Attacking WiFi networks with traffic injection

Why open and WEP 802.11 networks really suck

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Agenda

1. Introduction
2. Really quick WiFi 101
   - WiFi injection basics
3. Attacking WiFi networks
   - Where's the police - Managing management traffic
   - Breaking the shell - WEP cracking
   - All naked - Attacking stations
   - Let me free - Bypassing captive portals
4. WPA, WPA2 and 802.11i
5. Conclusion
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Introduction

This talk is yet another "people never learn" story

Goals

- WEP is one of the weakest security protocol on earth
- WEP is still widely deployed
- Open WiFi networks can be found almost anywhere

Things have to change...

Introduction

Of 802.11 traffic injection

Traffic injection is making things even worse

- Increases DoS capabilities
- Dramaticly increases WEP cracking capabilities
- Allows traffic tampering
- Allows stations specific attacks

Because attacks considered as theoritical are now practical

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802.11 keypoints

802.11[IEEE99] is an IEEE wireless communication standard
It's known as WiFi and is pushed by WiFi Alliance[WIFI] lobby

- CSMA/CA based
- Infrastructure vs. Ad-hoc
- Distribution System (DS)
- Management vs. data traffic
- Concept of association/authentication

802.11 security

Available security schemes are

- ESSID cloacking
- MAC address filtering
- Stations isolation
- WEP (Wired Equivalent Privacy[1])
- WPA (WiFi Protected Access)
- 802.11i/WPA2

The first 4 are weak and/or useless

[1] No, it does not stand for Weak Encryption Protocol :)

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Arbitrary frames injection

Very common for wired adapter, not for WiFi

- Need appropriate adapter/firmware
- Need appropriate driver
- 802.11 aware library makes things easier

Existing drivers/libs/tools[AIRJ] mostly focused on management traffic

Toolkit

Proper adapter and driver for monitor mode raw injection

- Hostap[HAP] (patched)
- Wlan-ng[WLAN] (patched)
- Atheros/Madwifi[MADW] (patched)
- Intersil Prism54[PR54] (SVN+patch)
- Some others...

Atheros is (imho) currently the best chipset

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Disclaimer :)

All materials described in this talk are for educational and demonstration purposes only.

DO NOT USE THEM ON OTHERS' NETWORKS WITHOUT THEIR AUTHORIZATION

You could break the law and face prosecution...

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Management traffic

Tampering

Completely unprotected regulation traffic...
You alter DS current state by tampering management traffic

- Reject association requests
- Inject disassociation frame
- Inject fake associations
- Wake up devices in sleep mode
- Etc.

Lot of DoSes...

Management traffic

Injection

Management traffic is easy to generate and inject

See Scapy[SCAP] packets classes :

- Dot11
- Dot11Disas
- Dot11AssoResp
- Dot11ReassoResp
- Dot11Deauth
- etc.

See Scapy in action[BIO04]

Management traffic

Rogue APs (1/2)

Full management traffic support

- Beacon frames emission
- Answers to assoc/auth requests
- Management traffic handling
- Forwarding data frames

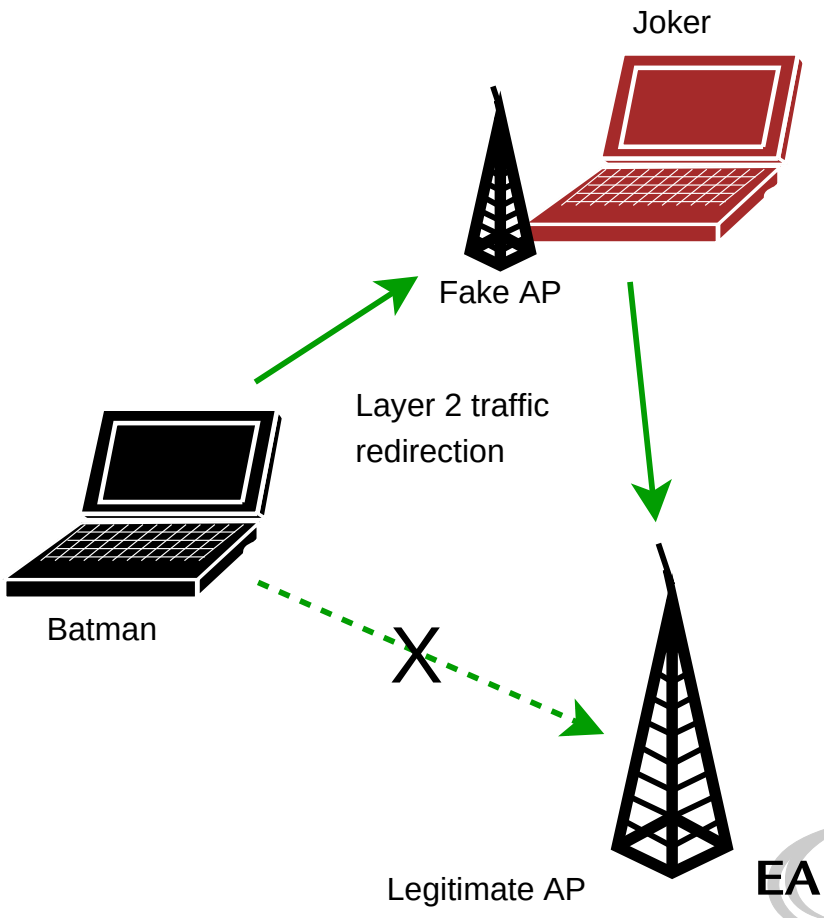
Management traffic

Rogue AP (2/2)

If you can be an AP, you can fake one...

- Cheap solution for low level traffic redirection
- Cool attacks against automatic "WiFi network managers" [KARM]

Rogue AP is the "poor man" attack that works so well



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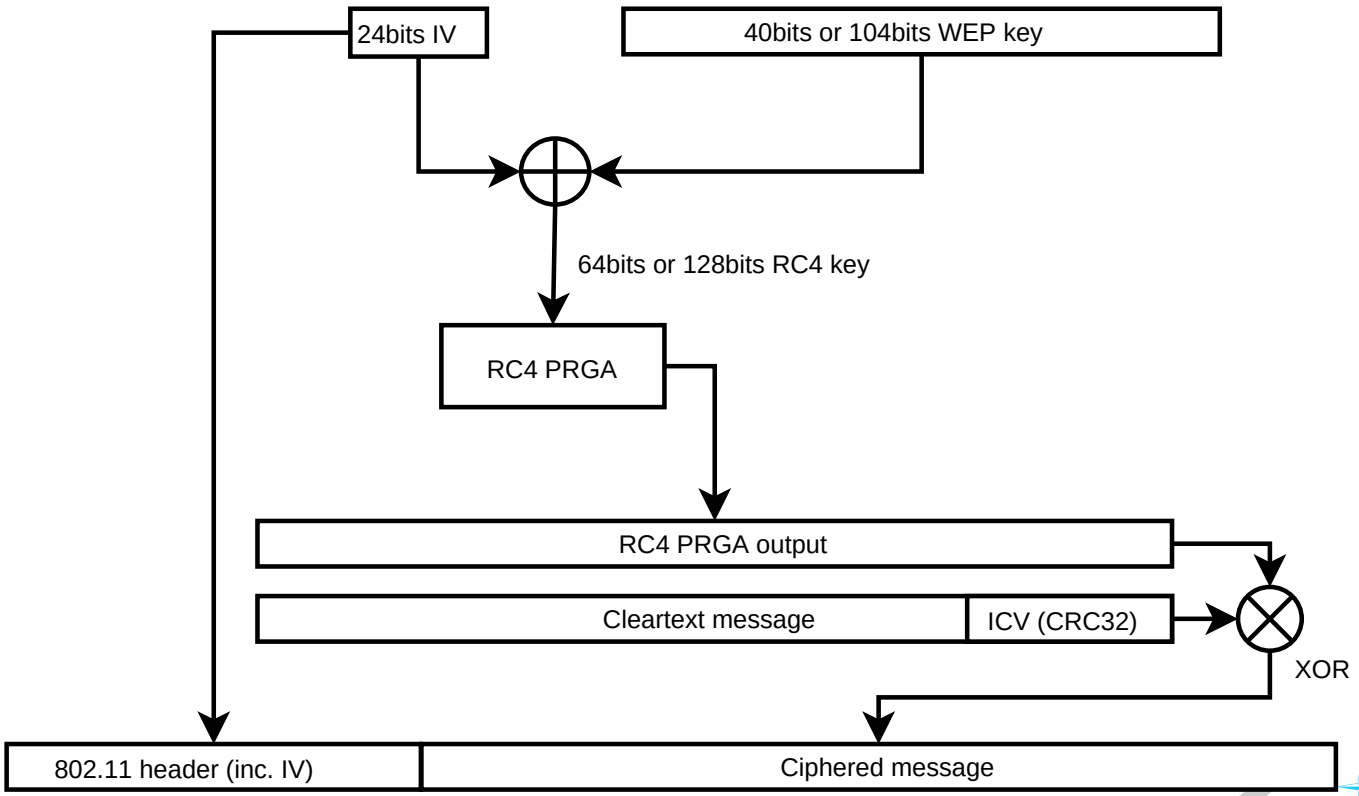
WEP cracking

WEP basics

- RC4 cipher
- Auth with RC4
- CRC32 ICV



WEP cracking

Attacks overview

Many flaws that can raise attacks possibilities

- IV collisions
- (Almost) Arbitrary frame injection
- Cleartext attacks (e.g. authentication challenge) and authentication bypass
- PRGA[2] output/IV couple table construction
- Fluhrer, Mantin and Shamir attack (weak IVs attack)
- Korek optimization of FMS attack based on solved cases
- Korek Chopchop attack

PRGA output/IV and FMS attacks need traffic gathering

[2] Pseudo Random Generation Algorithm

WEP cracking

IV collisions

First WiFi (in)security paper published in 2000[WAL00]

- Key space is 2^{24} whatever WEP key length
- More than 99% IV collision after only 12000 frames

Let C and C' two cleartexts ciphered using the same key K

Key collision info extraction

$$\begin{aligned} P &= C \oplus RC4(IV \parallel K) \\ P' &= C' \oplus RC4(IV \parallel K) \\ &\Rightarrow P \oplus P' = C \oplus C' \end{aligned}$$

RC4 weak keys problem mentionned[RW95]

WEP cracking

Cleartext attack

WEP authentication is vulnerable to cleartext attack
Let C be a cleartext challenge.

PRGA extraction

$$\begin{aligned} P &= WEP(C \parallel ICV(C)) \\ &= (C \parallel ICV(C)) \oplus RC4(IV \parallel K) \\ \Rightarrow &\quad RC4(IV \parallel K) = P \oplus (C \parallel ICV(C)) \end{aligned}$$

Payload header is 8 bytes, C is 128 bytes and ICV(C) is 4 bytes
So we can grab 140 bytes of PRGA output for given IV

Authentication bypass

"Your 802.11 Wireless Network Has No Clothes" [ASW01]

Challenge answer computation

$$P' = (C' \parallel ICV(C')) \oplus RC4(IV \parallel K)$$

Once one authentication is captured, we can compute any further answer P' to challenge C' using known PRGA output

PRGA output/IV tables

For every IV, grab PRGA output

- We know how to grab 140 bytes of PRGA output
- We can generate traffic with known PRGA output (e.g. GET / HTTP/1.0)
- We can have traffic generated and grab longer PRGA output (e.g. HTTP reply)

We can end up with a huge PRGA output/IV table (≈25GB) allowing one to decrypt any packet on the air
We can boost this attack playing with disassociations :)

WEP cracking

Modified frame injection

Let C be our cleartext message and C' a modification of C
Let $Mod = C \oplus C'$

Arbitrary message constant length modification

$$\begin{aligned} P &= WEP(C \parallel ICV(C)) \\ &= (C \parallel ICV(C)) \oplus RC4(IV \parallel K) \\ P' &= (C' \parallel ICV(C')) \oplus RC4(IV \parallel K) \\ &= (C \parallel ICV(C)) \oplus RC4(IV \parallel K) \oplus (Mod \parallel ICV(Mod)) \\ &= P \oplus (Mod \parallel ICV(Mod)) \end{aligned}$$

This means you can inject arbitrary layer 2 consistent WEP frames and have them decrypted...

WEP cracking

Arbitrary injection consequences

We can inject arbitrary 802.11 consistent traffic through WEP without key knowledge

- Launch oracle based attacks
- Stimulate network in order to create traffic

WEP cracking

Fluhrer, Mantin and Shamir attack

Article "Weaknesses in the Key Scheduling Algorithm of RC4"[FMS01], based on Roos and Wagner work

- Weak key = info about internal RC4 state
- Weak key + known first bytes of stream = info about K

So, what do we have ?

- RC4 key is IV|| K and IV is known
- C is a 802.11 frame, so we can guess first bytes

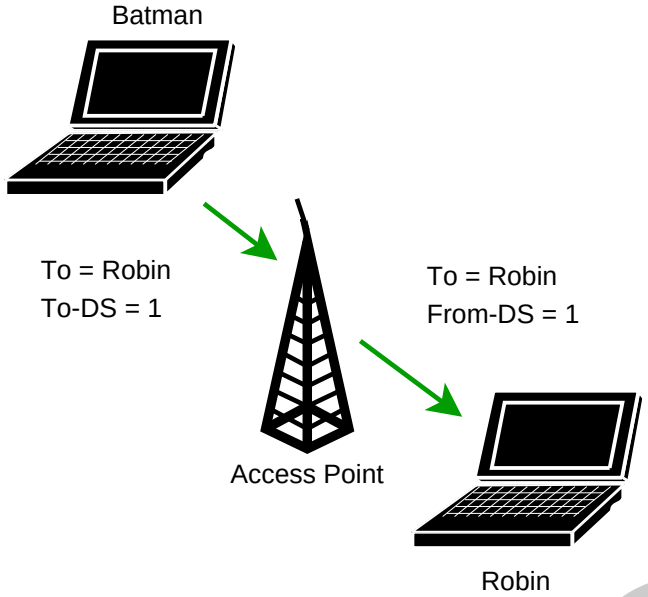
We have "known weak IVs" that provide informations about K and lead to an effective attack against WEP
Korek added other "solved cases"[KO04a]

WEP cracking

Korek Chopchop attack

Arbaugh first published an inductive attack againt WEP[ARB01]
Korek published a similar (reversed) inductive attack[KO04b] with a PoC called Chopchop

1. Grab a multicast/broadcast frame
2. Strip the last data byte
3. Guess last byte cleartext value
4. Correct frame ICV and reinject
5. See if AP forwards the new frame



Extremely effective on ARP traffic (10-20s per packet).

WEP cracking

Devine aircrack/aireplay WEP cracking

Using FMS and Korek optimizations, Christophe Devine released aircrack and aireplay[AIRC]

1. Capture an ARP request, optionnaly decrypted with Chopchop
2. Inject ARP request again and again
3. Stimulate traffic and collect unique IV
4. Crack WEP key with optimized FMS

Full WEP cracking is now a matter of minutes (movie[WWEP])
And aircrack can be optimized...

WEP cracking

So WEP is weak, but still in France...

Recent poll on french Linux dedicated portal

- 18% have no security at all
- 20% rely MAC filtering and/or SSID cloaking only
- 41% use WEP (64 or 128)
- 21% use WPA (PSK or EAP)

A recent study in business area "La Défense" (Paris) show 66% of wardrivable non-hotspot accesses are not protected...

WEP cracking

And in the US ?

Wardriving running Kismet from Chicago downtown to far suburbs (30 miles) : 1114 APs found

- 428 open networks (38%)
- 638 WEP networks (57%)
- 48 networks announcing WPA and/or WPA2 capabilities (5%)

No comment...

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Attacking stations

What about associated stations ?

Associated stations are almost naked

- LAN attacks (ARP, DHCP, DNS, etc.)
- Traffic interception and tampering
- Direct station attacks

Think of personal firewalls exception for local network...

Attacking stations

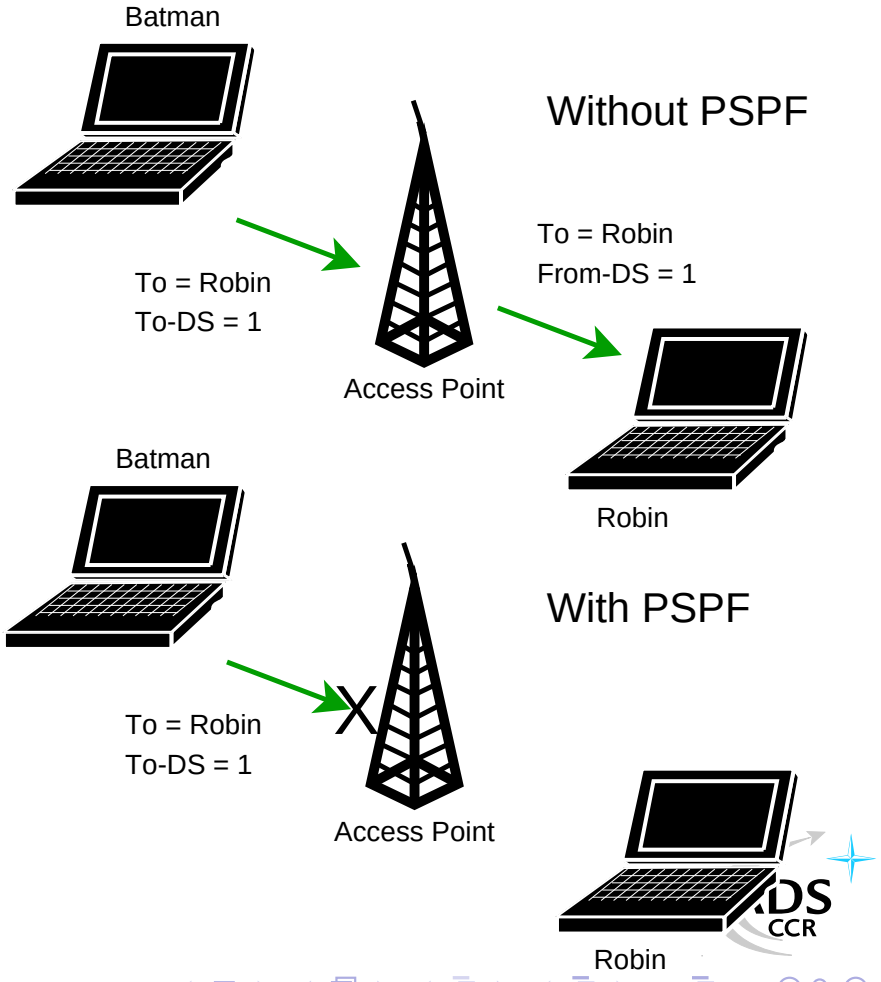
Station to station traffic prevention (isolation)

Security feature that blocks traffic within DS (e.g. Cisco PSPF)

- Station sends To-DS frame
- AP sees it's destinated to DS
- AP drops the frame

No From-DS frame, so no communication[a] : stations can't talk to each other...

[a] Does not work between 2 APs linked via wired network



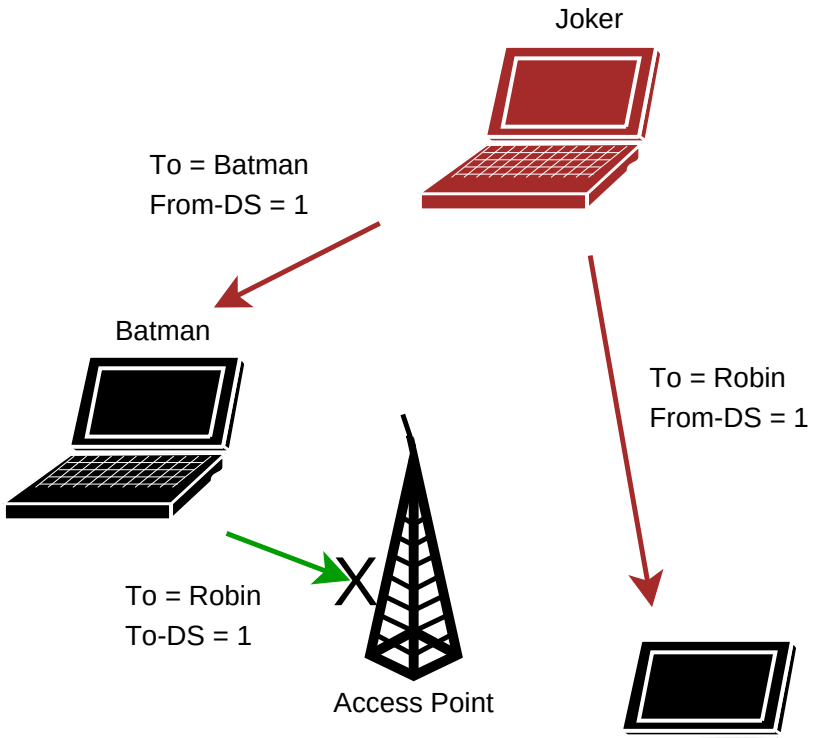
Attacking stations

Isolation bypass with injection

Joker can inject From-DS frames directly

- No need for AP benediction
- You can spoof about anyone
- You're still able to sniff traffic

Traffic injection allows complete isolation bypass



Attacking stations

Traffic tampering with injection

WiFi communication are just opened on the air

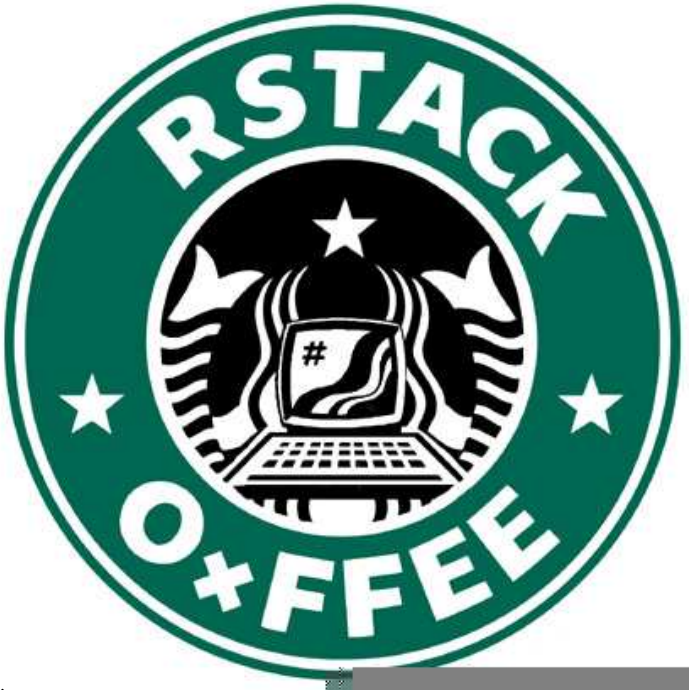
- Listen to WiFi traffic
- Match interesting requests
- Spoof the AP and inject your own answers
- Clap clap, you've done airpwn-like[AIRP] tool

Only think of injecting nasty stuff in HTTP traffic, just in case someone would dare to use MSIE on an open WLAN

Tampering traffic

Quick demo...

We Proudly R3wt



Download Wifiping/Wifidns at
`http://sid.rstack.org/index.php/Wifitap_EN`

Attacking stations

Full communication with injection

Sending traffic directly to stations without AP authorization

- Allows station to station communication
- Allows communicating if AP is out of reach
- Allows communication if AP refuses association

A smart way for talking to stations without being associated

Attacking stations

Proof of concept : Wifitap

Needed a PoC for PSPF-like systems bypass and wrote Wifitap

- Written in Python[PYTH]
- Relies on Scpay[SCAP]
- Uses tuntap device and OS IP stack
- Use WiFi frame injection and sniffing

Wifitap allows communication with station despite of AP restrictions

Attacking stations

Wifitap in short

How Wifitap works

Sending traffic

- Read ethernet from tuntap
- Add 802.11 headers
- Add BSSID, From-DS and WEP
- Inject frame over WiFi

Receiving traffic

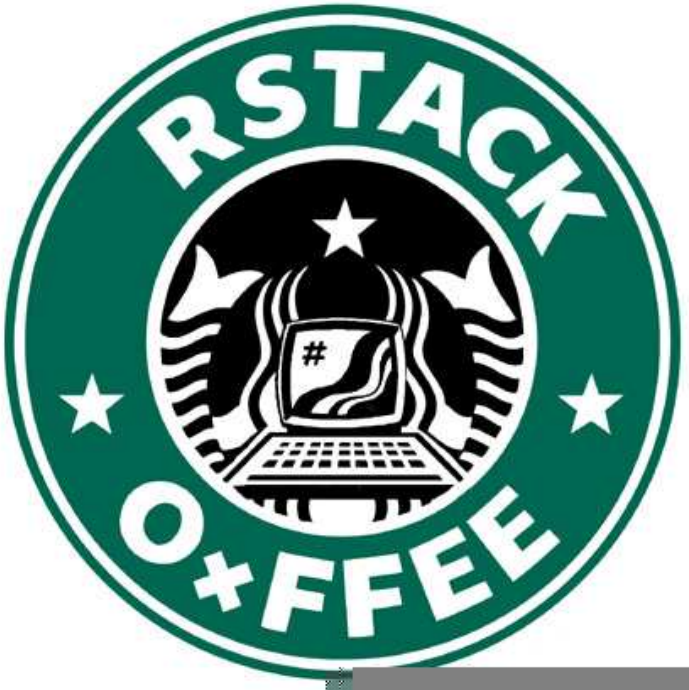
- Sniff 802.11 from BSSID
- Remove WEP layer if needed
- Remove 802.11 headers
- Send ethernet through tuntap

Attacker does not need to be associated

Attacking stations

Quick demo...

We Proudly R3wt



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Bypassing captive portals

Commercial WiFi hospots

Commercial public Internet access

- Captive portal based system
- Authentication to billing system through web portal
- Authorization for Internet access
- Authorization tracking based on MAC and/or IP

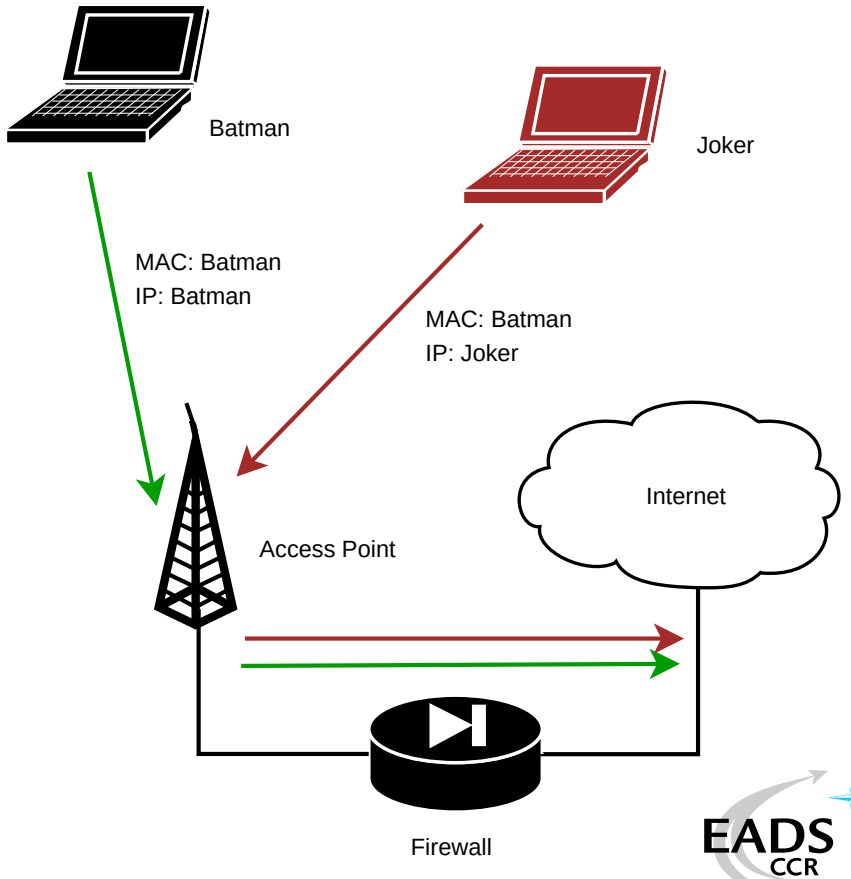
It would be nice to be free... For free !

Bypassing captive portals

MAC based authorization tracking

Authorized clients are identified by their MAC address

- MAC address is easy to spoof
- No MAC layer conflict on WiFi network
- Just need a different IP



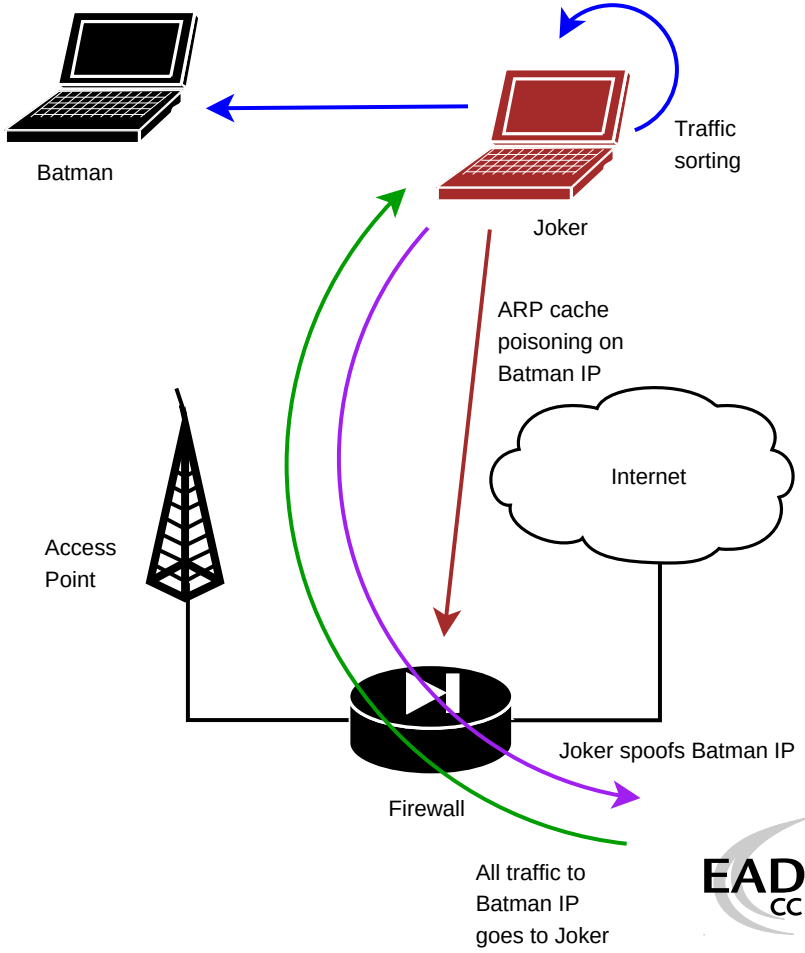
Bypassing captive portals

IP based authorization tracking

Authorized clients are identified by their IP address

- IP address are just a little more tricky to spoof
- ARP cache poisoning helps redirecting traffic
- Traffic redirection allows IP spoofing

See my LSM 2002 talk[BLA02], arp-sk website[ARPS] or MISC3[MISC]

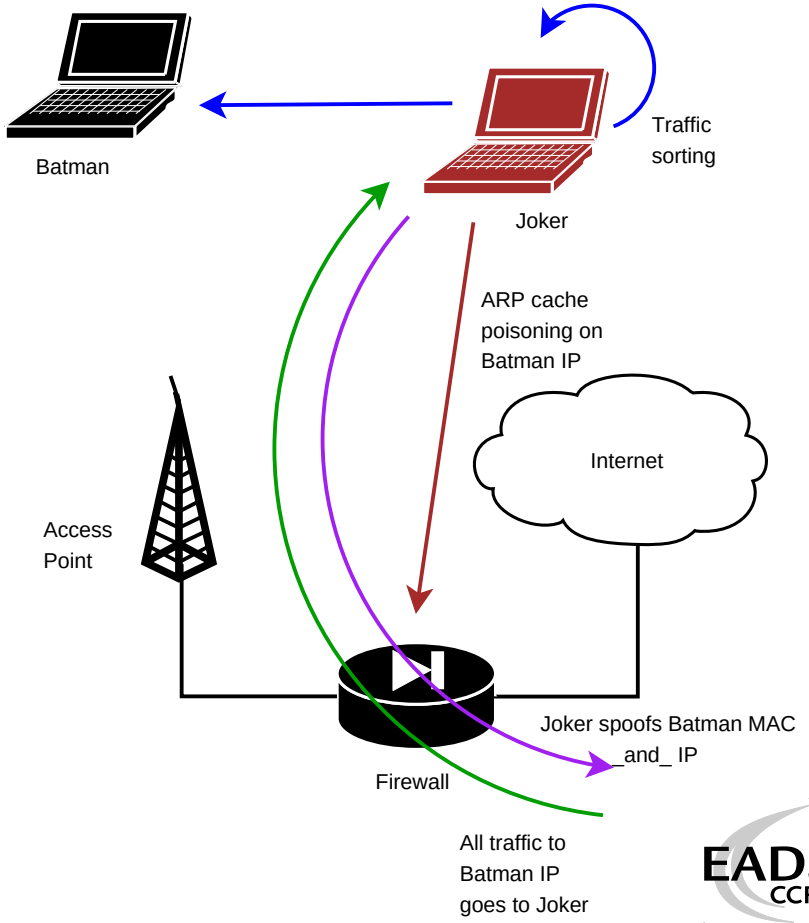


Bypassing captive portals

MAC+IP addresses based authorization tracking

The smart way for tracking people ?

- Previous technic won't help because of MAC address checking
- Send traffic with spoofed MAC address
- ARP cache poisoning and IP spoofing
- Hint : IP layer and MAC layer don't care much about each other



Bypassing captive portals

Hotspots with stations isolation

Some hotspots implement isolation in order to prevent clients from attacking each other

- Does not protect against "session" hijacking[3]
- Attacker eventually take over victim's session
- Victim does not have access anymore, and still pays for it

And among all, isolation is pretty useless...

[3] Side effect : tools like arpspoof won't work

Bypassing captive portals

Hotspot with stations isolation bypassing...

Hijacking people authorization is not very kind

- Use Wifitap to bypass isolation
- Now you can send your poor victim his traffic back

Your victim and you are both able to surf transparently

Now, you "can be a true gentlemanly [h|cr]acker" [ISCD] ;)

Bypassing captive portals

Additional tricks

Things that can be tested

- HTTP proxy left open on gateway
- ESTABLISHED,RELATED -j ACCEPT prevents connections drop when authorization expires on Linux based systems
- Administration network on the same VLAN, accessible through WiFi
- Man in the Middle to relay authentication (Fake AP, ARP MiM)
- DNS based communication[OZY] or tunneling[NSTX]

Misconfigurations tend to be less and less common
Nevertheless, traffic redirection and DNS stuff work :)

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WPA

Transitional recommandation[WPA] from WiFi Alliance (2003) extracted from IEEE work for infrastructure networks only

- New authentication scheme based on PSK or 802.1x
- New key generation and scheduling scheme for keys
- New integrity check through SHA1 based MIC with sequencing

Pretty solid solution that can prevent injection/replay

WPA2 and 802.11i

802.11i[IEEE04b] is a standard from IEEE for WiFi security
WPA2[WPA2] is a recommandation from WiFi Alliance based on 802.11i

- RSN[4] concept : security algorithms negociation
- Integrates Ad-Hoc security
- Authentication using 802.1x
- Ciphering using AES-CCMP
- Integrity check using CCMP MIC

Return to the roots and use of a real adapted ciphering solution

[4] Robust Security Network

WPA/WPA2 using Free Software

Building WPA/WPA2 aware network with free software

Client side

- wpa_supplicant[WPAS]
- WPA/WPA2/RSN supplicant
- Linux, BSD and... Win32 :)

SoftAP side

- hostapd[HAPD]
- WPA/WPA2/RSN and 802.1x[IEEE04a] authenticator
- Linux, BSD

WPA/WPA2

Some flaws already ?

Yet some flaws have been discovered regarding WPA/WPA2 security

- WPA weak PSK (<20 chars) bruteforce[MOS03] (movie[WWPA])
- Injection of spoofed first handshake message leads to memory exhaustion[HM04] (DOS)
- TEK attack in 2^{105} instead of 2^{128} (requires key knowledge)[MRH04]
- Counter-measures abuse (DOS) : traffic replay, dumb traffic injection

Moreover, nothing will ever protect from layer 1 based DoS attacks (bandwidth reservation, jamming)

So what ?

Although some flaws, WPA provides strong mechanisms for end users

- Good authentication mechanisms if properly used
- Real session management
- Session key management and re-keying
- Real integrity check
- Anti-replay, anti-injection mechanisms

WPA2 is even better.

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Conclusion

What we can see

- Lots of ISPs provide wireless/router/modem boxes with WEP support only
- Many WiFi compliant devices only support WEP (PSP, Zaurus, etc.) out of the box
- Most commercial hotspots are still open networks...

Conclusion

What we should see

WiFi environnement are highly insecure and tough to secure
You just can't cope with amateur style protection...

Then...

- Don't use WEP anymore, it "has no clothes" at all
- Don't use open networks for public access, use WPA/WPA2[a]
- Migrate to WPA, then WPA2 as soon as possible

[a] BTW, RADIUS is far better for AAA

Vendors, journalists, etc. : stop telling people WEP is OK
Manufacturers : provide WPA/WPA2 support out of the box
Maybe ending WEP support would be a good idea...

Thank you for your attention

Greetings to...

- EADS CCR/DCR/SSI team
- **Rstack.org** team
  http://www.rstack.org/
- **MISC Magazine**
  http://www.miscmag.com/
- **French Honeynet Project**
  http://www.frenchhoneynet.org/

Download theses slides from http://sid.rstack.org/

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