DirtyTooth: it's only Rock'n'Roll, but I like it!

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Executive Summary

Bluetooth communications are on the increase. Millions of users use the technology to connect to peripherals that simplify and provide greater comfort and experience. There is a trick or hack for iOS 10.3.3 and earlier and iOS 11 beta 4 that takes advantage of the management of the profiles causing a great impact on the privacy of millions of users who use Bluetooth technology daily. From the iOS device information leak caused by the incorrect management of profiles, a lot of information about the user and their background may be obtained.

1. Bluetooth devices

Bluetooth devices have undergone a proliferation. Its use with peripherals has meant that the expansion and use of technology have rocketed in recent years. Keyboards, mice, speakers, hands-free kits and a whole range of devices use Bluetooth technology to provide wireless communication to users and improve the usability of peripherals and entertainment elements.

All modern operating systems support and integrate the technology. Mobile operating systems such as Android, iOS and Windows Phone provide various ways of interacting with the different elements mentioned above.

1.1- Versions of Bluetooth

Bluetooth technology has been continually evolving over the years. The following table shows the different versions and updates:

Version	Year of introduction
Bluetooth v1.0	1999
Bluetooth v1.1	2002
Bluetooth v1.2	2003
Bluetooth v2.0 + EDR	2004
Bluetooth v2.1 + EDR	2007
Bluetooth v3.0 + HS	2009
Bluetooth v4.0	2010
Bluetooth v5.0	2016-2017

Table 1: Versions of Bluetooth technology

Version 2.1 incorporates an important function for this research - the possibility of not entering the PIN code to enable pairing of devices. Audio devices such as speakers or headphones with version 2.1 of Bluetooth do not require users to enter a PIN in order to effect pairing.

2.- Bluetooth Profiles

When a device wants to use a series of functions via Bluetooth, a profile is required to permit said functions. A profile is simply a specification of functions that can be performed via a Bluetooth connection, that is, a description of the actions that can be performed via the connection with the associated profile.

There are a wide variety of Bluetooth profiles. The official list contains 31 profiles, which provide various functions such as access to contacts, messages from the device, the ability to use hands-free, send audio to a device and so on. The range of functions is growing constantly.

2.1- Bluetooth Profiles on iOS

The iOS operating system supports a series of specific *Bluetooth* profiles. The following are the different profiles supported by the different devices:

1. *Hands-Free Profile (HFP 1.6).*
2. *Phone Book Access Profile (PBAP)*
3. *Advanced Audio Distribution Profile (A2DP)*
4. *Audio/Video Remote Control Profile (AVRCP 1.4)*
5. *Personal Area Network Profile (PAN)*
6. *Human Interface Device Profile (HID)*
7. *Message Access Profile (MAP)*

Device	HFP 1.6	PBAP	A2DP	AVRCP 1.4	PAN	HID	MAP
iPhone 4 and later	Yes	Yes	Yes	Yes	Yes	Yes	Yes
iPhone 3GS	Yes	Yes	Yes	Yes	Yes	Yes	-
iPhone 3G	Yes	Yes	Yes	Yes	Yes	-	-
iPhone Original	Yes	Yes	-	-	-	-	-
iPad 2 and later	Yes	-	Yes	Yes	Yes	Yes	-
iPad (1st Generation)	-	-	Yes	Yes	Yes	Yes	-
iPod Touch (4th Generation)	Yes	-	Yes	Yes	Yes	Yes	-
iPod Touch (2nd and 3rd Generation)	-	-	Yes	Yes	Yes	Yes	-

Table 2: Profiles supported on different Apple devices

3.- Hack: DirtyTooth

Bluetooth profiles access different mobile resources, so it is essential that proper permissions management is available from the operating system. Bluetooth allows a device to run different profiles, switching between them.

The operating system notifies you when there is a profile change on a device that is paired with the mobile device. In this research, a test was carried out on the iOS and Android operating systems and each gave very different results.

When a device is linked to a mobile and the former changes its profile, two circumstances may occur. The first is that the operating system detects the change of profile and therefore of functions and data to which the linked device can access and asks the user to accept the profile change. This takes the form of a secure notification, so that the user realizes that the connected Bluetooth device wants to access another profile and, therefore, the private information on the terminal. The second circumstance is that the operating system does not detect the profile change and allows it to be accomplished without notifying the user.

This second circumstance has been detected in iOS operating systems and has been defined as DirtyTooth. This trick or hack allows an attacker to impersonate the A2DP profile of a speaker so that a user's iOS device connects assuming it to be a speaker. A few moments after pairing, without having to enter a PIN, the device changes its profile to another. The iOS operating system does not notify this change and allows the attacker to access and download private information from the device.

3.1- Diagram

Before detailing the implementation, the following is a schematic example of what is used in the implementation of DirtyTooth. The diagram is valid for both the software and the hardware versions of the trick.

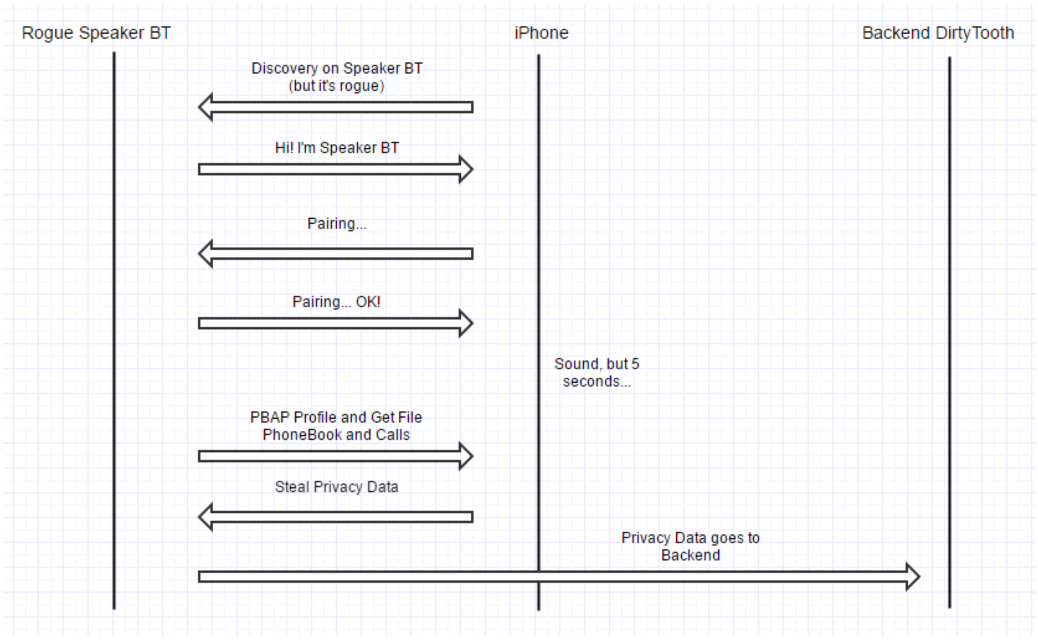
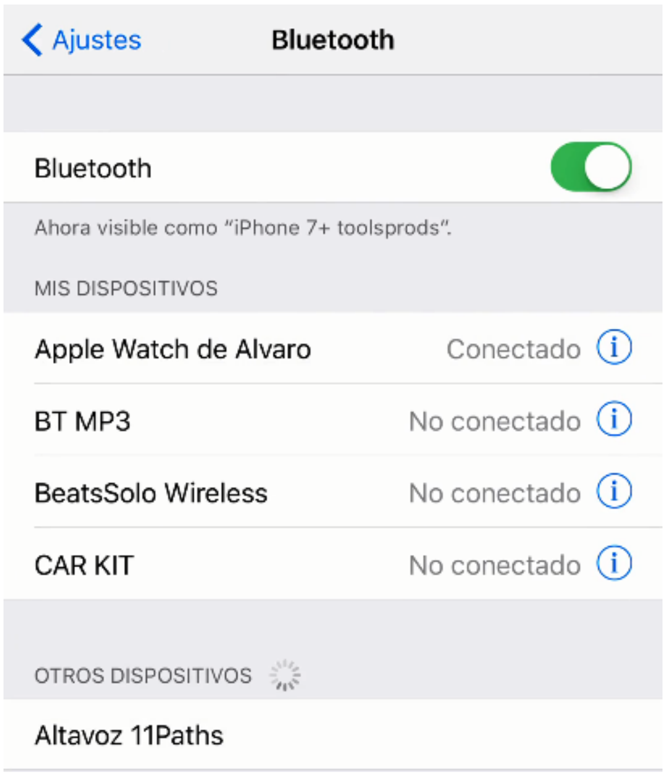


Figure 1: Flow diagram of DirtyTooth on iPhone

When the iOS system detects a Bluetooth signal, the user can visualize the device with which it wants to connect and a scenario like the following will be observed:


Ajustes
Bluetooth
Bluetooth
Ahora visible como "iPhone 7+ toolsprods".
MIS DISPOSITIVOS

Apple Watch de Alvaro	Conectado
BT MP3	No conectado
BeatsSolo Wireless	No conectado
CAR KIT	No conectado

OTROS DISPOSITIVOS
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Figure 2: Discovery of a Rogue Speaker

The speaker that appears in the Bluetooth discovery is announcing the A2DP profile, a profile to play audio via the Bluetooth connection. When the user clicks on it, the pairing is completed, with no need for a PIN in versions Bluetooth 2.1 or higher.

In the following image, you can see how the headphones icon shows in the upper right corner. The device that supplants a speaker for a few seconds has an A2DP profile.

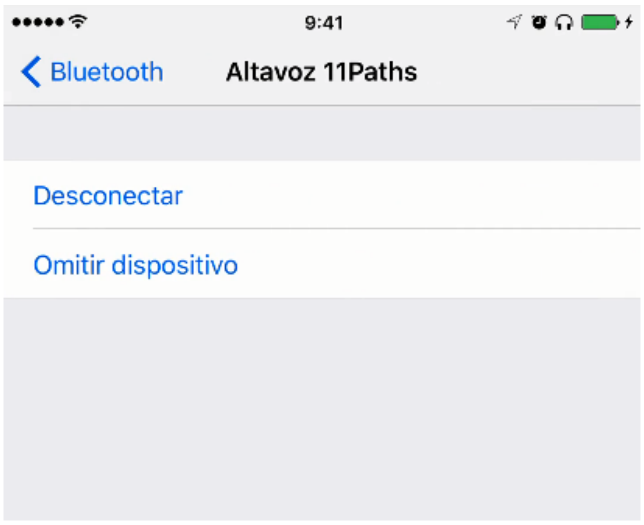
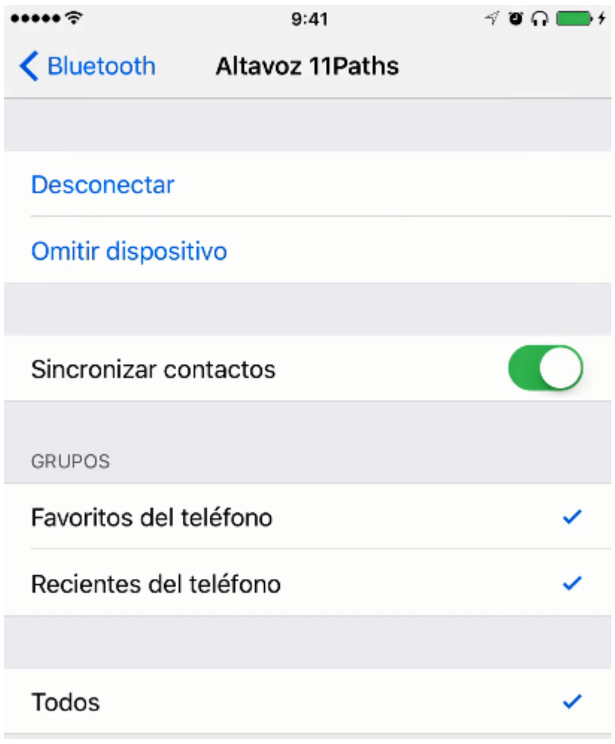

9:41
Bluetooth
Altavoz 11Paths
Desconectar
Omitir dispositivo

Figure 3: Device setup Linked to the A2DP Profile

After a few seconds, the attacker's device can change its profile to a PBAP profile for example. If this happens, iOS will perform the profile change without displaying any type of notification to the user. This is the moment when the attacker can access the contact list and download it.


9:41

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Desconectar

Omitir dispositivo

Sincronizar contactos ✓

GRUPOS

Favoritos del teléfono ✓

Recientes del teléfono ✓

Todos ✓

Figure 4: Switch to PBAP profile with automatic contacts synchronization

Note the existence of a setup fault or weakness in iOS. When the profile change is carried out without notification, the synchronization of contacts is enabled by default, giving access to the attacker.

The trick or hack can be extended to other profiles, as the operating system does not request authorization to change the profile. In the case of a MAP profile, in order to access the messages on the mobile device, a switch displays to synchronize messages, but in this case it is disabled by default, on the contrary to what happens in the case of the PBAP profile. In other words, the trick takes advantage of the lack of authorization to change profile and the default settings to synchronize elements on the device via the Bluetooth connection.

The elements that can be downloaded from the mobile device via the DirtyTooth hack are any elements that may be accessed via the profile to which it has been changed. A PBAP profile allows:

1. The request for and download of contacts from the device. This enables a potential attacker to extract all information from the contacts directory of the iOS operating system. The format in which they are extracted can vary between VCard 2.1 and 3.0.

2. The request for and download of call history, incoming and outgoing, from the device. This enables a potential attacker to extract the call register from the iOS operating system. The format in which they are extracted can vary between VCard 2.1 and 3.0.

Information extracted with the attacker's Rogue device can be sent via Internet to a server under the attacker’s control. Thus connecting iPhone devices with an audio device, even hands-free, with Bluetooth is a threat to user privacy.

The information that can be extracted from the terminal via a PBAP profile is as follows:

1. People to whom the user relates.
2. The user's phone number.
3. Companies with which the user relates.
4. Email addresses.
5. The card owner's contact information.
6. The call history.
7. The physical addresses of the people associated with the contact card.

This information can be processed on the Internet to achieve a greater level of detail and knowledge.

3.1.1- Software Implementation

The first approach to take advantage of the DirtyTooth hack was made via a software implementation. To carry out the hack the following components were used:

1. Raspberry Pi 3 Model B.
    1. 1.2GHz 64-bit quad-core ARMv8 CPU
    2. Bluetooth 4.1 module
    3. Bluetooth Low Energy (BLE)
2. PyBluez. A Python module that extends Bluetooth functionality in Python. Access to the resources is provided by Bluetooth technology.
3. PyOBEX. This package must be installed following the installation of PyBluez and implements the features of the OBEX protocol.

Here is the operation or algorithm implemented to perform DirtyTooth:

1. A .bashrc file was used, which on starting the Raspberry Pi 3 identifies the name with which the Bluetooth module will issue the signal and class. The following lines are added at the end of the file:

1. *pulseaudio -D*
2. *# sudo -u pi pulseaudio -D*
3. *sudo hciconfig hci0 name "NAME HERE"*
4. *sudo hciconfig hci0 class 0x240418*
5. *sudo hciconfig hci0 sspmode 1*
6. *sudo hciconfig hci0 piscan*
7. *sudo /usr/bin/hacktooth/dirtytooth.py &*

As you can see, the *hciconfig* command is the one that defines the class of the profile that is offered via Bluetooth.

2. Option *pulseaudio -D* allows the execution of *pulseaudio daemon*. The *sspmode* allows the module setup to specify the need to enter a PIN in the pairing process between speaker and the iPhone. By setting it to 1, it will not ask for a PIN, as long as the Bluetooth device version is equivalent to the 2.1 implementation or higher.
3. The dirtytooth.py file is in charge of automating the actions once the pairing is done. In the first instance the device is paired thanks to the commands entered in the .bashrc file.
4. Once a device is paired, the dirtytooth.py file is launched. This file will make the request by changing the class UUID. This is the moment that the hack enters iOS, as the operating system neither prohibits it nor notifies the user.

Looking more closely at the last point of the algorithm, we must emphasize that dirtytooth.py has a function that exploits the Bluetooth connection, via the PBAP profile, to obtain files.

```
def get_file(c, src_path, filename, book=True):
    if book:
        mimetype = b'x-bt/phonebook'
    else:
        mimetype = b'x-bt/vcard'

    hdrs, file = c.get(src_path, header_list=[headers.Type(mimetype)])
    write_file(filename, file)
    logfile("Done!\n")
```

Figure 5. Obtaining data via PBAP

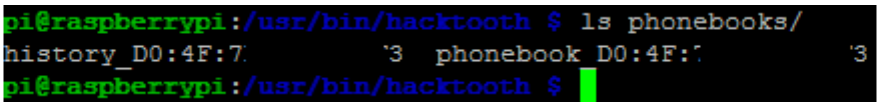
On the other hand, the function is used to obtain the list of contacts in VCard format and the call register in the same format.

```
      if not os.path.isfile("/usr/bin/hacktooth/phonebooks/phonebook_" +
device_address):
                get_file(c, prefix + "telecom/pb.vcf", "phonebook_" +
device_address)

      if not os.path.isfile("/usr/bin/hacktooth/phonebooks/history_" +
device_address):
                get_file(c, prefix + "telecom/cch.vcf", "history_" +
device_address)
```

Figure 6: Get list of contacts and call records via PBAP

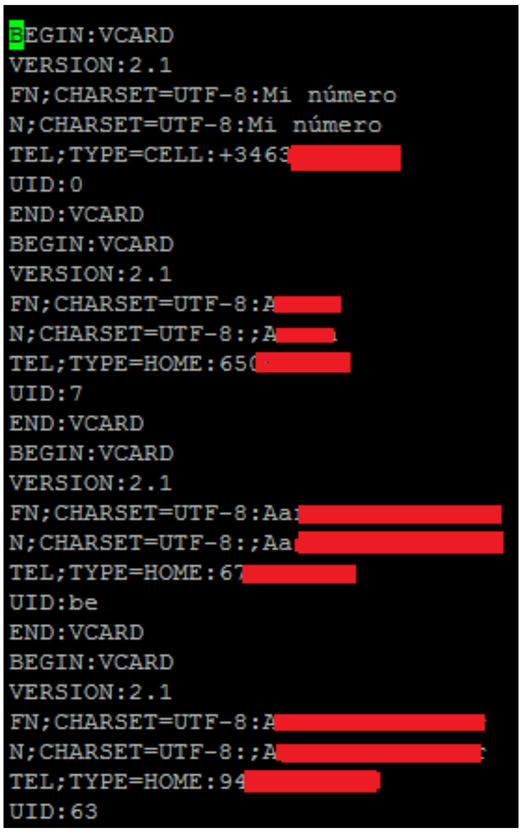
The sound continues to function, so the user does not detect any leakage of private information from the device. The files are temporarily stored before being sent to the backend via an Internet connection on the Raspberry for some files, as you can see in the image:



```
pi@raspberrypi:/usr/bin/hacktooth $ ls phonebooks/
history_D0:4F:7[redacted]3   phonebook_D0:4F:[redacted]3
pi@raspberrypi:/usr/bin/hacktooth $
```

Figure 7: Files extracted from the iPhone

Analyzing the file and format obtained the following information can be found. It is important to detect that the UID with a value of 0 belongs to the VCard in every iPhone and to the phone number and personal information of the owner of the iPhone.



```
BEGIN:VCARD
VERSION:2.1
FN;CHARSET=UTF-8:Mi número
N;CHARSET=UTF-8:Mi número
TEL;TYPE=CELL:+3463[redacted]
UID:0
END:VCARD
BEGIN:VCARD
VERSION:2.1
FN;CHARSET=UTF-8:A[redacted]
N;CHARSET=UTF-8:;A[redacted]
TEL;TYPE=HOME:65[redacted]
UID:7
END:VCARD
BEGIN:VCARD
VERSION:2.1
FN;CHARSET=UTF-8:Aa[redacted]
N;CHARSET=UTF-8:;Aa[redacted]
TEL;TYPE=HOME:67[redacted]
UID:be
END:VCARD
BEGIN:VCARD
VERSION:2.1
FN;CHARSET=UTF-8:A[redacted]
N;CHARSET=UTF-8:;A[redacted]
TEL;TYPE=HOME:94[redacted]
UID:63
```

Figure 8: UID with 0 belongs to owner of iPhone

3.1.2- Hardware Implementation

For the hardware implementation of the hack, a real Bluetooth speaker was used. The speaker was equipped with a series of modules that provide different functions:

1. A Bluetooth module that will supplant the real speaker
2. The core of the system is a *Teensy* board with a microSD connector. The *Teensy* was programmed with the *Teensyduino* framework in order to make use of the collection of libraries available for Arduino.
3. A 2G/GPRS *Adafruit* module was used for the Internet connection of the board.

With the Bluetooth module, the real speaker will be supplanted and the A2DP profile connection offered. The core is responsible for changing the profile to PBAP when the connection has been established with the iPhone. At this moment, thanks to the DirtyTooth hack, access to the iPhone contacts and call history will be given. As illustrated below:

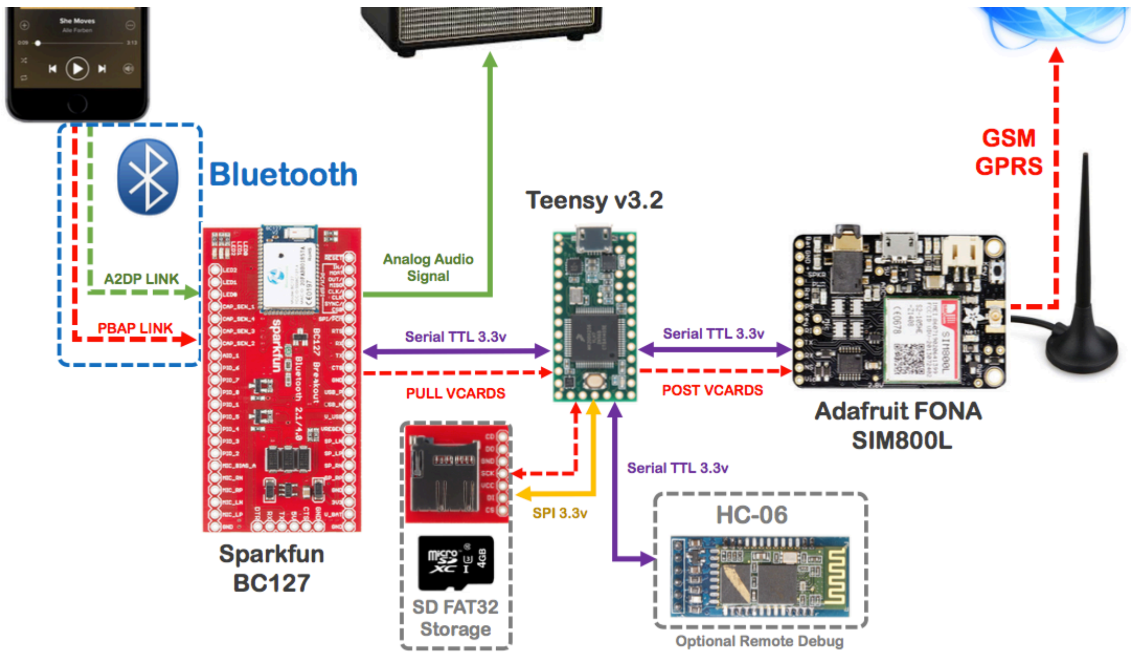


Figure 9: DirtyTooth hack hardware scheme

3.2- Systems Proven

In the case of the PBAP profile, the list of proven systems agrees with the models of iOS devices that have telephone functions, i.e. the iPhone. The models that can be used in the hack are:

1. *iPhone 3G.*
2. *iPhone 3GS.*
3. *iPhone 4 / 4S.*

4. *iPhone 5 / 5S.*
5. *iPhone 6 / 6S / Plus 6 / Plus 6S.*
6. *iPhone 7 / Plus 7.*

Currently, all iOS operating systems, compatible with the list of previous models, can be used with DirtyTooth. The current version of the operating system in the release of this document is iOS 10.3.3 and iOS 11 beta 4.

3.3- Scope and possibilities

The data that can be obtained via the DirtyTooth hack are:

1. People to whom the user relates.
2. The user's phone number.
3. Companies with which the user relates.
4. Email addresses.
5. The card owner's contact information.
6. The call history.
7. The physical addresses of people associated to the contacts card.

After processing this information, more relevant information might be obtained. The following is the type of data that can be derived and obtained from a contact theft:

1. Images from Facebook profiles.
2. Name of telephone operator.
3. A first level of relationship with companies and employees via LinkedIn.
4. MAC Wifi adapter address.
5. OS and model of terminal, APT-oriented.
6. Geographical location of landline numbers.
7. Owners of the landline numbers.
8. Interaction with the Telegram/WhatsApp API for image discovery, status information and connection time.

4.- Conclusions

The Bluetooth connection of iPhones with peripherals such as speakers, headphones or sound equipment imply risk for the user's privacy as these elements could extract private information from the iPhone, without the user being aware of it.

The DirtyTooth hack enables an attacker to extract private information from the iOS device and to know the user's relationships and environment, as well as data such as:

1. People to whom the user relates.
2. The user's telephone number.
3. Companies with which the user relates.
4. Email addresses.
5. The card owner's contact information.
6. The call history.
7. The physical addresses of people associated to the contacts card.

The hack or trick puts users' privacy at risk. The iOS operating system does not notify the profile change and allows the execution of the functions and actions associated with the new profile, so that the users' data are at risk of being stolen by a potential attacker.

Uploading the information to a server controlled by the attacker allows the information to be processed to attain a greater level of detail. Information can be exploited and much information can be obtained from the person's relationships.

In other words, DirtyTooth is a trick or hack that can take advantage of this accesibility configuration. It's a simply accesibility configuration potentially dangerous.

5.- References

- iOS Profiles – Bluetooth. https://support.apple.com/es-la/HT204387
- Specification Bluetooth. Requirements PIN. http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-121r1.pdf
- iOS 10.2.1 Security. https://support.apple.com/es-es/HT207482
- Specification of Profiles. Bluetooth. https://www.bluetooth.com/specifications/profiles-overview
- Bluez Libray Specification. https://people.csail.mit.edu/albert/bluez-intro/c212.html
- Components: BlueCreation BC127. https://www.sparkfun.com/products/11927
- Teensy. https://www.pjrc.com/teensy/

- 2G/GPRS Adafruit. https://learn.adafruit.com/adafruit-fona-mini-gsm-gprs-cellular-phone-module/overview
- Remote Debbugging Bluetooth. http://www.prometec.net/bt-hc06/
- PyBluez. https://github.com/karulis/pybluez