requests on APNs
- Firewall the virtual network, or do some segmentation
- Audit/pentest the virtual network against network attacks and vulnerabilities in services
- Monitor and block SIM/USIM cards that have a suspicious behavior
Conclusion

- With GSM intercoms we can:
  - open a door
  - call premium rate numbers
  - spy on conversations if ATS0 is supported

- Intercoms using the mobile network → same flaws as mobile phones

- Other devices in the IoT ecosystem use the mobile network

- M2M intercoms introduce new vectors of attack → much more destructive → require a simple Internet connection (no SDR tools needed)
  - But M2M SIM/USIM cards are also used in many other IoT products!

- Further work:
  - find a solution about the SIP vector,
  - start attacking intercoms’ basebands,
  - reduce the lab with an odroid device or another alternative :)
ANY QUESTIONS?

Thanks for your attention!