Wi-Fi Threats and Countermeaures

Gopinath KN (Gopi)

AirTight Networks
Secure Cloud-Managed Wi-Fi
http://airtightnetworks.com/

Wi-Fi Security: Hot Off the Press, Jun 2014

Cupid – a variant of OpenSSL Heartbleed bug in the Wi-Fi World

http://arstechnica.com/security/2014/06/meet-cupid-the-heartbleed-attack-spawns-evil-wi-fi-networks/

Meet "Cupid," the Heartbleed attack that spawns "evil" Wi-Fi networks

eap_heartbleed_client.pcapng [Wireshark 1.10.7 (v1.10.7-0-g6b931a1 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: ssl || eap Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
5337	50.942009000	IntelCor_e1	SenaoInt_4d:	EAP	54	Request, Identity
5339	50.944264000	SenaoInt_4d	IntelCor_e1:	EAP	66	Response, Identity
5341	50.947152000	IntelCor_e1	SenaoInt_4d:	EAP	55	Request, Protected EAP (EAP-PEAP)
5342	50.947174000	SenaoInt_4d	IntelCor_e1:	TLSv1	293	Client Hello, Heartbeat Request
5344	50.961611000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5345	50.961651000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)
5347	50.975154000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5355	50.985449000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)
5357	50.998587000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5359	51.000209000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)
5361	51.014874000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5363	51.015472000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)
5365	51.029286000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5368	51.030370000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)
5370	51.044075000	IntelCor_e1	SenaoInt_4d:	TLSv1	1452	Server Hello, Certificate, Server Hello Done, Encrypted Heartbeat, Encrypted Heartbeat, Encrypted Heartbeat, E
5378	51.047834000	SenaoInt_4d	IntelCor_e1:	EAP	60	Response, Protected EAP (EAP-PEAP)

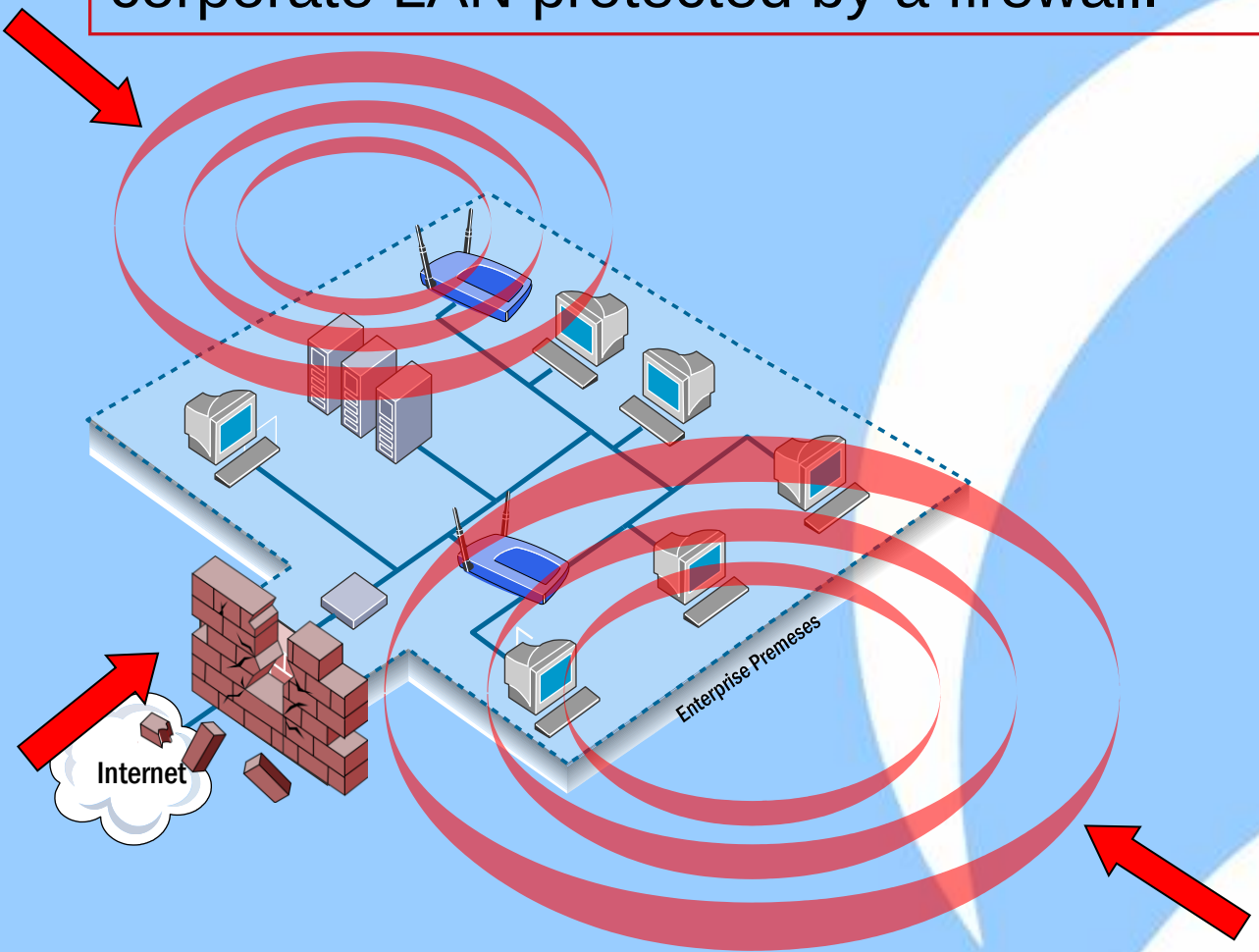
```
Code: Response (2)
Id: 35
Length: 239
Type: Protected EAP (EAP-PEAP) (25)
EAP-TLS Flags: 0x81
EAP-TLS Length: 229
Secure Sockets Layer
  TLSv1 Record Layer: Handshake Protocol: Client Hello
  TLSv1 Record Layer: Heartbeat Request
    Content Type: Heartbeat (24)
    Version: TLS 1.0 (0x0301)
    Length: 3
    Heartbeat Message
      Type: Request (1)
      Payload Length: 65000
```

```
00e0  00 0a 00 34 00 32 00 0e  00 0d 00 19 00 0b 00 0c   ...4.2.. ........
00f0  00 18 00 09 00 0a 00 16  00 17 00 08 00 06 00 07   ........ ........
0100  00 14 00 15 00 04 00 05  00 12 00 13 00 01 00 02   ........ ........
0110  00 03 00 0f 00 10 00 11  00 0f 00 01 01 18 03 01   ........ ........
0120  00 03 01 fd e8                                     ...
```

Payload Length (ssl.heartbeat_mes... | Packets: 6310 · Displayed: 107 (1.7%) · Load time: 0:01.450 | Profile: Default

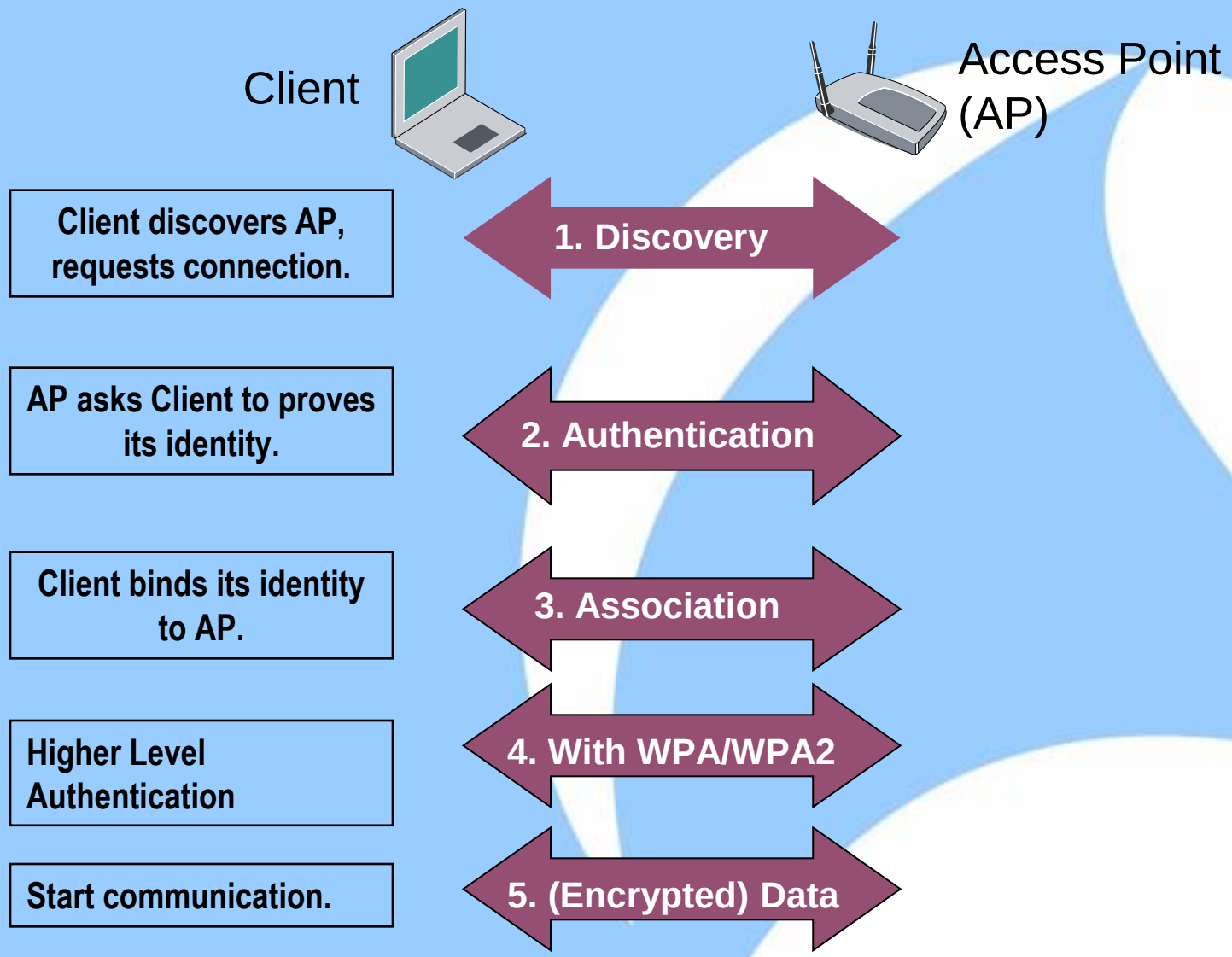
Wireless LAN Security Trivia

Myth: My wireless LAN is secure as it is attached to the corporate LAN protected by a firewall.

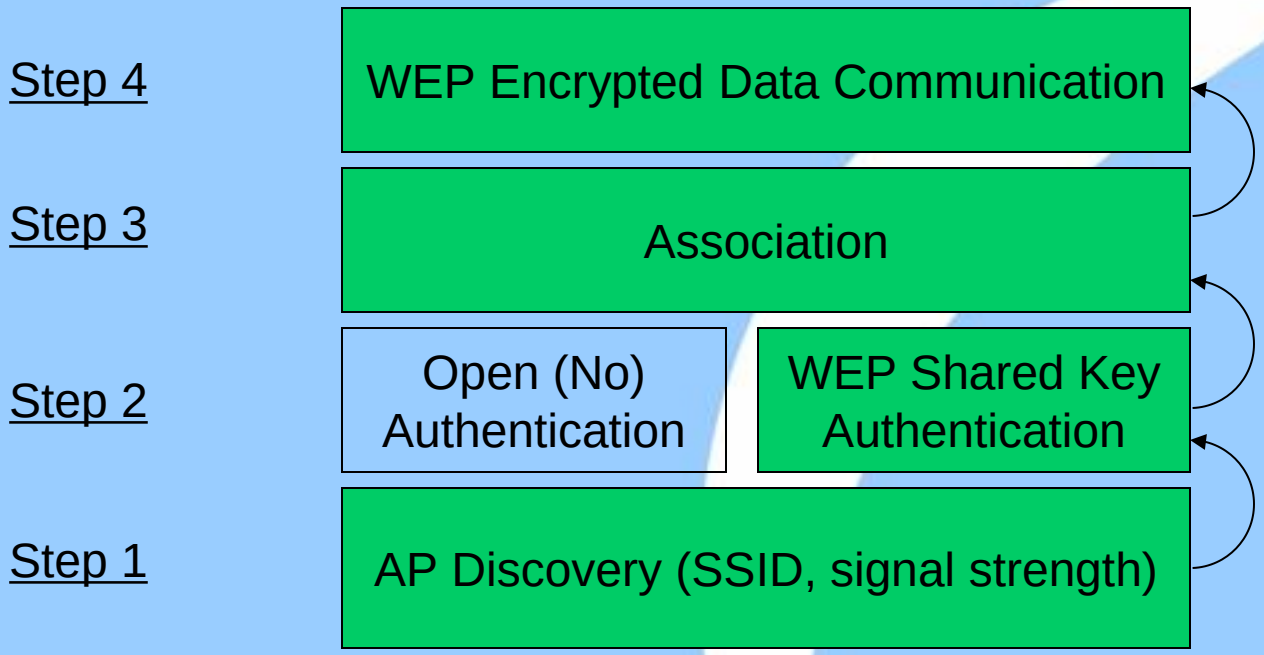


Authorized WLAN Security

Background: Stages of establishing a WiFi connection

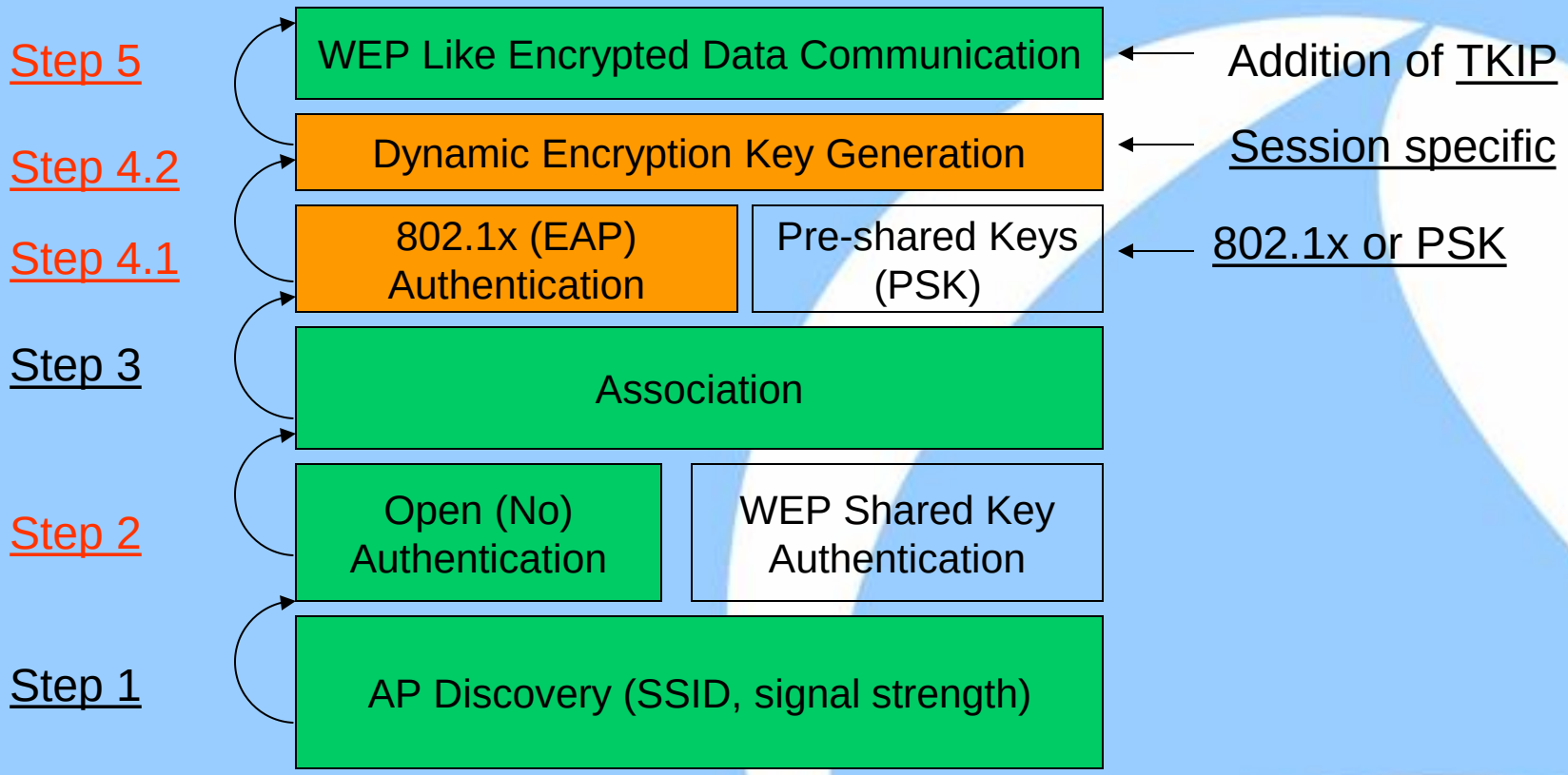


Stages of establishing a WEP-encrypted WiFi connection



WEP is broken. Let's move on!

Stages in establishing a WPA-encrypted WiFi connection



Pre-Shared Key (PSK) authentication & TKIP Encryption

- In PSK
  - Master keys are pre-configured in Client and AP
  - Encryption keys are derived using EAPOL 4-way handshake
  - Authentication Server is not needed
- TKIP
  - Band-aid on top of “WEP”

PSK vulnerability

- In WPA the master key is used to generate transient session keys
- With PSK, all devices are configured with the same passphrase (or password) that serves as the master key
- Like any other password, the strength of the passphrase determines if it can be guessed using a dictionary attack
  - Once passphrase is guessed, an attacker can generate transient keys to decrypt all traffic
- WPA-PSK and WPA2-PSK (also known as WPA-Personal, WPA2-Personal) are vulnerable to dictionary attack

Cloud Service for WiFi Cracking

If using WPA/WPA2 - PSK

Use a password with **at least eight** characters long and mix of **alphanumeric and special characters**

TKIP was considered safe enough

- RSA Security White Paper, “The Wireless Security Survey of New York City”, October 2008 says:

> **“While WPA1 was designed as a temporary replacement for WEP until WPA2 arrived, it would be incorrect to state that its security level is inferior to that of WPA2: Over the years of practical use, no exploitable WPA1-specific vulnerabilities have been discovered that are not present within WPA2.”**

- According to Payment Card Industry (PCI) Data Security Standard, version 1.2, October 2008:

Upgrade to WPA from WEP suffices to achieve PCI compliance.

TKIP vulnerability exposed for the first time

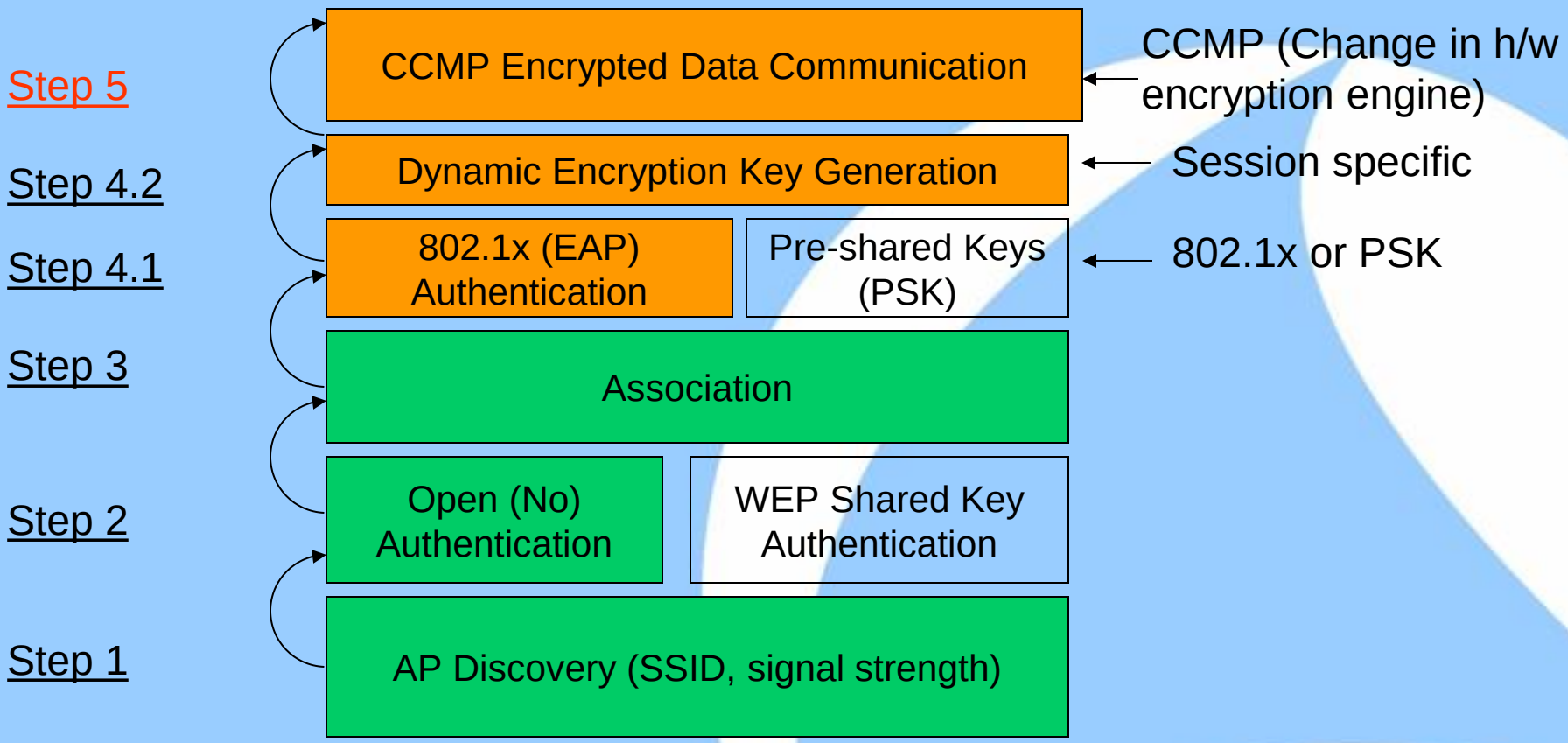
Erik Tews and Martin Beck Demonstrated at PacSec, Japan, Nov 2008

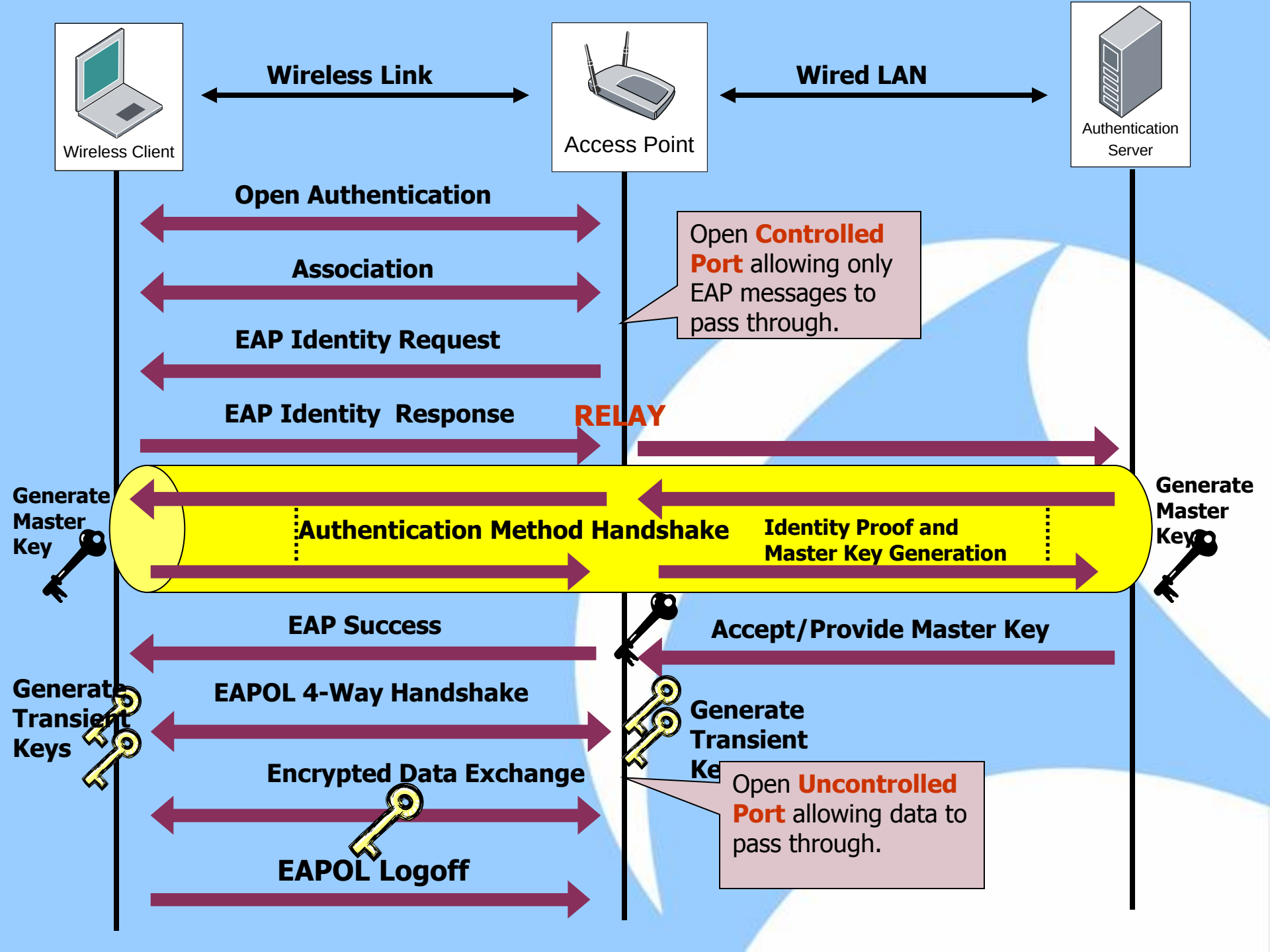
- For further technical details refer to:
  - Tkiptun-ng documentation: http://www.aircrack-ng.org/doku.php?id=tkiptun-ng
  - AirTight Knowledge Center

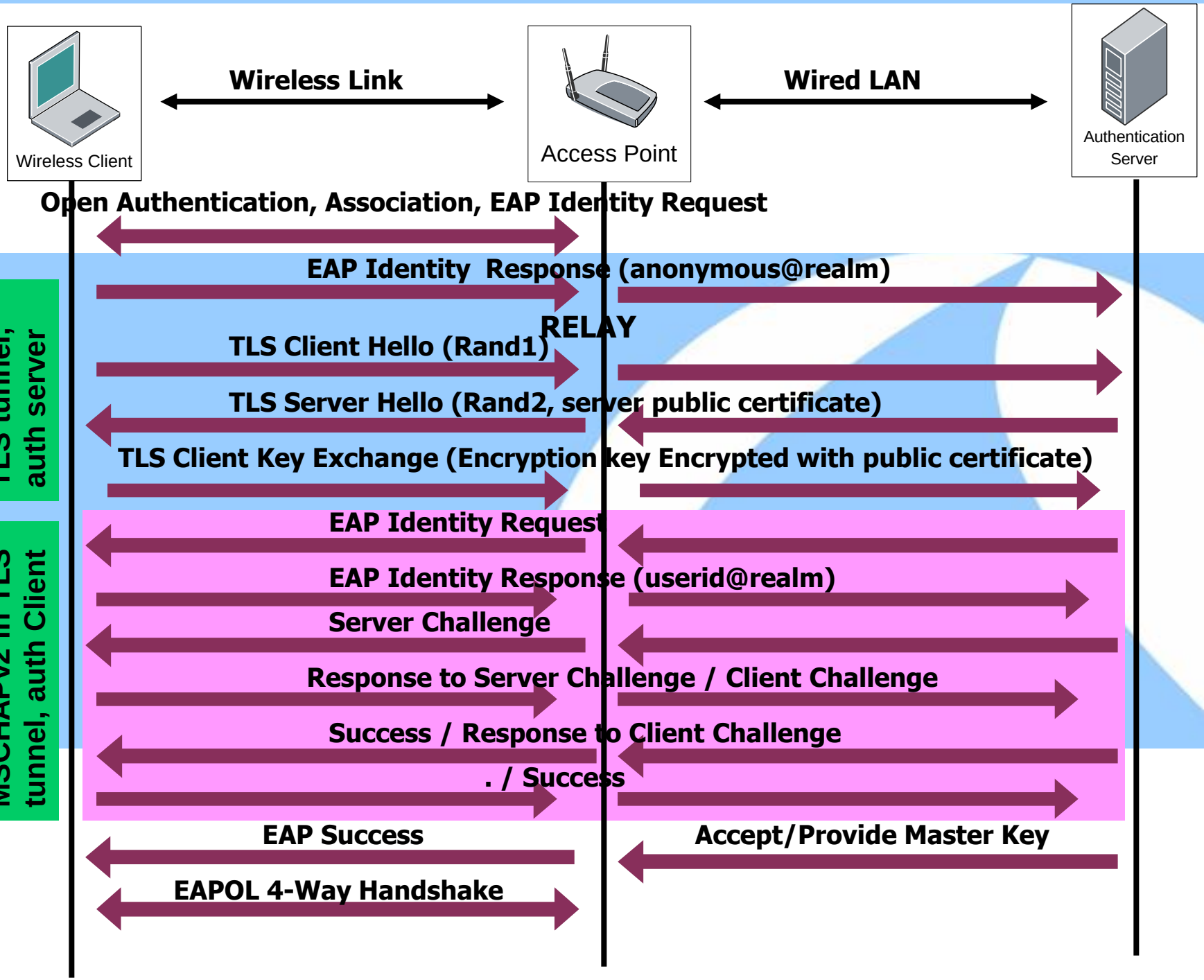
  http://www.airtightnetworks.com/home/resources/knowledge-center/wpa-wpa2-tkip-attack.html

Wi-Fi Alliance disallows the use of TKIP in high speed networks (e.g., 802.11n, 802.11ac)

Stages in establishing a WPA2 (802.11i) encrypted WiFi connection




Wireless Client
Wireless Link
Access Point
Wired LAN
Authentication Server
Open Authentication
Association
EAP Identity Request
EAP Identity Response
RELAY
Open Controlled Port allowing only EAP messages to pass through.
Generate Master Key
Authentication Method Handshake
Identity Proof and Master Key Generation
Generate Master Key
EAP Success
Accept/Provide Master Key
Generate Transient Keys
EAPOL 4-Way Handshake
Generate Transient Ke
Encrypted Data Exchange
EAPOL Logoff
Open Uncontrolled Port allowing data to pass through.


Wireless Client
Wireless Link
Access Point
Wired LAN
Authentication Server
Open Authentication, Association, EAP Identity Request
EAP Identity Response (anonymous@realm)
RELAY
TLS Client Hello (Rand1)
TLS Server Hello (Rand2, server public certificate)
TLS Client Key Exchange (Encryption key Encrypted with public certificate)
Phase 1: Est. TLS tunnel, auth server
EAP Identity Request
EAP Identity Response (userid@realm)
Server Challenge
Response to Server Challenge / Client Challenge
Success / Response to Client Challenge
. / Success
Phase 2: MSCHAPv2 in TLS tunnel, auth Client
EAP Success
Accept/Provide Master Key
EAPOL 4-Way Handshake

802.1x example: Protected Extensible Authentication Protocol (PEAP)

- PEAP is a popular authentication method supported over 802.1x
  - Supported in Windows XP, Windows Vista, Linux
- PEAP operates in 2 phases
  - Phase 1: Client authenticates the Authentication Server using TLS server certificate; builds an encrypted tunnel between Client and Authentication server
  - Phase 2: Another authentication method such as MSCHAPv2 (a two-way challenge and response password based authentication method) can be executed within this tunnel
- Word of caution: PEAP is not full-proof; depends on the configuration

More details: https://wiki.bc.net/atl-conf/download/attachments/12615756/PEAP_Shmoocon2008_Wright_Antoniewicz.pdf

Summary: wireless authentication and encryption

- WEP is fundamentally broken and it cannot be fixed
  - A variety of vulnerabilities and freely available attack tools
- PSK (WPA/WPA2) is vulnerable to dictionary attacks
  - Not for enterprise class security
  - Use strong passphrase
- TKIP vulnerable
  - Not a key cracking exploit
  - Can be used (in conjunction with QoS) to inject packets
- WPA2 with AES encryption and 802.1x authentication provides best known security (with proper configuration of course!)

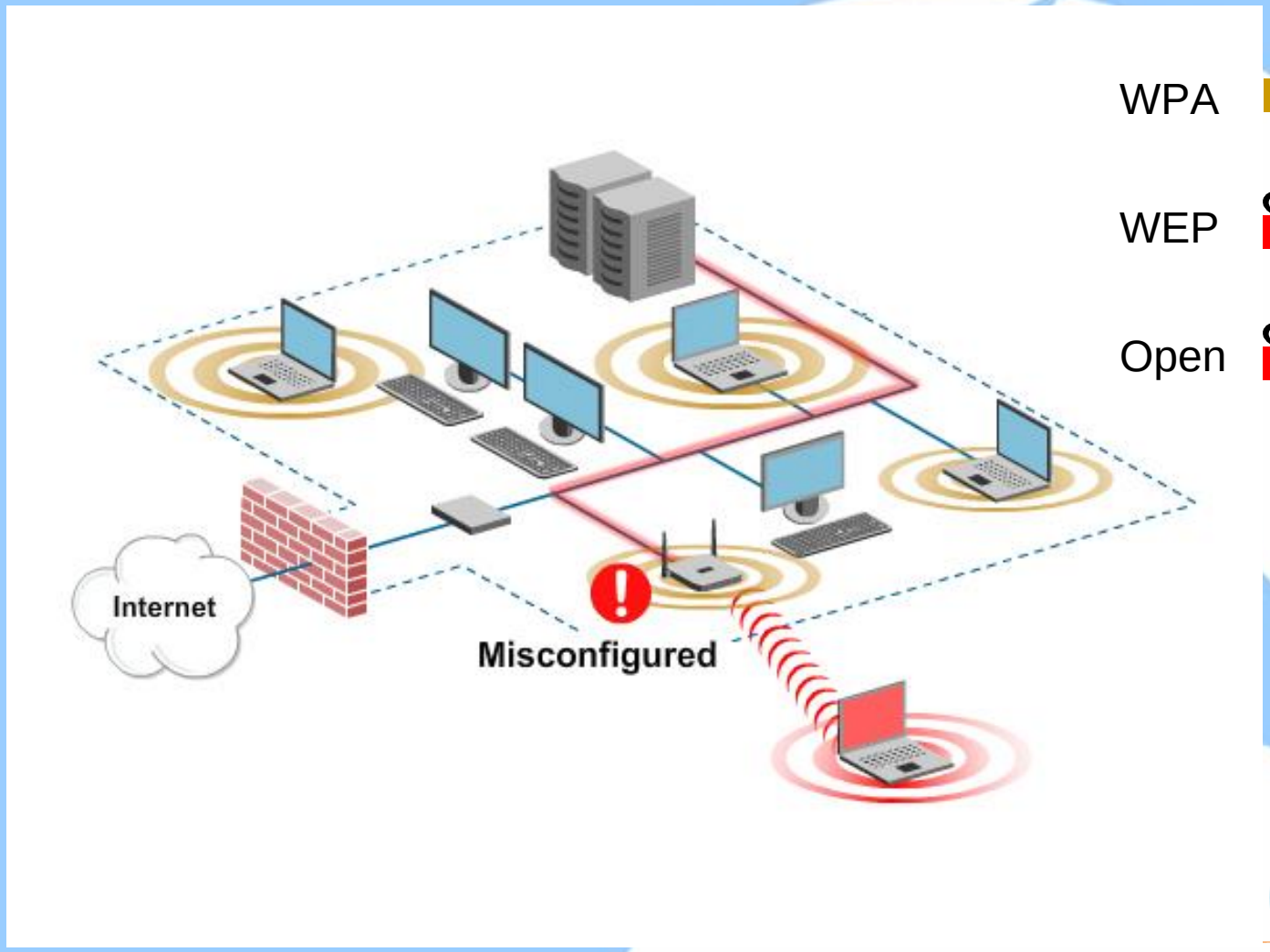
So, Is WPA2/802.11i Sufficient for Overall enterprise WLAN security?

Video

Threats Due To Unauthorized Wi-Fi Communication

Enterprise Security Perimeter Bypass: Five Common Scenarios

Scenario #1: Misconfigured Devices



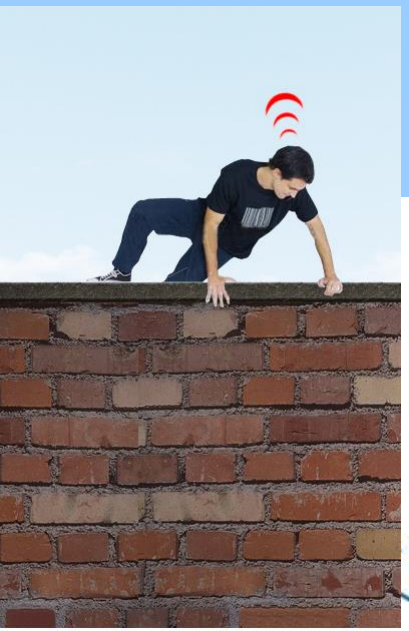
Misconfigured AP

3528	17.58836700	Htc_14:8b:9b	WibhuTec_90:03:50	802.11	48	Authentication, SN=2319, FN=0, Flags=....R...
3530	17.58963800	WibhuTec_90:03:50	Htc_14:8b:9b	802.11	48	Authentication, SN=256, FN=0, Flags=........
3531	17.59019100	WibhuTec_90:03:50	Htc_14:8b:9b	802.11	48	Authentication, SN=256, FN=0, Flags=....R...
3533	17.59181200	Htc_14:8b:9b	WibhuTec_90:03:50	802.11	132	Association Request, SN=2320, FN=0, Flags=........, SSID=test_ssid
3535	17.59947600	WibhuTec_90:03:50	Htc_14:8b:9b	EAPOL	151	Key (Message 1 of 4)
3581	17.66412000	Htc_14:8b:9b	WibhuTec_90:03:50	EAPOL	173	Key (Message 2 of 4)
3584	17.66736800	WibhuTec_90:03:50	Htc_14:8b:9b	EAPOL	207	Key (Message 3 of 4)
3587	17.67420100	Htc_14:8b:9b	WibhuTec_90:03:50	EAPOL	151	Key (Message 4 of 4)
15606	35.38862000	IntelCor_d0:29:a4	WibhuTec_a0:24:62	802.11	44	Deauthentication, SN=2763, FN=0, Flags=....R...
16957	37.12531000	IntelCor_35:f6:7e	WibhuTec_a1:b5:60	802.11	48	Authentication, SN=336, FN=0, Flags=........
16959	37.12669000	WibhuTec_a1:b5:60	IntelCor_35:f6:7e	802.11	48	Authentication, SN=256, FN=0, Flags=........
16961	37.12765300	IntelCor_35:f6:7e	WibhuTec_a1:b5:60	802.11	156	Association Request, SN=337, FN=0, Flags=........, SSID=Social_Spectrum
16968	37.14180200	WibhuTec_a1:b5:60	IntelCor_35:f6:7e	EAPOL	173	Key (Message 1 of 4)
16970	37.14267500	IntelCor_35:f6:7e	WibhuTec_a1:b5:60	EAPOL	191	Key (Message 2 of 4)
16971	37.14636200	WibhuTec_a1:b5:60	IntelCor_35:f6:7e	EAPOL	207	Key (Message 3 of 4)
16973	37.14719400	IntelCor_35:f6:7e	WibhuTec_a1:b5:60	EAPOL	151	Key (Message 4 of 4)
28491	53.98025700	WibhuTec_90:03:51	Htc_14:8b:9b	802.11	44	Deauthentication, SN=256, FN=0, Flags=........
28771	55.10168300	WibhuTec_90:03:51	Htc_14:8b:9b	802.11	44	Deauthentication, SN=256, FN=0, Flags=........
28928	55.65601300	WibhuTec_90:03:51	Htc_14:8b:9b	802.11	44	Deauthentication, SN=256, FN=0, Flags=........
29174	56.59162800	WibhuTec_90:03:51	Htc_14:8b:9b	802.11	44	Deauthentication, SN=256, FN=0, Flags=........
29195	56.65034100	Htc_14:8b:9b	WibhuTec_90:03:50	802.11	48	Authentication, SN=2488, FN=0, Flags=........
33049	72.24956500	IntelCor_04:4e:3f	WibhuTec_90:03:50	802.11	48	Authentication, SN=1360, FN=0, Flags=........
33051	72.25083500	WibhuTec_90:03:50	IntelCor_04:4e:3f	802.11	48	Authentication, SN=256, FN=0, Flags=........
33055	72.25872900	IntelCor_04:4e:3f	WibhuTec_90:03:50	802.11	116	Reassociation Request, SN=1361, FN=0, Flags=........, SSID=test_ssid
33057	72.26108500	WibhuTec_90:03:50	IntelCor_04:4e:3f	802.11	152	Reassociation Response, SN=257, FN=0, Flags=........
56513	106.3418240	WibhuTec_a0:27:a0	IntelCor_16:45:3b	802.11	48	Authentication, SN=256, FN=0, Flags=........
56650	106.4667880	IntelCor_16:45:3b	WibhuTec_a0:27:a0	802.11	87	Association Request, SN=98, FN=0, Flags=........, SSID=sampl1
64977	117.4266720	WibhuTec_90:03:50	Htc_14:8b:9b	802.11	48	Authentication, SN=256, FN=0, Flags=........
64979	117.4281810	Htc_14:8b:9b	WibhuTec_90:03:50	802.11	110	Association Request, SN=2968, FN=0, Flags=........, SSID=test_ssid
64980	117.4310590	WibhuTec_90:03:50	Htc_14:8b:9b	802.11	152	Association Response, SN=257, FN=0, Flags=........
64981	117.4324590	WibhuTec_90:03:50	Htc_14:8b:9b	802.11	152	Association Response, SN=257, FN=0, Flags=....R...

WPA2

Open

Scenario #2: Rogue Access Point



What are different types of Rogue APs

- Various permutations and combinations of
  - Bridging APs (on subnets coinciding with or different from wired interface address)
  - Router (NAT) APs (with and without MAC cloning)
  - APs with encrypted wireless links
  - APs with open wireless links
  - Soft APs (natively configured on wireless client or which use external devices such as USB sticks)

Windows 7 Virtual AP
Evolution of Wi-Fi support on laptops

Traditional Wi-Fi

Operate as client/ad-hoc

First Gen “Soft AP”

Convert laptop into AP

But, single function: Can operate either as AP OR client/ad-hoc

Windows 7 Virtual WiFi – The Next Gen Soft AP

Can operate as Soft AP and Client/Ad-hoc simultaneously

Windows 7 Soft AP: A User's Delight

- No new hardware/software needed
- Connect to two different wireless networks with a single card
- One virtual interface acts as a client
- Easy to configure the other interface as an AP or a client
- Configure other virtual interface in AP mode to
  - Form a personal wireless network with PDAs and other devices
  - Share Internet
  - Extend the range of an AP by introducing a hop

Scenario #3: Uncontrolled Clients

BYOD

Authorized Client Extrusions

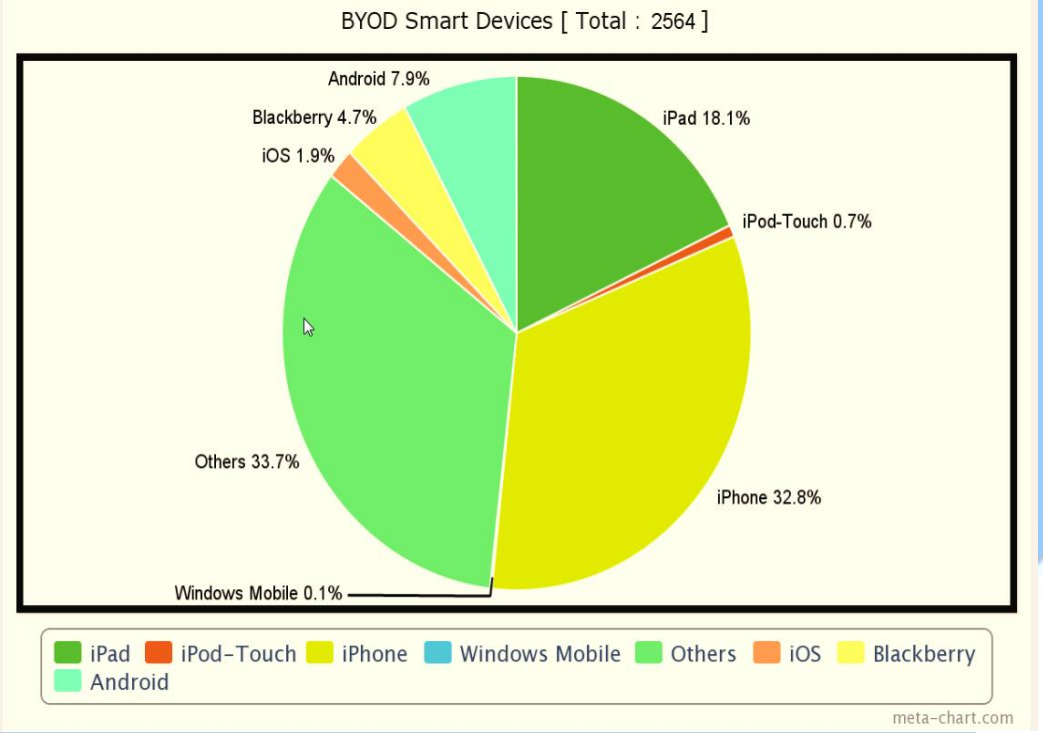
BYOD

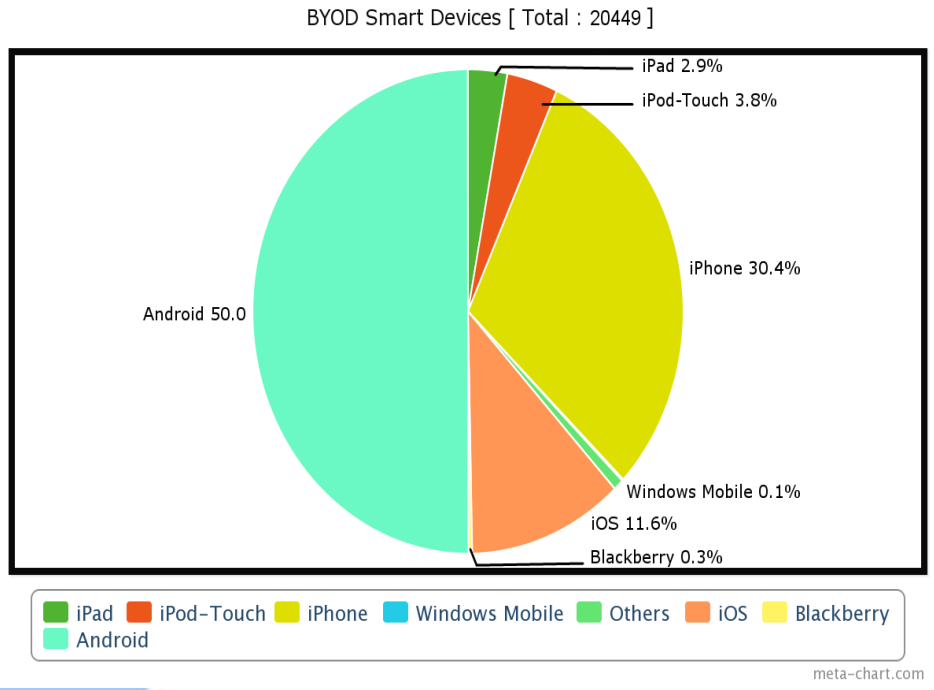
A Wireless Tsunami of Devices

Managing the “Unmanaged”

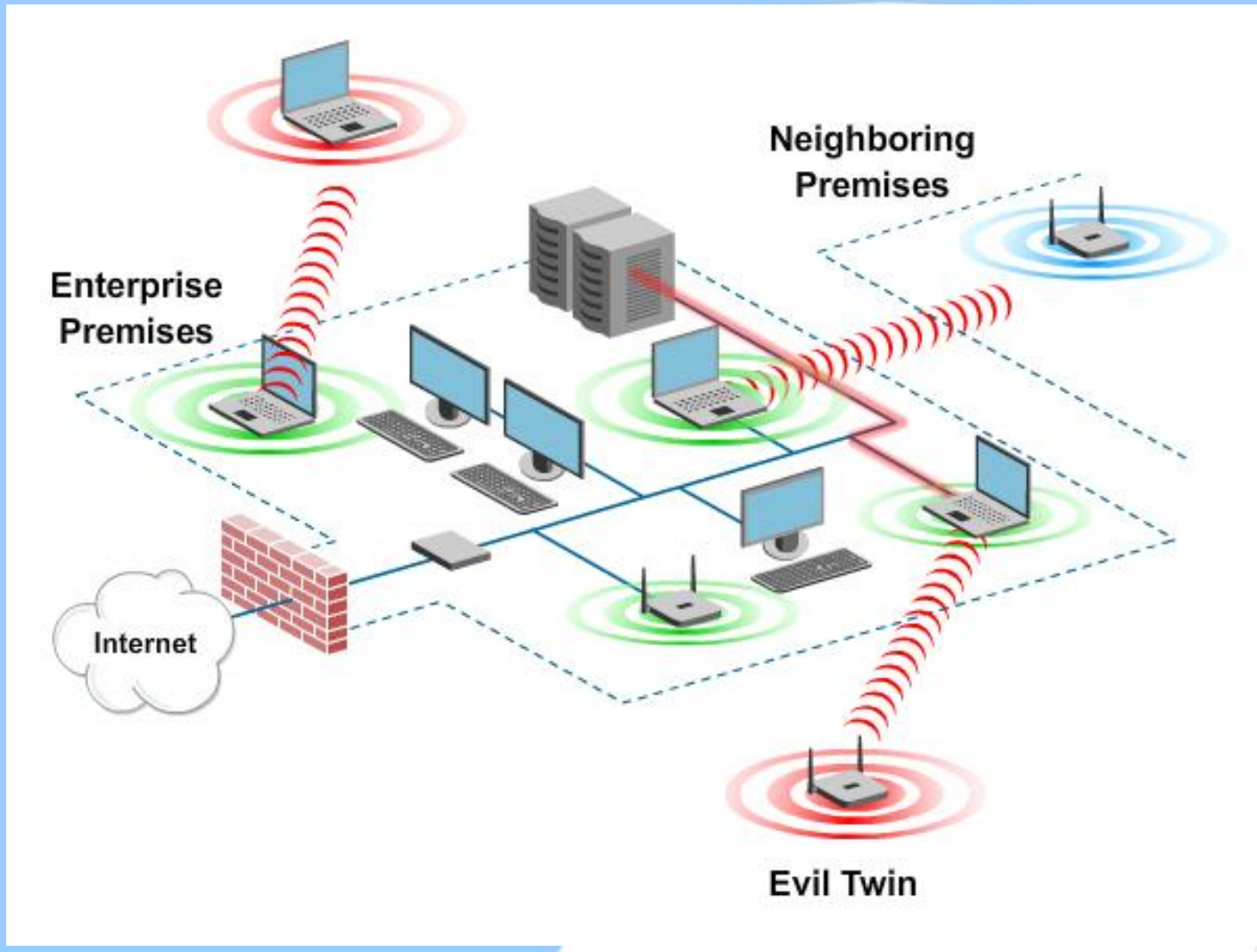
WPA2/802.1x cannot prevent unauthorized devices from accessing the enterprise network

Real-life Examples: BYOD is rampant!





Client Extrusions (Mis-associated Clients)



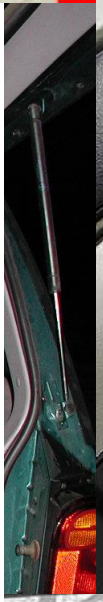
Misassociations: Deliberate or unwitting connections to external APs

- Deliberate
  - Employees get enticed to connect to Open external APs
    - Unprotected APs in the neighborhood, Hotspots
- Unwitting
  - Windows wireless connection utility caches earlier connected networks
  - Actively seeks to connect to those networks later
    - Most common with default SSIDs (linksys, default) and hotspot SSIDs (tmobile, GoogleWiFi)
- Traffic over such connections bypasses enterprise security controls

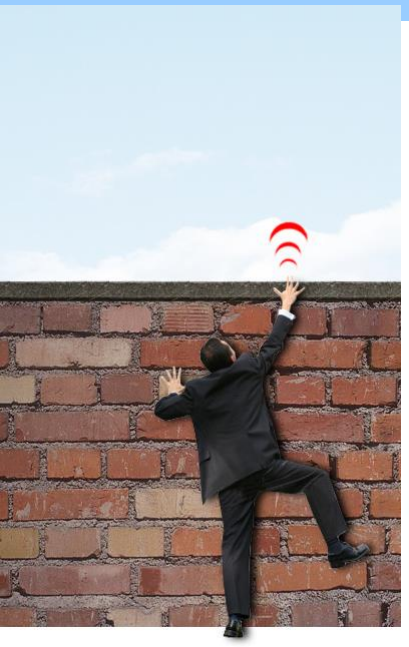
Mis-associations: Evil-Twin Attack

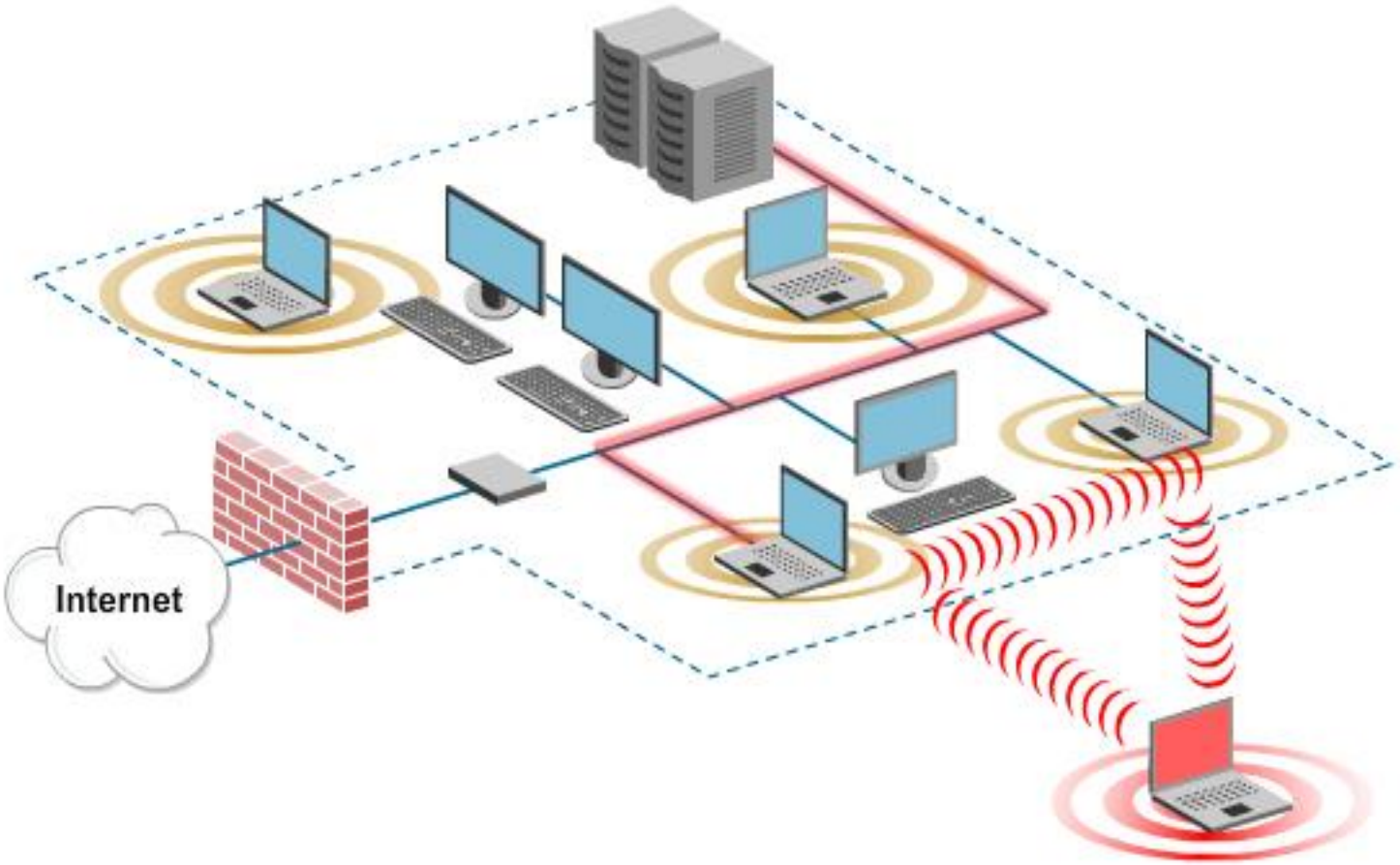
- An attacker sets up an AP that advertises SSID which is being probed by WiFi clients or that advertises SSID of a nearby enterprise or hotspot
- Induces WiFi clients into connecting to it
- Can launch variety of attacks after connection is established
  - Stealing sensitive corporate data
  - Man-in-the-middle/Wi-Phishing
  - Scanning the laptop for vulnerabilities (e.g., Metasploit)
- Honeypot attack tools are freely available over Internet
  - KARMA, Delegated
- Can be easily carried out using just a Smartphone!
  - "Smartpots" (http://www.marketwired.com/press-release/Smartphone-as-Attacker-AirTight-Demos-SmartPots-CSI-2010-Next-Generation-Wi-Fi-Attacks-1341134.htm)

Today, This is all you need!



Scenario #4: Ad Hoc Networks





“Known” Vulnerable SSIDs Probed For

103 distinct SSIDs recorded

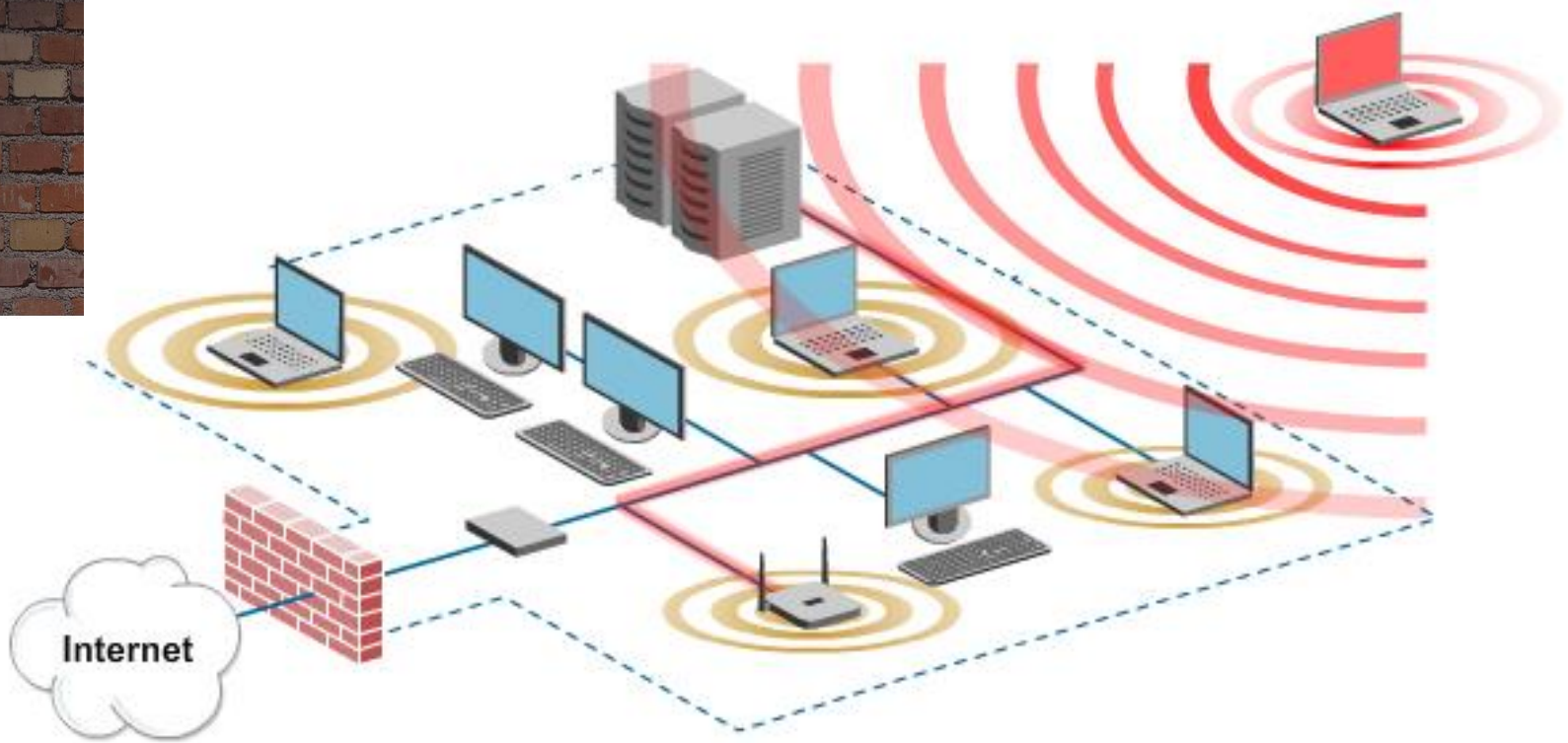
Certain (8%) Authorized Clients Probing for 5 or more SSIDs

Adhoc Authorized Clients!

565 distinct Adhoc SSIDs found, About half of them Vulnerable

15% of these are default SSIDs. 26,443 (7%) clients in adhoc mode.

Scenario #5: War Driving, DoS, Hacking Tools



DoS By Disassociation Flood

23409	38.42605500	WibhuTec_41:71:f0	Broadcast	802.11	311	Beacon frame, SN=67, FN=0, Flags=........, BI=100, SSID=dav_wpa
23412	38.43257800	WibhuTec_41:71:f3	Broadcast	802.11	419	Beacon frame, SN=3071, FN=0, Flags=........, BI=100, SSID=dav_open
23413	38.43632400	WibhuTec_d0:38:01	Broadcast	802.11	302	Beacon frame, SN=1353, FN=0, Flags=........, BI=100, SSID=LSDK_WPA2_an
23437	38.47897100	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3739, FN=0, Flags=........
23441	38.48951900	Pathscal_d0:05:c0	Broadcast	802.11	325	Beacon frame, SN=1005, FN=0, Flags=........, BI=100, SSID=NAT_TS
23442	38.49138700	WibhuTec_d0:33:c0	Broadcast	802.11	355	Beacon frame, SN=3721, FN=0, Flags=........, BI=100, SSID=vap1_open
23450	38.51418700	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3746, FN=0, Flags=........
23457	38.53431800	WibhuTec_41:71:f3	Broadcast	802.11	419	Beacon frame, SN=3072, FN=0, Flags=........, BI=100, SSID=dav_open
23471	38.55411500	WibhuTec_41:71:ff	Htc_14:8b:9b	802.11	174	Disassociate, SN=3753, FN=0, Flags=........
23482	38.57615600	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3758, FN=0, Flags=........
23488	38.58260300	WibhuTec_41:71:ff	Htc_14:8b:9b	802.11	174	Disassociate, SN=3760, FN=0, Flags=........
23527	38.67215800	Pathscal_00:11:80	Broadcast	802.11	337	Beacon frame, SN=1422, FN=0, Flags=........, BI=100, SSID=MK_11N1
23531	38.67931600	WibhuTec_41:71:ff	Htc_14:8b:9b	802.11	174	Disassociate, SN=3781, FN=0, Flags=........
23541	38.71328300	WibhuTec_90:6e:f0	Broadcast	802.11	302	Beacon frame, SN=1775, FN=0, Flags=........, BI=100, SSID=Piy2G-SSID
23548	38.72983600	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3790, FN=0, Flags=........
23556	38.74408800	WibhuTec_d0:38:01	Broadcast	802.11	302	Beacon frame, SN=1378, FN=0, Flags=........, BI=100, SSID=LSDK_WPA2_an
23569	38.76996800	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3798, FN=0, Flags=........
23575	38.78038500	Pathscal_d0:09:00	Broadcast	802.11	393	Beacon frame, SN=3229, FN=0, Flags=........, BI=100, SSID=PST-c75-1
23580	38.78705400	WibhuTec_d0:2a:20	Broadcast	802.11	361	Beacon frame, SN=3565, FN=0, Flags=........, BI=100, SSID=Spectrum
23583	38.78927700	WibhuTec_41:71:ff	Broadcast	802.11	174	Disassociate, SN=3802, FN=0, Flags=........
23584	38.78940800	WibhuTec_41:71:ff	Htc_14:8b:9b	802.11	174	Disassociate, SN=3803, FN=0, Flags=........

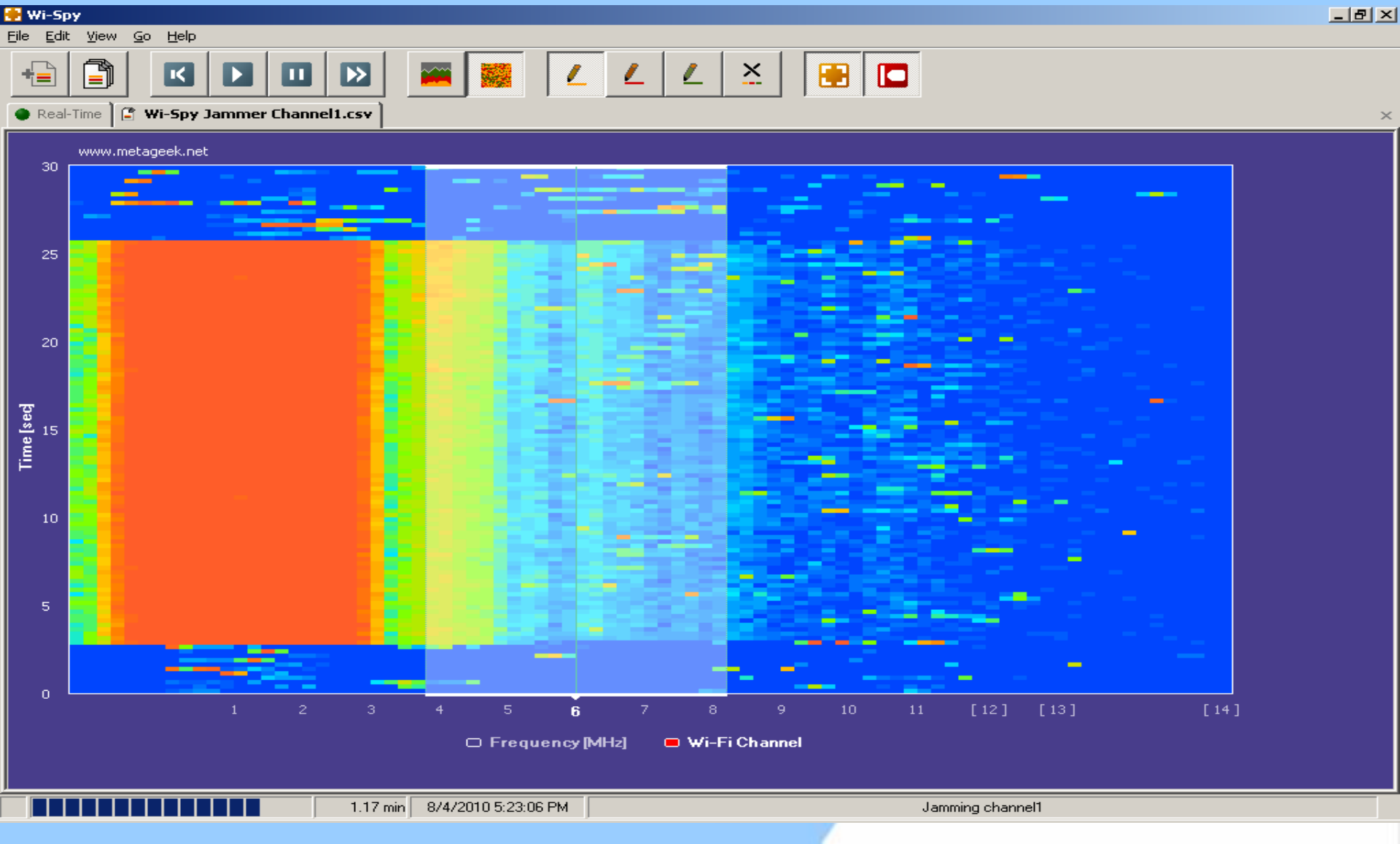
DoS By RTS Flood

2613	5.671256000	WibhuTec_d0:2a:20	Htc_14:8b:9b	802.11	345	Probe Response, SN=2175, FN=0, Flags=........, BI=100, SSID=Spectrum
2620	5.685225000	WibhuTec_d0:2a:21	Htc_14:8b:9b	802.11	323	Probe Response, SN=4010, FN=0, Flags=....R..., BI=100, SSID=ATNGuest
2955	6.322783000	WibhuTec_41:71:f0	Htc_14:8b:9b	802.11	296	Probe Response, SN=40, FN=0, Flags=....R..., BI=100, SSID=dav_wpa
3005	6.417642000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3006	6.417676000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3008	6.417908000	Cisco_40:e6:7f	Htc_14:8b:9b	802.11	274	QoS Data, SN=17, FN=0, Flags=.pm.R.F.
3013	6.422589000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3015	6.422641000	Cisco_40:e6:7f	Htc_14:8b:9b	802.11	264	QoS Data, SN=19, FN=0, Flags=.pm.R.F.
3021	6.424925000	Cisco_40:e6:7f	Htc_14:8b:9b	802.11	264	QoS Data, SN=21, FN=0, Flags=.p....F.
3084	6.530604000	LiteonTe_01:21:b3 (T	WibhuTec_d0:30:60 (RA	802.11	164	Request-to-send, Flags=........
3092	6.543894000	LiteonTe_01:21:b3 (T	WibhuTec_d0:30:60 (RA	802.11	164	Request-to-send, Flags=........
3460	7.215595000	SamsungE_4b:c1:f4 (T	WibhuTec_d0:2a:20 (RA	802.11	164	Request-to-send, Flags=........
3469	7.249669000	LiteonTe_01:21:b3 (T	WibhuTec_d0:30:60 (RA	802.11	164	Request-to-send, Flags=........
3524	7.321736000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3526	7.326179000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3527	7.326661000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3528	7.326688000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3529	7.327228000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3531	7.328814000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3532	7.330614000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3533	7.330647000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........
3534	7.330661000	WibhuTec_41:71:f0 (T	Htc_14:8b:9b (RA)	802.11	164	Request-to-send, Flags=........

DoS By NAV Duration

No.	NAV Duration	Time	Source	Destination	Protocol	Length	Info
761	0	1.898020000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
975	0	2.383255000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
1909	0	4.402240000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
2322	0	5.382442000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
2750	0	6.389207000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
2989	0	6.884010000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
4364	0	9.389662000	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5111	0	10.88282300(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5570	0	11.88507300(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5770	1742	12.28142600(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5771	1742	12.28611100(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5772	1742	12.28678800(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5774	1742	12.28789900(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5776	1742	12.29325100(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5777	1742	12.29380700(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5778	1742	12.29439800(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5779	1742	12.29505500(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5787	1782	12.30766000(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5788	1782	12.30906100(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5790	1782	12.30986400(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5794	1782	12.31195400(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5797	1782	12.31315600(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5799	1782	12.31379400(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C
5817	1782	12.33903400(	WibhuTec_90:03:50	Htc_14:8b:9b (RA)	802.11	38	Request-to-send, Flags=.....C

RF Jamming


Wi-Spy
File Edit View Go Help
Real-Time
Wi-Spy Jammer Channel1.csv
www.metageek.net
Time [sec]
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 [12] [13] [14]
Frequency [MHz]
Wi-Fi Channel
1.17 min
8/4/2010 5:23:06 PM
Jamming channel1

Wi-Fi Threats: A Quick View From the Trenches

Statistics From Real-Life Deployments
May-Jun 2014 (Data for 30 days)

Number of Sites / Threat Instance	Rogue AP	Client Mis-associations	Mobile Hotspots/ Virtual APs	DoS Attacks
Customer 1 (258)	84	4963	35	1
Customer 2 (188)	4	97	6	33
Customer 3 (507)	196	446	48	21

Threat Mitigation

Unfortunately, none of these strategies work!

Let’s ban Wi-Fi

We don’t have “that” problem because…

Use Strong Encryption and Authentication For Your Authorized WLAN (WPA2)!

But, this does not protect against threats due to unmanaged devices!

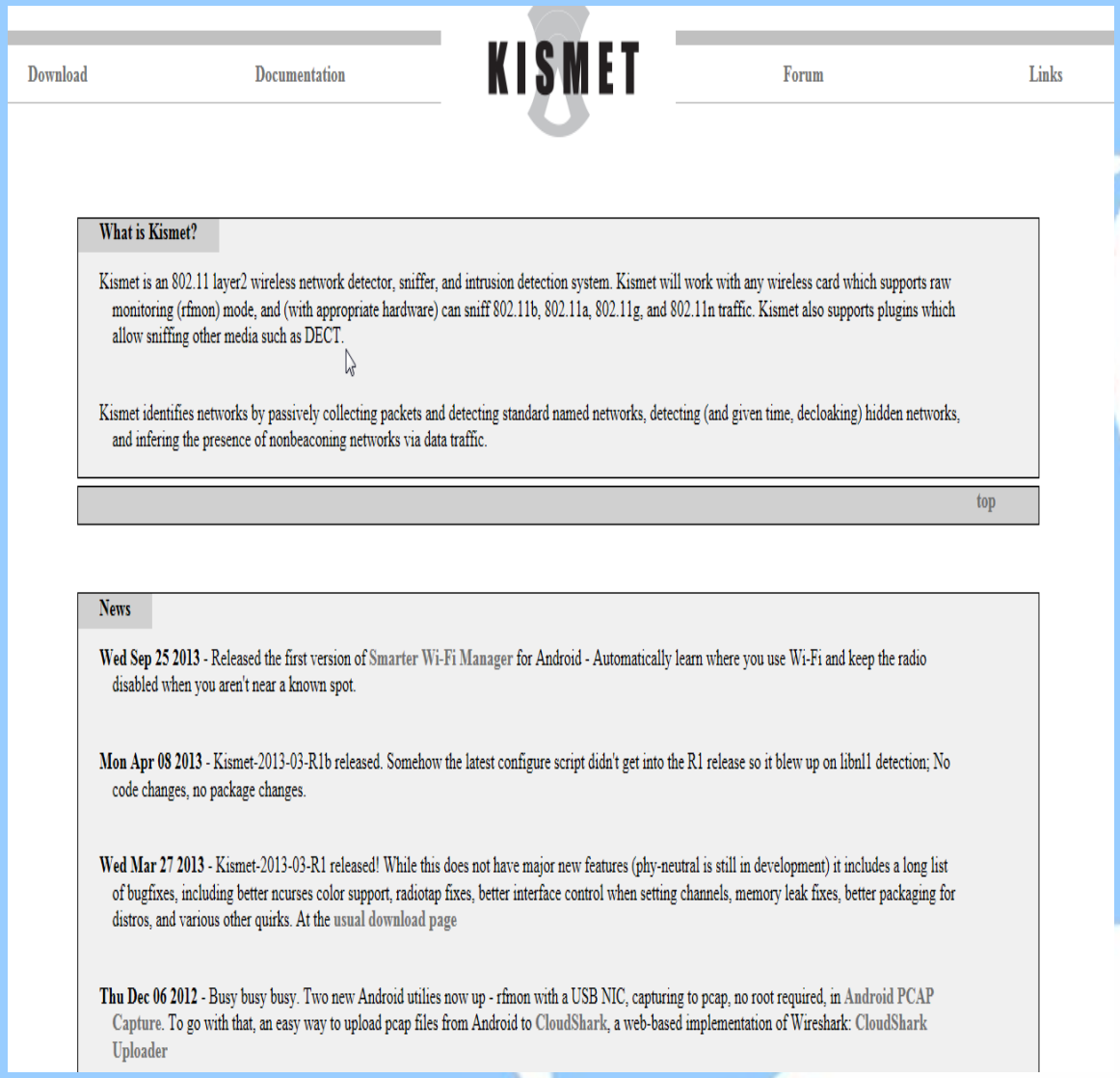
Packet Sniffers & Pen Testing Tools

Several Free and Commercial Sniffers available

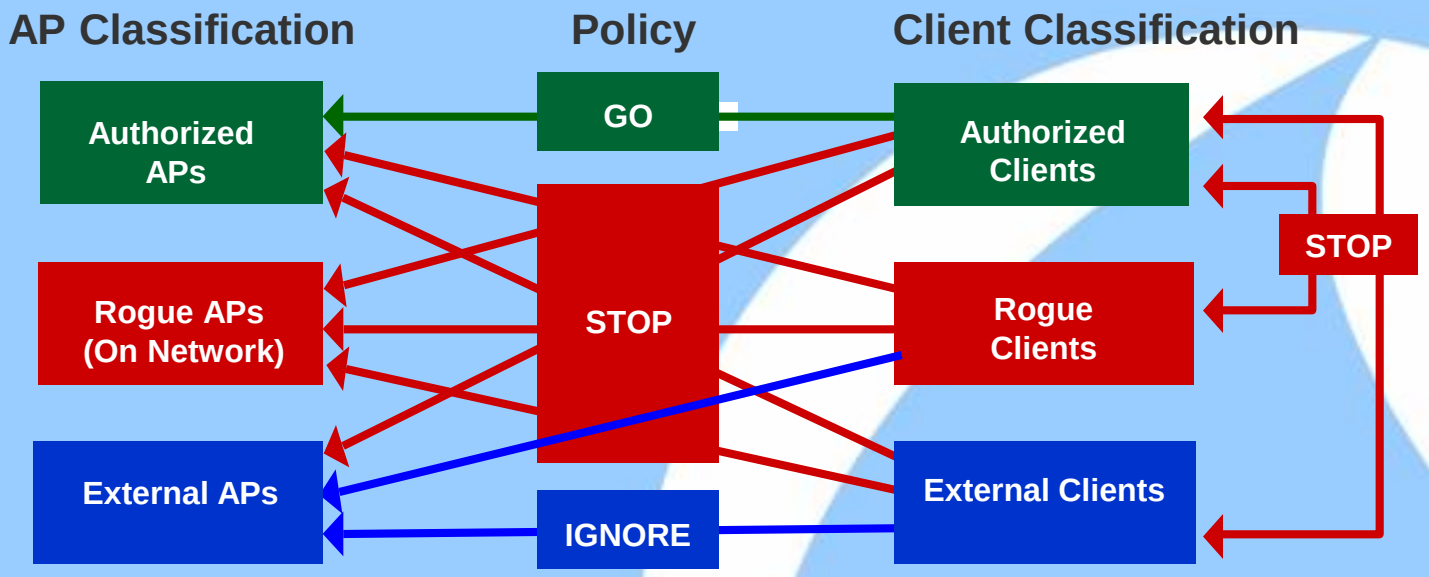
- Wireshark
- Airpcap
- Backtrack
- KARMA
- Metasploit
- AirCrack-ng

Wireless IDS (WIDS)

WIDS: Sniff and Detect Threats



Threat Mitigation: The Essence

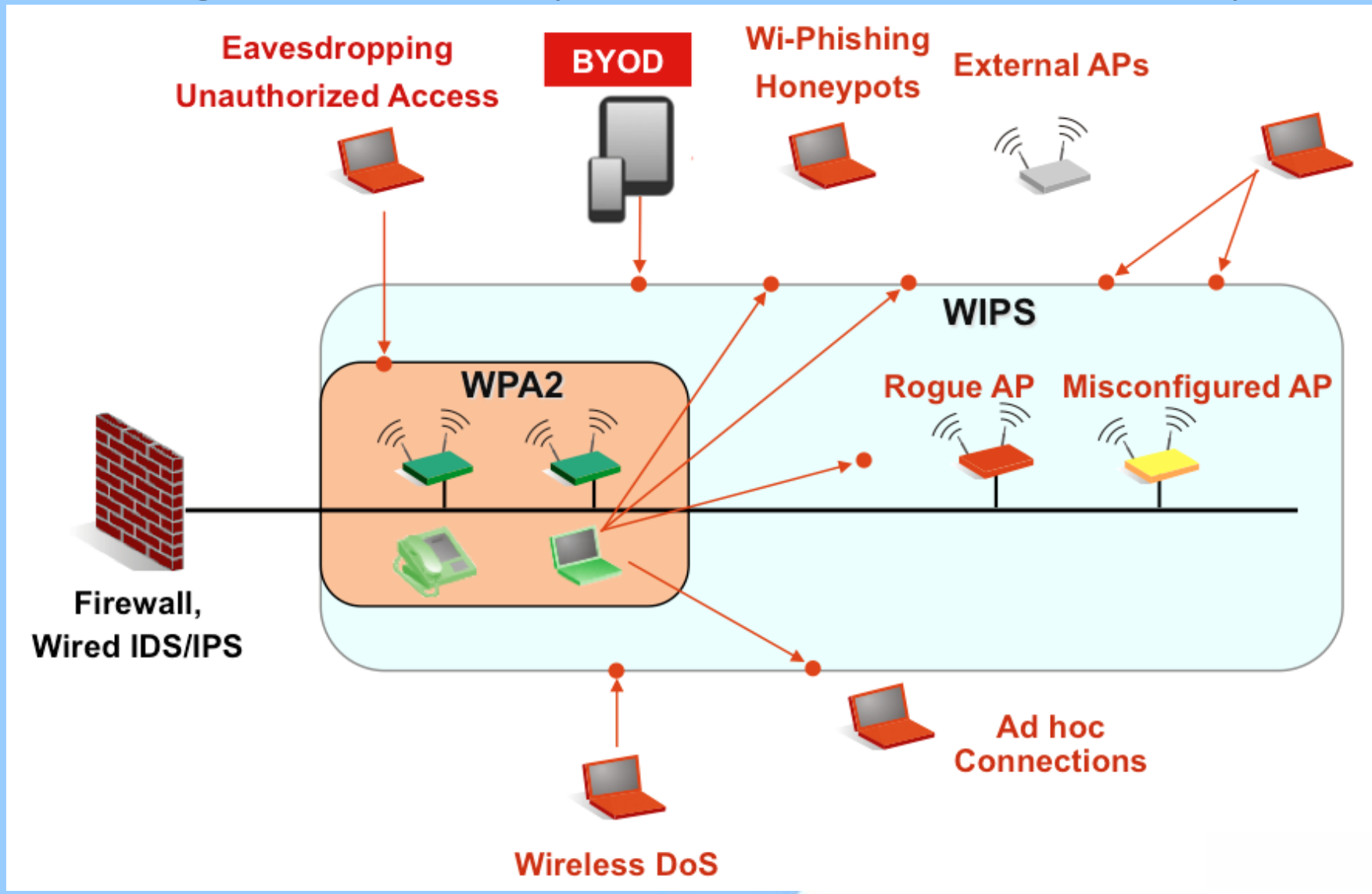


AUTOMATICALLY DETECT AND BLOCKS RED PATHS!

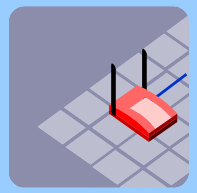
Wireless IPS (WIPS)

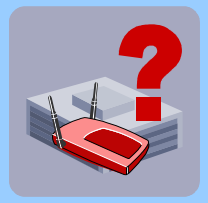
WIPS – 24x7 Visibility & Protection

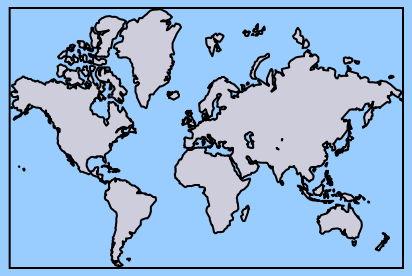
Adding another layer to Network Security



Capabilities of a WIPS



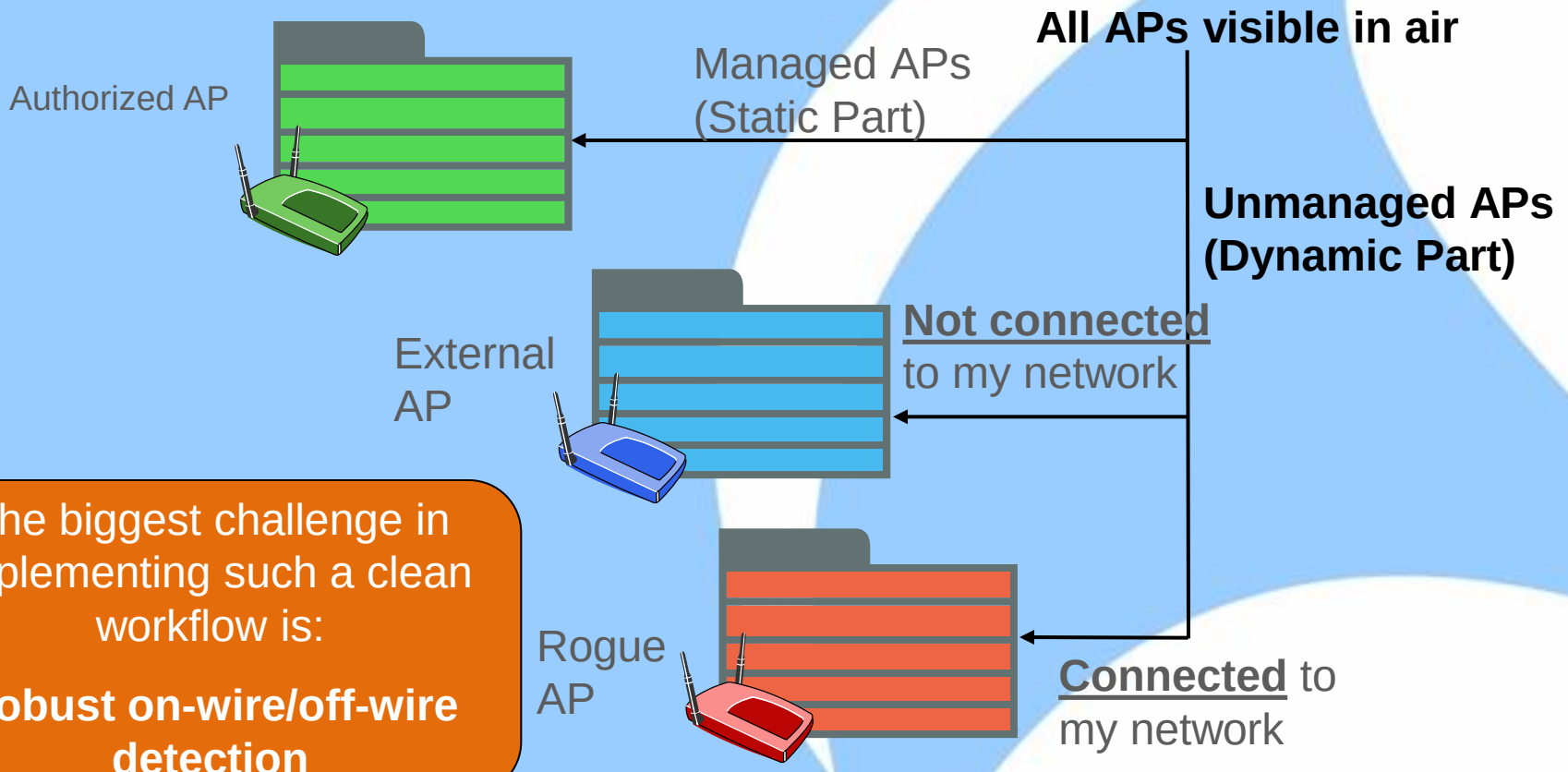




- Report wireless vulnerabilities proactively and detect all types of threats in real-time
- Classify what is a real threat and if it is on your network
- Automatically block unauthorized wireless activity
- Physically locate and remove threats
- Enforce security policies at multiple distributed sites without leaving your desk

Rogue AP Detection

- Automatically classifying APs visible in airspace into three categories: Authorized, External and Rogue



The biggest challenge in implementing such a clean workflow is:

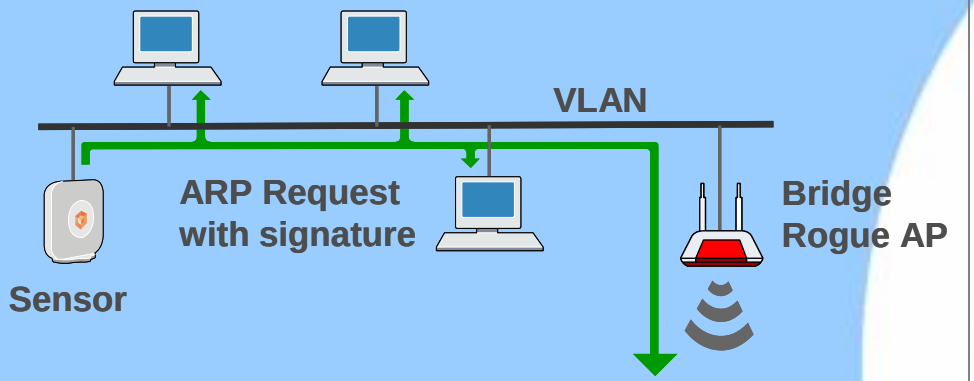
Robust on-wire/off-wire detection

Key Enabler For Connectivity

Definitive "on-wire / off-wire" test

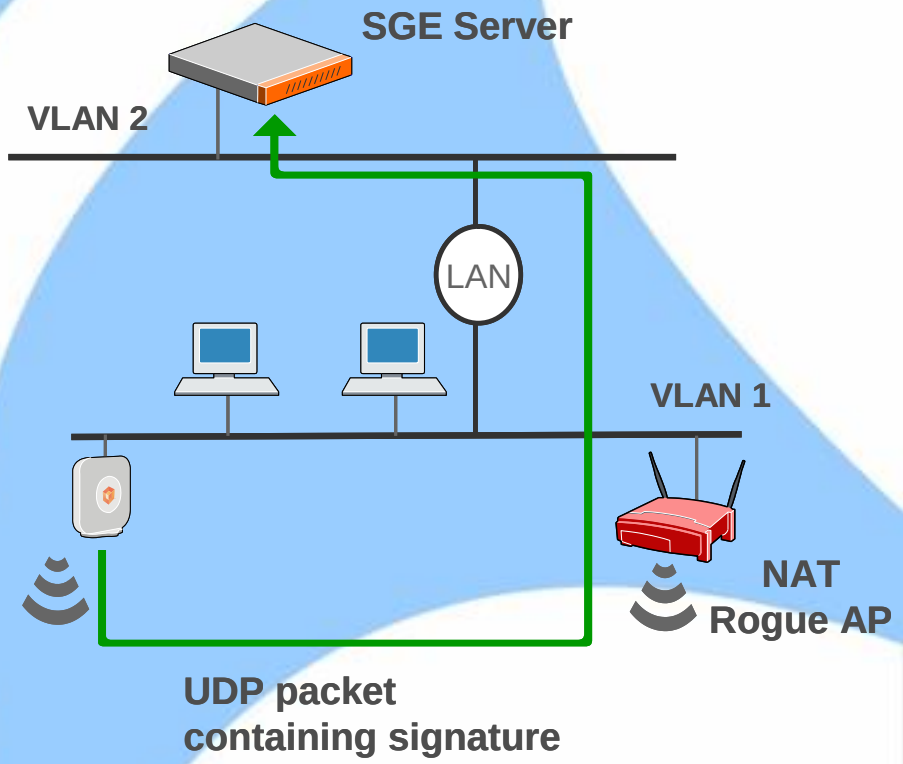
ARP Request Marker Packet

Sensor sends ARP requests with signatures on the wire and detects if any get forwarded onto the wireless side



UDP Reverse Marker Packet

Sensor sends UDP packets with signatures in the air and server detects if any get forwarded onto the wire

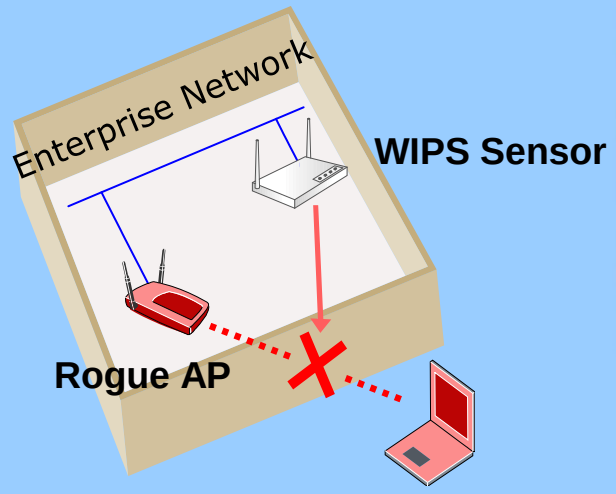


Can wire side only scanning protect from all Rogue AP

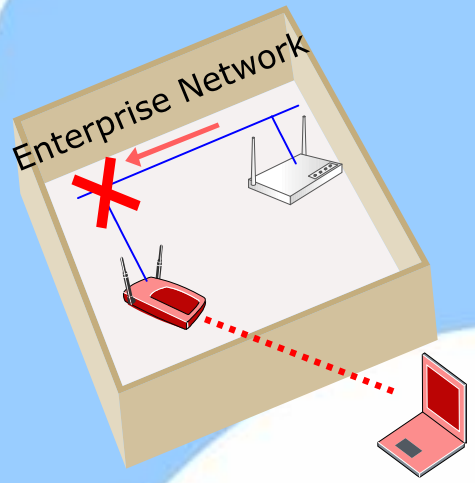
- No!
- Several Rogue AP types are undetectable by wire side only scanning, examples:
  - Bridging APs on a subnet inconsistent with their wired IP address (default configuration)
  - Soft APs
  - Router (NAT) APs with cloned wire side MAC address
- See http://blog.airtightnetworks.com/rogue-ap-detection-pci-compliance/ for more details

How does WIPS block Rogue AP

- Over the air quarantine
  - WIPS sensor blocks client's connection to Rogue AP by transmitting spoofed disconnection frames
  - Deauthentication is popularly used disconnection frame

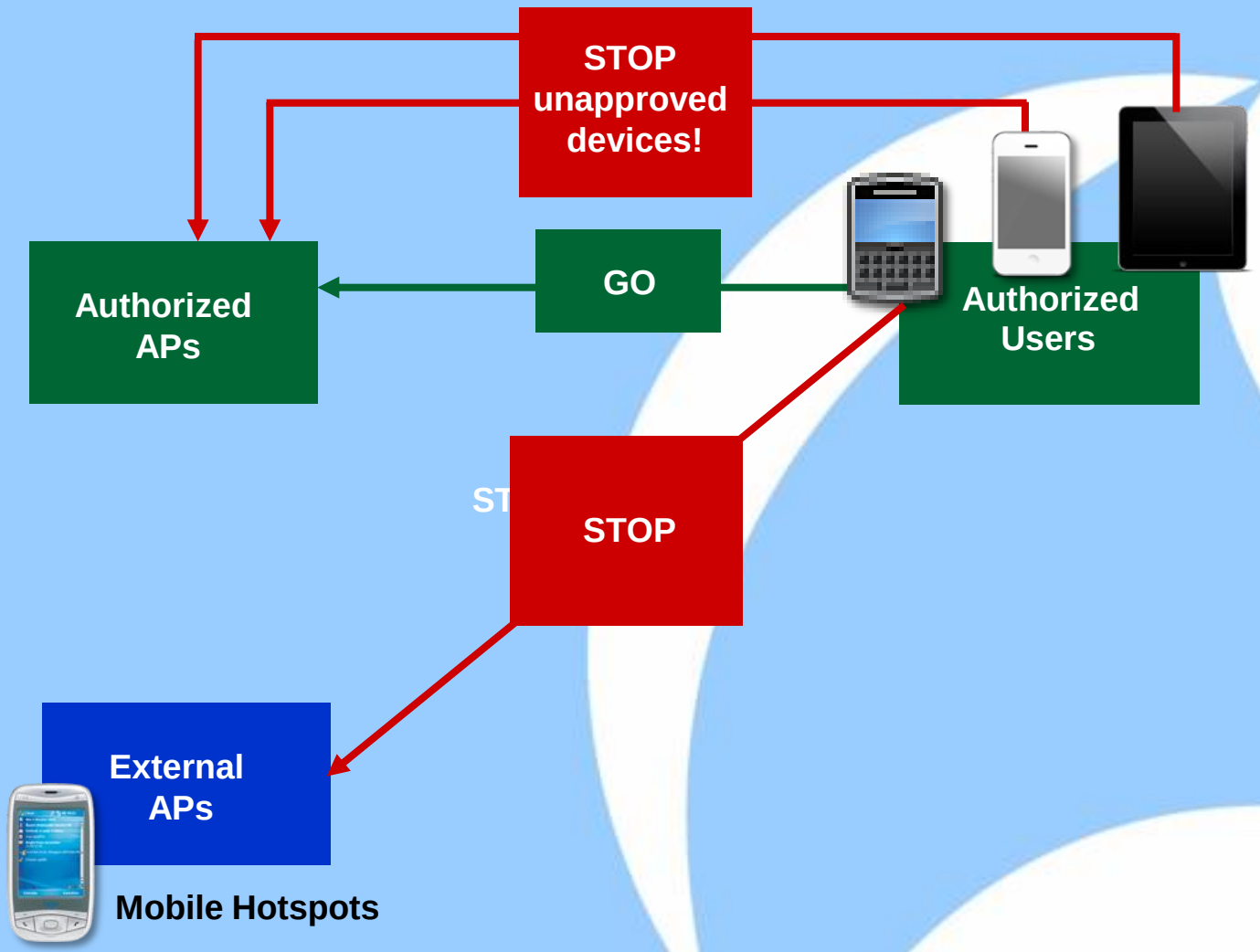


- Switch port disable
  - WIPS attempts to locate switch port into which Rogue AP is connected
  - If found, disables the switch port using SNMP



BYOD Mitigation

Extending the WIPS for BYOD Policy Enforcement



Automatic Device Fingerprinting and Classification

- MDM and NAC are unable to provide the first line of defense
- WIPS complements these solutions to fully automate secure BYOD

Android	30:39:26:4B:86:C1	30:39:26:4B:86:C1
Blackberry	BLACKBERRY-9FC8	30:69:4B:9C:FE:F7
Blackberry	BLACKBERRY-3300	40:6A:AB:E3:BA:C3
iPad	Var	74:E1:B6:BE:4B:AD
iPad	Sushmas-iPad.lo	FC:25:3F:AA:2E:AC
iPad	ATN	44:2A:60:9B:A1:C8
iPhone	Louiss-iPhone.l	58:1F:AA:61:A7:F7
iPhone	iPhone	00:1C:B3:65:73:94
iPhone	LAP119-PC	0C:77:1A:3B:42:0D
iPod-Touch	NP-	00:26:BB:BA:C7:A7
Windows-Mobile	Karan-HTC_90:11:1D	F8:DB:7F:90:11:1D
[illegible]	Nokia_2[illegible]	[illegible]C:E9:07:29:[illegible]

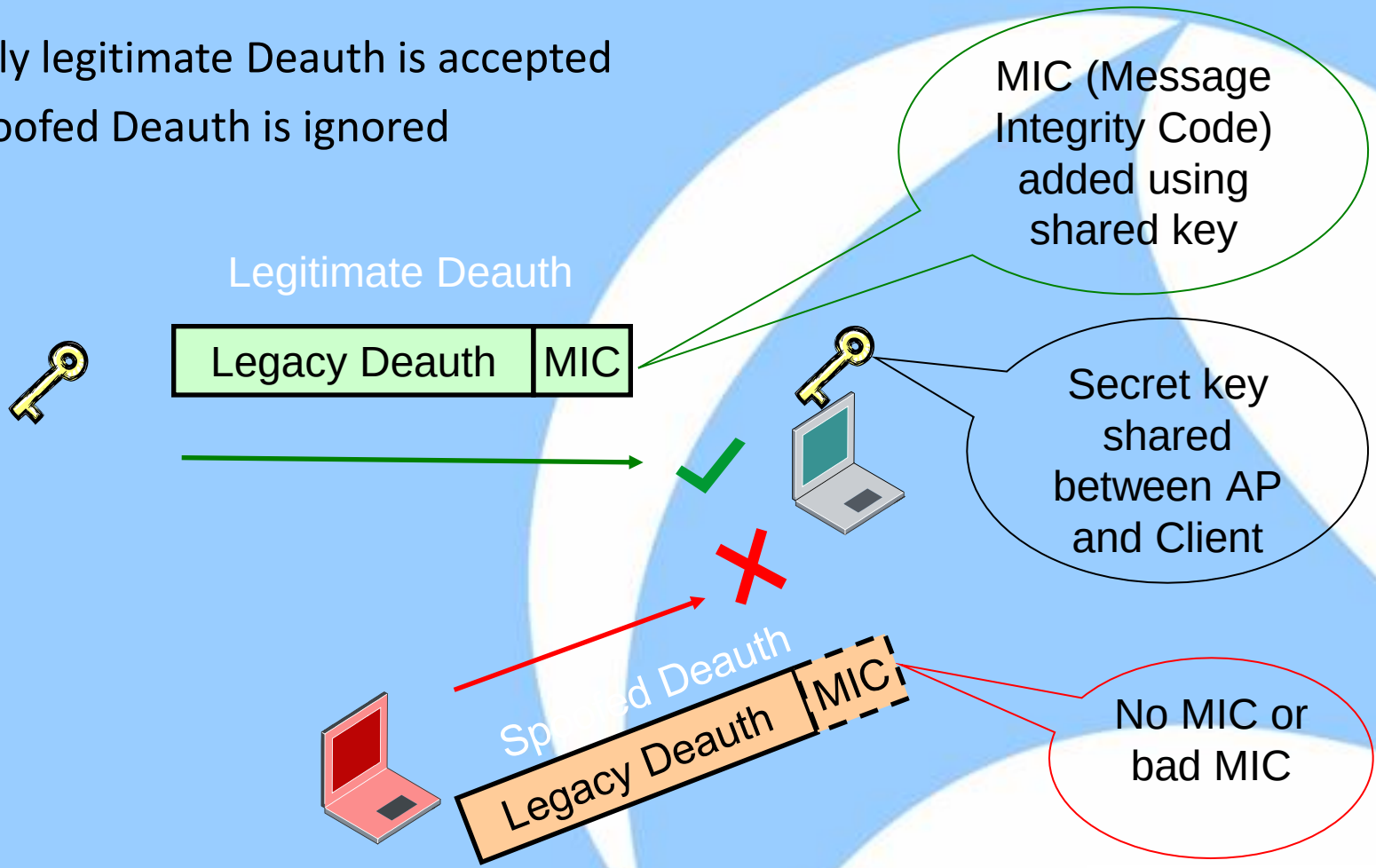
DoS Attack Mitigation

802.11w: Basic Idea

Can we introduce some notion of authentication/integrity in management frames so that a receiver can differentiate legitimate packets from that of an attacker?

802.11w based Deauthentication Attack Prevention

- Only legitimate Deauth is accepted
- Spoofed Deauth is ignored

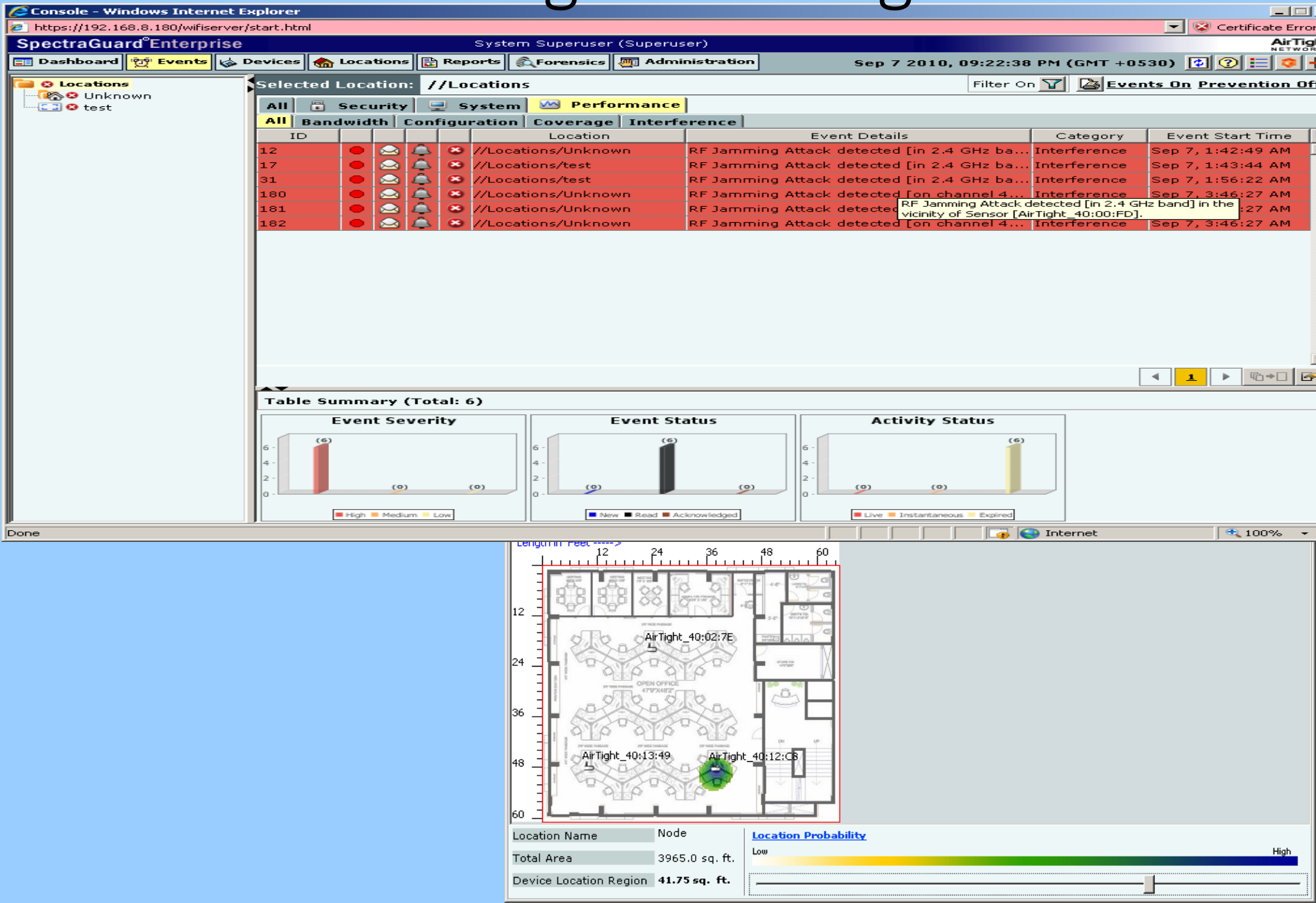


What does IEEE 802.11w achieve?

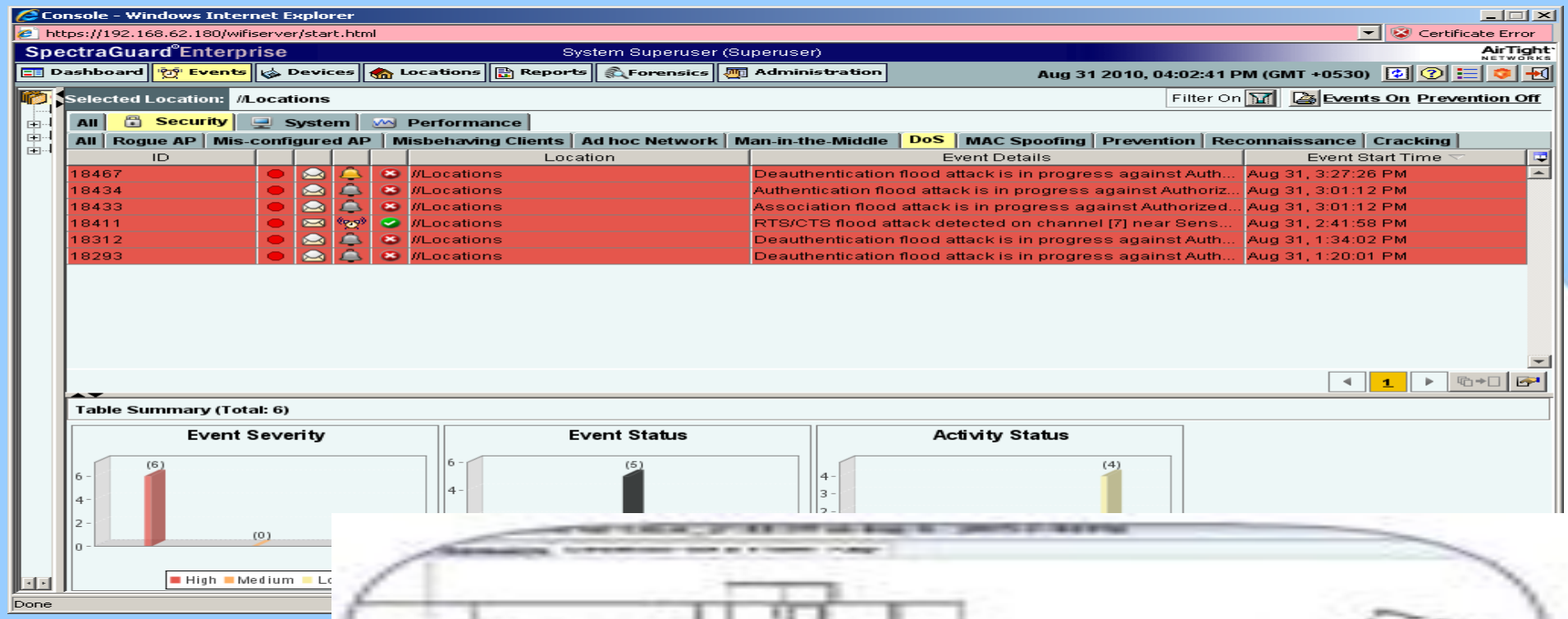
- 802.11w gets rid of certain types of DoS Attacks only
  - "Spoofed Disconnect" DoS attacks resulting from spoofing of
    - (i) Deauthentication (Deauth), (ii) Disassociation (Disassoc), (iii) Association (Assoc) Request in existing connection, or (iv) Authentication (Auth) Request in existing connection
- Certain "Action Management Frames" are also made anti-spoofing
  - Spectrum Management, QoS, BlockAck, Radio Measurement, Fast BSS Transition
- But, other DoS attacks are still possible!

WIPS Complements 802.11w by providing a detection & location based DoS mitigation workflow!

RF Jamming DOS Mitigation



MAC Level DoS Attacks



Summary: Five steps to protect against WiFi security breaches

Recommended Best Practice	WiFi deployed	WiFi not deployed
Use strong authentication and encryption: Use the best standards for authentication and encryption (e.g., WPA/WPA2) when deploying WiFi networks	✓	
Monitor guest WiFi access: Authenticate guest users and monitor unauthorized access when providing guest access over WiFi networks	✓	
Conduct wireless security audits and scans: Periodically conduct wireless scans to detect presence of unauthorized WiFi devices and activity in your premises.	✓	✓
Follow endpoint wireless security best practices: Promote WiFi security best practices among laptop users. Using wireless security endpoint security agent, enforce your enterprise policies seamlessly across all laptops and secure them even when they are away.	✓	✓
Use a Wireless Intrusion Prevention System (WIPS): Prevent leakage of sensitive data and protect your network from wireless security threats with 24/7 wireless monitoring	✓	✓

Limitations of Solutions Discussed So Far …

- No one can protect a mis-configured network – e.g., WEP or Open Wi-Fi Network ☺
- Educate your users – otherwise, technology solutions can just go only so much!

ACKNOWLEDGEMENTS

- Many Thanks To
  - Sharkfest organizing committee
  - Rohan Shah, AirTight Networks
  - Davneet Singh, AirTight Networks
  - Ranganath Jilla, AirTight Networks

Thank You

Questions?

gopi@airtightnetworks.com