Hacking apple accessories to pown iDevices
Wake up Neo! Your phone got pown!

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Who am I?

# @GotoHack
- DAY: Pentester & Team Leader
- NIGHT: Security Researcher

# Area of expertise
- Mobility / BYOD
- Web application
- Embedded systems
- Hardware Hacking

# Publications
- Les assises de la sécurité
  - To BYOD or not to BYOD
- GreHack 2012
  - Practical iOS Application Hacking
- HACK.lu 2012
  - Hacking iOS Application
- Hackito Ergo Sum 2013
  - Hacking apple accessories to pown iDevices
iDevices Attack surface

- **BootROM**
  - DFU Mode
    - IMG3 X509
- **LLB**
  - Fake DFU Mode
    - IMG3 X509
- **iBoot**
  - Recovery Mode
    - IMG3 X509
- **Kernel**
  - iTunes services:
    - Backup, AFC, ...
    - (USBMux)
  - Accessory Protocol (Serial)
- **Deamons**
- **Apps**

- **USB host / Apple Accessory**

- **Boottime**
- **Runtime**
iTunes Services
Mobilebackup services
   - Used by iTunes to backup the device

iDevice backup
   - Permit a user to restore personal data and settings
   - Abusing this service may allow an attacker
     - Retrieving personal and confidential data
       - SMS
       - Call Logs
       - application data
       - default preferences
       - data stored in the keychain (WiFi password, VPN Certificate Passwords).
     - Inject data to the device.
   - Can be password protected
# AFC (Apple File Connection)
- Service running on all iDevices
- Handled by /usr/libexec/afcd
- Used by iTunes to exchange files
- AFC clients can access certain files only
  - Files located in the Media folder
# House_arrest
- allows accessing to AppStore applications folders and their content.

# Using an AFC client, a user/attacker can download the application resources and data (documents, photos...).
  - Including “default preferences”
    * File where credentials are sometimes stored.
# Installation proxy
- Manages applications on a device
  - List installed applications.
  - Install an application on the device.
  - Upgrade an application on the device.
  - Uninstall an application from the device.
  - List archived applications.
  - Archive an application on the device
    - Creating a ZIP archive in the “ApplicationArchives” directory and uninstalling the application
  - Removes a previously archived application from the device

- Used by the com.apple.mobile.house_arrest
  - Enumerate and dump installed applications.
# Diagnostics relay

– Allows requesting iOS diagnostic information.
– Handles the following actions:
  • Puts the device into deep sleep mode and disconnects from host.
  • Restart the device and optionally show a user notification.
  • Shutdown of the device and optionally show a user notification.

– Used by evasi0n to update some caches by rebooting the device.
# File_Relay

- Allow paired devices to launch the following commands
  - AppleSupport,
  - Network,
  - WiFi,
  - SystemConfiguration,
  - VPN,
  - UserDatabases,
  - CrashReporter,
  - Tmp,
  - Caches

- All the files returned are stored in clear text in a CPIO archive
- Asking for UserDatabases allow retrieving
  - SMS, Contacts, Calendar and Email from databases in clear text.
# Libimobiledevice
- Cross-platform software library
- Developed by Nikias Bassen
- Handles the protocols to support iDevices.
- Based on the open source implementation of usbmuxd

# Pymobiledevice
- Lite python implementation
- Handles only most important protocols to support iDevices
- Based on the open source implementation of usbmuxd

# Allows other software to easily interact with the services hosted on the device.
Communicating with the Device through the Sync port may allow malicious dock station to
  • Retrieve & Inject
    – SMS
    – Call Logs
    – application data
    – default preferences
    – data stored in the keychain (using backup)
Communicating with iTunes Services
USBmuxd and USBmux protocol

Client side communication

# USBmuxd
- Daemon is started at system launch (on user system).
- Creates a listening UNIX Domain Socket at /var/run/usbmuxd.
- Wait for iDevice connections via USB
- Allows multiplexing of TCP connection over one USB pipe

Binay Data sent through UNIX Socket

USBMuxd

USBMux Client

Hello

Hello

device ID

TCP connect request
Lockdownd

# Lockdownd binary
- Responsible for several tasks
  - Pairing,
  - Activation,
  - Unlocking FairPlay certificates,
  - Delegating communications to other services
  - ...

- Listening on port 62078
  - Accessed through the usbmux protocol.
  - Packets
    - Data length : 32bits big endian word
    - Data : XML plist

- Only available after pairing.
  - First pairing require the device to be unlocked
iTunes’ service communication overview

- **iDevices**: lockdownd, AFC Service
- **Host**: libmobiledevice, AFC Client
- **AFC Commands**
- **AFC Results**
- **USBMuxd**
- **Pairing request**: Can you start afc service?
- **Pairing OK**: AFC service is running on port: XXXXX
- **Plist files sent over USB pipe**
**Lockdown protocol & Pairing**

XML Plist sent through USBmux

```
{Request=QueryType}
{Request=QueryType, Result=Success, Type=com.apple.mobile.lockdown}
{Request=GetValue, Label=xxxx}
{Request=GetValue, Label=xxxx, Value={ActivationPublicKey=xxxx, DevicePublicKey=xxxx, UniqueDeviceID=xxxx, DieID=xxx,...}}
{PairRecord={DevicePublicKey=xxxxx, DeviceCertificate=xxxx, HostCertificate=xxxx, HostID=xxxx, RootCertificate=xxxx, SystemBUID=xxxx}, Request=Pair}
{Request=Pair, EscrowBag=xxxx}
{PairRecord={DevicePublicKey=xxxxx, DeviceCertificate=xxxx, HostCertificate=xxxx, HostID=xxxx, RootCertificate=xxxx, SystemBUID=xxxx}, Request=ValidatePair}
{Request=ValidatePair}
{HostID=xxx, Request=StartSession}
{SessionID=xxx, Request=StartSession, EnableSessionSSL=True}
```
Summary

# Pairing is initiated on the USB Host side
# Unlocking the device is mandatory
Reversing an Apple MFI accessory
# Anatomy of an Accessory

MFI Alarm clock

- Apple dock connector
- Features:
  - Compatible with all iPods
  - Wake up to iPod
  - Full-function remote control
  - Charges iPod whilst connected
Opening the box...

Power supply & Audio Amplifier

iDevice interface

Mother board
Mother board analysis

- 4 Stereo input Preamplifier CD3314E0
- Micro Controller R5F2126 6NFPC6269
- LCD driver TM1621
- LCD Screen
- Command Buttons
- IR Receiver
In-System Programming

On-chip data flash (1Kbytes)
Internal ROM (32 Kbytes)

Not enough resources for hosting iPown features
iDevice interface
Reversing the Circuit

GND
5V
Tx
Rx
AC DET
IP DET
IPOD R
AGND
IPOD L

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

2V
550K
2.6V
49.9K
43.2K
49.9K
75K

Audio
RS232
Charging

J1 Device connector

J1 Device connector

RS232

J2

SOGEIT
What about the Lightning connector?

# In October 2012 Apple released the Lightning
- Apple proprietary bus and power connector
- Replace its previous proprietary 30-pin dock connector.
- Using 8 pins instead of 30
- Significantly more compact than the 30-pin dock connector
- Can be inserted with either face up.
- Embeds an authentication chip inside the cable.
  • Analyzing the Lightning connector will not be so easy.

# 30 pins adapters
- Allows to connect 30-pin accessories to devices featuring the Lightning connector.
- Successfully tested on the dock station used for our analysis
Sniffing the communications

- Standard 8N1 serial protocol.
- Data are sent @ 19200 bauds.
# Request/Response Structure

## Request & Response Structure

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>2</td>
<td>0xff 0x55</td>
</tr>
<tr>
<td>Length</td>
<td>1</td>
<td>Size of Mode + Command + Parameter</td>
</tr>
<tr>
<td>Mode</td>
<td>1</td>
<td>The mode the command is referring to.</td>
</tr>
<tr>
<td>Command</td>
<td>2</td>
<td>The two bytes command.</td>
</tr>
<tr>
<td>Parameter</td>
<td>0..n</td>
<td>Optional parameter, depending on the command.</td>
</tr>
<tr>
<td>Checksum</td>
<td>1</td>
<td>0x100 - (sum of all length / mode / command / parameter bytes) &amp; 0xFF</td>
</tr>
</tbody>
</table>

![Play button](https://nuxx.net/wiki/Apple_Accessory_Protocol)
Summary

# Hacking the firmware of the µC ?
   – Not relevant regarding our goal
     • We need some space to store user data...

# Developing a custom dock ?
   – Challenging but too much time consuming regarding this study.
   – USB pins are not used
     • Allows connecting another device that share the same power supply

# Hacking the dock and adding some hardware
   – The raspberry PI is meeting all our requirements
   – At least two USB ports
     • 1 to communicate with the connected device
     • 1 for a 3G / Wi-Fi adapter
   – 1 Ethernet port for debugging
   – GPIO (simulating user action on the dock)
   – Accepting 5V power supply.
Weaponizing an Apple MFI accessory
iPown Bill of materials

# 1 Raspberry pi
# 1 PodSocket
# 1 PodBreakout
# 1 USB Connector
# 1 mini USB Connector
# 1 WiFi USB Key
# 1 SDcard
Hardware Hacking
Reversing the Circuit

J1 Device Connector

Society
Hacked MFI accessory

This dock station is now powered by

http://www.raspberry.org/
Cliquez pour modifier le style des sous-titres du masque
iPown
Personal Data dumper...
What if our alarm clock could silently jailbreak our device in our sleep when we are dreaming?
iPown 2.0
Automating Jailbreak
Public Jailbreaks

# jailbreakme.com
- Exploits by comex, Grant Paul (chpwn), Jay Freeman (saurik) & MuscleNerd
- Targeting MobileSafari
- Could be used against an unwitting victim
- Only working on old devices

# Others other recent jailbreaks (absinthe 1&2, evasi0n)
- Require USB tethering.
- Require User interaction
  - iDevices refuse to communicate over USB if they are locked unless they have previously paired.
  - Lower security impact
  - only useful to the phone’s owner

# Are we really safe?
User Interaction in evasi0n...
# Pairing with the device
# Starting com.apple.mobile.file_relay service
# Retrieving the com.apple.mobile.installation.plist – plist file
# caches the list of installed applications
# Activating the apple “DemoApp.app”
# Restoring Hijacked “DemoApp.app” in /var/mobile – Using old mobilebackup simlink trick
# Updating the caches / Rebooting the device – “DemoApp.app” will show up on SpringBoard after restart”
# Evasi0n Stage 2

- Injecting symbolic link 1/2
  - `/var/db/timezone` -> `777 /var/tmp/launchd`
- Crashing `lockdonwd` 1/2
  - Chmod `777 /var/tmp/launchd`
- Injecting symbolic link 2/2
  - `/var/db/timezone` -> `777 /var/tmp/launchd/sock`
- Crashing `lockdonwd` 2/2
  - Chmod `777 /var/tmp/launchd/sock`
- Waiting for user to launch the “DemoApp.app”
- Injecting the remount payload
- Uploading Cydia files
# Executing “DemoApp.app” => Executing the remount script

```bash
#!/bin/launchctl submit -l remount -o
/var/mobile/Media/mount.stdout -e
/var/mobile/Media/mount.stderr -- /sbin/mount -v -t
hfs -o rw /dev/disk0s1s1
```

```xml
<key>EnvironmentVariables</key>
<dict>
    <key>LAUNCHD SOCKET</key>
    <string>/private/var/tmp/launchd/sock</string>
</dict>
```

- Launchctl interfaces with launchd to load, unload daemons/agents
- launchd’s IPC mechanism operates through Unix domain sockets.
- LAUNCHD SOCKET
  - Informs launchctl how to find the correct launchd socket
- Launchd runs as root and here launchctl runs as mobile
  - The socket and the daemon launchctl have been chmoded 777
  - Our mobile now able to communicate with the root user’s launchd
# Evasi0n

Stage 2: Remouting the file system in R/W

# launchd (runing as root) execute the remount script
# No mount point is specified in the script
  – The kernel use the script name as mount point
    • Generating errors messages on stderr
    • The size of mount.stderr growing up

# Evasion detects the “DemoApp.app” was launched
# Injecting another set of files unsing backup
  – Restoring timezone directory
  – Replacing “DemoApp.app” binary by a symbolink link pointing to /
    • The kernel use the script name as mount point
    • The file system is successfully remounted in RW
Evasi0n
Stage 3: Injecting final payload

# Creating a directory at /var/evasi0n containing 4 files
  - launchd.conf.
    - List of subcommands to run via launchctl when launchd starts
      - Remounting the filesystem in RW
      - Loading amfi.dylib library
      - Executing the evasi0n binary
  - amfi.dylib
    - Loaded with DYLD_INSERT_LIBRARY
    - Contains only lazy bindings and no TEXT section
      - No TEXT/text section means that there is nothing to sign
      - Overriding MISValidateSignature in order to always return 0
      - Allowing unsigned code execution
  - Evasi0n Binary :
    - Executed with root privilege in the early boot environment.
      - Launches the kernel exploit
  - Udid
    - Contains the UDID of the current device
Hijacking Music iPhone Application instead of “DemoApp.app”
- Launched when connect the device is connected to a dock
- Handle Remote accessory protocol
- We can trigger the remount payload automatically
- The payload can be triggered by the alarm
Simulating user action

Original Schematic

iPown Schematic
Cliquez pour modifier le style des sous-titres du masque Demo
Wake up Neo! Your phone got pwd...

Scenario

Room 1 : Victim

Room 2 : Attacker
Wake up Neo! Your phone got pwd....

Demo
Conclusion
Conclusion

# Apple made the choice of user experience instead of security.
– It is possible to build up a malicious device in order to get both the data and the control of iDevices.

“When things get up close and personal, the rule is always better safe than sorry"

Don’t connect your device to an untrusted dock station
And what about iOS7?

- In iOS 7 Apple Fix this attack vector.
Thank you for Listening
Questions?

Jan0 @planetbeing @pod2g
@MuscleNerd @pimskeks @ih8sn0w @i0n1c
@p0sixninja @saurik @Comex

Thanks to all members of the jailbreak community for sharing their work and all of my friends who helped me to prepare this talk.

Don’t learn to hack but hack to learn!