



## APPENDIX **A**

# wIPS Policy Alarm Encyclopedia

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This appendix provides an overview of the types on threats that wIPS addresses.

- [“Security IDS/IPS Overview” section on page A-2](#)
- [“Intrusion Detection—Denial-of-Service Attack” section on page A-3](#)

# Security IDS/IPS Overview

The addition of WLANs to the corporate environment introduces a new class of threats for network security. RF signals that penetrate walls and extend beyond intended boundaries can expose the network to unauthorized users. Rogue access points installed by employees for their personal use usually do not adhere to the corporate security policy. A rogue access point can put the entire corporate network at risk for outside penetration and attack. Not to understate the threat of the rogue access point, there are many other wireless security risks and intrusions such as mis-configured and unconfigured access points and DoS (denial-of-service) attacks.

The Cisco Adaptive Wireless IPS is designed to help manage against security threats by validating proper security configurations and detecting possible intrusions. With the comprehensive suite of security monitoring technologies, the Cisco Adaptive Wireless IPS alerts the user on more than 100 different threat conditions in the following categories:

- User authentication and traffic encryption
- Rogue and ad-hoc mode devices.
- Configuration vulnerabilities
- Intrusion detection on security penetration
- Intrusion detection on DoS attacks

To maximize the power of the Cisco Adaptive Wireless IPS, security alarms can be customized to best match your security deployment policy. For example, if your WLAN deployment includes access points made by a specific vendor, the product can be customized to generate the rogue access point alarm when an access point made by another vendor is detected by the access point or sensor.

## Pre-configured profiles for various WLAN environments

During installation, the user can select an appropriate profile based on the WLAN network implemented.

The Cisco Adaptive Wireless IPS provides separate profiles for:

- Enterprise best practice
- Enterprise rogue detection only
- Financial (Gramm-Leach-Bliley Act compliant)
- HealthCare (Health Insurance Portability and Accountability Act compliant)
- Hotspot implementing 802.1x security
- Hotspot implementing NO security
- Tradeshow environment
- Warehouse/manufacturing environment
- Government/Military (8100.2 directive compliant)
- Retail environment

When the administrator selects the appropriate profile, the Cisco Adaptive Wireless IPS will enable or disable alarms from the policy profile that are appropriate for that WLAN environment. For example, health care institutions can select the Healthcare profile and all alarms that are necessary to be HIPAA compliant will be enabled. The administrator still has the option after installation to enable or disable any alarm or change the threshold values as per individual preferences.

The Cisco Adaptive Wireless IPS system not only is an IDS (Intrusion Detection System), but also is an IPS (Intrusion Prevention System).

Cisco Adaptive Wireless IPS policies are included in two security subcategories: wIPS—Denial of Service (DoS) Attacks and wIPS—Security Penetration.

- [Intrusion Detection—Denial-of-Service Attack](#)
- [Intrusion Detection—Security Penetration](#)

## Intrusion Detection—Denial-of-Service Attack

Wireless DoS (denial-of-service) attacks aim to disrupt wireless services by taking advantage of various vulnerabilities of WLAN at layer one and two. DoS attacks may target the physical RF environment, access points, client stations, or the back-end authentication RADIUS servers. For example RF jamming attack with high power directional antenna from a distance can be carried out from the outside of your office building. Attack tools used by intruders leverage hacking techniques such as spoofed 802.11 management frames, spoofed 802.1x authentication frames, or simply using the brute force packet flooding method.

The nature and protocol standards for wireless are subject to some of these attacks. Cisco has developed Management Frame Protection, the basis of 802.11i, to proactively prevent many of these attacks. (For more information on MFP, refer to the Cisco WCS online help.) The Cisco Adaptive Wireless IPS contributes to this solution by an early detection system where the attack signatures are matched. The Cisco Adaptive Wireless IPS's DoS detection focuses on WLAN layer one (physical layer) and two (data link layer, 802.11, 802.1x). When strong WLAN authentication and encryption mechanisms are used, higher layer (IP layer and above) DoS attacks are difficult to execute. The wIPS server tightens your WLAN defense by validating strong authentication and encryption policies. In addition, the Cisco Adaptive Wireless IPS's Intrusion Detection on Denial-of-Service attacks and security penetration provides 24 X 7 air tight monitoring on potential wireless attacks.

Denial-of-Service Attacks include the following three subcategories:

- [Denial-of-Service Attack Against Access Points](#)
- [Denial-of-Service Attack Against Infrastructure](#)
- [DoS Attacks Against Client Station](#)

## Denial-of-Service Attack Against Access Points

DoS attacks against access points are typically carried out on the basis of the following assumptions:

- Access points have limited resources. For example, the per-client association state table.
- WLAN management frames and authentication protocols 802.11 and 802.1x have no encryption mechanisms.

Wireless intruders can exhaust access point resources, most importantly the client association table, by emulating large number of wireless clients with spoofed MAC addresses. Each one of these emulated clients attempts association and authentication with the target access point but leaves the protocol transaction mid-way. When the access point's resources and the client association table is filled up with these emulated clients and their incomplete authentication states, legitimate clients can no longer be serviced by the attacked access point. This creates a denial of service attack.

The Cisco Adaptive Wireless IPS tracks the client authentication process and identifies DoS attack signatures against the access point. Incomplete authentication and association transactions trigger the attack detection and statistical signature matching process. Detected DoS attack results in setting off wIPS alarms which includes the usual alarm detail description and target device information.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against frame and device spoofing. For more information on MFP, refer to the Cisco WCS online help.

DoS attacks against access points include:

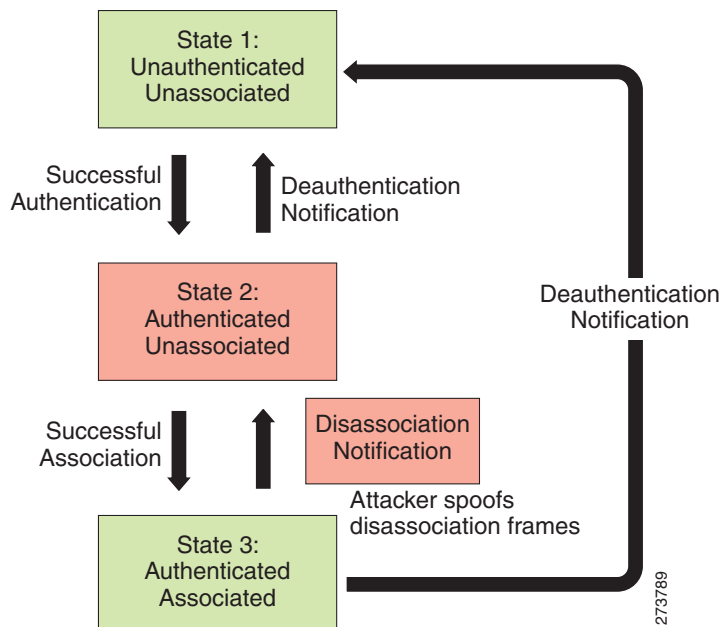
- [Denial-of-Service Attack: Association Flood](#)
- [Denial-of-Service Attack: Association Table Overflow](#)
- [Denial-of-Service Attack: Authentication Flood](#)
- [Denial-of-Service Attack: EAPOL-Start Attack](#)
- [Denial-of-Service Attack: PS Poll Flood Attack](#)
- [Denial-of-Service Attack: Unauthenticated Association](#)

## Denial-of-Service Attack: Association Flood

### Alarm Description and Possible Causes

This DoS attack exhausts the access point's resources, particularly the client association table, by flooding the access point with a large number of spoofed client associations. At the 802.11 layer, shared-key authentication is flawed and rarely used. The other alternative is open authentication (null authentication) that relies on higher level authentication such as 802.1x or VPN. Open authentication allows any client to authenticate and then associate. An attacker using such a vulnerability can emulate a large number of clients to flood a target access point's client association table by creating many clients. When the client association table overflows, legitimate clients cannot get associated; therefore, a DoS attack is committed.

**Figure A-1 Association Flood**



## wIPS Solution

The Cisco Adaptive Wireless IPS detects spoofed MAC addresses and tracks the 802.1x actions and data communication after a successful client association to detect this form of DoS attack. After this attack is reported by the Cisco Adaptive Wireless IPS, you may log onto this access point to inspect its association table for the number of client associations.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against frame and device spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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## Denial-of-Service Attack: Association Table Overflow

### Alarm Description and Possible Causes

Wireless intruders can exhaust access point resources, most importantly the client association table, by imitating a large number of wireless clients with spoofed MAC addresses. Each one of these imitated clients attempts association and authentication with the target access point. The 802.11 authentication typically completes because most deployments use 802.11 open system authentication, which is a null authentication process. Association with these imitated clients follows the authentication process. These imitated clients do not, however, follow up with higher level authentication such as 802.1x or VPN, which leaves the protocol transaction half-finished. At this point, the attacked access point maintains a state in the client association table for each imitated client. When the access point's resources and client association table is filled with these imitated clients and their state information, legitimate clients can no longer be serviced by the attacked access point. This creates a DoS (denial of service) attack.

## wIPS Solution

The Cisco Adaptive Wireless IPS tracks the client authentication process and identifies a DoS attack signature against an access point. Incomplete authentication and association transactions trigger the Cisco Adaptive Wireless IPS's attack detection and statistical signature matching process.

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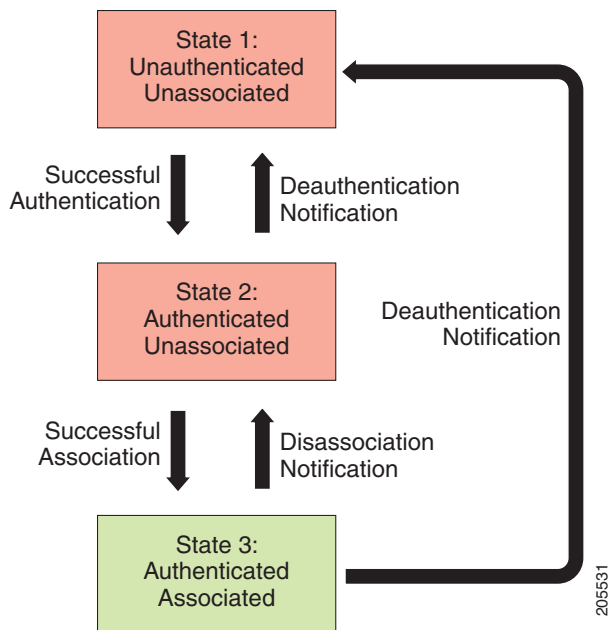
## Denial-of-Service Attack: Authentication Flood

Attack tool: Void11

### Alarm Description and Possible Causes

IEEE 802.11 defines a client state machine for tracking station authentication and association status. Wireless clients and access points implement such a state machine according to the IEEE standard (see [Figure A-2](#)). On the access point, each client has a state recorded in the access point's client table (association table). This recorded state has a size limit that can either be a hard-coded number or a number based on the physical memory constraint.

Figure A-2 Authentication Flood



A form of DoS attack floods the access point's client state table (association table) by imitating many client stations (MAC address spoofing) sending authentication requests to the access point. Upon receipt of each individual authentication request, the target access point creates a client entry in State 1 of the association table. If open system authentication is used for the access point, the access point returns an *authentication success* frame and moves the client to State 2. If shared-key authentication is used for the access point, the access point sends an *authentication challenge* to the attacker's imitated client, which does not respond. In this case, the access point keeps the client in State 1. In either case, the access point contains multiple clients hanging in either State 1 or State 2 which fills up the access point association table. When the table reaches its limit, legitimate clients cannot authenticate and associate with this access point. This results in a DoS attack.

**wIPS Solution**

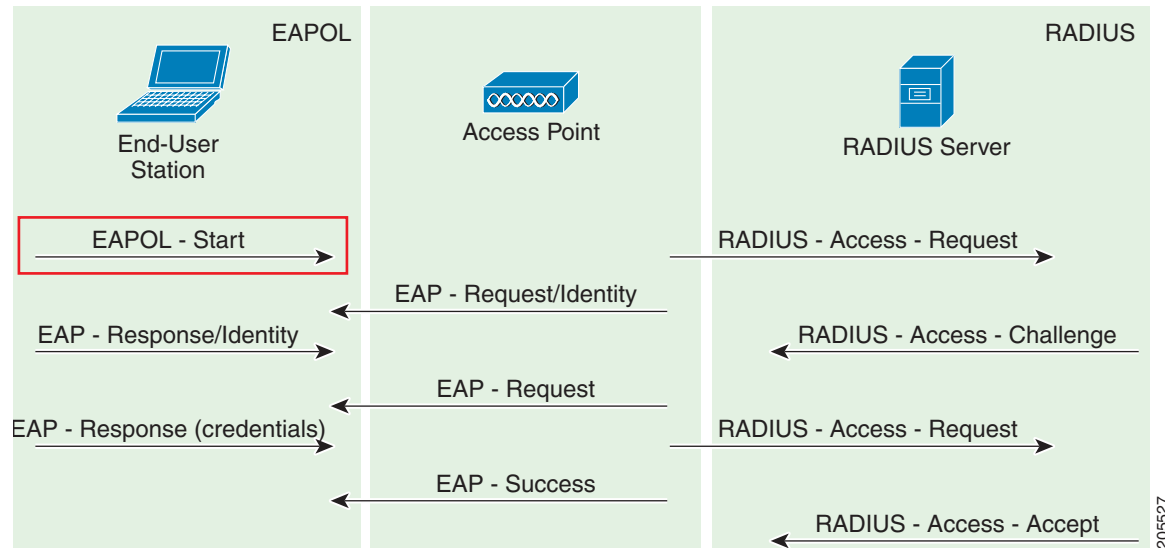
The Cisco Adaptive Wireless IPS detects this form of DoS attack by tracking client authentication and association states. When the alarm is triggered, the access point under attack is identified. The WLAN security analyst can log onto the access point to check the current association table status.

**Denial-of-Service Attack: EAPOL-Start Attack**

**Alarm Description and Possible Causes**

The IEEE 802.1x standard defines the authentication protocol using EAP over LANs (EAPOL). The 802.1x protocol starts with an EAPOL-Start frame sent by the client station to begin the authentication transaction. The access point responds to an EAPOL-start frame with a EAP-identity-request and some internal resource allocation.

Figure A-3 EAPOL-Start Protocol and EAPOL-Start Attack



An attacker attempts to disrupt an access point by flooding it with EAPOL-start frames to exhaust the access point internal resources.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this form of DoS attack by tracking the 802.1x authentication state transition and particular attack signature.

## Denial-of-Service Attack: PS Poll Flood Attack

### Alarm Description and Possible Causes

Power management is probably one of the most critical features of wireless LAN devices. Power management helps to conserve power by enabling stations to remain in power saving state mode for longer periods of time and to receive data from the access point only at specified intervals.

The wireless client device must inform the access point of the length of time that it will be in the sleep mode (power save mode). At the end of the time period, the client wakes up and checks for waiting data frames. After it completes a handshake with the access point, it receives the data frames. The beacons from the access point also include the Delivery Traffic Indication Map (DTIM) to inform the client when it needs to wake up to accept multicast traffic.

The access point continues to buffer data frames for the sleeping wireless clients. Using the Traffic Indication Map (TIM), the access point notifies the wireless client that it has buffered data buffered. Multicast frames are sent after the beacon that announces the DTIM.

The client requests the delivery of the buffered frames using PS-Poll frames to the access point. For every PS-Poll frame, the access point responds with a data frame. If there are more frames buffered for the wireless client, the access point sets the data bit in the frame response. The client then sends another PS-Poll frame to get the next data frame. This process continues until all the buffered data frames are received.

A potential hacker could spoof the MAC address of the wireless client and send out a flood of PS-Poll frames. The access point then sends out the buffered data frames to the wireless client. In reality, the client could be in the power safe mode and would miss the data frames.

### wIPS Solution

The Cisco Adaptive Wireless IPS can detect this DoS attack that can cause the wireless client to lose legitimate data. Locate and remove the device from the wireless environment.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against frame and device spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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## Denial-of-Service Attack: Unauthenticated Association

### Alarm Description and Possible Causes

A form of DoS attack is to exhaust the access point's resources, particularly the client association table, by flooding the access point with a large number of spoofed client associations. At the 802.11 layer, shared-key authentication is flawed and rarely used. The other alternative is open authentication (null authentication) which relies on higher level authentication such as 802.1x or VPN. Open authentication allows any client to authenticate and then associate. An attacker using such a vulnerability can imitate a large number of clients to flood a target access point's client association table by creating many clients. When the client association table overflows, legitimate clients cannot get associated causing a DoS attack.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects spoofed MAC addresses and tracks 802.1x actions and data communication after a successful client association to detect this form of DoS attack. After this attack is reported by the Cisco Adaptive Wireless IPS, you may log onto this access point to inspect its association table for the number of client associations.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against frame and device spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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## Denial-of-Service Attack Against Infrastructure

In addition to attacking access points or client stations, the wireless intruder may target the RF spectrum or the back-end authentication RADIUS server for DoS (denial-of-service) attacks. The RF spectrum can be easily disrupted by injecting RF noise generated by a high power antenna from a distance. Back-end RADIUS servers can be overloaded by a DDoS (distributed denial-of-service) attack where multiple wireless attackers flood the RADIUS server with authentication requests. This attack does not require a successful authentication to perform the attack.

DoS attacks against infrastructure include:

- [Denial-of-Service Attack: CTS Flood](#)
- [Denial-of-Service Attack: Queensland University of Technology Exploit](#)



- Denial-of-Service attack: RF Jamming Attack
- Denial of Service: RTS Flood
- Denial-of-Service Attack: Virtual Carrier Attack

## Denial-of-Service Attack: CTS Flood

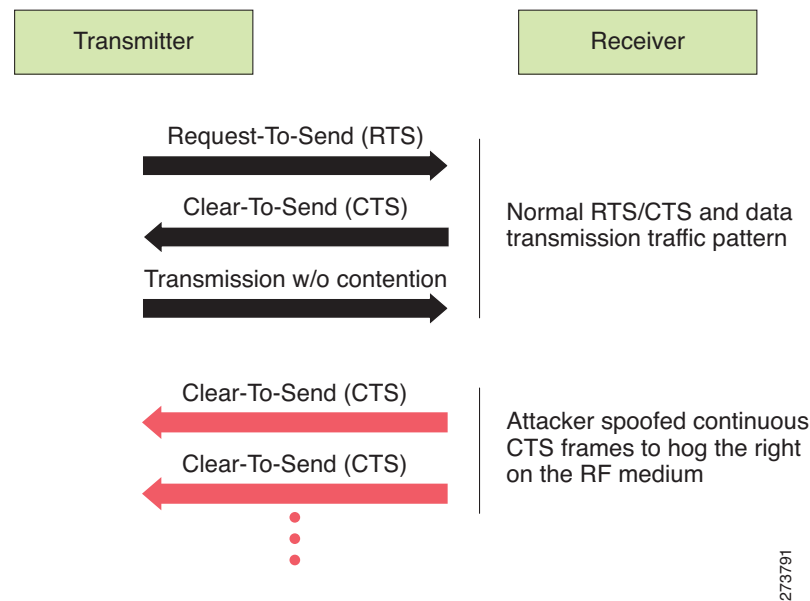
Attack tool: CTS Jack

### Alarm Description and Possible Causes

As an optional feature, the IEEE 802.11 standard includes the RTS/CTS (request-to-send/clear-to-send) functionality to control the station access to the RF medium. The wireless device ready for transmission sends a RTS frame in order to acquire the right to the RF medium for a specified time duration. The receiver grants the right to the RF medium to the transmitter by sending a CTS frame of the same time duration. All wireless devices observing the CTS frame should yield the media to the transmitter for transmission without contention.

A wireless DoS attacker might take advantage of the privilege granted to the CTS frame to reserve the RF medium for transmission. By transmitting back-to-back CTS frames, an attacker can force other wireless devices sharing the RF medium to hold back their transmission until the attacker stops transmitting the CTS frames.

**Figure A-4 CTS Spoof and Challenge to RF Control**



### wIPS Solution

The Cisco Adaptive Wireless IPS detects the abuse of CTS frames for a DoS attack.

## Denial-of-Service Attack: Queensland University of Technology Exploit

Denial of Service Vulnerability in IEEE 802.11 Wireless Devices: US-CERT VU#106678 & Aus-CERT AA-2004.02

### Alarm Description and Possible Causes

802.11 WLAN devices use Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) as the basic access mechanism in which the WLAN device listens to the medium before starting any transmission and backs-off when it detects any existing transmission taking place. Collision avoidance combines the physical sensing mechanism and the virtual sense mechanism that includes the Network Allocation Vector (NAV), the time before which the medium is available for transmission. Clear Channel Assessment (CCA) in the DSSS protocol determines whether a WLAN channel is clear so an 802.11b device can transmit on it.

Mark Looi, Christian Wullems, Kevin Tham and Jason Smith from the Information Security Research Centre, Queensland University of Technology, Brisbane, Australia, have recently discovered a flaw in the 802.11b protocol standard that could potentially make it vulnerable to DoS radio frequency jamming attacks.

This attack specifically attacks the CCA functionality. According to the AusCERT bulletin, "an attack against this vulnerability exploits the CCA function at the physical layer and causes all WLAN nodes within range, both clients and access points, to defer transmission of data for the duration of the attack. When under attack, the device behaves as if the channel is always busy, preventing the transmission of any data over the wireless network."

This DoS attack affects DSSS WLAN devices including IEEE 802.11, 802.11b, and low-speed (below 20Mbps) 802.11g wireless devices. IEEE 802.11a (using OFDM), high-speed (above 20Mbps using OFDM) 802.11g wireless devices are not affected by this attack. Devices that use FHSS are also not affected.

Any attacker using a PDA or a laptop equipped with a WLAN card can launch this attack on SOHO and enterprise WLANs. Switching to the 802.11a protocol is the only solution or known protection against this DoS attack.

For more information on this DoS attack refer to:

- [www.isrc.qut.edu.au](http://www.isrc.qut.edu.au)
- [www.isrc.qut.edu.au/wireless](http://www.isrc.qut.edu.au/wireless)
- <http://www.uscert.org.au/render.html?it=4091>
- <http://www.kb.cert.org/vuls/id/106678>

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this DoS attack and sets off the alarm. Locate and remove the responsible device from the wireless environment.

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## Denial-of-Service attack: RF Jamming Attack

### Alarm Description and Possible Causes

WLAN reliability and efficiency depend on the quality of the radio frequency (RF) media. Each RF is susceptible to RF noise impact. An attacker using this WLAN vulnerability can perform two types of DoS attacks:

- **Disrupt WLAN service**—At the 2.4 GHz unlicensed spectrum, the attack may be unintentional. A cordless phone, Bluetooth devices, microwave, wireless surveillance video camera, or baby monitor can all emit RF energy to disrupt WLAN service. Malicious attacks can manipulate the RF power at 2.4 GHz or 5 GHz spectrum with a high-gain directional antenna to amplify the attack impact from a distance. With free-space and indoor attenuation, a 1-kW jammer 300 feet away from a building can jam 50 to 100 feet into the office area. The same 1-kW jammer located inside a building can jam 180 feet into the office area. During the attack, WLAN devices in the target area are out of wireless service.
- **Physically damage AP hardware**—An attacker using a high-output transmitter with directional high gain antenna 30 yards away from an access point can pulse enough RF power to damage electronics in the access point putting it being permanently out of service. Such High Energy RF (HERF) guns are effective and are inexpensive to build.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects continuous RF noise over a certain threshold for a potential RF jamming attack.

Cisco Spectrum Intelligence also provides specific detection of non-802.11 jamming devices. For more information on Cisco Spectrum Intelligence, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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## Denial of Service: RTS Flood

### Alarm Description and Possible Causes

As an optional feature, the IEEE 802.11 standard includes the RTS/CTS (Request-To-Send/Clear-To-Send) functionality to control access to the RF medium by stations. The wireless device ready for transmission sends an RTS frame in order to acquire the right to the RF medium for a specified duration. The receiver grants the right to the RF medium to the transmitter by sending a CTS frame of the same duration. All wireless devices observing the CTS frame should yield the RF medium to the transmitter for transmission without contention.

A wireless denial-of-service attacker may take advantage of the privilege granted to the CTS frame to reserve the RF medium for transmission. By transmitting back-to-back RTS frames with a large transmission duration field, an attacker reserves the wireless medium and force other wireless devices sharing the RF medium to hold back their transmissions.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects the abuse of RTS frames for denial-of-service attacks.

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## Denial-of-Service Attack: Virtual Carrier Attack

### Alarm Description and Possible Causes

The virtual carrier-sense attack is implemented by modifying the 802.11 MAC layer implementation to allow random duration values to be sent periodically. This attack can be carried out on the ACK, data, RTS, and CTS frame types by using large duration values. By doing this the attacker can prevent channel access to legitimate users.

Under normal circumstances, the only time a ACK frame carries a large duration value is when the ACK is part of a fragmented packet sequence. A data frame legitimately carries a large duration value only when it is a sub-frame in a fragmented packet exchange.

One approach to deal with this attack is to place a limit on the duration values accepted by nodes. Any packet containing a larger duration value is truncated to the maximum allowed value. Low cap and high cap values can be used. The low cap has a value equal to the amount of time required to send an ACK frame, plus media access backoffs for that frame. The low cap is used when the only packet that can follow the observed packet is an ACK or CTS. This includes RTS and all management (such as association) frames. The high cap is used when it is valid for a data packet to follow the observed frame. The limit in this case needs to include the time required to send the largest data frame, plus the media access backoffs for that frame. The high cap must be used in two places: when observing an ACK (because the ACK may be part of a MAC level fragmented packet) and when observing a CTS.

A station that receives an RTS frame also receives the data frame. The IEEE 802.11 standard specifies the exact times for the subsequent CTS and data frames. The duration value of RTS is respected until the following data frame is received or not received. Either the observed CTS is unsolicited or the observing node is a hidden terminal. If this CTS is addressed to a valid in-range station, the valid station can nullify this by sending a zero duration null function frame. If this CTS is addressed to an out-of-range station, one method of defense is to introduce authenticated CTS frames containing cryptographically signed copies of the preceding RTS. With this method, there is a possibility of overhead and feasibility issues.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this DoS attack. Locate the device and take appropriate steps to remove it from the wireless environment.

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## DoS Attacks Against Client Station

DoS attacks against wireless client station are typically carried out based upon the fact that 802.11 management frames and 802.1x authentication protocols have no encryption mechanism and thus can be spoofed. For example, wireless intruders can disrupt the service to a client station by continuously spoofing a 802.11 disassociation or deauthentication frame from the access point to the client station.

Besides the 802.11 authentication and association state attack, there are similar attack scenarios for 802.1x authentication. For example, 802.1x EAP-Failure or EAP-logoff messages are not encrypted and can be spoofed to disrupt the 802.1x authenticated state to disrupt wireless service.

Cisco Adaptive Wireless IPS tracks the client authentication process and identifies DoS attack signatures. Incomplete authentication and association transactions trigger the attack detection and statistical signature matching process. Detected DoS attack results in setting off wIPS alarms that include the usual alarm detail description and target device information.

DoS attacks against client station include:

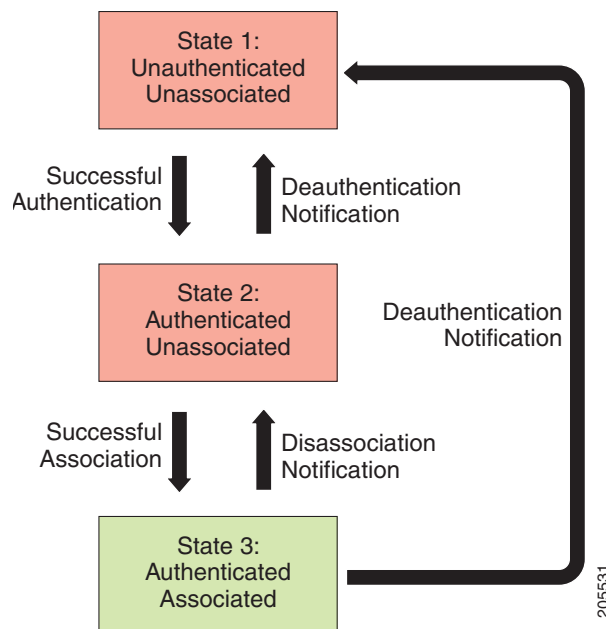
- “Denial-of-Service Attack: Authentication Failure Attack” section on page A-13
- “Denial-of-Service Attack: Deauthentication Broadcast” section on page A-14
- “Denial-of-Service Attack: Disassociation Flood” section on page A-17
- “Denial-of-Service Attack: EAPOL Logoff Attack” section on page A-18
- “Denial-of-Service Attack: FATA Jack Tool Detected” section on page A-19
- “Denial-of-Service Attack: Premature EAP Failure Attack” section on page A-21
- “Denial-of-Service Attack: Premature EAP Success Attack” section on page A-22

## Denial-of-Service Attack: Authentication Failure Attack

### Alarm Description and Possible Causes

IEEE 802.11 defines a client state machine for tracking station authentication and association status. Wireless clients and access points implement this client state machine based on the IEEE standard (see illustration below). A successfully associated client remains in State 3 in order to continue wireless communication. A client in State 1 and in State 2 cannot participate in the WLAN data communication process until it is authenticated and associated to State 3. IEEE 802.11 defines two authentication services: open system authentication and shared key authentication. Wireless clients go through one of these authentication processes to associate with an access point. (see [Figure A-5](#)).

**Figure A-5 Authentication Failure Attack**



A denial-of-service (DoS) attack spoofs invalid authentication request frames (with bad authentication service and status codes) being sent from an associated client in State 3 to an access point. Upon receipt of the invalid authentication requests, the access point updates the client to State 1, which disconnects client’s wireless service.

**wIPS Solution**

The Cisco Adaptive Wireless IPS detects this form of a DoS attack by monitoring for spoofed MAC addresses and authentication failures. This alarm may also indicate an intrusion attempt. When a wireless client fails too many times in authenticating with an access point, the server raises this alarm to indicate a potential intruder's attempt to breach security.



**Note**

This alarm focuses on IEEE 802.11 authentication methods, such as open system and shared key. EAP and 802.1x based authentications are monitored by other alarms.

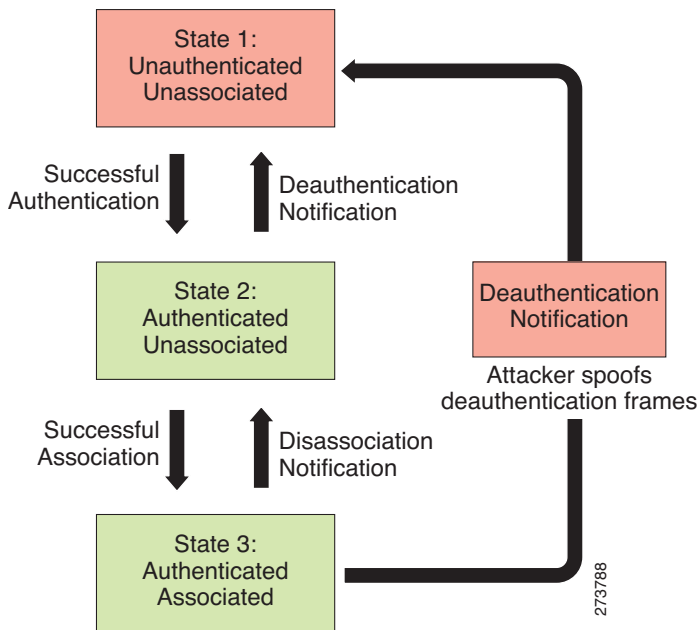
**Denial-of-Service Attack: Deauthentication Broadcast**

Attack tool: WLAN Jack, Void11, Hunter Killer

**Alarm Description and Possible Causes**

IEEE 802.11 defines a client state machine for tracking the station authentication and association status. Wireless clients and access points implement this state machine according to the IEEE standard. A successfully associated client remains in State 3 to continue wireless communication. A client in State 1 and State 2 cannot participate in WLAN data communication until it is authenticated and associated to State 3.

**Figure A-6 Deauthentication Broadcast Attack**



A form of DoS attack sends all clients of an access point to the unassociated or unauthenticated State 1 by spoofing deauthentication frames from the access point to the broadcast address. With current client adapter implementation, this form of attack is very effective and immediate in disrupting wireless services against multiple clients. Typically, client stations reassociate and reauthenticate to regain service until the attacker sends another deauthentication frame.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this form of DoS attack by detecting spoofed deauthentication frames and tracking client authentication and association states. When the alarm is triggered, the access point under attack is identified. The WLAN security analyst can log onto the access point to verify the current association table status.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against MAC spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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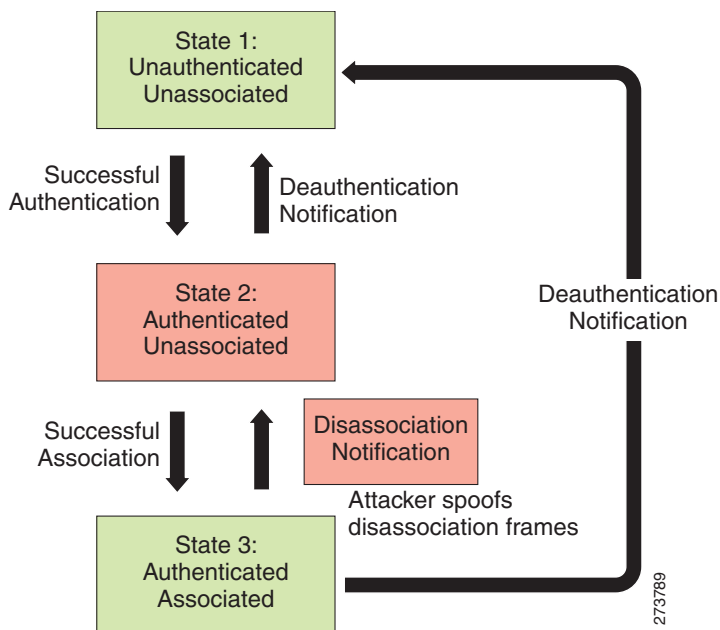
## Denial-of-Service Attack: Deauthentication Flood

Attack tool: WLAN Jack, Void11

### Alarm Description and Possible Causes

IEEE 802.11 defines a client state machine for tracking station authentication and association status. Wireless clients and access points implement this state machine according to the IEEE standard. A successfully associated client stays in State 3 in order to continue wireless communication. A client in State 1 and State 2 cannot participate in WLAN data communication until it is authenticated and associated to State 3.

**Figure A-7 Deauthentication Flood Attack**



A form of DoS attack aims to send an access point's client to the unassociated or unauthenticated State 1 by spoofing deauthentication frames from the access point to the client unicast address. With current client adapter implementations, this form of attack is very effective and immediate for disrupting wireless services against the client. Typically, client stations reassociate and reauthenticate to regain service until the attacker sends another deauthentication frame. An attacker repeatedly spoofs the deauthentication frames to keep all clients out of service.

**wIPS Solution**

The Cisco Adaptive Wireless IPS detects this form of DoS attack by detecting spoofed deauthentication frames and tracking client authentication and association states. When the alarm is triggered, the access point and client under attack are identified. The WLAN security officer can log onto the access point to check the current association table status.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against MAC spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

**Denial-of-Service Attack: Disassociation Broadcast**

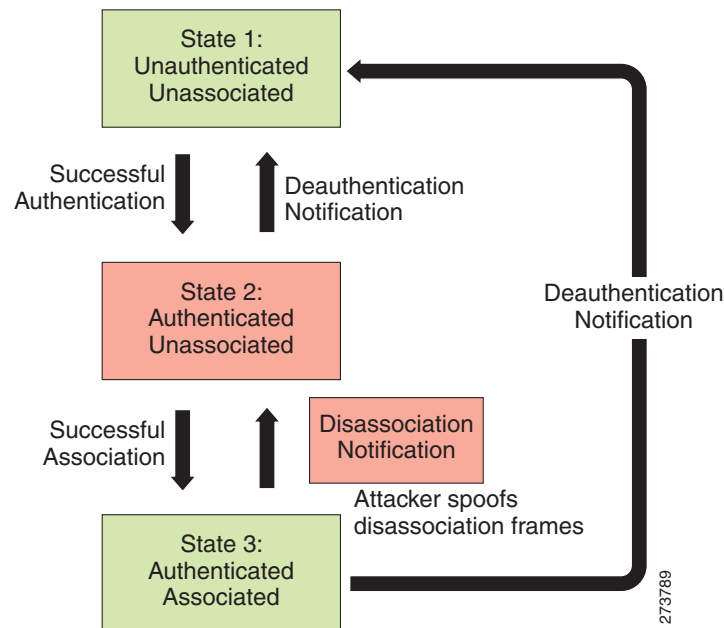
Attack tool: ESSID Jack

**Alarm Description and Possible Causes**

IEEE 802.11 defines a client state machine for tracking the station authentication and association status. Wireless clients and access points implement this state machine according to the IEEE standard. A successfully associated client station stays in State 3 in order to continue wireless communication. A client station in State 1 and State 2 can not participate in WLAN data communication until it is authenticated and associated to State 3.



Figure A-8 Disassociation Broadcast Attack



A form of DoS attack aims to send an access point's client to the unassociated or unauthenticated State 2 by spoofing disassociation frames from the access point to the broadcast address (all clients). With current client adapter implementations, this form of attack is effective and immediate for disrupting wireless services against multiple clients. Typically, client stations reassociate to regain service until the attacker sends another disassociation frame. An attacker repeatedly spoofs the disassociation frames to keep all clients out of service.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this form of DoS attack by detecting spoofed disassociation frames and tracking client authentication and association states. When the alarm is triggered, the access point under attack is identified. The WLAN security officer can log onto the access point to check the current association table status.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against MAC spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

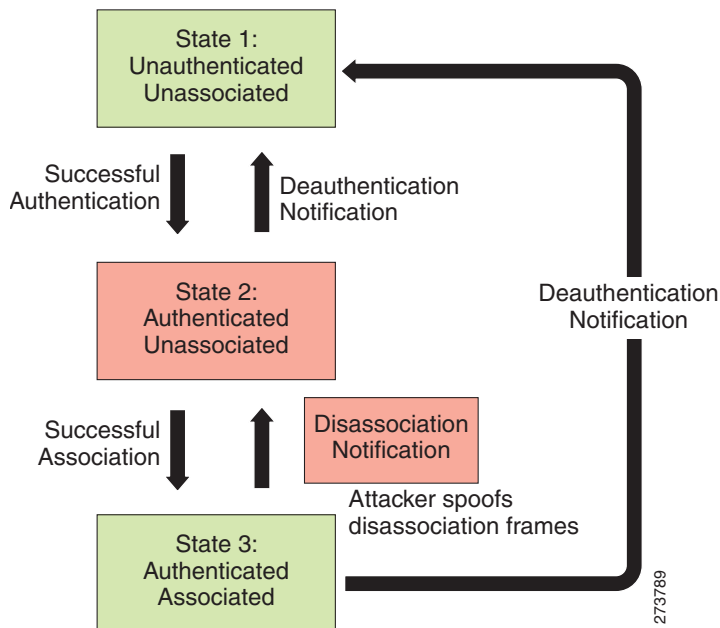
## Denial-of-Service Attack: Disassociation Flood

Attack tool: ESSID Jack

### Alarm Description and Possible Causes

IEEE 802.11 defines a client state machine for tracking the station authentication and association status. Wireless clients and access points implement this state machine according to the IEEE standard. A successfully associated client stays in State 3 in order to continue wireless communication. A client in State 1 and State 2 cannot participate in WLAN data communication until it is authenticated and associated to State 3.

**Figure A-9 Disassociation Flood Attack**



A form of DoS attack aims to send an access point to the unassociated or unauthenticated State 2 by spoofing disassociation frames from the access point to a client. With client adapter implementations, this form of attack is effective and immediate for disrupting wireless services against this client. Typically, client stations reassociate to regain service until the attacker sends another disassociation frame. An attacker repeatedly spoofs the disassociation frames to keep the client out of service.

**wIPS Solution**

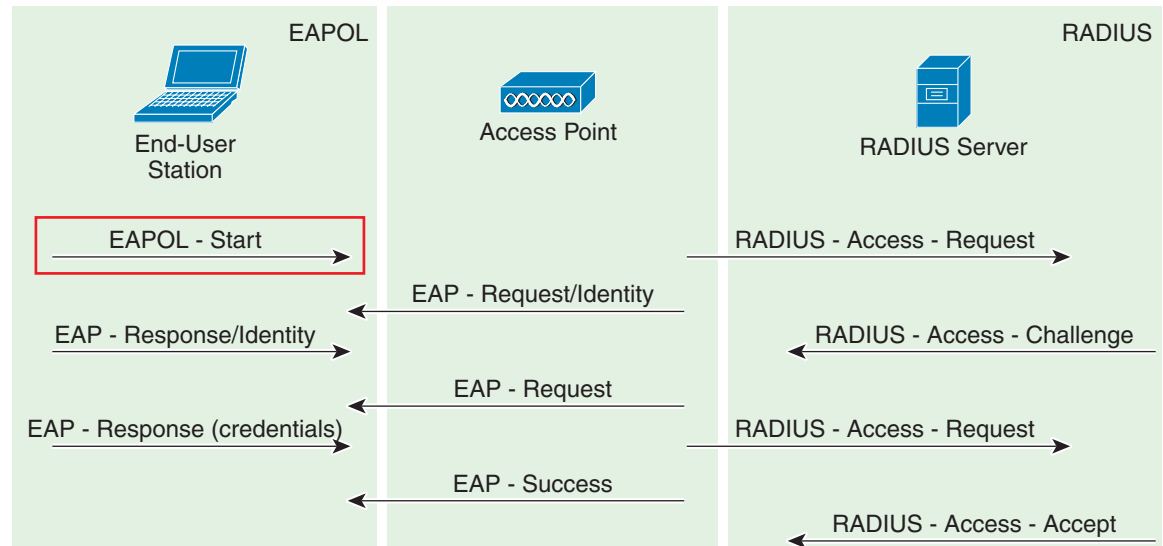
The Cisco Adaptive Wireless IPS detects this form of DoS attack by detecting spoofed disassociation frames and tracking client authentication and association states. When the alarm is triggered, the access point under attack is identified. The WLAN security officer can log onto the access point to check the current association table status.

**Denial-of-Service Attack: EAPOL Logoff Attack**

**Alarm Description and Possible Causes**

The IEEE 802.1x standard defines the authentication protocol using Extensible Authentication Protocol (EAP) over LANs or EAPOL. The 802.1x protocol starts with a EAPOL-start frame to begin the authentication transaction. At the end of an authenticated session when a client station logs off, the client station sends an 802.1x EAPOL-logoff frame to terminate the session with the access point.

Figure A-10 EAPOL Logoff Attack



Because the EAPOL-logoff frame is not authenticated, an attacker can potentially spoof this frame and log the user off the access point, thus committing a DoS attack. The fact that the client is logged off from the access point is not obvious until it attempts communication through the WLAN. Typically, the disruption is discovered and the client re-associates and authenticates automatically to regain the wireless connection. The attacker can continuously transmit the spoofed EAPOL-logoff frames to be effective on this attack.

### wIPS Solution

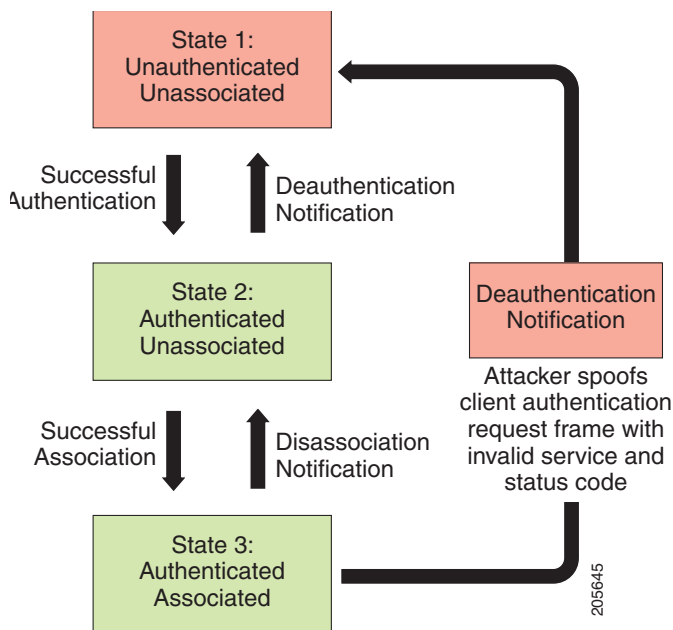
The Cisco Adaptive Wireless IPS detects this form of DoS attack by tracking 802.1x authentication states. When the alarm is triggered, the client and access point under attack are identified. The WLAN security officer logs onto the access point to check the current association table status.

## Denial-of-Service Attack: FATA Jack Tool Detected

### Alarm Description and Possible Causes

IEEE 802.11 defines a client state machine for tracking station authentication and association status. Wireless clients and access points implement this state machine based on the IEEE standard. A successfully associated client station stays in State 3 in order to continue wireless communication. A client station in State 1 and in State 2 cannot participate in the WLAN data communication process until it is authenticated and associated to State 3. IEEE 802.11 defines two authentication services: open system and shared key. Wireless clients go through one of these authentication processes to associate with an access point.

**Figure A-11 Invalid Authentication Request Spoof**



A form of DoS attack spoofs invalid authentication request frames (with bad authentication service and status codes) from an associated client in State 3 to an access point. Upon reception of the invalid authentication requests, the access point updates the client to State 1, which disconnects its wireless service.

FATA-jack is one of the commonly used tools to run a similar attack. It is a modified version of WLAN-jack and it sends authentication-failed packets along with the reason code of the previous authentication failure to the wireless station. This occurs after it spoofs the MAC address of the access point. FATA-jack closes most active connections and at times forces the user to reboot the station to continue normal activities.

**wIPS Solution**

The Cisco Adaptive Wireless IPS detects the use of FATA-jack by monitoring on spoofed MAC addresses and authentication failures. This alarm may also indicate an intrusion attempt. When a wireless client fails too many times in authenticating with an access point, the Cisco Adaptive Wireless IPS raises this alarm to indicate a potential intruder's attempt to breach security.

  
**Note**

This alarm focuses on 802.11 authentication methods (such as open system and shared key). EAP and 802.1x based authentications are monitored by other alarms.

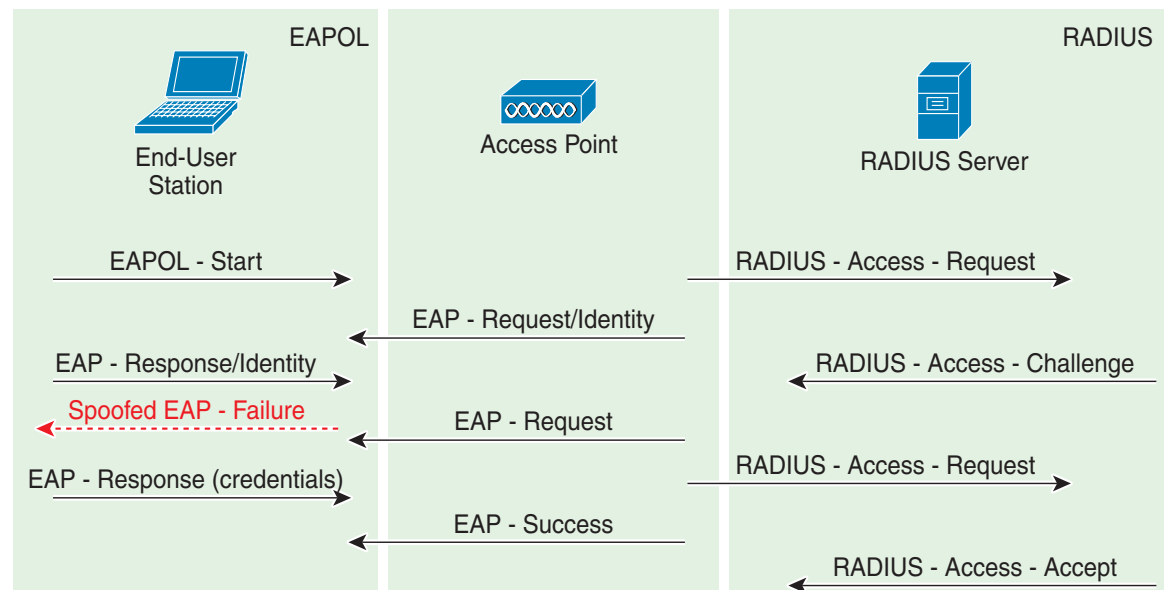
Cisco Management Frame Protection also provides complete proactive protection against frame and device spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

## Denial-of-Service Attack: Premature EAP Failure Attack

### Alarm Description and Possible Causes

The IEEE 802.1x standard defines the authentication protocol using Extensible Authentication Protocol over LANs or EAPOL. The 802.1x protocol starts with an EAPOL-Start frame to begin the authentication transaction. When the 802.1x authentication packet exchange is complete with the back-end RADIUS server, the access point sends an EAP-success or EAP-failure frame to the client to indicate authentication success or failure.

**Figure A-12** Premature EAP Failure Attack



The IEEE 802.1X specification prohibits a client from displaying its interface when the required mutual authentication is not complete. This enables a well-implemented 802.1x client station to avoid being fooled by a fake access point sending premature EAP-success packets.

An attacker keeps the client interface from appearing by continuously spoofing pre-mature EAP-failure frames from the access point to the client to disrupt the authentication state on the client.

### wIPS Solution

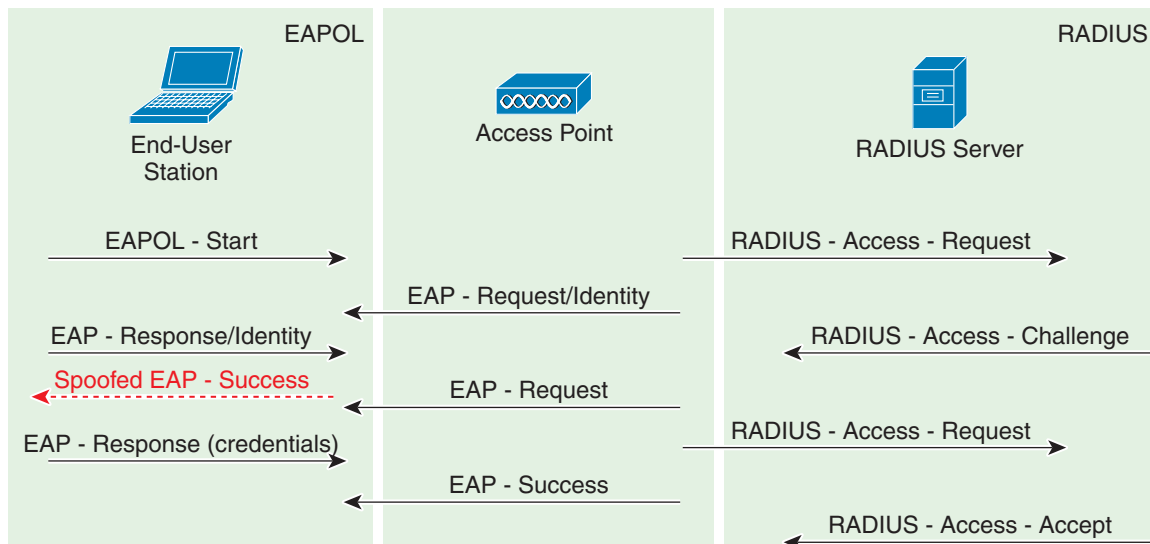
The Cisco Adaptive Wireless IPS detects this form of DoS attack by tracking the spoofed premature EAP-failure frames and the 802.1x authentication states for each client station and access point. Find the device and remove it from the wireless environment.

## Denial-of-Service Attack: Premature EAP Success Attack

### Alarm Description and Possible Causes

The IEEE 802.1x standard defines the authentication protocol using Extensible Authentication Protocol over LANs or EAPOL. The 802.1x protocol starts with an EAPOL-start frame to begin the authentication transaction. When the 802.1x authentication packet exchange is completed with the back-end RADIUS server, the access point sends an EAP-success frame to the client to indicate a successful authentication.

Figure A-13 EAP Success Attack



The IEEE 802.1X specification prohibits a client from displaying its interface when the required mutual authentication has not been completed. This enables a well-implemented 802.1x client station to avoid being fooled by a fake access point sending premature EAP-success packets to bypass the mutual authentication process.

An attacker keeps the client interface from appearing by continuously spoofing premature EAP-success frames from the access point to the client to disrupt the authentication state.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects this form of DoS attack by tracking spoofed premature EAP-success frames and the 802.1x authentication states for each client station and access point. Find the device and remove it from the wireless environment.

## Intrusion Detection—Security Penetration

A form of wireless intrusion is to breach the WLAN authentication mechanism in order to gain access to the wired network or the wireless devices. Dictionary attacks on the authentication method is a common attack against an access point. The intruder can also attack the wireless client station during its association process with an access point. For example, a faked access point attack on a unsuspecting

wireless client may fool the client into associating with faked access point. This attack allows the intruder to gain network access to the wireless station and potentially hack into its file system. The intruder can then use the station to access the wired enterprise network.

These security threats can be prevented if mutual authentication and strong encryption techniques are used. The Cisco Adaptive Wireless IPS looks for weak security deployment practices as well as any penetration attack attempts. The Cisco Adaptive Wireless IPS ensures a strong wireless security umbrella by validating the best security policy implementation as well as detecting intrusion attempts. If such vulnerabilities or attack attempts are detected, the Cisco Adaptive Wireless IPS generates alarms to bring these intrusion attempts to the administrator's notice.

Security penetration attacks include:

- [Airsnarf Attack Detected](#)
  - [Potential Chopchop Attack in Progress](#)
  - [Day-0 Attack by WLAN Performance Anomaly](#)
  - [Day-0 Attack by WLAN Security Anomaly](#)
  - [Day-0 Attack by Device Performance Anomaly](#)
  - [Day-0 Attack by Device Security Anomaly](#)
  - [Device Probing for Access Points](#)
  - [Dictionary Attack on EAP Methods](#)
  - [EAP Attack Against 802.1x Authentication](#)
  - [Fake Access Points Detected](#)
  - [Fake DHCP Server Detected \(Potential wireless phishing\)](#)
  - [Fast WEP Crack \(ARP Replay\) Detected](#)
  - [Potential Fragmentation Attack in Progress](#)
  - [Hot-Spotter Tool Detected \(Potential Wireless Phishing\)](#)
  - [Malformed 802.11 Packets Detected](#)
  - [Man-in-the-Middle Attack Detected](#)
  - [Monitored Device Detected](#)
  - [NetStumbler Detected](#)
  - [NetStumbler Victim Detected](#)
  - [Publicly Secure Packet Forwarding \(PSPF\) Violation](#)
  - [Potential ASLEAP Attack Detected](#)
  - [Potential Honey Pot AP Detected](#)
  - [Soft AP or Host AP Detected](#)
  - [Spoofed MAC Address Detected](#)
  - [Suspicious After-Hours Traffic Detected](#)
  - [Unauthorized Association by Vendor List](#)
  - [Unauthorized Association Detected](#)
  - [Wellenreiter Detected](#)
-

## Airsnarf Attack Detected

### Alarm Description and Possible Causes

A hotspot is any location where Wi-Fi network access is made available for the general public. Hotspots are found in airports, hotels, coffee shops, and other places where business people tend to congregate. They are important network access services for business travelers.

Customers are able to connect to the legitimate access point and receive service using a wireless-enabled laptop or handheld. Most hotspots do not require the user to have any advanced authentication mechanism to connect to the access point other than popping up a web page for the user to log in. The criterion for entry is dependent only on whether or not the subscriber has paid the subscription fees. In a wireless hotspot environment, no one should be trusted. Due to current security concerns, some WLAN hotspot vendors are using 802.1x or higher authentication mechanisms to validate the identity of the user.

The four components of a basic hotspot network include:

- Hotspot Subscribers—Valid users with a wireless-enabled laptop or handheld and valid login for accessing the hotspot network.
- WLAN Access Points—Can be small office or home office (SOHO) gateways or enterprise-level access points depending upon the hotspot implementation.
- Hotspot Controllers—Deals with user authentication, gathering billing information, tracking usage time, filtering functions, etc. This can be an independent machine or incorporated in the access point itself.
- Authentication Server—Contains the login credentials for the subscribers. Most hotspot controllers verify subscribers' credentials with the authentication server.

Airsnarf is a wireless access point setup utility that shows how a hacker can steal username and password credentials from public wireless hotspots.

Airsnarf, a shell script-based tool, creates a hotspot complete with a captive portal where the users enter their login information. Important values such as local network information, gateway IP address, and SSID can be configured within the airsnarf configuration file. This tool initially broadcasts a very strong signal that disassociates the hotspot wireless clients from the authorized access point connected to the Internet. The wireless clients assume that they are temporarily disconnected from the Internet due to some unknown issue and they try to log in again. Wireless clients that associate to the Airsnarf access point receive the IP address, DNS address, and gateway IP address from the rogue Airsnarf access point instead of the legitimate access point installed by the hotspot operator. A web page requests a username and password and the DNS queries are resolved by the rogue Airsnarf access point. The username and password entered are collected by the hacker.

The username and password can be used in any other hotspot location of the same provider anywhere in the nation without the user realizing the misuse. The only case where it could have lesser impact is if the hotspot user is connected using a pay-per-minute usage scheme.

The Airsnarf tool can also penetrate the laptop clients that are unknowingly connected to the Airsnarf access point. The AirSnarf tool can be downloaded by hackers from <http://airsnarf.shmoo.com/>

### wIPS Solution

The Cisco Adaptive Wireless IPS detects the wireless device running the AirSnarf tool. Appropriate action must be taken by the administrator to remove the AirSnarf tool from the WLAN environment.

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## Potential Chopchop Attack in Progress

### Alarm Description and Possible Causes

It is well publicized that a WLAN device using a static WEP key for encryption is vulnerable to various WEP cracking attacks. Refer to *Weaknesses in the Key Scheduling Algorithm of RC4 - I* by Scott Fluhrer, Itsik Mantin, and Adi Shamir for more information.

A cracked WEP secret key offers no encryption protection for data to be transmitted, leading to compromised data privacy. The WEP key, which is in most cases 64-bit or 128-bit (some vendors also offer 152-bit encryption), is a secret key specified by the user, linked with the 24-bit IV (Initialization Vector). The chopchop tool was written for the Linux operating system by Korek to exploit a weakness in WEP and decrypt the WEP data packet. However, the chopchop tool only reveals the plaintext. The attacker uses the packet capture file of a previously injected packet during the initial phase and decrypts the packet by retransmitting modified packets to the attacked network. When the attack is completed, the chopchop tool produces an unencrypted packet capture file and another file with Pseudo Random Generation Algorithm (PRGA) information determined during the decryption process. The PRGA is then XORed with the cyphertext to obtain the plaintext.

Example commands that indicate a chopchop attack:

```
aireplay-ng -4 -h XX:XX:XX:XX:XX:XX -b YY:YY:YY:YY:YY:YY ath0
```

where

- 4: Indicates a chopchop attack
- h XX:XX:XX:XX:XX:XX: Identifies a MAC address of an associated client
- b YY:YY:YY:YY:YY:YY: Identifies the MAC address of the access point
- ath0: Identifies the wireless interface name

Access points that drop data packets shorter than 60 bytes may not be vulnerable to this kind of attack. If an access point drops packets shorter than 42 bytes, aireplay will try to guess the rest of the missing data, as far as the headers are predictable. If an IP packet is captured, it additionally checks if the checksum of the header is correct after guessing the missing parts of it. This attack requires at least one WEP data packet. A chopchop attack also works against dynamic WEP configurations. The Cisco Adaptive Wireless IPS is able to detect potential attacks using the chopchop tool.

### wIPS Solution

The Cisco Adaptive Wireless IPS activates an alert when a potential chopchop attack is in progress. WEP should not be used in the corporate environment and appropriate measures should be taken to avoid any security holes in the network and upgrade the wireless network infrastructure and devices to use the more secure IEEE 802.11i standard.

## Day-0 Attack by WLAN Performance Anomaly

### Alarm Description and Possible Causes

WLAN performance efficiency is constantly challenged by the dynamics of the RF environment and the mobility of client devices. A closely monitored and well tuned WLAN system can achieve a higher throughput than a poorly managed one. Radio Resource Management (RRM) built into the Cisco Unified

Wireless Network monitors and dynamically corrects performance issues found in the RF environment. Further performance anomaly monitoring may be done via the Wireless IPS system. For more information on RRM, refer to the Cisco WCS online help.

The Cisco Adaptive Wireless IPS ensures WLAN performance and efficiency by monitoring the WLAN on a continued basis and alerting the wireless administrator on early warning signs for trouble. Performance alarms are generated and classified in the following categories in the event of any performance degradation:

- **RF Management**—The Cisco Adaptive Wireless IPS monitors the physical RF environment that is dynamic and very often the source of WLAN performance problems. While monitoring on the RF environment, the server characterizes the following WLAN fundamentals and reports problems accordingly:
  - Channel interference and channel allocation problems
  - Channel noise and non-802.11 signals
  - WLAN RF service under-coverage area
  - Classic RF hidden-node syndrome
- **Problematic traffic pattern**—Many WLAN performance problems including the RF multi-path problem manifest themselves in the MAC layer protocol transactions and statistics. By tracking and analyzing the wireless traffic, the Cisco Adaptive Wireless IPS is able to spot performance inefficiencies and degradations early on. In many cases, the Cisco Adaptive Wireless IPS can determine the cause of the detected performance problem and suggest counter measures. The Cisco Adaptive Wireless IPS tracks MAC layer protocol characteristics including the following:
  - Frame CRC error
  - Frame re-transmission
  - Frame speed (1, 2, 5.5, 11, ... Mbps) usage and distribution
  - Layer 2 frame fragmentation
  - Access point and station association, reassociation and disassociation relationship
  - Roaming hand-off
- **Channel or device overloaded**—The Cisco Adaptive Wireless IPS monitors and tracks the load to ensure smooth operation with both channel bandwidth limitation or the WLAN device resource capacity. In the event of unsatisfactory performance by the WLAN due to under-provisioning or over-growth, the Cisco Adaptive Wireless IPS raises alarms and offers specific details. RF has no boundaries that could lead to your WLAN channel utilization to increase significantly even when your neighbor installs new WLAN devices in an adjoining channel. The Cisco Adaptive Wireless IPS monitors your WLAN to ensure proper bandwidth and resource provisioning.
- **Deployment and operation error**—The Cisco Adaptive Wireless IPS scans the airwaves for configuration and operation errors. The following specific areas are continuously monitored:
  - Inconsistent configuration among access points servicing the same SSID
  - Configuration against the principles of best practice
  - Connection problems caused by client/access point mismatch configuration
  - WLAN infrastructure device down or reset
  - Flaws in WLAN device implementation
- **IEEE 802.11e and VoWLAN issues**—The IEEE 802.11e standard adds quality-of-service (QoS) features and multimedia support to the existing 802.11 a/b/g wireless standard. This is done while maintaining full backward compatibility with these standards. The QoS feature is critical to voice and

video applications. Wireless LAN has limited bandwidth and high overheads as compared to the traditional wired Ethernet. The throughput is reduced for a variety of reasons including the RTS/CTS mechanism, packet fragmentation, packet retransmission, acknowledgements, and collisions.

## wIPS Solution

The Cisco Adaptive Wireless IPS has detected a single Performance Intrusion policy violation on a large number of devices in the wireless network. Either the number of devices violating the specific policy in the time period specified are observed or there is a sudden percentage increase in the number of devices as specified in the threshold settings for the alarm. Depending on the Performance Intrusion violation, it is suggested that the devices be monitored and located to carry out further analysis.

For example:

- If the *AP overloaded by stations alarm* is generated by a large number of devices, it may indicate that a hacker has generated thousands of stations and forcing them to associate to the corporate access point. If this occurs, legitimate corporate clients cannot connect to the access point.
  - *Excessive frame retries* on the wireless devices may indicate such things as noise, interference, packet collisions, multi-path, and hidden node syndrome.
- 

## Day-0 Attack by WLAN Security Anomaly

### Alarm Description and Possible Causes

The addition of WLANs in the corporate environment introduces a whole new class of threats for network security. RF signals that penetrate walls and extend beyond intended boundaries can expose the network to unauthorized users. Rogue access points installed by employees for their personal use usually do not adhere to the corporate security policy. A rogue access point can put the entire corporate network at risk of outside penetration and attack. Besides rogue access points, there are many other wireless security vulnerabilities which compromise the wireless network such as misconfigured and unconfigured access points. There can also be DoS (denial-of-service) attacks from various sources against the corporate network.

Cisco WCS provides automated security vulnerability assessment within the wireless infrastructure that proactively reports any security vulnerabilities or mis-configurations. Further assessment may be done over-the-air via the Wireless IPS system. With the comprehensive suite of security monitoring technologies, the Cisco Adaptive Wireless IPS alerts the user on more than 100 different threat conditions in the following categories:

- **User authentication and traffic encryption (Static WEP encryption, VPN, Fortress, Cranite, 802.11i and 802.1x)**—Common security violations in this category (authentication and encryption) include mis-configurations, out-of-date software or firmware, and suboptimal choice of corporate security policy.
- **Rogue, monitored, and ad-hoc mode devices**—Rogue devices must be detected and removed immediately in order to protect the integrity of the wireless and wired enterprise network.
- **Configuration vulnerabilities**—Implementing a strong deployment policy is fundamental to a secure WLAN. However, enforcing the policy requires constant monitoring to catch violations caused by mis-configuration or equipment vendor implementation errors. With the increased trend on laptops with built-in Wi-Fi capabilities, the complexity of WLAN configuration extends beyond access points to the user laptops. WLAN device configuration management products can make the configuration process easier, but the need for validation persists especially in laptops with built-in but unused and unconfigured Wi-Fi.

- **Intrusion detection on security penetration**—A form of wireless intrusion includes breaching the WLAN authentication mechanism in order to gain access to the wired network or the wireless devices. A Dictionary attack on the authentication method is a very common attack against an access point. The intruder can also attack the wireless client station during its association process with an access point. For example, a faked AP attack on a unsuspecting wireless client may fool the client into associating with a fake access point. This attack allows the intruder to gain network access to the wireless station and potentially hack into its file system. The intruder can then use the station to access the wired enterprise network.
- **Intrusion detection on denial-of-service attacks**—Wireless DoS (denial-of-service) attacks aim to disrupt wireless services by taking advantage of various vulnerabilities of WLAN at layer one and two. DoS attacks may target the physical RF environment, access points, client stations, or the back-end authentication RADIUS servers. For example, RF jamming attack with high power directional antenna from a distance can be carried out from the outside of your office building. Attack tools used by intruders leverage hacking techniques such as spoofed 802.11 management frames, spoofed 802.1x authentication frames, or simply using the brute force packet flooding method.

## wIPS Solution

The Cisco Adaptive Wireless IPS has detected a single Security IDS/IPS policy violation on a large number of devices in the wireless network. Either the number of devices violating the specific policy in the time period specified are observed or there is a sudden percentage increase in the number of devices as specified in the threshold settings for the alarm. Depending on the Security IDS/IPS violation, it is suggested that the devices are monitored and located to carry out further analysis to check if they are compromising the Enterprise wireless network in any way (attack or vulnerability). If this is an increase in the number of rogue devices, it may indicate an attack against the network. The WLAN administrator may use the integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find it.

If there is a sudden increase in the number of client devices with encryption disabled, it may be necessary to revisit the Corporate Security Policy and enforce users to use the highest level of encryption and authentication according to the policy rules.

## Day-0 Attack by Device Performance Anomaly

### Alarm Description and Possible Causes

WLAN performance efficiency is constantly challenged by the dynamics of the RF environment and the mobility of client devices. A closely monitored and well tuned WLAN system can achieve a higher throughput than a poorly managed one. Radio Resource Management built into the Cisco Unified Wireless Network monitors and dynamically corrects performance issues found in the RF environment. Further performance anomaly monitoring may be done via the Wireless IPS system. For more information on RRM, refer to the Cisco WCS online help.

The Cisco Adaptive Wireless IPS ensures WLAN performance and efficiency by monitoring the WLAN on a continued basis and alerting the wireless administrator on early warning signs for trouble. Performance alarms are generated and classified in the following categories in the event of any performance degradation:

- **RF Management**—The Cisco Adaptive Wireless IPS monitors the physical RF environment that is dynamic and very often the source of WLAN performance problems. While monitoring on the RF environment, the server characterizes the following WLAN fundamentals and reports problems accordingly:

- Channel interference and channel allocation problems
- Channel noise and non-802.11 signals
- WLAN RF service under-coverage area
- Classic RF hidden-node syndrome
- **Problematic traffic pattern**—Many WLAN performance problems including the RF multi-path problem manifest themselves in the MAC layer protocol transactions and statistics. By tracking and analyzing the wireless traffic, the Cisco Adaptive Wireless IPS is able to spot performance inefficiencies and degradations early on. In many cases, the Cisco Adaptive Wireless IPS can determine the cause of the detected performance problem and suggest counter measures. The Cisco Adaptive Wireless IPS tracks MAC layer protocol characteristics including the following:
  - Frame CRC error
  - Frame re-transmission
  - Frame speed (1, 2, 5.5, 11, ... Mbps) usage and distribution
  - Layer 2 frame fragmentation
  - Access point and station association/reassociation/disassociation relationship
  - Roaming hand-off
- **Channel or device overloaded**—The Cisco Adaptive Wireless IPS monitors and tracks the load to ensure smooth operation with both channel bandwidth limitation or the WLAN device resource capacity. In the event of unsatisfactory performance by the WLAN due to under-provisioning or over-growth, the Cisco Adaptive Wireless IPS raises alarms and offers specific details. RF has no boundaries that could lead to your WLAN channel utilization to increase significantly even when your neighbor installs new WLAN devices in an adjoining channel. The Cisco Adaptive Wireless IPS monitors your WLAN to ensure proper bandwidth and resource provisioning.
- **Deployment and operation error**—The Cisco Adaptive Wireless IPS scans the airwaves for configuration and operation errors. The following specific areas are continuously monitored:
  - Inconsistent configuration among access points servicing the same SSID
  - Configuration against the principles of best practice
  - Connection problems caused by client/access point mismatch configuration
  - WLAN infrastructure device down or reset
  - Flaws in WLAN device implementation
- **IEEE 802.11e and VoWLAN issues**—The IEEE 802.11e standard adds QoS (quality-of-service) features and multimedia support to the existing 802.11 a/b/g wireless standard. This is done while maintaining full backward compatibility with these standards. The QoS feature is critical to voice and video applications. Wireless LAN has limited bandwidth and high overheads as compared to the traditional wired Ethernet. The throughput is reduced for a variety of reasons including the RTS/CTS mechanism, packet fragmentation, packet retransmission, acknowledgements, and collisions.

To maximize the power of the Cisco Adaptive Wireless IPS, performance alarms can be customized to best match your WLAN deployment specification. For example, if your WLAN is designed for all users to use 5.5 and 11 Mb/s speed only, customize the threshold for performance alarm 'Low speed tx rate exceeded' to reflect such an expectation.

## wIPS Solution

The Cisco Adaptive Wireless IPS detects a device violating a large number of performance intrusion policies. This device has either generated a large number of performance intrusion violations in the time period specified or there is a sudden percentage increase as specified in the threshold settings for the various alarms. It is suggested that the device is monitored and located to carry out further analysis to check if this device is causing any issues in the overall performance of the network.

For example, if there is a device which has caused an increase in the number of "access points overloaded by stations" and "access points overloaded by utilization" alarms, this could indicate that the access point cannot handle the stations. The administrator may need to reconsider re-deployment of the access points.

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## Day-0 Attack by Device Security Anomaly

### Alarm Description and Possible Causes

The addition of WLANs in the corporate environment introduces a new class of threats for network security. RF signals that penetrate walls and extend beyond intended boundaries can expose the network to unauthorized users. Rogue access points installed by employees for their personal use usually do not adhere to the corporate security policy. Rogue access points can put the entire corporate network at risk for outside penetration and attack. Besides rogue access points, there are many other wireless security vulnerabilities which compromise the wireless network such as misconfigured and unconfigured access points. There can also be DoS attacks from various sources against the corporate network.

Cisco WCS provides automated security vulnerability assessment within the wireless infrastructure that proactively reports any security vulnerabilities or mis-configurations. Further assessment may be done over-the-air via the Wireless IPS system. With the comprehensive suite of security monitoring technologies, the Cisco Adaptive Wireless IPS alerts the user on more than 100 different threat conditions in the following categories:

- **User authentication and traffic encryption (Static WEP encryption, VPN, Fortress, Cranite, 802.11i and 802.1x)**—Common security violations in this category (authentication and encryption) include mis-configurations, out-of-date software or firmware, and suboptimal choice of corporate security policy.
- **Rogue, monitored, and ad-hoc mode devices**—Rogue devices must be detected and removed immediately in order to protect the integrity of the wireless and wired enterprise network.
- **Configuration vulnerabilities**—Implementing a strong deployment policy is fundamental to a secure WLAN. However, enforcing the policy requires constant monitoring to catch violations caused by mis-configuration or equipment vendor implementation errors. With the increased trend on laptops with built-in Wi-Fi capabilities, the complexity of WLAN configuration extends beyond access points to the user laptops. WLAN device configuration management products can make the configuration process easier, but the need for validation persists especially in laptops with built-in but unused and unconfigured Wi-Fi.
- **Intrusion detection on security penetration**—A form of wireless intrusion includes breaching the WLAN authentication mechanism in order to gain access to the wired network or the wireless devices. A Dictionary attack on the authentication method is a very common attack against an access point. The intruder can also attack the wireless client station during its association process with an access point. For example, a faked AP attack on a unsuspecting wireless client may fool the client into associating with a fake access point. This attack allows the intruder to gain network access to the wireless station and potentially hack into its file system. The intruder can then use the station to access the wired enterprise network.

- **Intrusion detection on DoS attacks**—Wireless DoS (denial-of-service) attacks aim to disrupt wireless services by taking advantage of various vulnerabilities of WLAN at layer one and two. DoS attacks may target the physical RF environment, access points, client stations, or the back-end authentication RADIUS servers. For example, RF jamming attack with high power directional antenna from a distance can be carried out from the outside of your office building. Attack tools used by intruders leverage hacking techniques such as spoofed 802.11 management frames, spoofed 802.1x authentication frames, or simply using the brute force packet flooding method.

## wIPS Solution

The Cisco Adaptive Wireless IPS detects a device violating a large number of Security IDS/IPS policies. This device has either generated a number of Security IDS/IPS violations in the time period specified or there is a sudden percentage increase as specified in the threshold settings for the various alarms. The device should be monitored and located to carry out further analysis to check if this device is compromising the Enterprise Wireless Network in any way (attack or vulnerability). If this is a rogue device, the WLAN administrator may use the integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find it.

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## Device Probing for Access Points

Some commonly used scan tools include: NetStumbler (newer versions), MiniStumbler (newer versions), MACStumbler, WaveStumbler, PrismStumbler, dStumbler, iStumbler, Aerosol, Boingo™ Scans, WiNc™, AP Hopper, NetChaser, Microsoft Windows XP scans.

## Alarm Description and Possible Causes

The Cisco Adaptive Wireless IPS detects wireless devices probing the WLAN and attempting association (such as association request for an access point with any SSID).

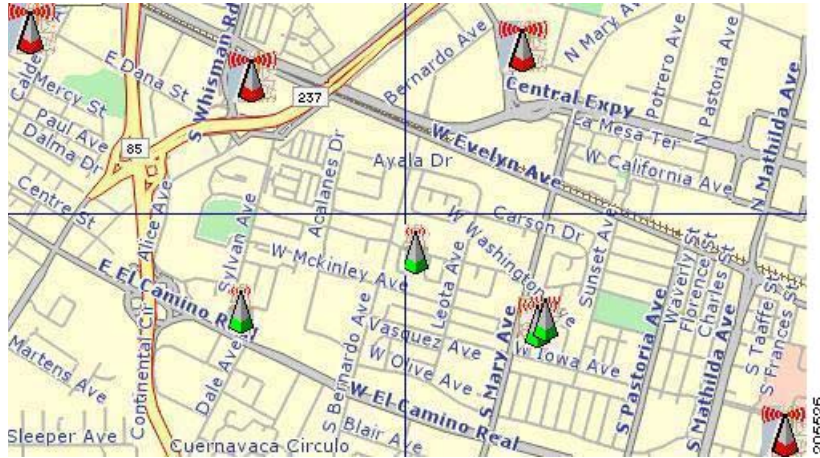
Such devices could pose potential security threats in one of the following ways:

- War-driving, WiLDing (Wireless LAN Discovery), war-chalking, war-walking, war cycling, war-lightrailing, war-busing, and war-flying.
- Legitimate wireless client attempting risky promiscuous association.

War-driving, war-chalking, war-walking, and war-flying activities include:

- **War-driving**—A wireless hacker uses war-driving tools to discover access points and publishes information such as MAC address, SSID, and security implemented on the Internet with the access points' geographical location information (see [Figure A-14](#)).

Figure A-14 Access Point Locations Posted on the Internet



- **War-chalking**—War-chalkers discover WLAN access points and mark the WLAN configuration at public locations with universal symbols (see below).

Figure A-15 War Chalker Universal Symbols

let's warchalk..!	
KEY	SYMBOL
OPEN NODE	ssid X bandwidth
CLOSED NODE	ssid O
WEP NODE	ssid access contact W bandwidth

blackbeltjones.com/warchalking 205648

- **War-walking**—War-walking is similar to war-driving, but the hacker is on foot instead of a car.
- **War-flying**—War-flying refers to sniffing for wireless networks from the air. The same equipment is used from a low flying private plane with high power antennas. It has been reported that a Perth, Australia-based war-flier picked up e-mail and Internet relay chat sessions from an altitude of 1,500 feet on a war-flying trip.

### Legitimate Wireless Client Attempting Risky Association

The second potential security threat for this alarm may be more damaging. Some of these alarms could be from legitimate and authorized wireless clients on your WLAN who are attempting to associate with any available access point including your neighbor's access point or the more damage-causing rogue access point. This potential security threat can be from a Microsoft Windows XP laptop with a built-in Wi-Fi card or laptops using wireless connectivity tools such as the Boingo™ client utility and the WiNc™ client utility. When associated, this client station can be accessed by an intruder leading to a major security breach. Even worse, the client station may bridge the unintended access point with your company's wired LAN. Typically, laptops are equipped with built-in Wi-Fi cards and, at the same, are physically attached to your company WLAN for network connectivity. Your wired network is exposed



if the Windows bridging service is enabled on that Windows laptop. To be secure, configure all client stations with specific SSIDs to avoid associating with an unintended access point. Also consider mutual authentication such as 802.1x and various EAP methods.

The Cisco Adaptive Wireless IPS also detects a wireless client station probing the WLAN for an anonymous association such as an association request for an access point with any SSID) using the NetStumbler tool. The device probing for access point alarm is generated when hackers use the latest versions of the NetStumbler tool. For older versions, the NetStumbler detected alarm is triggered.

NetStumbler is the most widely used tool for war-driving and war-chalking. The NetStumbler web site (<http://www.netstumbler.com/>) offers MiniStumbler software for use on Pocket PC hardware, saving war-walkers from carrying heavy laptops. It can run on a machine running Windows 2000, Windows XP, or more recent operating systems. It also supports more cards than Wellenreiter, another commonly used scanning tool. War-walkers like to use MiniStumbler and similar products to search shopping malls and retail stores.

### WIPS Solution

To prevent your access points from being discovered by these hacking tools, configure the access points to not broadcast SSIDs. Use the Cisco Adaptive Wireless IPS to determine which access points are broadcasting (announcing) their SSID in the beacons.

---

## Dictionary Attack on EAP Methods

### Alarm Description and Possible Causes

IEEE 802.1x provides an EAP framework for wired or wireless LAN authentication. An EAP framework allows flexible authentication protocol implementation. Some implementations of 802.1x or WPA use authentication protocols such as LEAP, MD5, OTP (one-time-password), TLS, and TTLS. Some of these authentication protocols are based upon the username and password mechanism in which the username is transmitted without encryption and the password is used to answer authentication challenges.

Most password-based authentication algorithms are susceptible to dictionary attacks. During a dictionary attack, an attacker gains the username from the unencrypted 802.1x identifier protocol exchange. The attacker then tries to guess a user's password to gain network access by using every word in a dictionary of common passwords or possible combinations of passwords. A dictionary attack relies on a password being a common word, name, or combination of both with a minor modification such as a trailing digit or two.

A dictionary attack can take place actively online, where an attacker repeatedly tries all the possible password combinations. Online dictionary attacks can be prevented using lock-out mechanisms available on the authentication server (RADIUS servers) to lock out the user after a certain number of invalid login attempts. A dictionary attack can also take place offline, where an attacker captures a successful authentication challenge protocol exchange and then tries to match the challenge response with all possible password combinations. Unlike online attacks, offline attacks are not easily detected. Using a strong password policy and periodically expiring user passwords significantly reduces an offline attack tool's success.

### WIPS Solution

The Cisco Adaptive Wireless IPS detects online dictionary attacks by tracking 802.1x authentication protocol exchange and the user identifier usages. When a dictionary attack is detected, the alarm message identifies the username and attacking station's MAC address.

The Cisco Adaptive Wireless IPS advises switching username and password based authentication methods to encrypted tunnel based authentication methods such as PEAP and EAP-FAST, which are supported by many vendors including Cisco.

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## EAP Attack Against 802.1x Authentication

### Alarm Description and Possible Causes

IEEE 802.1x provides an Extensible Authentication Protocol (EAP) framework for wired or wireless LAN authentication. An EAP framework allows flexible authentication protocol implementation. Some implementations of 802.1x or WPA use authentication protocols such as LEAP, MD5, OTP (one-time-password), TLS, TTLS, and EAP-FAST. Some of these authentication protocols are based upon the username and password mechanism, where the username is transmitted clear without encryption and the password is used to answer authentication challenges.

Most password-based authentication algorithms are susceptible to dictionary attacks. During a dictionary attack, an attacker gains the username from the unencrypted 802.1x identifier protocol exchange. The attacker attempts to guess a user's password and gain network access by using every "word" in a dictionary of common passwords or possible combinations of passwords. A dictionary attack relies on the fact that a password is often a common word, name, or combination of words or names with a minor modification such as a trailing digit or two.

Intruders with the legitimate 802.1x user identity and password combination (or valid certificate) can penetrate the 802.1x authentication process without the proper knowledge of the exact EAP-type. The intruder tries different EAP-types such as TLS, TTLS, LEAP, EAP-FAST, or PEAP to successfully log onto the network. This is a trial and error effort because there are only a handful of EAP-types for the intruder to try and manage to get authenticated to the network.

### wIPS Solution

The Cisco Adaptive Wireless IPS detects an attempt by an intruder to gain access to the network using different 802.1x authentication types. Take appropriate steps to locate the device and remove it from the wireless environment.

---

## Fake Access Points Detected

### Alarm Description and Possible Causes

The Fake AP tool is meant to protect your WLAN acting as a decoy to confuse war-drivers using NetStumbler, Wellenreiter, MiniStumbler, Kismet, and so on. The tool generates beacon frames imitating thousands of counterfeit 802.11b access points. War-drivers encountering a large number of access points cannot identify the real access points deployed by the user. This tool, although very effective in fending off war-drivers, poses other disadvantages such as bandwidth consumption, misleading legitimate client stations, and interference with the WLAN management tools. Running the Fake AP tool in your WLAN is not recommended.

## wIPS Solution

The administrator should locate the device running the Fake AP tool and remove it from the wireless environment.

---

## Fake DHCP Server Detected (Potential wireless phishing)

### Alarm Description and Possible Causes

Dynamic Host Configuration Protocol (DHCP) is used for assigning dynamic IP addresses to devices on a network.

DHCP address assignment takes place as follows:

- 
- Step 1** The client NIC sends out a DHCP discover packet, indicating that it requires a IP address from a DHCP server.
  - Step 2** The server sends a DHCP offer packet with the IP address.
  - Step 3** The client NIC sends a DHCP request, informing the DHCP server that it wants to be assigned the IP address sent by the servers offer.
  - Step 4** The server returns a DHCP ACK, acknowledging that the NIC has sent a request for a specific IP address.
  - Step 5** The client's interface assigns or binds the initially offered IP address from the DHCP server.

The DHCP server should be a dedicated machine and part of the enterprise wired network or it could be a wireless/wired gateway. Other wireless devices can have the DHCP service running innocently or maliciously so as to disrupt the WLAN IP service. Wireless clients that are requesting an IP address from the DHCP server may then connect to these fake DHCP servers to get their IP address because the clients do not have any means to authenticate the server. These fake DHCP servers may give the clients non-functional network configurations or divert all the client's traffic through them. The hackers can then eavesdrop on every packet sent by the client. With the aid of rogue DNS servers, the hacker could also send the users to fake web page logins to get username and password credentials. It could also give out non-functional and non-routable IP addresses to achieve a DoS attack. This sort of attack is generally against a WLAN without encryption such as hotspots or trade show networks.

## wIPS Solution

The Cisco Adaptive Wireless IPS detects such wireless STAs running the DHCP service and providing IP addresses to unaware users.

When the client is identified and reported, the WLAN administrator may use the integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find the device.

---

## Fast WEP Crack (ARP Replay) Detected

### Alarm Description and Possible Causes

It is well publicized that WLAN devices using static WEP key for encryption are vulnerable to WEP key cracking attack (Refer to *Weaknesses in the Key Scheduling Algorithm of RC4 - I* by Scott Fluhrer, Itsik Mantin, and Adi Shamir).

The WEP secret key that has been cracked by any intruder results in no encryption protection, thus leading to compromised data privacy. The WEP key that is in most cases 64-bit or 128-bit (few vendors also offer 152-bit encryption) consists of the secret key specified by the user linked with the 24-bit IV (Initialization Vector). The IV that is determined by the transmitting station can be reused frequently or in consecutive frames, thus increasing the possibility of the secret key to be recovered by wireless intruders.

The most important factor in any attack against the WEP key is the key size. For 64-bit WEP keys, around 150K unique IVs and for 128-bit WEP keys around 500k to a million unique IVs should be enough. With insufficient traffic, hackers have created a unique way of generating sufficient traffic to perform such an attack. This is called the replay attack based on arp-request packets. Such packets have a fixed length and can be spotted easily. By capturing one legitimate arp-request packet and resending them repeatedly, the other host responds with encrypted replies, providing new and possibly weak IVs.

### wIPS Solution

The Cisco Adaptive Wireless IPS alerts on weak WEP implementations and recommends a device firmware upgrade if available from the device vendor to correct the IV usage problem. Ideally, enterprise WLAN networks can protect against WEP vulnerability by using the TKIP (Temporal Key Integrity Protocol) encryption mechanism, which is now supported by most enterprise level wireless equipment. TKIP enabled devices are not subject to any such WEP key attacks.

Cisco WCS also provides automated security vulnerability scanning that proactively reports any access points configured to utilize weak encryption or authentication. For more information on automated security vulnerability scanning, refer to the Cisco WCS online help.

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## Potential Fragmentation Attack in Progress

### Alarm Description and Possible Causes

It is well publicized that a WLAN device using a static WEP key for encryption is vulnerable to various WEP cracking attacks. Refer to *Weaknesses in the Key Scheduling Algorithm of RC4 - I* by Scott Fluhrer, Itsik Mantin, and Adi Shamir for more information.

A cracked WEP secret key offers no encryption protection for data to be transmitted which leadw to compromised data privacy. The WEP key, which is in most cases 64-bit or 128-bit (few vendors also offer 152-bit encryption), is the secret key specified by the user and linked with the 24-bit IV (Initialization Vector).

According to <http://www.aircrack-ng.org/doku.php?id=fragmentation&s=fragmentation>, the aircrack program obtains a small amount of keying material from the packet and then attempts to send ARP and/or LLC packets with known information to an access point. If the packet gets successfully echoed back by the access point, then a larger amount of keying information can be obtained from the returned packet. This cycle is repeated several times until 1500 bytes (less in some cases) of PRGA are obtained.

This attack does not recover the WEP key itself, but merely obtains the PRGA. The PRGA can then be used to generate packets with *packetforge-ng* which can be used for various injection attacks.

Example commands that indicate a fragmentation attack:

```
aireplay-ng -5 -h XX:XX:XX:XX:XX:XX -b YY:YY:YY:YY:YY:YY ath0
```

where

- 5: Indicates a fragmentation attack
- h XX:XX:XX:XX:XX:XX: Identifies a MAC address of an associated client
- b YY:YY:YY:YY:YY:YY: Identifies the MAC address of the access point
- ath0: Identifies the wireless interface name

## wIPS Solution

The Cisco Adaptive Wireless IPS detects potential fragmentation attacks in progress against the Wi-Fi network. Further, wIPS recommends that WEP not be used in the corporate environment and that appropriate measures be taken to avoid any security holes in the network, and upgrade the wireless network infrastructure and devices to use the more secure IEEE 802.11i standard.

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## Hot-Spotter Tool Detected (Potential Wireless Phishing)

### Alarm Description and Possible Causes

A hotspot is any location where Wi-Fi network access available for the general public. Hotspots are often found in airports, hotels, coffee shops, and other places where business people tend to congregate. It is currently one of the most important network access service for business travelers. The customer requires a wireless-enabled laptop or handheld to connect to the legitimate access point and to receive service. Most hotspots do not require the user to have an advanced authentication mechanism to connect to the access point, other than using a web page to log in. The criterion for entry is only dependent on whether or not the subscriber has paid subscription fees. In a wireless hotspot environment, no one should trust anyone else. Due to current security concerns, some WLAN hotspot vendors are using 802.1x or higher authentication mechanisms to validate the identity of the user.

Basic components of a WLAN Hotspot network

The four components of a basic hotspot network are:

- Hotspot Subscribers—Valid users with a wireless enabled laptop or handheld and valid login for accessing the hotspot network.
- WLAN Access Points—SOHO gateways or enterprise level access points depending upon the hotspot implementation.
- Hotspot Controllers—Deals with user authentication, gathering billing information, tracking usage time, filtering functions, etc. This can be an independent machine or can be incorporated in the access point itself.
- Authentication Server—Contains the login credentials for the subscribers. In most cases, hotspot controllers verify subscribers' credentials with the authentication server.

*Hotspotter* automates a method of penetration against wireless clients, independent of the encryption mechanism used. Using the Hotspotter tool, the intruder can passively monitor the wireless network for probe request frames to identify the SSIDs of the networks of the Windows XP clients.

After it acquires the preferred network information, the intruder compares the network name (SSID) to a supplied list of commonly used hotspot network names. When a match is found, the Hotspotter client acts as an access point. The clients then authenticate and associate unknowingly to this fake access point.

When the client gets associated, the Hotspotter tool can be configured to run a command such as a script to kick off a DHCP daemon and other scanning against the new victim.

Clients are also susceptible to this kind of attack when they are operating in different environments (home and office) while they are still configured to include the hotspot SSID in the Windows XP wireless connection settings. The clients send out probe requests using that SSID and make themselves vulnerable to the tool.

### wIPS Solution

When the rogue access point is identified and reported by the Cisco Adaptive Wireless IPS, the WLAN administrator may use the integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find the rogue device.

---

## Malformed 802.11 Packets Detected

### Alarm Description and Possible Causes

Hackers using illegal packets (malformed non-standard 802.11 frames) can force wireless devices to behave in an unusual manner. Illegal packets can cause the firmware of a few vendor's wireless NICs to crash.

Examples of such vulnerability includes NULL probe response frame (null SSID in the probe response frame) and oversized information elements in the management frames. These ill-formed frames can be broadcasted to cause multiple wireless clients to crash.

### wIPS Solution

The Cisco Adaptive Wireless IPS can detect these illegal packets that may cause some NICs to lock up and crash. Also, wireless clients experiencing blue screen or lock-up problem during the attack period should consider upgrading the WLAN NIC driver or the firmware.

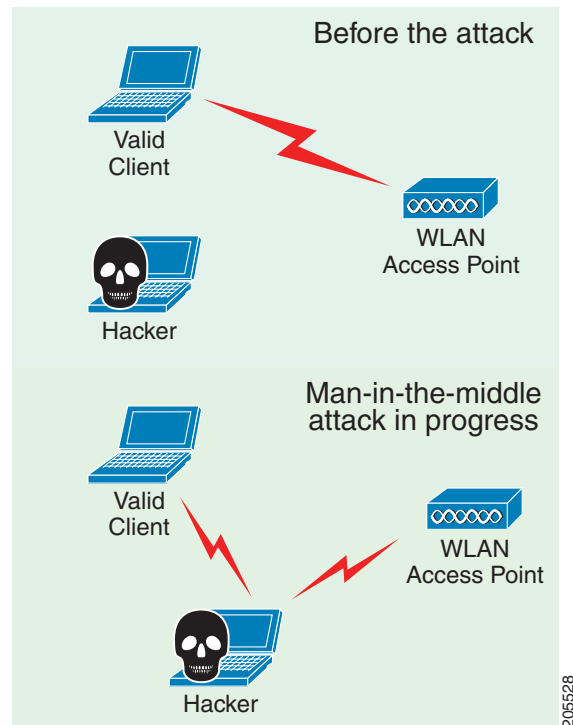
When the client is identified and reported by the Cisco Adaptive Wireless IPS, the WLAN administrator may use the device locator to locate it.

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## Man-in-the-Middle Attack Detected

### Alarm Description and Possible Causes

Man-in-the-middle (MITM) attack is one of the most common 802.11 attacks that can lead to confidential corporate and private information being leaked to hackers. In a MITM attack, the hacker can use a 802.11 wireless analyzer and monitor 802.11 frames sent over the WLAN. By capturing the wireless frames during the association phase, the hacker gets IP and MAC address information about the wireless client card and access point, association ID for the client, and the SSID of the wireless network.

**Figure A-16 Man-in-the-Middle Attack**

A common MITM attack involves the hacker sending spoofed disassociation or deauthentication frames. The hacker station then spoofs the MAC address of the client to continue an association with the access point. At the same time, the hacker sets up a spoofed access point in another channel to keep the client associated. All traffic between the valid client and access point then passes through the hacker's station.

One of the most commonly used MITM attack tools is Monkey-Jack.

### wIPS Solution

The Cisco Adaptive Wireless IPS recommends the use of strong encryption and authentication mechanisms to thwart any MITM attacks by hackers. One way to avoid such an attack is to prevent MAC address spoofing by using MAC address exclusion lists and monitoring the RF channel environment.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against MITM attacks. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

## Monitored Device Detected

### Alarm Description and Possible Causes

There are some cases in which the access points and STAs activity must be continuously monitored:

- Malicious intruders attempting to hack into the enterprise wired network must be monitored. It is important to keep track of these access points and STAs to help avoid repeated rogue-related and intrusion attempt problems.

- Lost enterprise wireless equipment must be located.
- Vulnerable devices with previous security violations must be monitored.
- Devices used by ex-employees who may have not returned all their wireless equipment must be monitored.

These nodes may be added to the monitor list to alert the wireless administrator the next time the access point or STA shows up in the RF environment.

## wIPS Solution

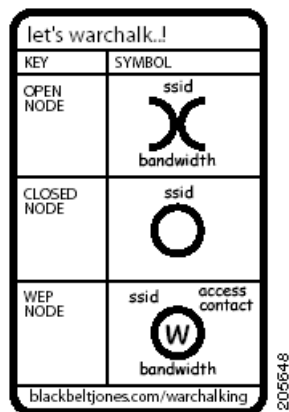
The wireless administrator can add the access point or STA to the monitor list by identifying it as a monitored device on the Cisco Adaptive Wireless IPS.

## NetStumbler Detected

### Alarm Description and Possible Causes

The Cisco Adaptive Wireless IPS detects a wireless client station probing the WLAN for an anonymous association (such as an association request for an access point with any SSID) using the NetStumbler tool. The *Device probing for Access Point* alarm is generated when hackers use recent versions of the NetStumbler tool. For older versions, the Cisco Adaptive Wireless IPS generates the *NetStumbler detected* alarm.

**Figure A-17** War-Chalker Universal Symbols



NetStumbler is the most widely used tool for war-driving and war-chalking. A wireless hacker uses war-driving tools to discover access points and to publish their information (MAC address, SSID, security implemented, etc.) on the Internet with the access points' geographical location information. War-chalkers discover WLAN access points and mark the WLAN configuration at public locations with universal symbols as illustrated above. War-walking is similar to war-driving, but the hacker is on foot instead of a car. The NetStumbler web site (<http://www.netstumbler.com/>) offers MiniStumbler software for use on Pocket PC hardware, saving war-walkers from carrying heavy laptops. It can run on a machine running Windows 2000, Windows XP, or later versions. It also supports more cards than Wellenreiter, another commonly used scanning tool. War-walkers like to use MiniStumbler and similar products to sniff shopping malls and big-box retail stores. War-flying is sniffing for wireless networks from the air. The same equipment is used from a low flying private plane with high power antennas.



## wIPS Solution

To prevent your access points from being discovered by these hacking tools, configure your access points to not broadcast its SSID. You can use the Cisco Adaptive Wireless IPS to see which of your access points is broadcasting an SSID in the beacons.

Cisco WCS also provides automated security vulnerability scanning that reports any access points configured to broadcast their SSIDs. For more information on automated security vulnerability scanning, refer to the Cisco WCS online help.

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## NetStumbler Victim Detected

### Alarm Description and Possible Causes

The Cisco Adaptive Wireless IPS detects a wireless client station probing the WLAN for an anonymous association (such as association request for an access point with any SSID) using the NetStumbler tool. The Device probing for access point alarm is generated when hackers more recent versions of the NetStumbler tool. For older versions, the Cisco Adaptive Wireless IPS generates the NetStumbler detected alarm.

NetStumbler is the most widely used tool for war-driving, war-walking, and war-chalking. A wireless hacker uses war-driving tools to discover access points and publish their information (MAC address, SSID, security implemented, etc.) on the Internet with the access points' geographical location information. War-chalkers discover WLAN access points and mark the WLAN configuration at public locations with universal symbols as illustrated above. War-walking is similar to war-driving, but the hacker conducts the illegal operation on foot instead of by car. The NetStumbler web site (<http://www.netstumbler.com/>) offers MiniStumbler software for use on Pocket PC hardware, saving war-walkers from carrying heavy laptops. It can run on a machine running Windows 2000, Windows XP, or later. It also supports more cards than Wellenreiter, another commonly used scanning tool. War-walkers typically use MiniStumbler and similar products to sniff shopping malls and big-box retail stores. War-flying is sniffing for wireless networks from the air. The same equipment is used, but from a low-flying private plane with high-power antennas. It has been reported that a Perth, Australia-based war-flier picked up e-mail and Internet Relay Chat sessions from an altitude of 1,500 feet on a war-flying trip.

## wIPS Solution

The Cisco Adaptive Wireless IPS alerts the user when it observes that a station running Netstumbler is associated to a corporate access point. To prevent your access points from being discovered by these hacking tools, configure your access points to not broadcast its SSID. You can use the Cisco Adaptive Wireless IPS to see which access point is broadcasting its SSID in the beacons.

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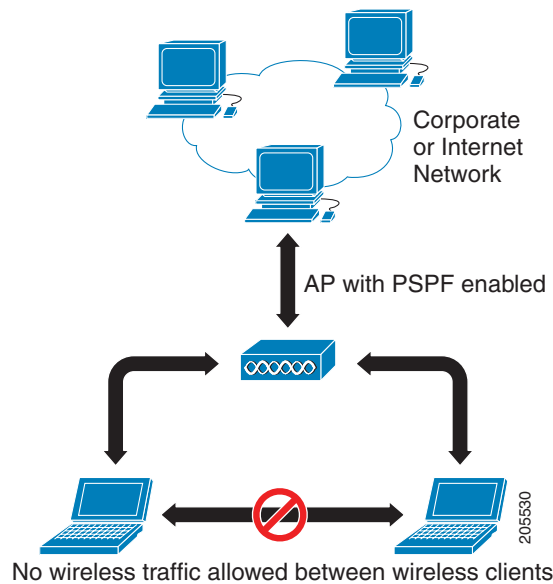
## Publicly Secure Packet Forwarding (PSPF) Violation

### Alarm Description and Possible Causes

Publicly Secure Packet Forwarding (PSPF) is a feature implemented on WLAN access points to block wireless clients from communicating with other wireless clients. With PSPF enabled, client devices cannot communicate with other client devices on the wireless network.

For most WLAN environments, wireless clients communicate only with devices such as web servers on the wired network. By enabling PSPF it protects wireless clients from being hacked by a wireless intruder. PSPF is effective in protecting wireless clients especially at wireless public networks (hotspots) such as airports, hotels, coffee shops, and college campuses where authentication is null and anyone can associate with the access points. The PSPF feature prevents client devices from inadvertently sharing files with other client devices on the wireless network.

**Figure A-18 PSPF Enabled On The Network**



## wIPS Solution

The Cisco Adaptive Wireless IPS detects PSPF violations. If a wireless client attempts to communicate with another wireless client, the Cisco Adaptive Wireless IPS raises an alarm for a potential intrusion attack. This alarm does not apply if your WLAN deploys wireless printers or VoWLAN applications because these applications rely on wireless client-to-client communication.

## Potential ASLEAP Attack Detected

### Alarm Description and Possible Causes

WLAN devices using static WEP key for encryption are vulnerable to the WEP key cracking attack (See *Weaknesses in the Key Scheduling Algorithm of RC4-I* by Scott Fluhrer, Itsik Mantin, and Adi Shamir for more information).

Cisco Systems introduced LEAP (Lightweight Extensible Authentication Protocol) to leverage the existing 802.1x framework to avoid such WEP key attacks. The Cisco LEAP solution provides mutual authentication, dynamic per session and per user keys, and configurable WEP session key time out. The LEAP solution was considered a stable security solution and is easy to configure.

There are hacking tools that compromise wireless LAN networks running LEAP by using off-line dictionary attacks to break LEAP passwords. After detecting WLAN networks that use LEAP, this tool de-authenticates users which forces them to reconnect and provide their username and password credentials. The hacker captures packets of legitimate users trying to re-access the network. The attacker can then analyze the traffic off-line and guess the password by testing values from a dictionary.

The main features of the ASLEAP tool include:

- Reading live from any wireless interface in RFMON mode with libpcap.
- Monitoring a single channel or performing channel hopping to look for target networks running LEAP.
- Actively deauthenticating users on LEAP networks, forcing them to reauthenticate. This allows quick LEAP password captures.
- Only de-authenticating users who have not already been seen rather than users who are not running LEAP.
- Reading from stored libpcap files.
- Using a dynamic database table and index to allow quick lookups on large files. This reduces the worst-case search time to .0015% as opposed to lookups in a flat file.
- Writing only the LEAP exchange information to a libpcap file.

This could be used to capture LEAP credentials with a device short on disk space (like an iPaq); the LEAP credentials are then stored in the libpcap file on a system with more storage resources to mount the dictionary attack.

The source and Win32 binary distribution for the tool are available at <http://asleap.sourceforge.net>.

Cisco Systems has developed the Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling (EAP-FAST) protocol which stops these dictionary attacks. EAP-FAST helps prevent man-in-the-middle attacks, dictionary attacks, and packet and authentication forgery attacks. In EAP-FAST, a tunnel is created between the client and the server using a PAC (Protected Access Credential) to authenticate each other. After the tunnel establishment process, the client is then authenticated using the user-name and password credentials.

Some advantages of EAP-FAST include:

- It is not proprietary.
- It is compliant with the IEEE 802.11i standard.
- It supports TKIP and WPA.
- It does not use certificates and avoids complex PKI infrastructures.
- It supports multiple Operating Systems on PCs and Pocket PCs.

## WIPS Solution

The Cisco Adaptive Wireless IPS detects the deauthentication signature of the ASLEAP tool. When detected, the server alerts the wireless administrator. The user of the attacked station should reset the password. The best solution to counter the ASLEAP tool is to replace LEAP with EAP-FAST in the corporate WLAN environment.

Cisco WCS also provides automated security vulnerability scanning that proactively reports any access points configured to utilize weak encryption or authentication. For more information on automated security vulnerability scanning, refer to Cisco WCS online help.

## Potential Honey Pot AP Detected

### Alarm Description and Possible Causes

The addition of WLANs in the corporate environment introduces a whole new class of threats for network security. RF signals that penetrate walls and extend beyond intended boundaries can expose the network to unauthorized users. A rogue access point can put the entire corporate network at risk for outside penetration and attack. Not to understate the threat of the rogue access point, there are many other wireless security risks and intrusions such as mis-configured access points, unconfigured access points, and DoS (denial-of-service) attacks.

One of the most effective attacks facing enterprise networks implementing wireless is the use of a honey pot access point. An intruder uses tools such as NetStumbler, Wellenreiter, and MiniStumbler to discover the SSID of the corporate access point. Then the intruder sets up an access point outside the building premises or, if possible, within the premises and broadcasts the discovered corporate SSID. An unsuspecting client then connects to this honey pot access point with a higher signal strength. When associated, the intruder performs attacks against the client station because traffic is diverted through the honey pot access point.

### wIPS Solution

When a honey pot access point is identified and reported by the Cisco Adaptive Wireless IPS, the WLAN administrator may use the integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find the rogue device.

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## Soft AP or Host AP Detected

Host AP tools: Cqure AP

### Alarm Description and Possible Causes

A host-based access point (desktop or a laptop computer serving as a wireless access point) represents two potential threats to enterprise security. First, host based access points are not typically part of the enterprise wireless infrastructure and are likely to be rogue devices which do not conform to the corporate security policy. Second, host-based access points are used by wireless attackers as a convenient platform to implement various known intrusions such as man-in-the-middle, honey-pot access point, access point impersonation, and DoS (denial-of-service) attacks. Since software tools for turning a desktop or laptop into an access point can be easily downloaded from the Internet, host-based access points are more than just a theoretical threat.

Some laptops are shipped with the HostAP software pre-loaded and activated. When the laptops connect to the enterprise wireless network, they expose the wireless network to the hackers.

## wIPS Solution

The Cisco Adaptive Wireless IPS's detected soft access point should be treated as a rogue access point as well as a potential intrusion attempt. When the soft access point is identified and reported by the Cisco Adaptive Wireless IPS, the WLAN administrator may use integrated over-the-air physical location capabilities, or trace device on the wired network using rogue location discovery protocol (RLDP) or switchport tracing to find the rogue device.

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## Spoofed MAC Address Detected

Spoofing tools may include the following: SMAC, macchanger, and SirMACsAlot.

### Alarm Description and Possible Causes

A wireless intruder can disrupt a wireless network using a wide range of available attack tools, many of which are available as free downloads from the Internet. Most of these tools rely on a spoofed MAC address which masquerades as an authorized wireless access point or as an authorized client. By using these tools, an attacker can launch various denial of service (DoS) attacks, bypass access control mechanisms, or falsely advertise services to wireless clients.

## wIPS Solution

The Cisco Adaptive Wireless IPS detects a spoofed MAC address by following the IEEE authorized OUI (vendor ID) and 802.11 frame sequence number signature.

Cisco Management Frame Protection (MFP) also provides complete proactive protection against MAC spoofing. For more information on MFP, refer to the *Cisco Wireless Control System Configuration Guide* or the Cisco WCS online help.

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## Suspicious After-Hours Traffic Detected

### Alarm Description and Possible Causes

One way to detect a wireless security penetration attempt is to match wireless usage against the time when there is not supposed to be any wireless traffic. The wIPS server monitors traffic patterns against the office-hours configured for this alarm to generate alerts when an abnormality is found. Specific suspicious wireless usage sought after by the wIPS server during after-office hours includes the following:

- Client station initiating authentication or association requests to the office WLAN that may indicate security breach attempts.
- Wireless data traffic that may indicate suspicious download or upload over the wireless network.

## wIPS Solution

For global wIPS deployment, the configurable office-hour range is defined in local time. The access point or sensor can be configured with a time zone to facilitate management. For the office and manufacturing floor mixed WLAN, one can define one set of office hours for the office WLAN SSID

and another set for the manufacturing floor WLAN SSID. If this alarm is triggered, the administrator should look for the devices responsible for the suspicious traffic and remove them from the wireless environment.

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## Unauthorized Association by Vendor List

### Alarm Description and Possible Causes

In the enterprise WLAN environment, rogue stations cause security concerns and undermine network performance. They take up air space and compete for network bandwidth. Since an access point can only accommodate a limited number of stations, it rejects association requests from stations when its capacity is reached. An access point laden with rogue stations denies legitimate stations the access to the network. Common problems caused by rogue stations include connectivity problems and degraded performance.

### wIPS Solution

The Cisco Adaptive Wireless IPS enables network administrators to include vendor information in a policy profile to allow the system to effectively detect stations in use on the WLAN that are not approved vendor products. An alarm is triggered.

When the alarm has been triggered, the unauthorized station must be identified and actions must be taken to resolve the issue. One way is to block it using the rogue containment.

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## Unauthorized Association Detected

### Alarm Description and Possible Causes

In an enterprise network environment, rogue access points installed by employees do not usually follow the network's standard deployment practice and therefore compromise the integrity of the network. They are loopholes in network security and make it easy for intruders to hack into the enterprise wired network. One of the major concerns that most wireless network administrators face is unauthorized associations between stations in an ACL and a rogue access point. Since data to and from the stations flows through the rogue access point, it leaves the door open for hackers to obtain sensitive information.

Rogue stations cause security concerns and undermine network performance. They take up air space and compete for bandwidths on the network. Since an access point can only serve a certain number of stations, it rejects association requests from stations once its capacity is reached. An access point laden with rogue stations denies legitimate stations access to the network. Common problems caused by rogue stations include disrupted connections and degraded performance.

### wIPS Solution

The Cisco Adaptive Wireless IPS can automatically alert network administrators to any unauthorized access point-station association it has detected on the network through this alarm. When the alarm is triggered, the rogue or unauthorized device must be identified and actions must be taken to resolve the reported issue.

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## Wellenreiter Detected

### Alarm Description and Possible Causes

The Cisco Adaptive Wireless IPS detects a wireless client station probing the WLAN for an anonymous association (such as association request for an access point with any SSID) using the Wellenreiter tool.

Wellenreiter is a commonly used tool for war-driving and war-chalking. A wireless hacker uses war-driving tools to discover access points and to publish their information (MAC address, SSID, security implemented, etc.) on the Internet with the access points' geographical location information. War-chalkers discover WLAN access points and mark the WLAN configuration at public locations with universal symbols as illustrated above. War-walking is similar to war-driving, but the hacker is on foot instead of a car. War-walkers like to use Wellenreiter and similar products to sniff shopping malls and big-box retail stores. War-flying is sniffing for wireless networks from the air. The same equipment is used, but from a low flying private plane with high power antennas. It has been reported that a Perth, Australia-based war-flier picked up email and Internet Relay Chat sessions from an altitude of 1,500 feet on a war-flying trip.

The tool supports Prism2, Lucent, and Cisco based cards. The tool can discover infrastructure and ad-hoc networks that are broadcasting SSIDs, their WEP capabilities, and can provide vendor information automatically. It also creates an ethereal/tcpdump-compatible dumpfile and an Application savefile. It also has GPS support. Users can download the tool from <http://www.wellenreiter.net/index.html>

### WIPS Solution

To prevent your access points from being discovered by these hacking tools, configure your access points to not broadcast its SSID. You can use the Cisco Adaptive Wireless IPS to see which of your access points is broadcasting an SSID in the beacons.

Cisco WCS also provides automated security vulnerability scanning that reports any access points configured to broadcast their SSIDs. For more information on automated security vulnerability scanning, refer to the WCS online help.

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