
# Wi-Fi Advanced Stealth

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# Who Are We?

Network security “geeks” (?) in R&D labs

- Working for France Telecom - Orange (major telco)

Speakers at security-focused conferences

- ShmooCon, ToorCon, FIRST, Blackhat, Eurosec…

Wi-Fi security focused speakers ;-)

- “Wi-Fi Security: What’s Next” – ToorCon 2003
- “Design and Implementation of a Wireless IDS” – ToorCon 2004 and ShmooCon 2005
- “Wi-Fi Trickery, or How To Secure (?), Break (??) and Have Fun With Wi-Fi” – ShmooCon 2006

# 2006…

We released 3 new tools at ShmooCon 2006

- Raw Fake AP: an enhanced Fake AP tool using **RAW** injection for increased effectiveness
- Raw Glue AP: a Virtual AP catching every client in a virtual quarantine area
- Raw Covert: a tricky 802.11 covert channel using valid **ACK** frames

We introduced other tools at BlackHat US 2006

Tricks to “hide” access points and stations (madwifi patches)

- From scanners and wireless IDS

Raw Covert v2: new implementation (python) and features

All this stuff is available at

- http://rfakeap.tuxfamily.org

# 1

# Wi-Fi Stealth Tricks

# 802.11 Havoc!

Since a couple of years, some wireless drivers are much more “flexible” than Prism2/2.5/3 based…

- Full **RAW** injection capabilities (possible to modify some critical fields like fragmentation, sequence number, BSS Timestamp…)
  - Demonstrated by Raw Fake AP, Raw Glue AP and Raw Covert
- Tweaking the driver may also become attractive!

Such drivers are

- Madwifi-{old|ng} for Atheros chipsets
- Prism54.org for Prism54 chipsets
- Realtek…

New capabilities implies new risks to address…

- Especially for Wireless IDS vendors

# (Two Ways To) Achieve Stealth…

Possibilities are somewhat infinite…

- We decided to show only two ways that can be extended

Tweaks in 802.11 drivers to implement a new “proprietary” protocol over 802.11 bands

- Madwifi patches

Covert channel using 802.11 valid frames

- Raw Covert (as a proof-of-concept)

# 2
# Hiding Ourselves

# Quick Reminder

IEEE 802.11 standards define what 802.11 is

- At PHY and MAC layers
- Modulation, frequencies…
- State machine, frame fields…
- Security mechanisms

To be Wi-Fi compliant, every implementation must comply with the 802.11 standard and be certified by the Wi-Fi Alliance certification process

Usual stuff if you want to (officially) be interoperable…

# Main Idea

What would happen if you implement your own 802.11 stack?!

- Stations that probe for APs will (probably) not see you…
- Wireless sniffers will (probably) not understand you, requiring manual inspection…
- Wireless IDS will (probably) not detect you…

Quite stealthy, no?

What about your own (undetectable) personal AP?

- Sure the CSO won't appreciate ☺
- Sure wardrivers won't appreciate either (until now…)

# Implementation

Successfully tested on Atheros chipsets with a patched **`madwifi-ng`** driver

- Patched stations and access points will be able to see and associate themselves (they speak the same language)
- But non patched stations will not see patched access points, and thus cannot associate to them

Test bed

- Windows XP supplicant and NetStumbler
- Wireless Tools (**`iwlist`**) with
  - **`hostap`**, (unpatched) **`madwifi-ng`**, **`ipw2100`**, **`prism54`**

# Live Demonstration

First, we set up a “special” Access Point

- one laptop with a patched **`madwifi-ng`** in master mode

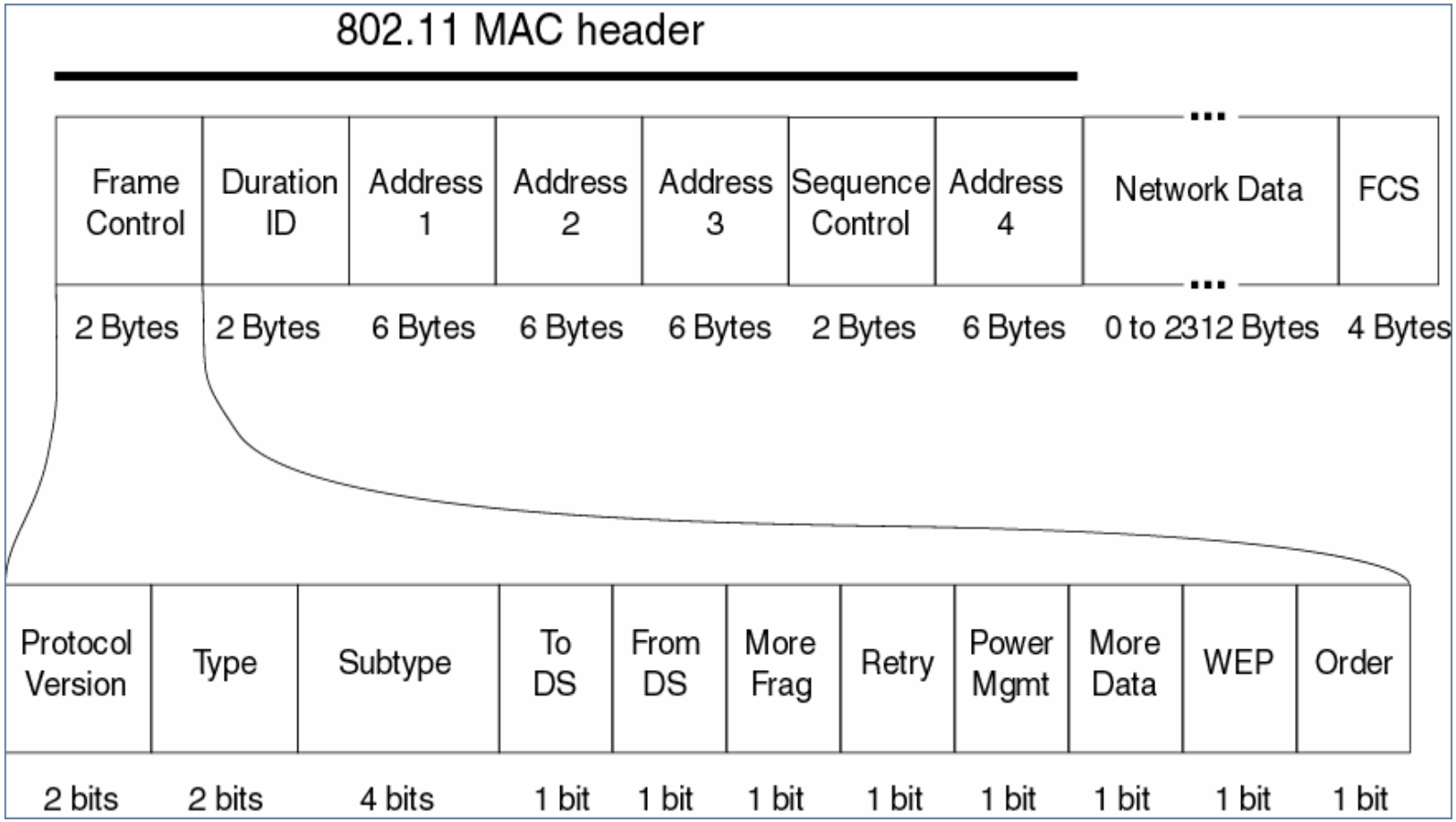
Then we scan for this AP with unpatched **`madwifi-ng`**

- **`iwlist`** (active scan facilities under *nix)
- Kismet (passive scanner under *nix)
- Netsumbler (active scanner under Windows)

Then, we use our “special” client (patched drivers)

- Tada… it works…

# Design Details



# WTF Is This? Trivial Tweaks!

- What about changing FC field? ;-)
- What about a protocol version of 1? ;-)
  - 802.11 is protocol version 0
- What about swapping types?
  - Management (value 0)
  - Control (value 1)
  - Data (value 2)
  - Reserved (value 3)
- What about swapping subtypes?
  - Is this a Probe Request or a Probe Response? ;-)

# Not So Trivial Tweaks

Everything is possible… Make your own MAC protocol

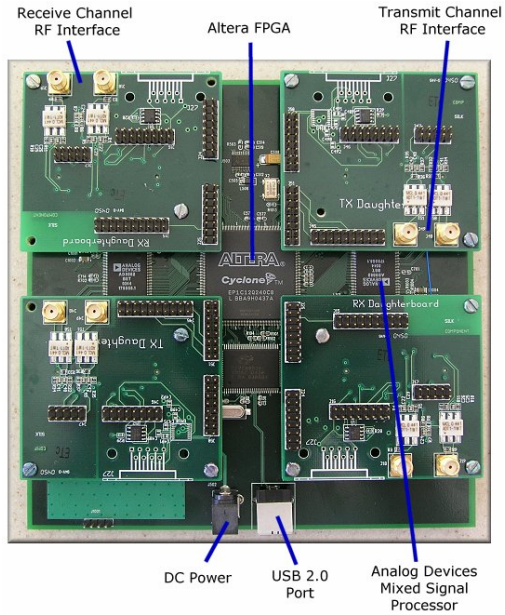
SoftMAC: A Flexible Wireless Research Platform

http://systems.cs.colorado.edu/projects/softmac

GNU Radio: The GNU Software Radio

http://www.gnu.org/software/gnuradio/

Universal Software Radio Peripheral (USRP)



# Proto Tweak (1<>0)

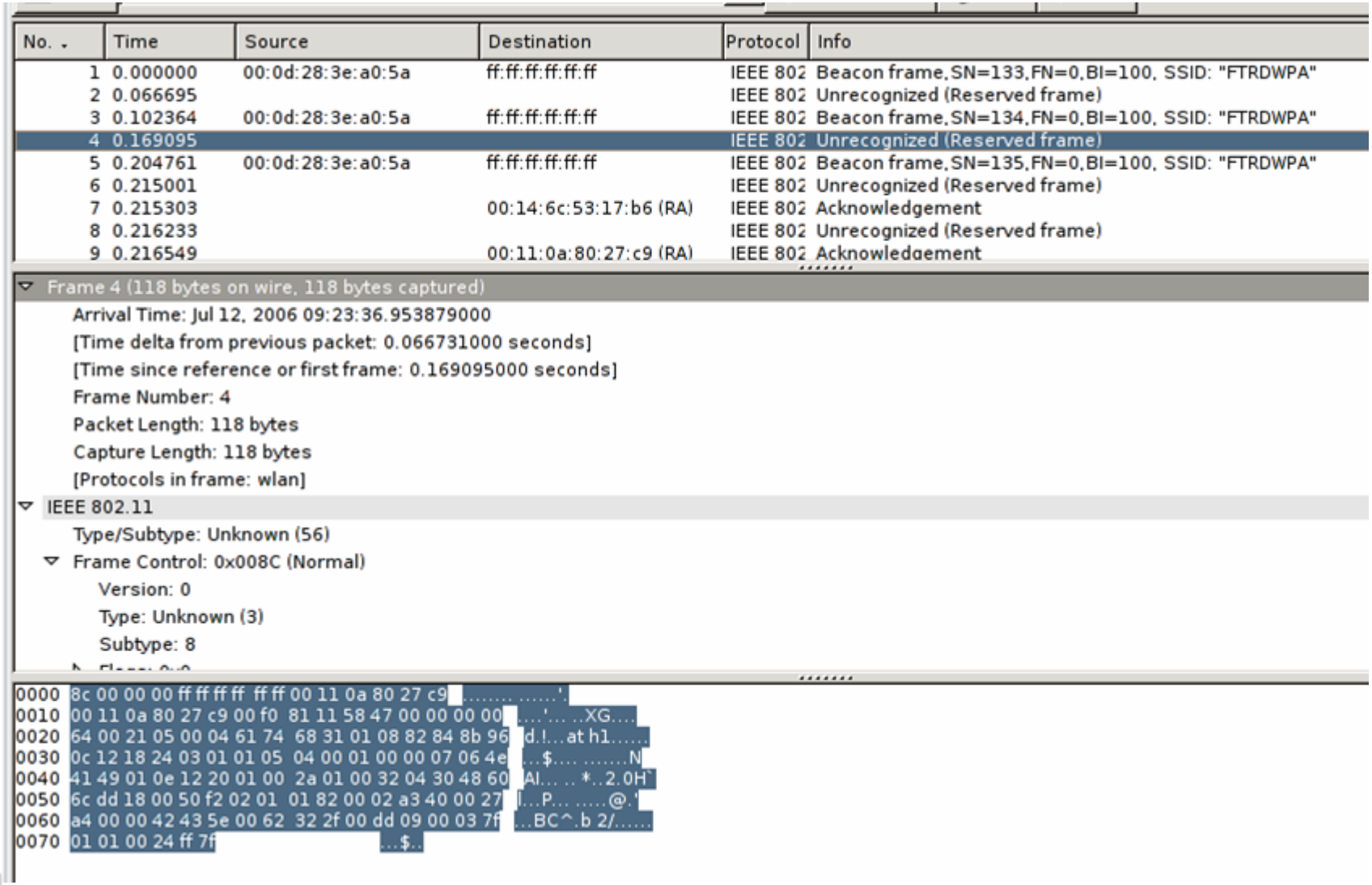
| Chipset | Driver | iwlist | Netstumbler |
|---|---|---|---|
| Prism54 | Prism54 1.2 | Not detected | Not tested |
| Prism2.5 | Hostap 0.4.4 | Not detected | Not tested |
| Atheros ar5212 | Madwifi-ng r1527 | Not detected | Not tested |
| Atheros ar5211 | 2.4.1.30 (win) | Not detected | Not detected |
| Centrino 2100 | Ipw2100 1.1.3 | Not detected | Not tested |
| Atheros | Madwifi-ng patched | OK ! | Not tested |

# About Kismet

Kismet runs in monitor mode

Will spot some of our patched Access Points
…it depends on the tweak
Depends also on firmware driver filtering in monitor mode

Or will report high « Discrd » packets number ☺


No. | Time | Source | Destination | Protocol | Info
1 0.000000 00:0d:28:3e:a0:5a ff:ff:ff:ff:ff:ff IEEE 802 Beacon frame, SN=133, FN=0, BI=100, SSID: "FTRDWPA"
2 0.066695 IEEE 802 Unrecognized (Reserved frame)
3 0.102364 00:0d:28:3e:a0:5a ff:ff:ff:ff:ff:ff IEEE 802 Beacon frame, SN=134, FN=0, BI=100, SSID: "FTRDWPA"
4 0.169095 IEEE 802 Unrecognized (Reserved frame)
5 0.204761 00:0d:28:3e:a0:5a ff:ff:ff:ff:ff:ff IEEE 802 Beacon frame, SN=135, FN=0, BI=100, SSID: "FTRDWPA"
6 0.215001 IEEE 802 Unrecognized (Reserved frame)
7 0.215303 00:14:6c:53:17:b6 (RA) IEEE 802 Acknowledgement
8 0.216233 IEEE 802 Unrecognized (Reserved frame)
9 0.216549 00:11:0a:80:27:c9 (RA) IEEE 802 Acknowledgement
Frame 4 (118 bytes on wire, 118 bytes captured)
Arrival Time: Jul 12, 2006 09:23:36.953879000
[Time delta from previous packet: 0.066731000 seconds]
[Time since reference or first frame: 0.169095000 seconds]
Frame Number: 4
Packet Length: 118 bytes
Capture Length: 118 bytes
[Protocols in frame: wlan]
IEEE 802.11
Type/Subtype: Unknown (56)
Frame Control: 0x008C (Normal)
Version: 0
Type: Unknown (3)
Subtype: 8
0000 8c 00 00 00 ff ff ff ff ff ff 00 11 0a 80 27 c9
0010 00 11 0a 80 27 c9 00 f0 81 11 58 47 00 00 00 00
0020 64 00 21 05 00 04 61 74 68 31 01 08 82 84 8b 96
0030 0c 12 18 24 03 01 01 05 04 00 01 00 00 07 06 4e
0040 41 49 01 0e 12 20 01 00 2a 01 00 32 04 30 48 60
0050 6c dd 18 00 50 f2 02 01 01 82 00 02 a3 40 00 27
0060 a4 00 00 42 43 5e 00 62 32 2f 00 dd 09 00 03 7f
0070 01 01 00 24 ff 7f

# 3
# Raw Covert

# Raw Covert (1/4)

Covert channel

- In information theory, a covert channel is a communications channel that does a writing-between-the-lines form of communication.
- Source: Wikipedia, the free encyclopedia

Writing between-the-lines

- Use valid frames to carry additional information
- Valid frames could be management, control or data frames

This tool is ‘only’ an example! Possibilities are infinite!

# Raw Covert (2/4)

With 802.11, this may be performed by many means

- Using a proprietary protocol within valid or invalid frames
- It gives infinite possibilities thanks to **RAW** injection

(Some) 802.11 frames are not considered as ‘malicious’

- Control frames like **ACK** are lightweight and non suspicious!
  - Frame control (16 bits)
  - Duration Field (16 bits)
  - Receiver Address (48 bits)
- (Usually) not analyzed by wireless IDS
  - No source nor BSSID addresses ;-) only a receiver@!

(Some) 802.11 drivers do not give back **ACK** frames in monitor mode (operated in the firmware: e.g. HostAP)

- Increasing stealthyness

# Raw Covert (3/4)

How it works?

- A client encodes the information and sends **ACKs** over the air
- A server listens for **ACKs** and tries to decode the information

Basically, it uses a magic number in receiver address

- 2 bytes

Basically, it encodes the covert channel in receiver address

- E.g. 4 bytes

Several **ACK** frames are needed to send information

# Raw Covert (4/4)

Issues

- **ACK** frames can be missed, wireless is not a reliable medium! ;-)
- Detection may be performed (only) with anomaly detection

Enhancements

- Basic remote shell and file transfer
- Tun/tap interface → DONE

Possible enhancements for the covert channel

- Using invalid frames
- Using Information Elements in 802.11 frames (but could be easily detected)
- Using existing communications (clients and access points)

# Raw Covert Enhancements (1/2)

Invalid frames (in the 802.11 sense, i.e. proprietary frames)

- But would (?) be detected by any wireless IDS performing sanity check on every frame

FCS invalid frames

- Should require driver/firmware modifications to inject bad FCS
- Wireless IDSs do not analyze such bad frames
- But should be detected with FCSerr statistics (even if harder to diagnose as a covert channel)

# Raw Covert Enhancements (2/2)

Invalid FCS monitoring

Usually a bit is set by the firmware when a FCS is invalid

Most drivers discard packets with bad FCS thanks to this information

- **`HAL_RXERR_CRC`** for madwifi
- **`rfmon_header->flags & 0x01`** for prism54

HostAP driver has a facility

- **`prism2_param interface monitor_allow_fcserr 1`**

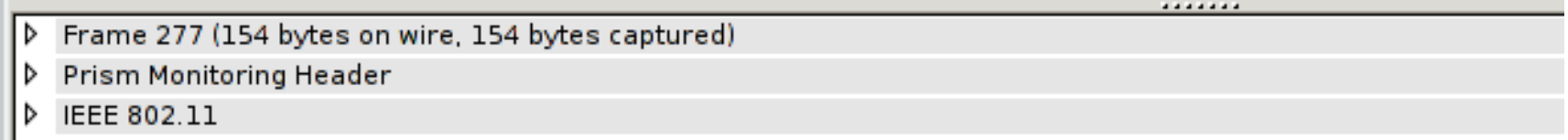
# Live Demonstration

Live demo!

Did you detect it? ;-)

Filter: wlan.fc.type_subtype == 29 | Expression... | Clear

| No. | Time | Source | Destination | Protocol | Info |
|---|---|---|---|---|---|
| 277 | 13.729472 | | 01:02:00:2a:00:00 (RA) | IEEE 802 | Acknowledgement |
| 281 | 13.729844 | | 03:04:ff:ff:ff:ff (RA) | IEEE 802 | Acknowledgement |
| 283 | 13.730136 | | 03:04:ff:ff:ba:c2 (RA) | IEEE 802 | Acknowledgement |
| 285 | 13.730345 | | 03:04:70:cc:18:de (RA) | IEEE 802 | Acknowledgement |
| 287 | 13.730552 | | 03:04:08:06:00:01 (RA) | IEEE 802 | Acknowledgement |
| 289 | 13.730861 | | 03:04:08:00:06:04 (RA) | IEEE 802 | Acknowledgement |
| 291 | 13.731171 | | 03:04:00:01:ba:c2 (RA) | IEEE 802 | Acknowledgement |
| 293 | 13.731481 | | 03:04:70:cc:18:de (RA) | IEEE 802 | Acknowledgement |
| 295 | 13.731789 | | 03:04:01:01:01:01 (RA) | IEEE 802 | Acknowledgement |
| 296 | 13.732100 | | 03:04:00:00:00:00 (RA) | IEEE 802 | Acknowledgement |
| 297 | 13.732410 | | 03:04:00:00:01:01 (RA) | IEEE 802 | Acknowledgement |
| 298 | 13.732864 | | 03:04:01:02:00:00 (RA) | IEEE 802 | Acknowledgement |
| 300 | 13.734388 | | 05:06:00:00:00:00 (RA) | IEEE 802 | Acknowledgement |
| 324 | 14.761486 | | 01:02:00:2a:00:00 (RA) | IEEE 802 | Acknowledgement |
| 327 | 14.761964 | | 03:04:ff:ff:ff:ff (RA) | IEEE 802 | Acknowledgement |
| 329 | 14.762225 | | 03:04:ff:ff:ba:c2 (RA) | IEEE 802 | Acknowledgement |
| 331 | 14.762546 | | 03:04:70:cc:18:de (RA) | IEEE 802 | Acknowledgement |
| 333 | 14.762863 | | 03:04:08:06:00:01 (RA) | IEEE 802 | Acknowledgement |



# 4

# 802.11 Fuzzing

# Fuzzing Concepts (1/2)

## Fuzzing

Fuzz testing is a software testing technique. The basic idea is to attach the inputs of a program to a source of random data. If the program fails (for example, by crashing, or by failing built-in code assertions), then there are defects to correct.

*From Wikipedia, the free encyclopedia*

# Fuzzing Concepts (2/2)

Fuzzing is not something really new…

Remember ISIC?

- http://www.packetfactory.net/projects/ISIC/

But it is still of interest…

Recent work on Bluetooth Fuzzing (Pierre Betouin)

- http://www.secuobs.com/bss-0.6.tar.gz

Fuzzing with Scapy… (Phil Biondi)

- Plenty of cool things to do with scapy…

# Fuzzing 802.11

IEEE 802.11 amendments are more and more numerous

802.11e, 802.11i, 802.11k, 802.11r, 802.11s, 802.11w…

Axiom

Complexity ➔ more code ➔ more bugs ➔ more vulnerabilities

Guess what? IEEE 802.11 may be susceptible to fuzzing!

# Fuzzing 802.11

Not so trivial… keep in mind the 802.11 state machine

Each step of the 802.11 protocol may be fuzzed

- Scanning process: probe requests and responses, beacons
- Authentication process: authentication requests and responses
- (Re-)Association process: (re-)association requests and responses

Station's associated state can be fuzzed only if

- Station is in state « Authenticated, Not Associated »
- (Optionally) There was an (re-)association request sent by the station to the access point were he was previously authenticated

# Fuzzing 802.11

- Easiest part: fuzzing clients thanks to probe responses and beacons
  - Listen for probe requests and send back appropriate probe response
- Fuzzing probe responses and beacons
  - Inconsistent Information Elements (Type Length Value)
    - E.g. a SSID Information Element with a length above 32 bytes
    - E.g. a short 802.11 frame (incomplete SSID IE)
  - Incomplete frame length…

# Fuzzing 802.11

Seems to be quite a hot topic (much renewed interest)

- Apple patches
- Centrino patches

David Maynor / Johnny Cache blackhat talk last august…

They released « Fuzz-E »…

More on this soon…



# Thanks for your attention

*Tools, patches available at*

http://rfakeap.tuxfamily.org

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# References


Laurent Oudot's **wknock**

http://www.rstack.org/oudot/wknock/

Pierre Betouin's **Bluetooth Stack Smasher**

http://www.secuobs.com/bss-0.6.tar.gz

**scapy** (Phil Biondi)

http://www.secdev.org

SoftMAC: A Flexible Wireless Research Platform

http://systems.cs.colorado.edu/projects/softmac

MadWiFi patches and rawcovert

http://rfakeap.tuxfamily.org