Welcome to

6. Wifi Security

Communication and Network Security 2020

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Slides are available as PDF, kramse@Github

6-Wifi-Security.tex in the repo security-courses

Goals for today

Todays goals:

- Introduce wireless networks
- Present the common security standards, and some tools used
- Discuss how to secure wireless best, infrastructure and/or encryption

Photo by Thomas Galler on Unsplash

Plan for today

Subjects

- Wifi standarder IEEE 802.11
- Authentication Protocols RADIUS, PAP, CHAP, EAP
- Port Based Network Access Control IEEE 802.1x
- Security problems in wireless protocols
- Security problems in wireless encryption
- Hacking wireless networks

Exercises

- Wifi scanning, aka wardriving
- WPA hacking with a short password

Time schedule

- 17:00 - 18:15
  Introduction and basics
- 30min break
- 18:45 - 19:30
- 15min break
- 19:45 -20:30 45min

Reading Summary

PPA chapter 12, 13 - 60 pages
Skim:
`http://aircrack-ng.org/doku.php?id=cracking_wpa`

Reading Summary, continued

PPA chapter 12: Packet Analysis for Security

- Reconnaissance An attacker's first step
- SYN Scan and fingerprinting
- Traffic Manipulation ARP Cache Poisoning / spoofing
- Analyzing traffic from malware, exploit kits and ransomware

Reading Summary, continued

PPA chapter 13: Wireless Packet Analysis

- Sniffing channels
- Wireless card modes, Managed, Ad-hoc and Monitor mode
- 802.11 packet structure
- Wireless security

Wifi standarder IEEE 802.11

802.11 er arbejdsgruppen under IEEE

De mest kendte standarder idag indenfor trådløse teknologier:

- 802.11b 11Mbps versionen
- 802.11g 54Mbps versionen
- 802.11n endnu hurtigere
- 802.11i Security enhancements Robust Security Network RSN

New names soon:
Wi-Fi 6 to identify devices that support 802.11ax technology
Wi-Fi 5 to identify devices that support 802.11ac technology
Wi-Fi 4 to identify devices that support 802.11n technology

Kilde: `http://grouper.ieee.org/groups/802/11/index.html`

802.11 modes og frekvenser

Access point kører typisk i *access point mode* også kaldet infrastructure mode
- al trafik går via AP, mest typiske

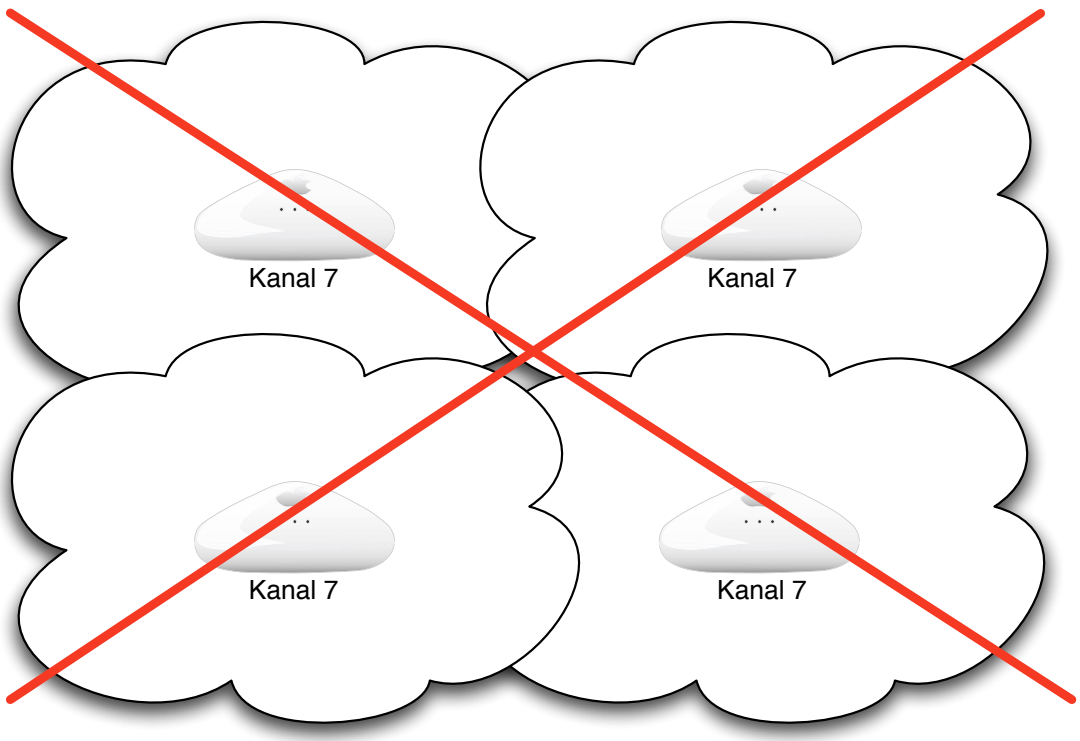
Alternativt kan wireless kort oprette ad-hoc netværk
- hvor trafikken går direkte mellem netkort

Frekvenser op til kanal 11 og 12+13 i DK/EU

Helst 2 kanaler spring for 802.11b AP der placeres indenfor rækkevidde

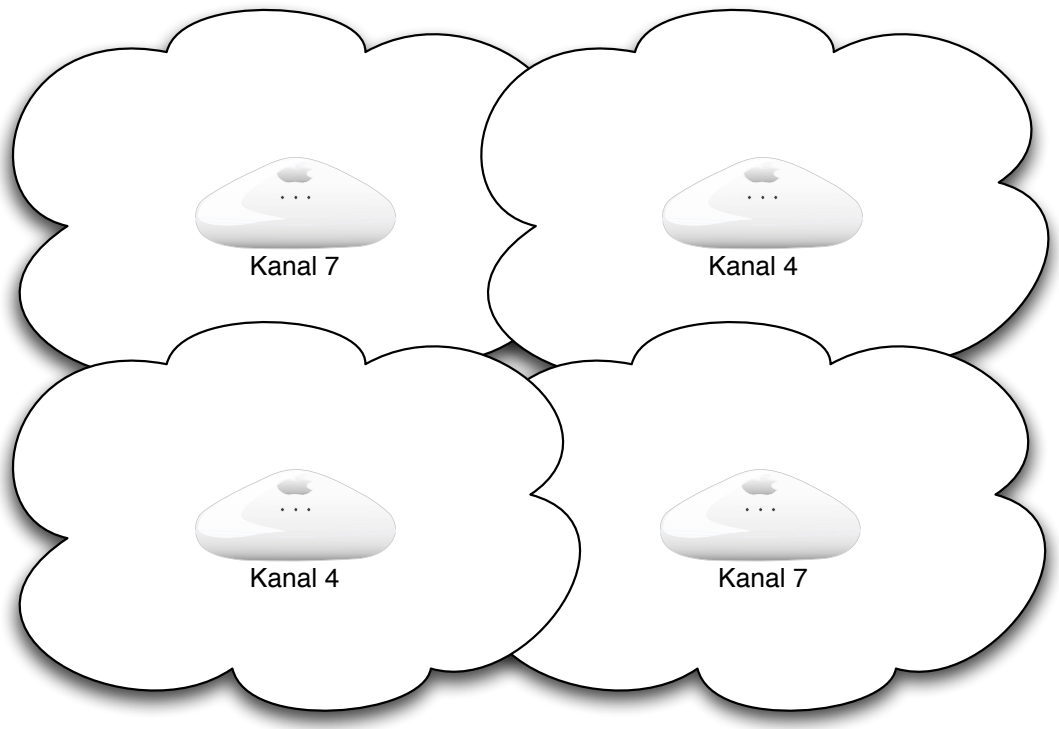
Helst 4 kanaler spring for 802.11g AP der placeres indenfor rækkevidde

Eksempel på netværk med flere AP'er



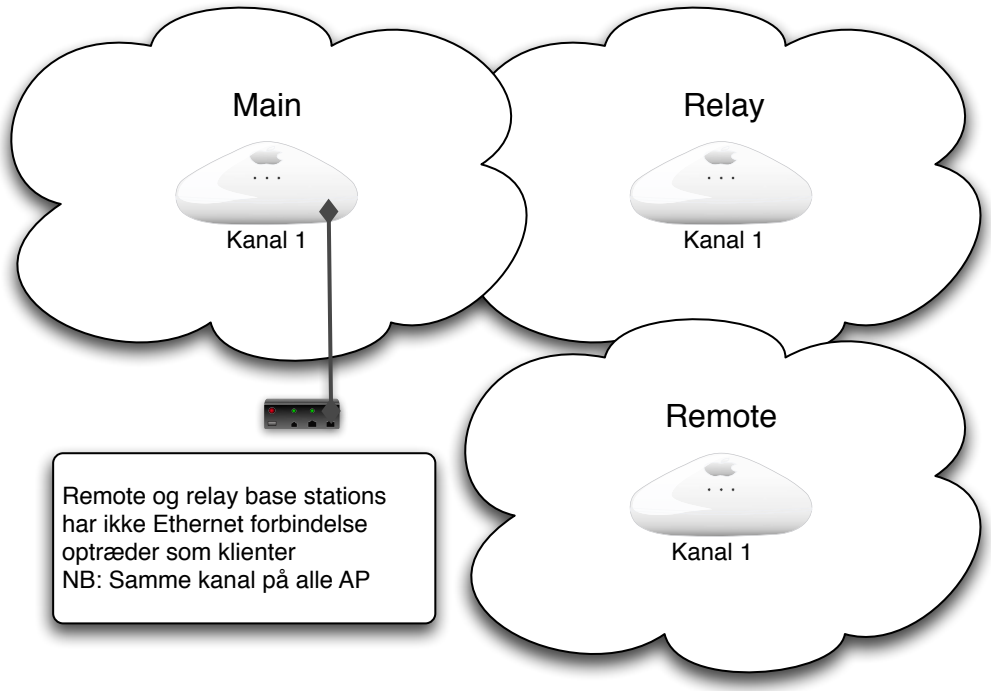
(802.11 uden WDS)

Eksempel på netværk med flere AP'er



(802.11 uden WDS)

Wireless Distribution System WDS



(802.11 med WDS)

Se også: `http://en.wikipedia.org/wiki/Wireless_Distribution_System`

Er trådløse netværk interessante?

wireless 802.11

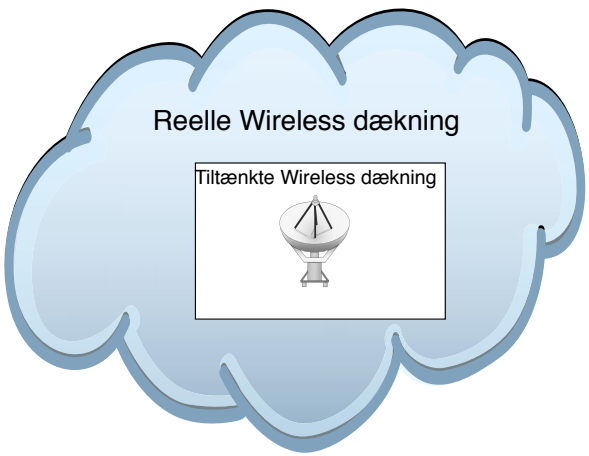
Sikkerhedsproblemer i de trådløse netværk er mange

- Fra lavt niveau - eksempelvis ARP, 802.11
- dårlige sikringsmekanismer - WEP
- dårligt udstyr - mange fejl
- usikkkerhed om implementering og overvågning

Trådløst udstyr er blevet meget billigt!

Det er et krav fra brugerne - trådløst er lækkert

Konsekvenserne



- Værre end Internetangreb - anonymt
- Kræver ikke fysisk adgang til lokationer
- Konsekvenserne ved sikkerhedsbrud er generelt større
- Typisk får man direkte LAN eller Internet adgang!

Værktøjer

- Wirelessscanner - Kali og Airodump
- Wireless Injection - aireplay-ng
- Aircrack-ng pakken generelt
- Kali `http://www.kali.org/`

Konsulentens udstyr wireless, eksempel kort

Varenummer: 2225730

TP-Link TL-WN722N

Hi-Speed USB - 802.11b, 802.11g, 802.11n

På lager, 1-2 dages levering
(Billigste fragt: 0 kr.)
Ret land

Køb

120,00 kr.
(96,00 kr.)

4 stk på lager i Århus
0 stk på lager i Viborg
0 stk på lager i København

Laptop or Netbook, I typically use USB wireless cards

NB: de indbyggede er ofte ringe til wifi pentest - så check før køb ;-)

Access Points - get a small selection for testing

Books:

- Kali Linux Wireless Penetration Testing: Beginner's Guide Beginner's Guide, Vivek Ramachandran, Cameron Buchanan, March 2015
  Also checkout his home page `http://www.vivekramachandran.com/`

Kali Nethunter

- **802.11 Wireless Injection** and **AP mode** support with multiple supported USB wifi cards.
- Capable of running **USB HID Keyboard attacks**, much like the **Teensy** device is able to do.
- **Supports BadUSB MITM attacks**. Plug in your Nethunter to a victim PC, and have your traffic relayed though it.
- Contains a **full Kali Linux toolset**, with many tools available via a simple menu system.
- **USB Y-cable support** in the Nethunter kernel – use your OTG cable while still charging your Nexus device!
- **Software Defined Radio support**. Use **Kali Nethunter** with your HackRF to explore the wireless radio space.

Source: `https://www.kali.org/kali-linux-nethunter/`

Hackerværktøjer

Der benyttes en del værktøjer:

- Nmap, Nping - tester porte, godt til firewall admins `http://nmap.org`
- Metasploit Framework gratis på `http://www.metasploit.com/`
- Wireshark avanceret netværkssniffer - `http://http://www.wireshark.org/`
- Kismet `http://www.kismetwireless.net/`
- Aircrack-ng set of tools `http://www.aircrack-ng.org/`
- Pyrit GPU cracker `http://code.google.com/p/pyrit/`
- Reaver brute force WPS `https://code.google.com/p/reaver-wps/`

Typisk brug af 802.11 udstyr

Wireless Access Point

netværket - typisk Ethernet

et access point - forbindes til netværket

Basal konfiguration

Når man tager fat på udstyr til trådløse netværk opdager man:

SSID - nettet skal have et navn

frekvens / kanal - man skal vælge en kanal, eller udstyret vælger en automatisk

der er nogle forskellige metoder til sikkerhed

Wireless networking sikkerhed i 802.11

Sikkerheden er baseret på nogle få forudsætninger

- SSID - netnavnet
- WEP *kryptering* - Wired Equivalent Privacy
- WPA kryptering - Wi-Fi Protected Access, SSID indgår i denne!
- måske MAC flitrering, kun bestemte kort må tilgå accesspoint

Forudsætninger

Til gengæld er disse forudsætninger ofte ikke tilstrækkelige ...

- WEP er nem at knække, lad helt være med at bruge WEP
- WPA PSK er baseret på en DELT hemmelighed som alle stationer kender
- nøglen ændres sjældent, og det er svært at distribuere en ny

SSID - netnavnet

Service Set Identifier (SSID) - netnavnet

32 ASCII tegn eller 64 hexadecimale cifre

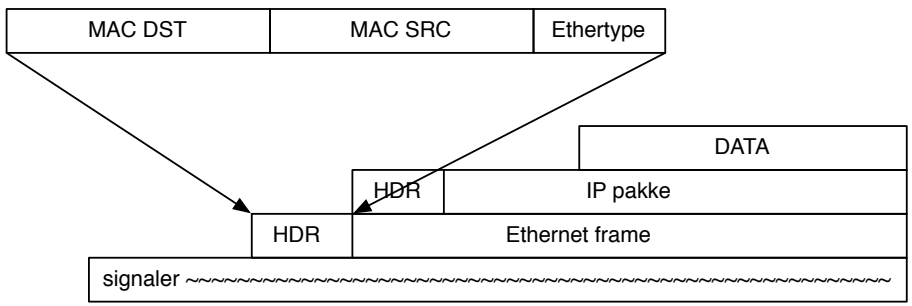
Udstyr leveres typisk med et standard netnavn

- Cisco - tsunami
- Linksys udstyr - linksys
- Apple Airport, 3Com m.fl. - det er nemt at genkende dem

SSID kaldes også for network id NWID

SSID broadcast - udstyr leveres oftest med broadcast af SSID

Hacking eksempel - det er ikke magi



MAC filtrering på trådløse netværk - Alle netkort har en MAC fra fabrikken

Kun godkendte kort tillades adgang til netværket

Netkort tillader at man overskriver denne adresse midlertidigt

MAC adressen på kortene er med i alle pakker der sendes

MAC adressen er aldrig krypteret, for hvordan skulle pakken så nå frem?

Myten om MAC filtrering

Eksemplet med MAC filtrering er en af de mange myter

Hvorfor sker det?

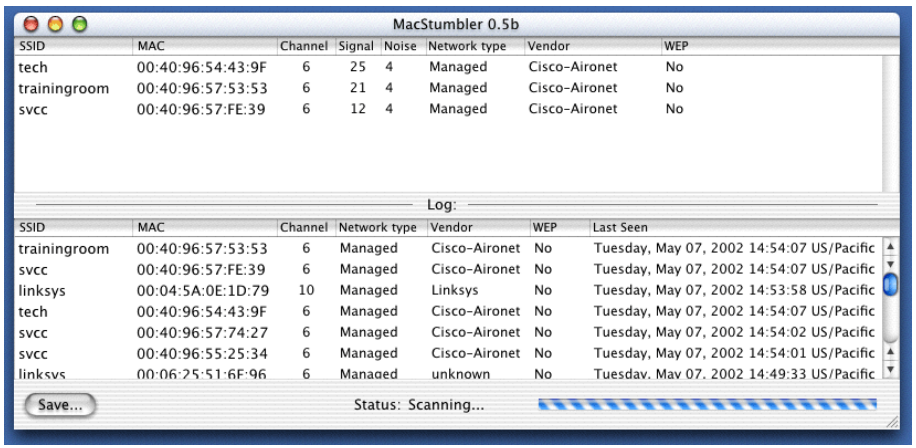
- Marketing - producenterne sætter store mærkater på æskerne
- Manglende indsigt - forbrugerne kender reelt ikke koncepterne
- Hvad *er* en MAC adresse egentlig
- Relativt få har forudsætningerne for at gennemskue dårlig sikkerhed

Løsninger?

- Udbrede viden om usikre metoder til at sikre data og computere
- Udbrede viden om sikre metoder til at sikre data og computere

MAC filtrering

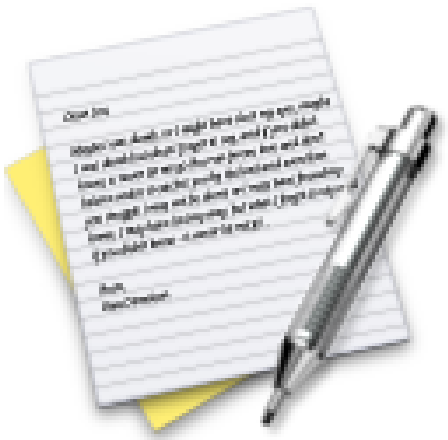
Demo: wardriving med airodump-ng



man tager et trådløst netkort og en bærbar computer og noget software:

- Tidligere brugte man diverse "stumbler", som MacStumbler eller Kismet
- Idag bruger vi Airodump-ng fra Aircrack-ng.org/Kali

Øvelse: airodump-ng



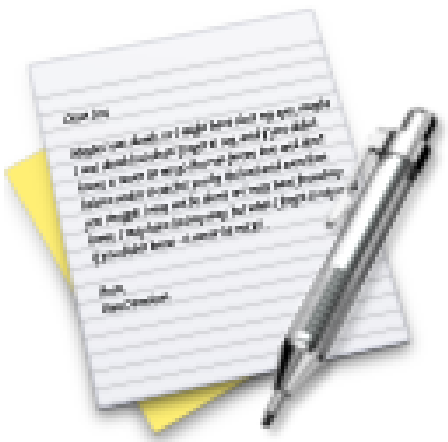
Vi afprøver nu airodump-ng

Lån eller køb et netkort, hvis jeg har flere

Brug dele af guiden

`http://www.aircrack-ng.org/doku.php?id=simple_wep_crack`

Exercise



Now lets do the exercise

Wardriving Up to 60min

which is number **38** in the exercise PDF.

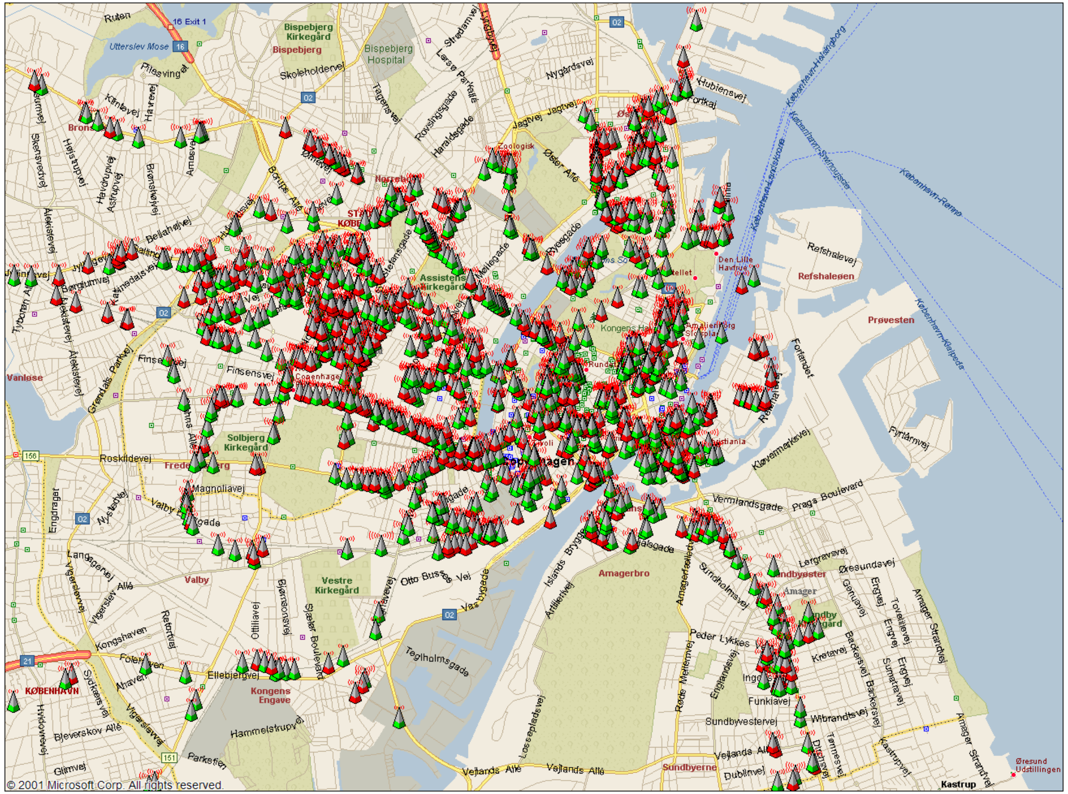
Resultater af wardriving

Hvad opdager man ved wardriving?

- at WEP/WPA IKKE krypterer hele pakken
- at alle pakker indeholder MAC adressen
- WPA/WEP nøglen skifter sjældent
- Mange wireless er fejlkonfigureret på forskellig vis

Man kan altså lytte med på et netværk med WEP/WPA,
genbruge en anden maskines MAC adresse
- og måske endda bryde krypteringen.

Storkøbenhavn



Informationsindsamling

Det vi har udført er informationsindsamling

Indsamlingen kan være aktiv eller passiv indsamling i forhold til målet for angrebet

passiv kunne være at lytte med på trafik eller søge i databaser på Internet

aktiv indsamling er eksempelvis at sende ICMP pakker og registrere hvad man får af svar

Cryptography

Cryptography or cryptology is the practice and study of techniques for secure communication

Modern cryptography is heavily based on mathematical theory and computer science practice; cryptographic algorithms are designed around computational hardness assumptions, making such algorithms hard to break in practice by any adversary

Symmetric-key cryptography refers to encryption methods in which both the sender and receiver share the same key, to ensure confidentiality, example algorithm AES

Public-key cryptography (like RSA) uses two related keys, a key pair of a public key and a private key. This allows for easier key exchanges, and can provide confidentiality, and methods for signatures and other services

Source: `https://en.wikipedia.org/wiki/Cryptography`

Kryptografiske principper

Algoritmerne er kendte

Nøglerne er hemmelige

Nøgler har en vis levetid - de skal skiftes ofte

Et successfuldt angreb på en krypto-algoritme er enhver genvej som kræver mindre arbejde end en gennemgang af alle nøglerne

Nye algoritmer, programmer, protokoller m.v. skal gennemgås nøje!

Se evt. Snake Oil Warning Signs: Encryption Software to Avoid
`http://www.interhack.net/people/cmcurtin/snake-oil-faq.html`

IEEE 802.11 Security fast forward

In 2001, a group from the University of California, Berkeley presented a paper describing weaknesses in the 802.11 Wired Equivalent Privacy (WEP) security mechanism defined in the original standard; they were followed by **Fluhrer, Mantin, and Shamir's** paper titled "Weaknesses in the Key Scheduling Algorithm of RC4". Not long after, Adam Stubblefield and AT&T publicly announced the first **verification of the attack**. In the attack, they were able to intercept transmissions and gain unauthorized access to wireless networks.

Source: `http://en.wikipedia.org/wiki/IEEE_802.11`

IEEE 802.11 Security fast forward

The IEEE set up a dedicated task group to create a replacement security solution, **802.11i** (previously this work was handled as part of a broader 802.11e effort to enhance the MAC layer). The Wi-Fi Alliance announced an **interim specification called Wi-Fi Protected Access (WPA)** based on a subset of the then current IEEE 802.11i draft. These started to appear in products in **mid-2003**. **IEEE 802.11i (also known as WPA2)** itself was ratified in **June 2004**, and uses government strength encryption in the **Advanced Encryption Standard AES,** instead of RC4, which was used in WEP. The modern recommended encryption for the home/consumer space is **WPA2 (AES Pre-Shared Key) and for the Enterprise space is WPA2 along with a RADIUS authentication server** (or another type of authentication server) and a strong authentication method such as EAP-TLS.

Source: `http://en.wikipedia.org/wiki/IEEE_802.11`

IEEE 802.11 Security fast forward

In January 2005, the IEEE set up yet another task group "w"to protect management and broadcast frames, which previously were sent unsecured. Its standard was published in 2009.[24]

In **December 2011**, a security flaw was revealed that affects wireless routers with the **optional Wi-Fi Protected Setup (WPS)** feature. While WPS is not a part of 802.11, **the flaw allows a remote attacker to recover the WPS PIN and, with it, the router's 802.11i password in a few hours**.

WPS WTF?! - det er som om folk bevidst saboterer wireless sikkerhed!

Source: `http://en.wikipedia.org/wiki/IEEE_802.11`

WEP kryptering

WEP *kryptering* - med nøgler der specificeres som tekst eller hexadecimale cifre

typisk 40-bit, svarende til 5 ASCII tegn eller 10 hexadecimale cifre eller 104-bit 13 ASCII tegn eller 26 hexadecimale cifre

WEP er baseret på RC4 algoritmen der er en *stream cipher* lavet af Ron Rivest for RSA Data Security

De første fejl ved WEP

Oprindeligt en dårlig implementation i mange Access Points

Fejl i krypteringen - rettet i nyere firmware

WEP er baseret på en DELT hemmelighed som alle stationer kender

Nøglen ændres sjældent, og det er svært at distribuere en ny

WEP som sikkerhed

WEP bør ikke bruges overhovedet mere

WEP er for simpel til et større netværk - eksempelvis 20 brugere

Firmaer bør efter min mening bruge andre sikkerhedsforanstaltninger

Hvordan udelukker man en bestemt bruger?

WEP sikkerhed

AirSnort is a wireless LAN (WLAN) tool which recovers encryption keys. AirSnort operates by passively monitoring transmissions, computing the encryption key when enough packets have been gathered. https://github.com/kramse/conference-open-8021x 802.11b, using the Wired Equivalent Protocol (WEP), is crippled with numerous security flaws. Most damning of these is the weakness described in "Weaknesses in the Key Scheduling Algorithm of RC4 "by Scott Fluhrer, Itsik Mantin and Adi Shamir. Adam Stubblefield was the first to implement this attack, but he has not made his software public. AirSnort, along with WEPCrack, which was released about the same time as AirSnort, are the first publicly available implementaions of this attack. `http://airsnort.shmoo.com/`

major cryptographic errors

weak keying - 24 bit er allerede kendt - 128-bit = 104 bit i praksis

small IV - med kun 24 bit vil hver IV blive genbrugt oftere

CRC-32 som integritetscheck er ikke *stærkt* nok kryptografisk set

Authentication gives pad - giver fuld adgang - hvis der bare opdages *encryption pad* for en bestemt IV. Denne IV kan så bruges til al fremtidig kommunikation

Konklusion: Kryptografi er svært

WEP cracking - airodump og aircrack

airodump - opsamling af krypterede pakker

aircrack - statistisk analyse og forsøg på at finde WEP nøglen

Med disse værktøjer er det muligt at knække *128-bit nøgler*!

Blandt andet fordi det reelt er 104-bit nøgler ☺

tommelfingerregel - der skal opsamles mange pakker ca. 100.000 er godt

Links:

`http://www.cr0.net:8040/code/network/aircrack/` aircrack

`http://www.securityfocus.com/infocus/1814` WEP: Dead Again

airodump opsamling

```
BSSID              CH  MB  ENC  PWR  Packets   LAN IP / # IVs   ESSID

00:03:93:ED:DD:8D   6  11       209    801963            540180   wanlan
```

Når airodump kører opsamles pakkerne

Lås airodump fast til een kanal, -c eller –channel

Startes med airmon og kan skrive til capture filer:

```
airmon-ng start wlan0
airodump-ng --channel 6 --write testfil wlan0mon
```

aircrack - WEP cracker

```
$ aircrack -n 128 -f 2 aftendump-128.cap
                                aircrack 2.1
* Got  540196! unique IVs | fudge factor = 2
* Elapsed time [00:00:22] | tried 12 keys at 32 k/m
KB    depth   votes
 0    0/  1   CE(  45) A1(  20) 7E(  15) 98(  15) 72(  12) 82(  12)
 1    0/  2   62(  43) 1D(  24) 29(  15) 67(  13) 94(  13) F7(  13)
 2    0/  1   B6( 499) E7(  18) 8F(  15) 14(  13) 1D(  12) E5(  10)
 3    0/  1   4E( 157) EE(  40) 29(  39) 15(  30) 7D(  28) 61(  20)
 4    0/  1   93( 136) B1(  28) 0C(  15) 28(  15) 76(  15) D6(  15)
 5    0/  2   E1(  75) CC(  45) 39(  31) 3B(  30) 4F(  16) 49(  13)
 6    0/  2   3B(  65) 51(  42) 2D(  24) 14(  21) 5E(  15) FC(  15)
 7    0/  2   6A( 144) 0C(  96) CF(  34) 14(  33) 16(  33) 18(  27)
 8    0/  1   3A( 152) 73(  41) 97(  35) 57(  28) 5A(  27) 9D(  27)
 9    0/  1   F1(  93) 2D(  45) 51(  29) 57(  27) 59(  27) 16(  26)
10    2/  3   5B(  40) 53(  30) 59(  24) 2D(  15) 67(  15) 71(  12)
11    0/  2   F5(  53) C6(  51) F0(  21) FB(  21) 17(  15) 77(  15)
12    0/  2   E6(  88) F7(  81) D3(  36) E2(  32) E1(  29) D8(  27)
      KEY FOUND! [ CE62B64E93E13B6A3AF15BF5E6 ]
```

Hvor lang tid tager det?

Opsamling a data - ca. en halv time på 802.11b ved optimale forhold

Tiden for kørsel af aircrack fra auditor CD på en Dell CPi 366MHz Pentium II laptop:

```
$ time aircrack -n 128 -f 2 aftendump-128.cap
...
real    5m44.180s   user  0m5.902s     sys  1m42.745s
```

Tiden for kørsel af aircrack på en VIA CL-10000 1GHz CPU med almindelig disk OpenBSD:

```
25.12s real     0.63s user     2.14s system
```

For 10 år siden :-P

Erstatning for WEP- WPA

Det anbefales at bruge:

Kendte VPN teknologier eller WPA

baseret på troværdige algoritmer

implementeret i professionelt udstyr

fra troværdige leverandører

udstyr der vedligeholdes og opdateres

Man kan måske endda bruge de eksisterende løsninger - fra hjemmepc adgang, mobil adgang m.v.

Erstatninger for WEP

Der findes idag andre metoder til sikring af trådløse netværk

802.1x Port Based Network Access Control

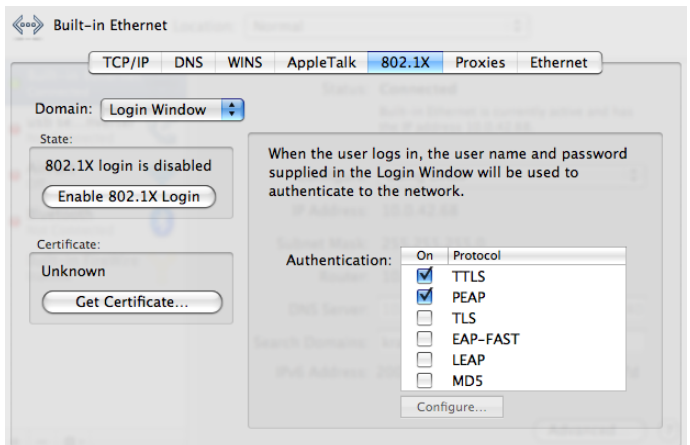
WPA - Wi-Fi Protected Access)
WPA = 802.1X + EAP + TKIP + MIC

nu WPA2

> WPA2 is based on the final IEEE 802.11i amendment to the 802.11 standard and is eligible for FIPS 140-2 compliance.

Kilde: http://www.wifialliance.org/OpenSection/protected_access.asp

IEEE 802.1x Port Based Network Access Control



- Nogle switche tillader at man benytter 802.1x
- Denne protokol sikrer at man valideres før der gives adgang til porten
- Når systemet skal have adgang til porten afleveres brugernavn og kodeord/certifikat
- Denne protokol indgår også i WPA Enterprise

802.1x og andre teknologier

802.1x i forhold til MAC filtrering giver væsentlige fordele

MAC filtrering kan spoofes, hvor 802.1x kræver det rigtige kodeord

Typisk benyttes RADIUS og 802.1x integrerer således mod både LDAP og Active Directory

WPA eller WPA2?

WPA2 is based upon the Institute for Electrical and Electronics Engineers (IEEE) 802.11i amendment to the 802.11 standard, which was ratified on July 29, 2004.

Q: How are WPA and WPA2 similar?
A: Both WPA and WPA2 offer a high level of assurance for end-users and network administrators that their data will remain private and access to their network restricted to authorized users. Both utilize 802.1X and Extensible Authentication Protocol (EAP) for authentication. Both have Personal and Enterprise modes of operation that meet the distinct needs of the two different consumer and enterprise market segments.
Q: How are WPA and WPA2 different?
A: WPA2 provides a **stronger encryption mechanism** through **Advanced Encryption Standard (AES)**, which is a requirement for some corporate and government users.

Kilde: http://www.wifialliance.org WPA2 Q and A

WPA Personal eller Enterprise

Personal - en delt hemmelighed, preshared key

Enterprise - brugere valideres op mod fælles server

Hvorfor er det bedre?

- Flere valgmuligheder - passer til store og små
- WPA skifter den faktiske krypteringsnøgle jævnligt - TKIP
- Initialisationsvektoren (IV) fordobles 24 til 48 bit
- Imødekommer alle kendte problemer med WEP!
- Integrerer godt med andre teknologier - RADIUS

- EAP - Extensible Authentication Protocol - individuel autentifikation
- TKIP - WPA Temporal Key Integrity Protocol - nøgleskift og integritet
- MIC - Message Integrity Code - Michael, ny algoritme til integritet
- CCMP - WPA2 AES / Counter Mode CBC-MAC Protocol

Authentication Protocols RADIUS, PAP, CHAP, EAP

- Used for verifying credentials, typically username and password
- Extensible Authentication Protocol EAP
  `https://en.wikipedia.org/wiki/Extensible_Authentication_Protocol`
- Challenge-Handshake Authentication Protocol
  `https://en.wikipedia.org/wiki/Challenge-Handshake_Authentication_Protocol`
- Password Authentication Protocol
  `https://en.wikipedia.org/wiki/Password_Authentication_Protocol`

Remote Authentication Dial-In User Service RADIUS

RADIUS er en protokol til autentificering af brugere op mod en fælles server

Remote Authentication Dial In User Service (RADIUS)

RADIUS er beskrevet i RFC-2865

RADIUS kan være en fordel i større netværk med

- dial-in
- administration af netværksudstyr
- trådløse netværk
- andre RADIUS kompatible applikationer

`https://en.wikipedia.org/wiki/RADIUS`

Hint: Jeg har publiceret en RADIUS konfiguration der giver WPA Enterprise - med vilkårligt brugernavn og kode!
`https://github.com/kramse/conference-open-8021x`

WPA cracking

Nu skifter vi så til WPA og alt er vel så godt?

Desværre ikke!

Du skal vælge en laaaaang passphrase, ellers kan man sniffe WPA handshake når en computer går ind på netværket!

Med et handshake kan man med aircrack igen lave off-line bruteforce angreb!

Nye angreb gør at man ikke engang behøver et klient handshake, men kan snakke med AP alene!

WPA cracking demo

Vi konfigurerer AP med Henrik42 som WPA-PSK/passhrase

Vi finder netværk kismet eller airodump

Vi starter airodump mod specifik kanal

Vi spoofer deauth og opsamler WPA handshake

Vi knækker WPA :-)

Brug manualsiderne for programmerne i aircrack-ng pakken!

WPA cracking med aircrack - start

```
slax ~ # aircrack-ng -w dict wlan-test.cap
Opening wlan-test.cap
Read 1082 packets.

#  BSSID              ESSID           Encryption

1  00:11:24:0C:DF:97  wlan            WPA (1 handshake)
2  00:13:5F:26:68:D0  Noea            No data - WEP or WPA
3  00:13:5F:26:64:80  Noea            No data - WEP or WPA
4  00:00:00:00:00:00                  Unknown

Index number of target network ?  1
```

WPA cracking med aircrack - start

```
          [00:00:00] 0 keys tested (0.00 k/s)

                     KEY FOUND! [ Henrik42 ]

Master Key     : 8E 61 AB A2 C5 25 4D 3F 4B 33 E6 AD 2D 55 6F 76
                 6E 88 AC DA EF A3 DE 30 AF D8 99 DB F5 8F 4D BD
Transcient Key : C5 BB 27 DE EA 34 8F E4 81 E7 AA 52 C7 B4 F4 56
                 F2 FC 30 B4 66 99 26 35 08 52 98 26 AE 49 5E D7
                 9F 28 98 AF 02 CA 29 8A 53 11 EB 24 0C B0 1A 0D
                 64 75 72 BF 8D AA 17 8B 9D 94 A9 31 DC FB 0C ED

EAPOL HMAC     : 27 4E 6D 90 55 8F 0C EB E1 AE C8 93 E6 AC A5 1F
```

Min Thinkpad X31 med 1.6GHz Pentium M knækker ca. 150 Keys/sekund

Encryption key length

Encryption key lengths & hacking feasibility

Type of Attacker	*Budget*	Tool	*Time & Cost/Key 40 bit*	*Time & Cost/Key 56 bit*
Regular User	Minimal $400	Scavenged computer time FPGA	1 week 5 hours ($.08)	Not feasible 38 years ($5,000)
Small Business	$10,000	FPGA [1]	12 min.($.08)	556 days ($5,000)
Corporate Department	$300,000	FPGA ASIC [2]	24 sec. ($.08) 0.18 sec. ($.001)	19 days ($5,000) 3 hours ($38)
Large Corporation	$10M	ASIC	0.005 sec.($0.001)	6 min. ($38)
Intelligence Agency	$300M	ASIC	0.0002 sec.($0.001)	12 sec. ($38)

Old, but think about your attackers and their budgets!

Kilde: `http://www.mycrypto.net/encryption/encryption_crack.html`

New attack on WPA/WPA2 using PMKID

This attack was discovered accidentally while looking for new ways to attack the new WPA3 security standard. WPA3 will be much harder to attack because of its modern key establishment protocol called "Simultaneous Authentication of Equals"(SAE).

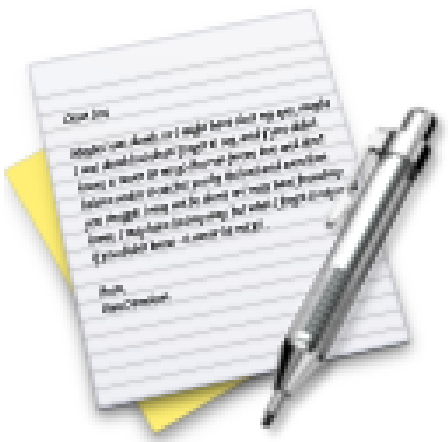
The main difference from existing attacks is that in this attack, capture of a full EAPOL 4-way handshake is not required. The new attack is performed on the RSN IE (Robust Security Network Information Element) of a single EAPOL frame.

At this time, we do not know for which vendors or for how many routers this technique will work, but we think it will work against all 802.11i/p/q/r networks with roaming functions enabled (most modern routers).

The main advantages of this attack are as follow: No more regular users required - because the attacker directly communicates with the AP (aka "client-less"attack) No more waiting for a complete 4-way handshake between the regular user and the AP No more eventual retransmissions of EAPOL frames (which can lead to uncrackable results) No more eventual invalid passwords sent by the regular user No more lost EAPOL frames when the regular user or the AP is too far away from the attacker No more fixing of nonce and replaycounter values required (resulting in slightly higher speeds) No more special output format (pcap, hccapx, etc.) - final data will appear as regular hex encoded string

- `https://hashcat.net/forum/thread-7717.html` New attack on WPA/WPA2 using PMKID
- `https://www.evilsocket.net/2019/02/13/Pwning-WiFi-networks-with-bettercap-and-the-PMKID-clie`

Exercise



Now lets do the exercise

Aircrack-ng 30 min

which is number **39** in the exercise PDF.

WPA cracking med Pyrit

Pyrit takes a step ahead in attacking WPA-PSK and WPA2-PSK, the protocol that today de-facto protects public WIFI-airspace. The project's goal is to estimate the real-world security provided by these protocols. Pyrit does not provide binary files or wordlists and does not encourage anyone to participate or engage in any harmful activity. **This is a research project, not a cracking tool.**

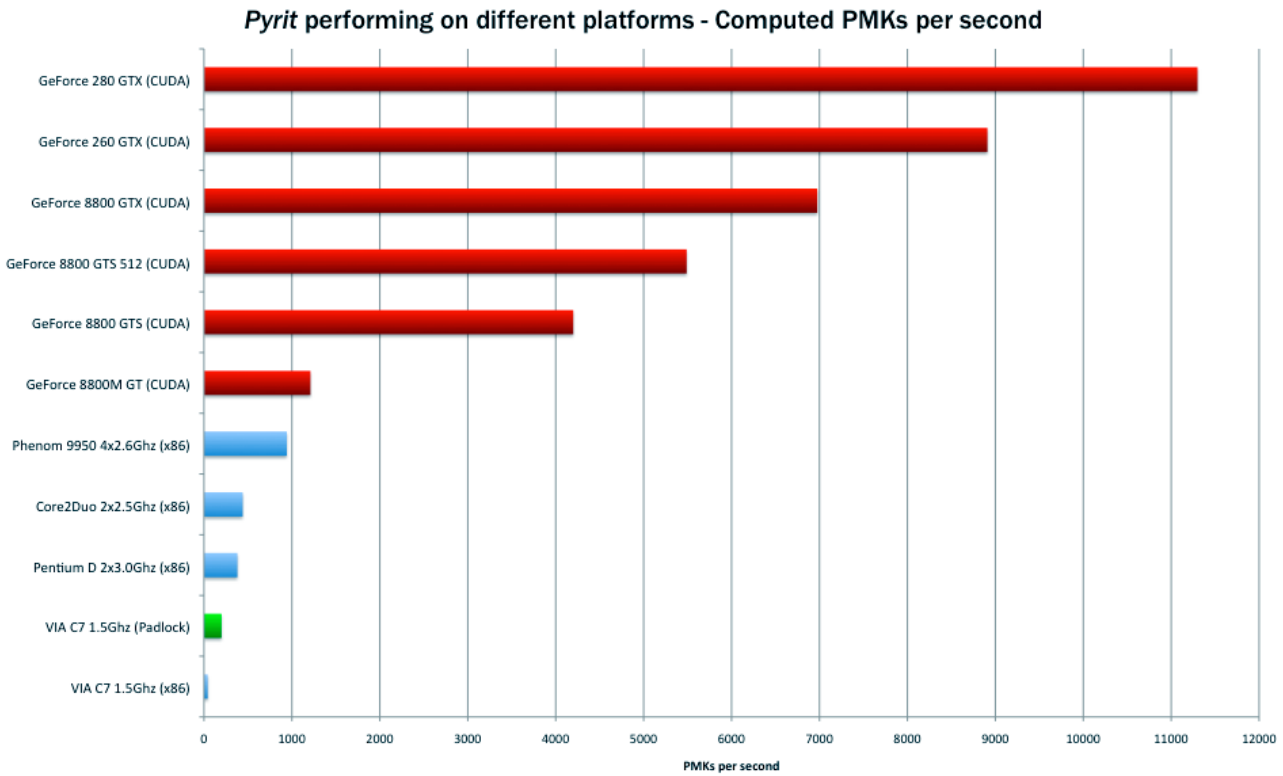
Pyrit's implementation allows to create massive databases, pre-computing part of the WPA/WPA2-PSK authentication phase in a space-time-tradeoff. The performance gain for real-world-attacks is in the range of three orders of magnitude which urges for re-consideration of the protocol's security. Exploiting the computational power of GPUs, *Pyrit* is currently by far the most powerful attack against one of the world's most used security-protocols.

sloooow, plejede det at være - 150 keys/s på min Thinkpad X31

Kryptering afhænger af SSID! Så check i tabellen er minutter.

`http://pyrit.wordpress.com/about/`

Tired of WoW?



Kilde: `http://code.google.com/p/pyrit/`

Hashcat Cracking passwords and secrets

- Hashcat is the world's fastest CPU-based password recovery tool.
- oclHashcat-plus is a GPGPU-based multi-hash cracker using a brute-force attack (implemented as mask attack), combinator attack, dictionary attack, hybrid attack, mask attack, and rule-based attack.
- oclHashcat-lite is a GPGPU cracker that is optimized for cracking performance. Therefore, it is limited to only doing single-hash cracking using Markov attack, Brute-Force attack and Mask attack.
- John the Ripper password cracker old skool men stadig nyttig

Source:
`http://hashcat.net/wiki/`
`http://www.openwall.com/john/`
`http://hashcat.net/wiki/doku.php?id=cracking_wpawpa2`

Wi-Fi Protected Setup, WPS hacking - Reaver

Reaver Open Source Reaver implements a brute force attack against Wifi Protected Setup (WPS) registrar PINs in order to recover WPA/WPA2 passphrases, as described in `http://sviehb.files.wordpress.com/2011/12/viehboeck_wps.pdf`.

Reaver has been designed to be a robust and practical attack against WPS, and has been tested against a wide variety of access points and WPS implementations.

On average Reaver will recover the target AP's plain text WPA/WPA2 passphrase in 4-10 hours, depending on the AP. In practice, it will generally take half this time to guess the correct WPS pin and recover the passphrase.

Hvad betyder ease of use?

Source:

`https://code.google.com/p/reaver-wps/`

`http://lifehacker.com/5873407/how-to-crack-a-wi+fi-networks-wpa-password-with-reaver`

WPS Design Flaws used by Reaver

Design Flaw #1

Option / Authentication	Physical Access	Web Interface	PIN
Push-button-connect	X		
PIN – Internal Registrar		X	
PIN – External Registrar			X

WPS Options and which kind of authentication they actually use.

As the External Registrar option does not require any kind of authentication apart from providing the PIN, it is potentially vulnerable to brute force attacks.

Pin only, no other means necessary

Source:
`http://sviehb.files.wordpress.com/2011/12/viehboeck_wps.pdf`

WPS Design Flaws used by Reaver

IEEE 802.11/EAP Expanded Type, Vendor ID: WFA (0x372A), Vendor Type: SimpleConfig (0x01)			
M1	Enrollee → Registrar	N1 || Description || PK_E	Diffie-Hellman Key Exchange
M2	Enrollee ← Registrar	N1 || N2 || Description || PK_R || Authenticator	
M3	Enrollee → Registrar	N2 || E-Hash1 || E-Hash2 || Authenticator	
M4	Enrollee ← Registrar	N1 || R-Hash1 || R-Hash2 || $E_{KeyWrapKey}$(R-S1) || Authenticator	proove posession of 1st half of PIN
M5	Enrollee → Registrar	N2 || $E_{KeyWrapKey}$(E-S1) || Authenticator	proove posession of 1st half of PIN
M6	Enrollee ← Registrar	N1 || $E_{KeyWrapKey}$(R-S2) || Authenticator	proove posession of 2nd half of PIN
M7	Enrollee → Registrar	N2 || $E_{KeyWrapKey}$(E-S2 ||ConfigData) || Authenticator	proove posession of 2nd half of PIN, send AP configuration
M8	Enrollee ← Registrar	N1 || $E_{KeyWrapKey}$(ConfigData) || Authenticator	set AP configuration

Enrollee = AP Registrar = Supplicant = Client/Attacker PK_E = Diffie-Hellman Public Key Enrollee PK_R = Diffie-Hellman Public Key Registrar Authkey and KeyWrapKey are derived from the Diffie-Hellman shared key. Authenticator = $HMAC_{Authkey}$(last message || current message) $E_{KeyWrapKey}$ = Stuff encrypted with KeyWrapKey (AES-CBC)	PSK1 = first 128 bits of $HMAC_{AuthKey}$(1st half of PIN) PSK2 = first 128 bits of $HMAC_{AuthKey}$(2nd half of PIN) E-S1 = 128 random bits E-S2 = 128 random bits E-Hash1 = $HMAC_{AuthKey}$(E-S1 || PSK1 || PK_E || PK_R) E-Hash2 = $HMAC_{AuthKey}$(E-S2 || PSK2 || PK_E || PK_R) R-S1 = 128 random bits R-S2 = 128 random bits R-Hash1 = $HMAC_{AuthKey}$(R-S1 || PSK1 || PK_E || PK_R) R-Hash2 = $HMAC_{AuthKey}$(R-S2 || PSK2 || PK_E || PK_R)

1	2	3	4	5	6	7	0
1st half of PIN				2nd half of PIN			checksum

Reminds me of NTLM cracking, crack parts independently

Source:
`http://sviehb.files.wordpress.com/2011/12/viehboeck_wps.pdf`

WPS Design Flaws used by Reaver

Design flaw #2

An attacker can derive information about the correctness of parts the PIN from the AP´s responses.

- If the attacker receives an EAP-NACK message after sending M4, he knows that the 1st half of the PIN was incorrect.
- If the attacker receives an EAP-NACK message after sending M6, he knows that the 2nd half of the PIN was incorrect.

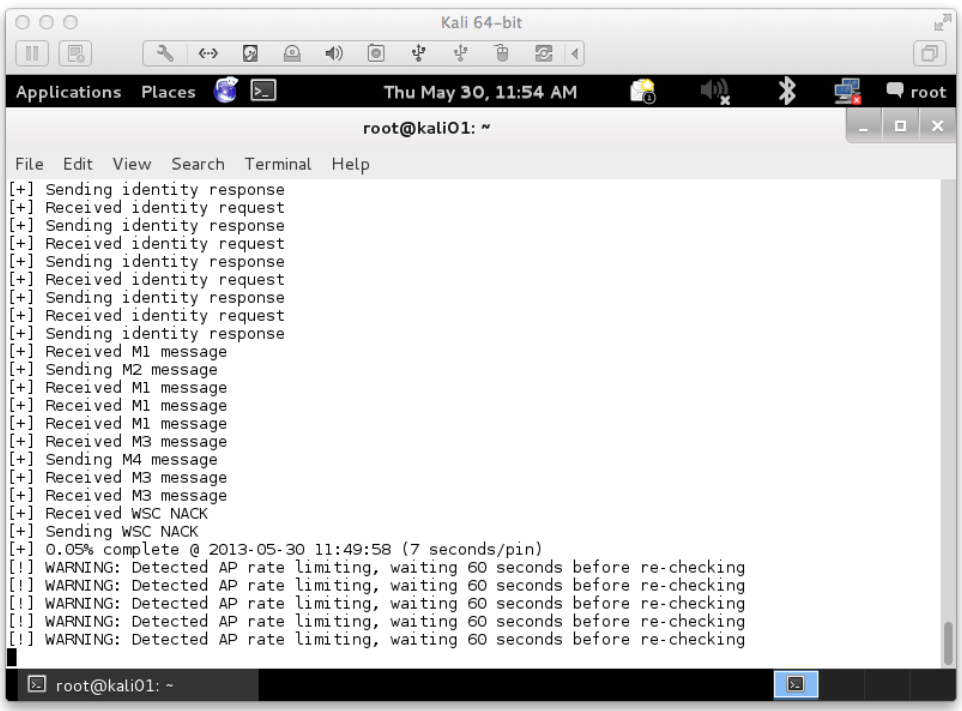
This form of authentication dramatically decreases the maximum possible authentication attempts needed from 10^8 (=100.000.000) to $10^4 + 10^4$ (=20.000).

As the 8th digit of the PIN is always a checksum of digit one to digit seven, there are at most $10^4 + 10^3$ (=11.000) attempts needed to find the correct PIN.

100.000.000 is a lot, 11.000 is not

Source:
`http://sviehb.files.wordpress.com/2011/12/viehboeck_wps.pdf`

Reaver Rate limiting



Make no mistake, it will work!

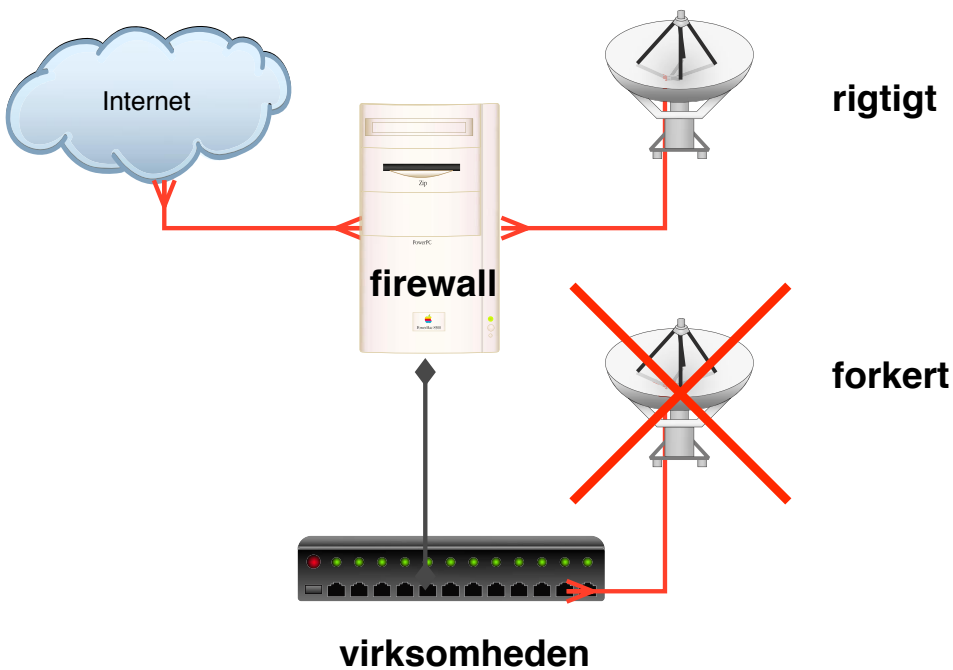
Når adgangen er skabt

Så går man igang med de almindelige værktøjer

Fyodor Top Network Security Tools `http://www.sectools.org`

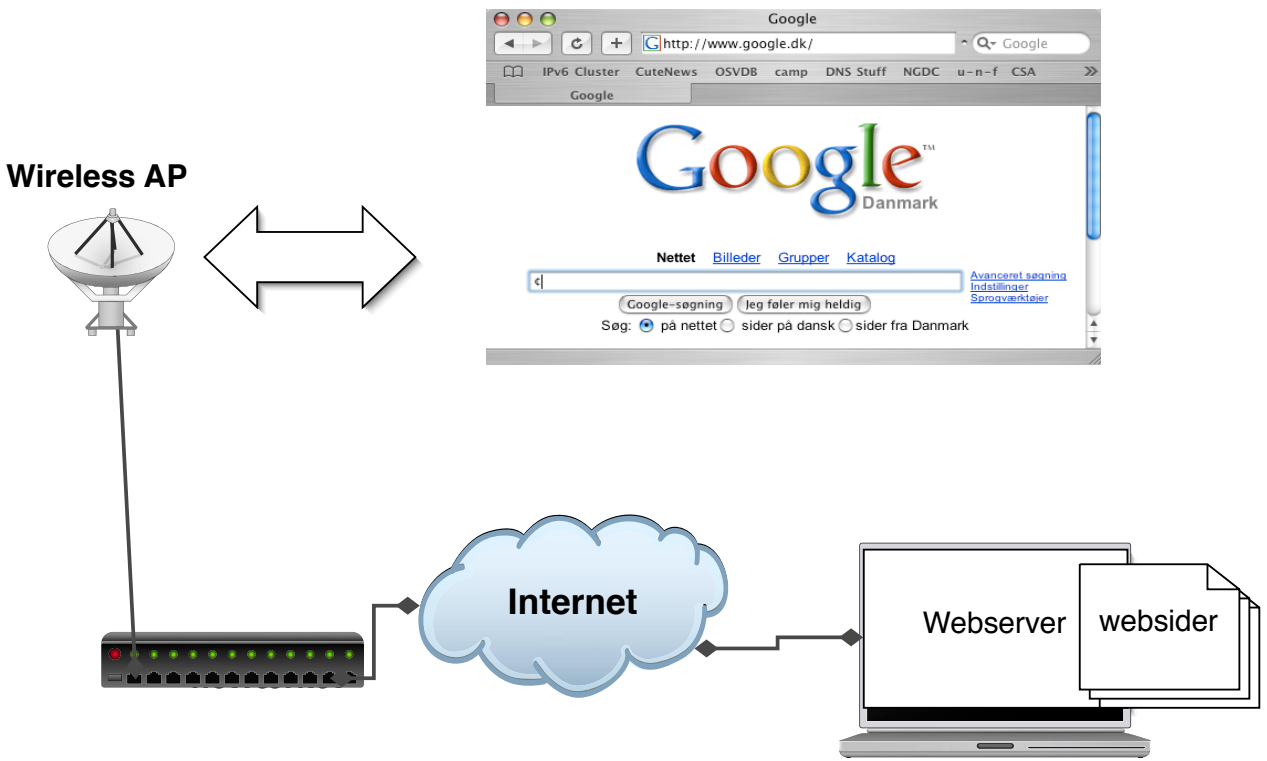
Forsvaret er som altid - flere lag af sikkerhed!

Infrastrukturændringer

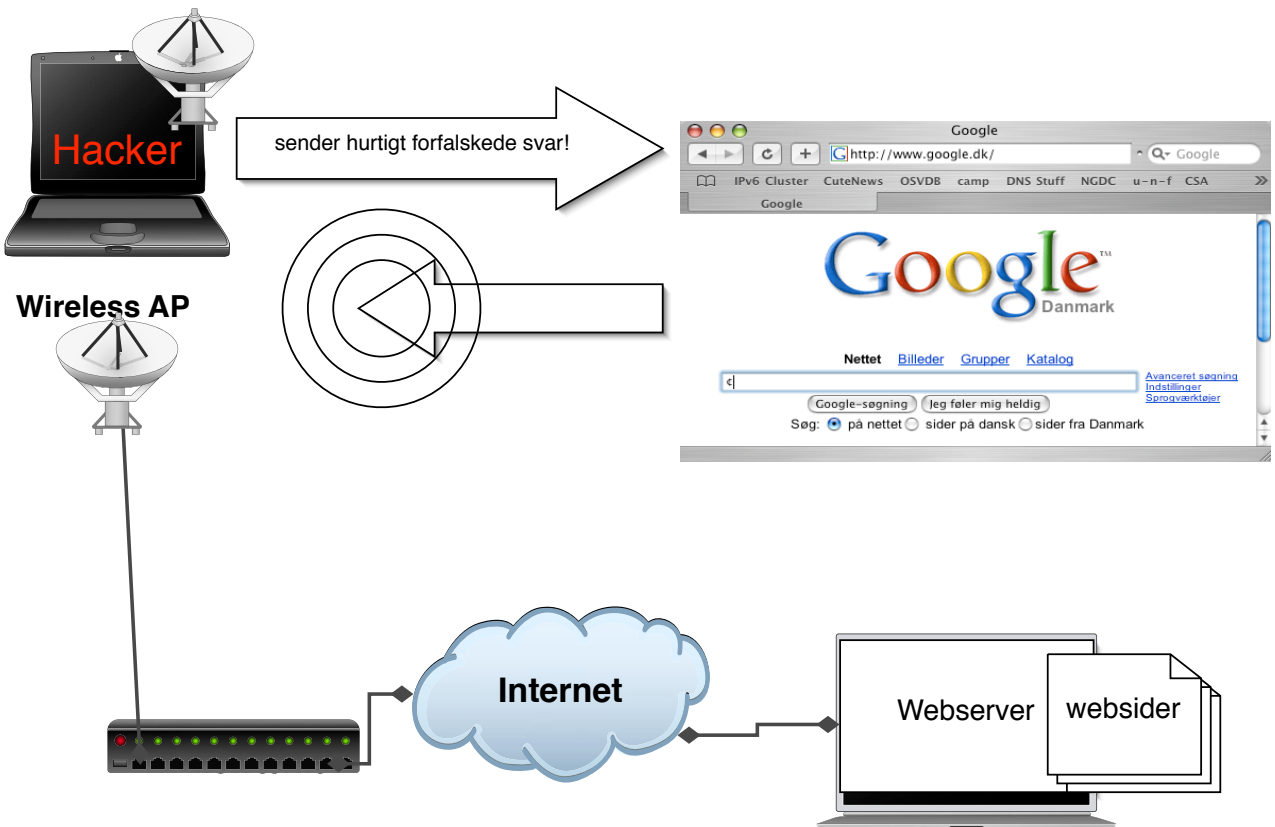


Sådan bør et access point logisk forbindes til netværket

Normal WLAN brug



Packet injection - airpwn



Airpwn teknikker

Klienten sender forespørgsel

Hackerens program airpwn lytter og sender så falske pakker

Hvordan kan det lade sig gøre?

- Normal forespørgsel og svar på Internet tager 50ms
- Airpwn kan svare på omkring 1ms angives det
- Airpwn har alle informationer til rådighed

Airpwn på Defcon 2004 - findes på Sourceforge
`http://airpwn.sourceforge.net/`

NB: Airpwn som demonstreret er begrænset til TCP og ukrypterede forbindelser

Hjemmenetværk for nørder

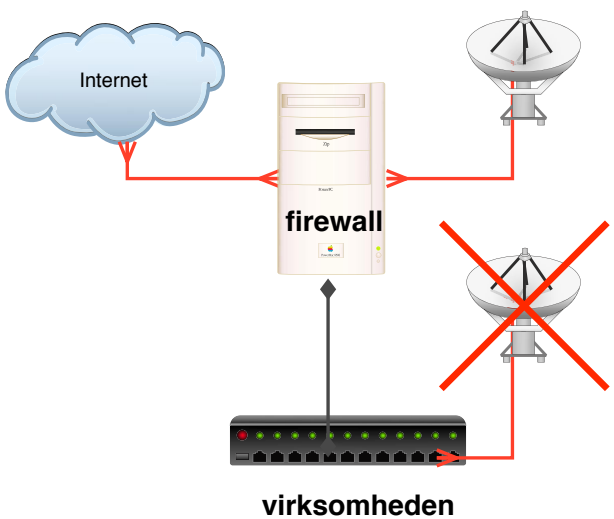
Lad være med at bruge et wireless-kort i en PC til at lave AP, brug et AP

Husk et AP kan være en router, men den kan ofte også blot være en bro

Brug WPA og overvej at lave en decideret DMZ til WLAN

Placer AP hensigtsmæddigt og gerne højt, oppe på et skab eller lignende

Recommendations for wireless networks



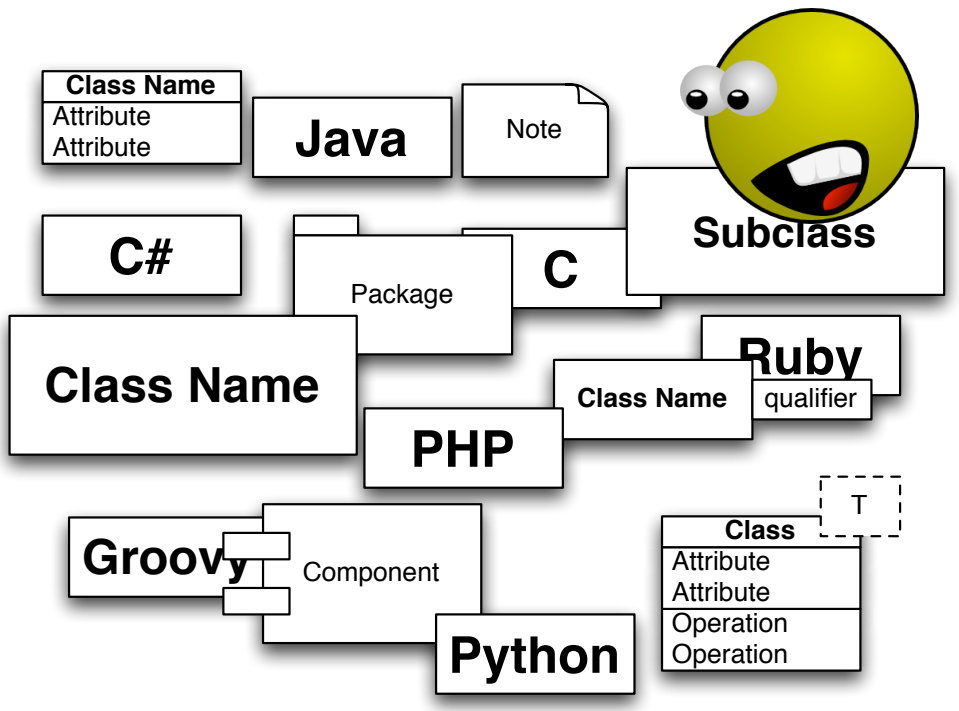
rigtig

- Use a specific SSID - network name, influences the WPA PSK keying
- Never use WEP
- Use WPA PSK or Enterprise, or at least some VPN with individual user logins

forkert

- When using WPA Personal/PSK passphrase must be long, like +40 chars!
- Place network Access Points on the network where they can be monitored. Separate VLAN, isolated from the cabled LAN
- Have rules for the use of wireless networks, also for persons travelling - "Always use VPN when using insecure wireless in hotels, airports etc."

Bonus: Next step, software sikkerhed



Wireless AP implementerer protokoller med hardware+software

Sårbare AP'er - 1

Hvordan bygger man et billigt Access Point?

- En embedded kerne
- En embedded TCP/IP stak
- Noget 802.11 hardware
- Et par Ethernet stik
- eventuelt et modem
- Tape ...

Hvad med efterfølgende opdatering af software?

Sårbare AP'er - 2

Eksempler på access point sårbarheder:

Konfigurationsfilen kan hentes uden autentificering - inkl. WEP nøgler

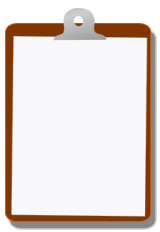
Konfigurationen sker via SNMP - som sender community string i klar tekst

Wi-Fi Protected Setup,(WPS) kan ikke slås helt fra

...

Konklusionen er klar - hardwaren er i mange tilfælde ikke sikker nok til at anvende på forretnings-kritiske LAN segmenter!

For Next Time



Think about the subjects from this time, write down questions

Check the plan for chapters to read in the books

Visit web sites and download papers if needed

Retry the exercises to get more confident using the tools