# Fun with SOHO Router 101

by Jhe@HITCON-CMT

# Who am I ?

- Jhe
- Co-founder of UCCU
- know a little
  - Web security
  - Binary exploitation
  - Parseltongue (python)

What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

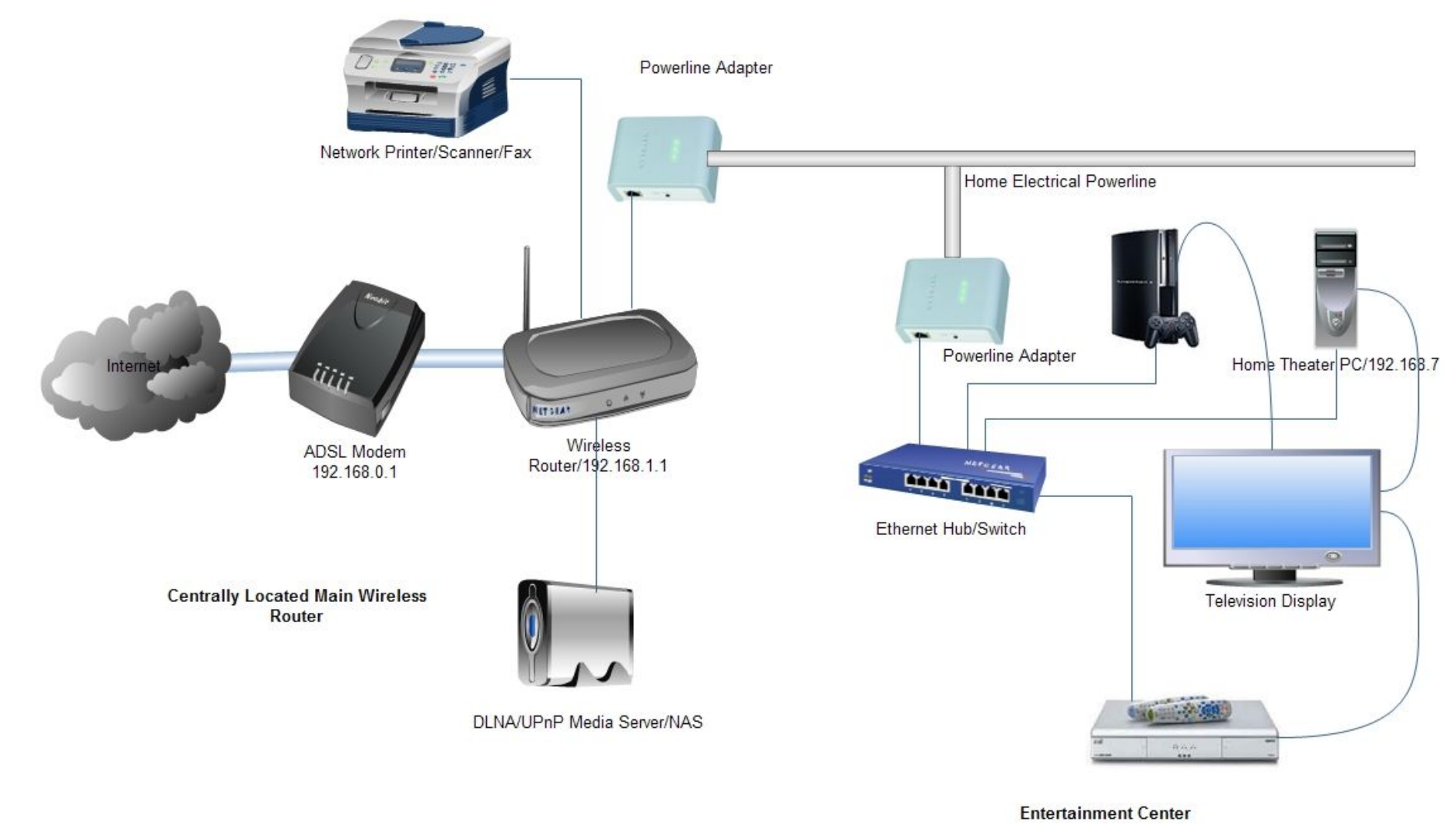
UCCU

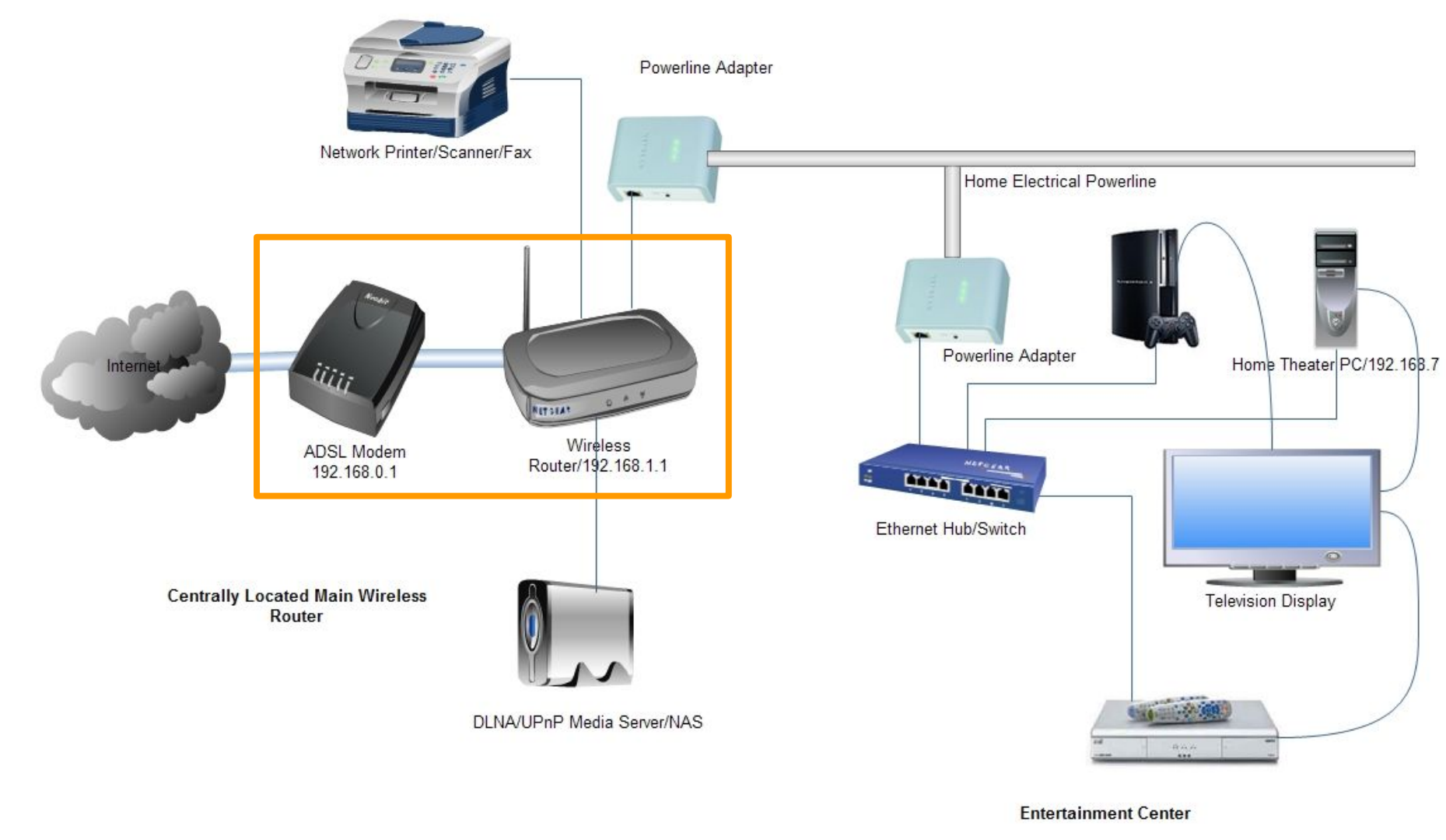
# What is SOHO Router

- Small Office / Home Office
- functions
  - NAT, VPN, Dynamic DNS,
  - Port forwarding, Firewall, Wireless
  - DHCP, MAC filter,  Remote Mgt.
  - Ad. block

# What is SOHO Router

- Small Office / Home Office
- functions
  - NAT, VPN, Dynamic DNS,
  - Port forwarding, Firewall, Wireless
  - DHCP, MAC filter,  Remote Mgt.
  - Ad. block


Powerline Adapter
Network Printer/Scanner/Fax
Home Electrical Powerline
Internet
Powerline Adapter
Home Theater PC/192.168.7
ADSL Modem
192.168.0.1
Wireless
Router/192.168.1.1
Ethernet Hub/Switch
Television Display
Centrally Located Main Wireless
Router
DLNA/UPnP Media Server/NAS
Entertainment Center


Network Printer/Scanner/Fax
Powerline Adapter
Home Electrical Powerline
Internet
ADSL Modem
192.168.0.1
Wireless
Router/192.168.1.1
Powerline Adapter
Home Theater PC/192.168.7
Ethernet Hub/Switch
Television Display
Centrally Located Main Wireless
Router
DLNA/UPnP Media Server/NAS
Entertainment Center


CISCO


TP-LINK®
The Reliable Choice


D-Link®
Building Networks for People


LINKSYS™


net-core 磊科


Tenda®


NETGEAR®

What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# Firmware overview

Two ways to debug

- Hardware
  - JTAG, Serial / UART console …
- Software
  - Just download it from official website

# Firmware overview

Two ways to debug

- Hardware
  - JTAG, Serial / UART console ...
- Software
  - Just download it from official website

# Firmware overview

- File system
  - SquashFS, JFFS2, cramfs, YAFFS ...
- Architecture
  - MIPS/MIPSEL,ARM,PPC,x86,x86-64 ...
- Bootloader

What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# Reversing engineering

- Static analysis
  - firmware extraction
  - reversing binary (IDA Pro … )
  - something hardcode
  - open source code
  - known vulnerabilities

# Reversing engineering

- Dynamic analysis
  - firmware extraction
  - run with emulator(QEMU,Gdb,IDA Pro)
  - port scanning
  - Web security testing

# Reversing engineering

Prerequisite

- binwalk
  - analysis, reverse engineering, extracting

# Reversing engineering

Prerequisite

- binwalk
- fmk (firmware mod kit)
  - build firmware,unsquash,uncramfs …

# Reversing engineering

## Prerequisite

- binwalk
- fmk
- Linux

# Reversing engineering

## Extraction

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> file BR-6430nS_v1.15.bin
BR-6430nS_v1.15.bin: data
┌[jhe@arch] [/dev/pts/1]
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> binwalk BR-6430nS_v1.15.bin

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
11280         0x2C10          LZMA compressed data, properties: 0x5D, dictionary size: 8388608 bytes, uncompressed siz
e: 2301952 bytes
655360        0xA0000         Squashfs filesystem, big endian, version 2.0, size: 1285994 bytes, 500 inodes, blocksize
: 65536 bytes, created: 2013-10-11 06:34:54
```

# Reversing engineering

## Extraction

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> file BR-6430nS_v1.15.bin
BR-6430nS_v1.15.bin: data
┌[jhe@arch] [/dev/pts/1]
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> binwalk BR-6430nS_v1.15.bin

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
11280         0x2C10          LZMA compressed data, properties: 0x5D, dictionary size: 8388608 bytes, uncompressed siz
e: 2301952 bytes
655360        0xA0000         Squashfs filesystem, big endian, version 2.0, size: 1285994 bytes, 500 inodes, blocksize
: 65536 bytes, created: 2013-10-11 06:34:54
```

# Reversing engineering

## Extraction

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> file BR-6430nS_v1.15.bin
BR-6430nS_v1.15.bin: data
┌[jhe@arch] [/dev/pts/1]
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> binwalk BR-6430nS_v1.15.bin

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
11280         0x2C10          LZMA compressed data, properties: 0x5D, dictionary size: 8388608 bytes, uncompressed siz
e: 2301952 bytes
655360        0xA0000         Squashfs filesystem, big endian, version 2.0, size: 1285994 bytes, 500 inodes, blocksize
: 65536 bytes, created: 2013-10-11 06:34:54
```

# Reversing engineering

## Extraction

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> binwalk BR-6430nS_v1.15.bin

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
11280         0x2C10          LZMA compressed data, properties: 0x5D, dictionary size: 8388608 bytes, uncompressed siz
e: 2301952 bytes
655360        0xA0000         Squashfs filesystem, big endian, version 2.0, size: 1285994 bytes, 500 inodes, blocksize
: 65536 bytes, created: 2013-10-11 06:34:54
```

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> dd if=BR-6430nS_v1.15.bin bs=1 skip=655360 of=squashfs.out
1286146+0 records in
1286146+0 records out
1286146 bytes (1.3 MB, 1.2 MiB) copied, 2.71206 s, 474 kB/s
┌[jhe@arch] [/dev/pts/1]
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> file squashfs.out
squashfs.out: Squashfs filesystem, big endian, version 2.0, 1285994 bytes, 500 inodes, blocksize: 65536 bytes, created
: Fri Oct 11 06:34:54 2013
```

# Reversing engineering

## Extraction

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> binwalk BR-6430nS_v1.15.bin

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
11280         0x2C10          LZMA compressed data, properties: 0x5D, dictionary size: 8388608 bytes, uncompressed siz
e: 2301952 bytes
655360        0xA0000         Squashfs filesystem, big endian, version 2.0, size: 1285994 bytes, 500 inodes, blocksize
: 65536 bytes, created: 2013-10-11 06:34:54
```

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> dd if=BR-6430nS_v1.15.bin bs=1 skip=655360 of=squashfs.out
1286146+0 records in
1286146+0 records out
1286146 bytes (1.3 MB, 1.2 MiB) copied, 2.71206 s, 474 kB/s
┌[jhe@arch] [/dev/pts/1]
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> file squashfs.out
squashfs.out: Squashfs filesystem, big endian, version 2.0, 1285994 bytes, 500 inodes, blocksize: 65536 bytes, created
: Fri Oct 11 06:34:54 2013
```

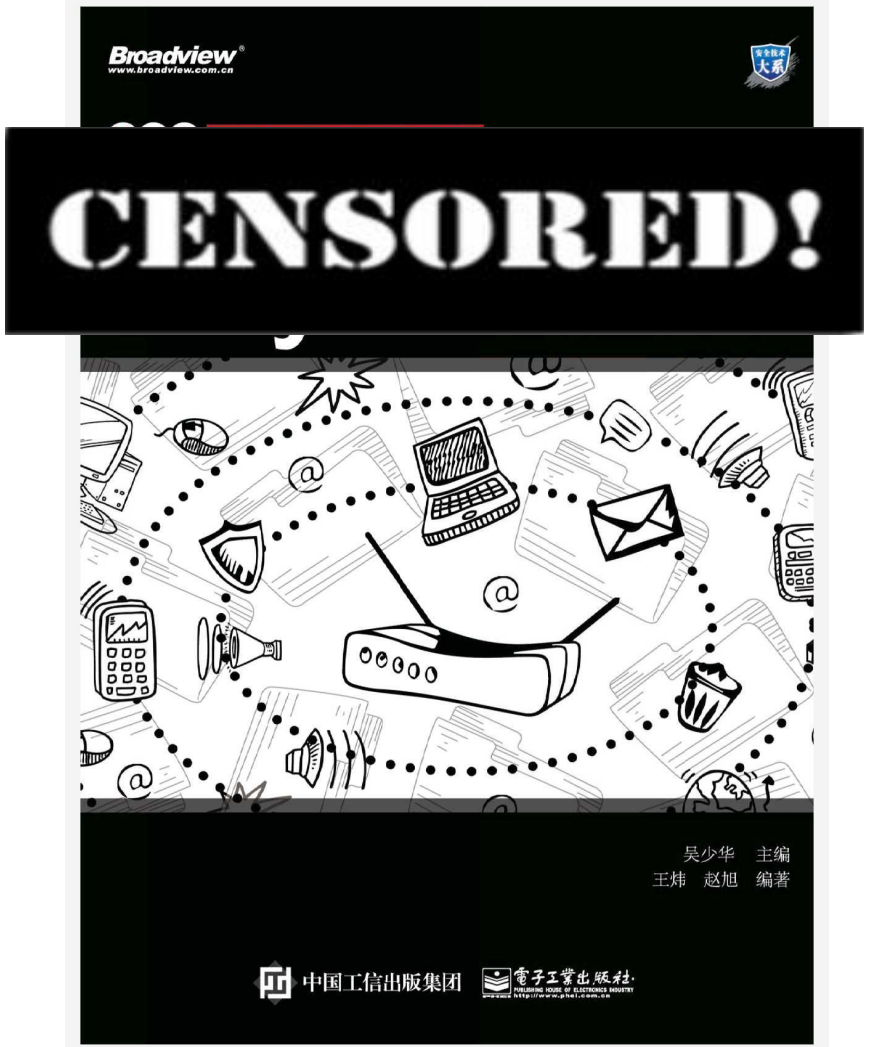
# Reversing engineering

## Extraction

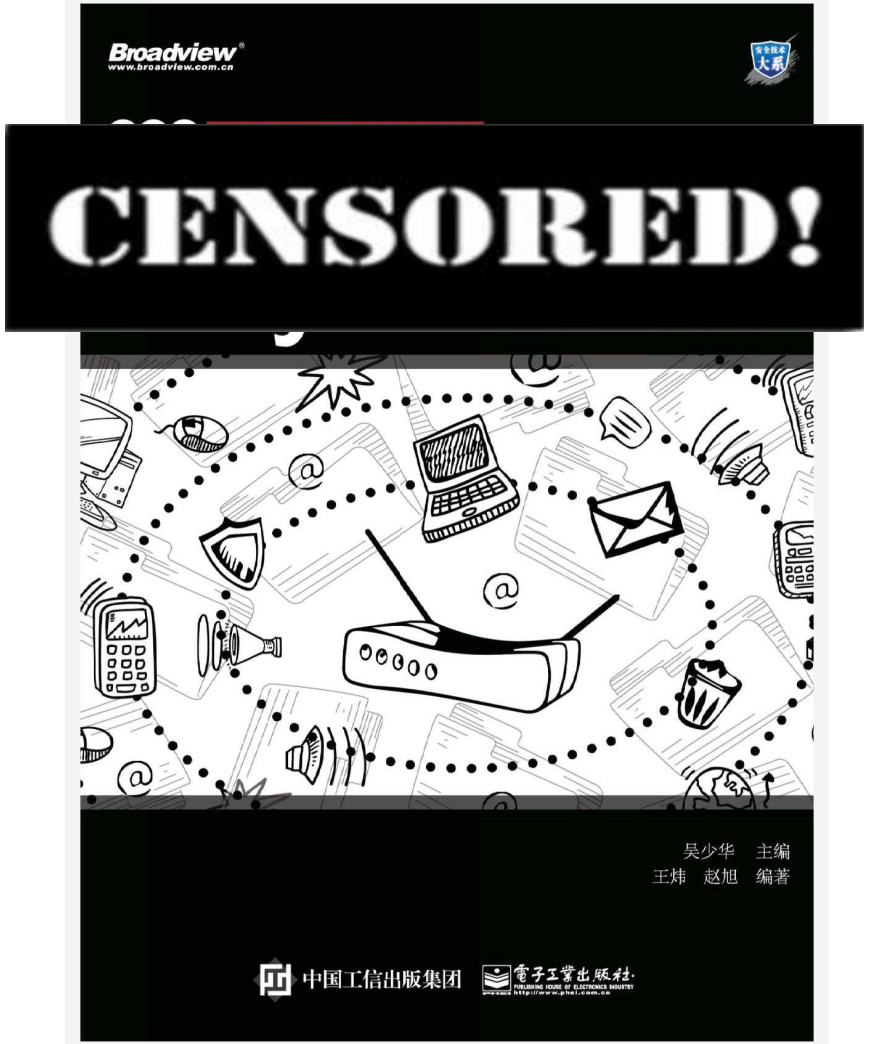
```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> ../../fmk/unsquashfs_all.sh squashfs.out
Attempting to extract SquashFS .X file system...


Trying ./src/squashfs-2.1-r2/unsquashfs-lzma...
created 370 files
created 34 directories
created 67 symlinks
created 0 devices
created 0 fifos
File system sucessfully extracted!
MKFS="./src/squashfs-2.1-r2/mksquashfs-lzma"
```

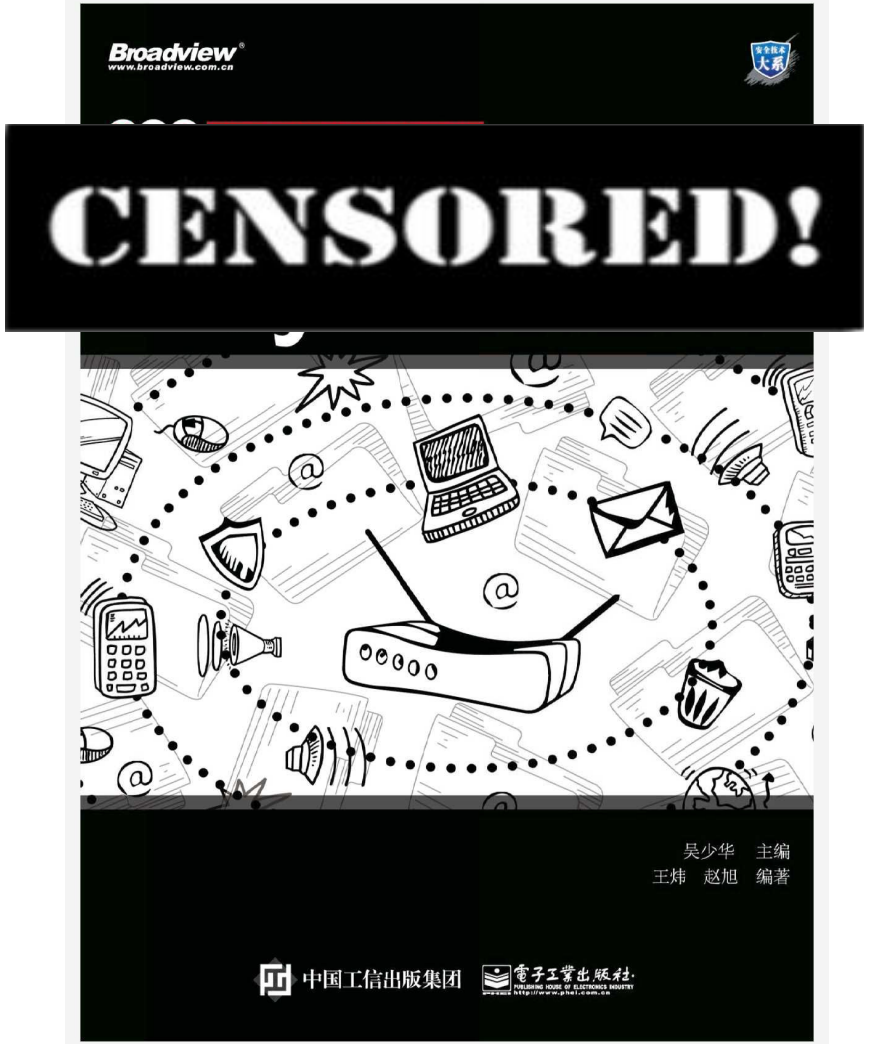
Some of you may have this



It is true


Broadview
www.broadview.com.cn
CENSORED!
吴少华 主编
王炜 赵旭 编著
中国工信出版集团
電子工業出版社

But not that easy



# Example

build emulation environment

- QEMU(arm, mips, mipsel)
- Cross-compilation

# Example

repair runtime environment

1. run with QEMU
2. if ERROR_ECCURRED then

   function hijacking with LD_PRELOAD

   goto 1

# Firmadyne

- System for emulation and dynamic analysis of Linux-based firmware
- Toolchain
- Console
- Nvram
- Testing with metasploit framework

What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# Common vulnerabilities

- XSS, CSRF
- Command Injection
- Denial of Service
- Information Disclosure
- Weak / Default Password

# Common vulnerabilities

- Broken Authentication
- Buffer overflow
- Backdoor

# Common vulnerabilities

- Broken Authentication
- Buffer overflow
- Backdoor

What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# Real world case

BR_6430nS_v1.15

- why this one ?

# Real world case

BR_6430nS_v1.15

- why this one ?
- short story

# Real world case

BR_6430nS_v1.15

- why this one ?
- short story

# Real world case

BR_6430nS_v1.15

- why this one ?
- short story

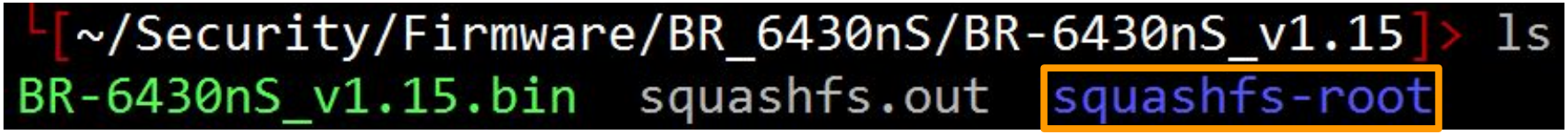
# Real world case

BR_6430nS_v1.15

- why this one ?
- short story


# Real world case

# Real world case



# Real world case

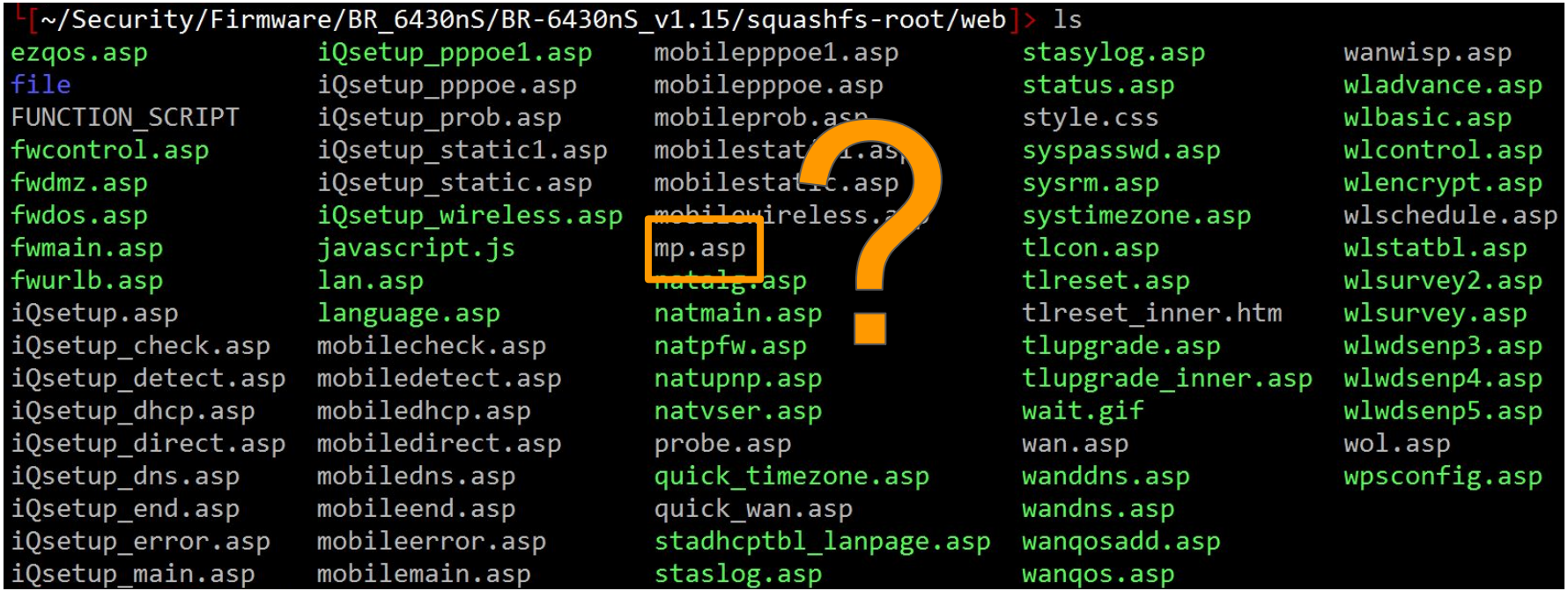
```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15]> ls
BR-6430nS_v1.15.bin  squashfs.out  squashfs-root
```

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15/squashfs-root]> ls
bin  dev  etc  lib  linuxrc  proc  sbin  tmp  usr  var  web
```

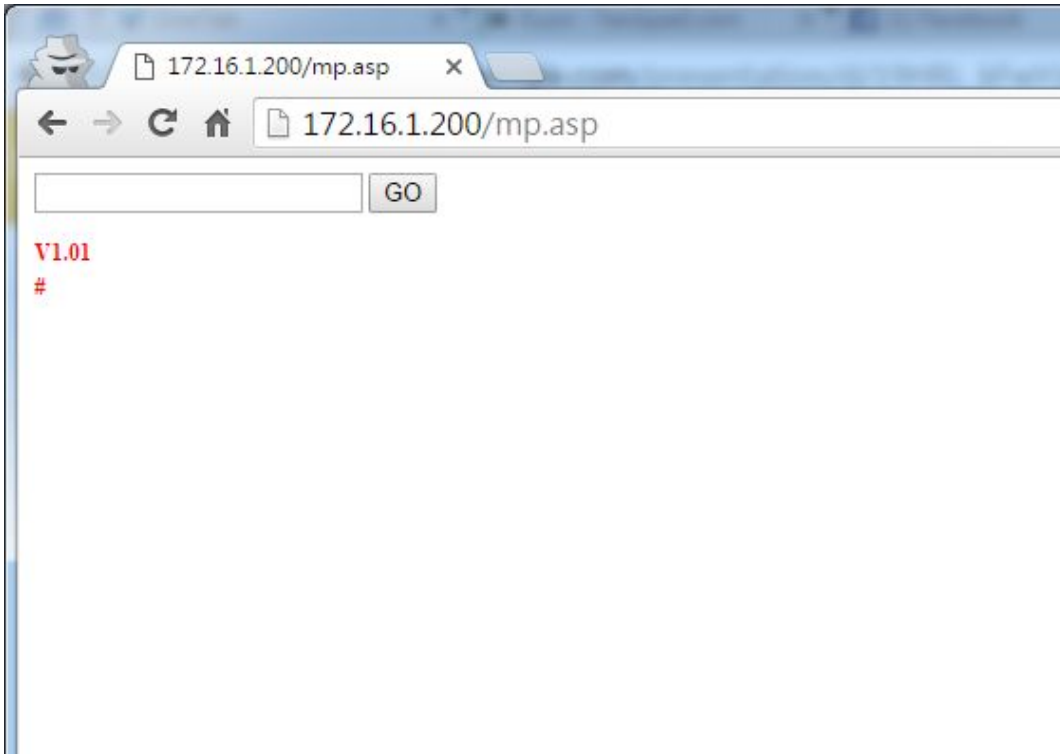
# Real world case

```
└[~/Security/Firmware/BR_6430nS/BR-6430nS_v1.15/squashfs-root/web]> ls
ezqos.asp           iQsetup_pppoe1.asp    mobilepppoe1.asp        stasylog.asp          wanwisp.asp
file                iQsetup_pppoe.asp     mobilepppoe.asp         status.asp            wladvance.asp
FUNCTION_SCRIPT     iQsetup_prob.asp      mobileprob.asp          style.css             wlbasic.asp
fwcontrol.asp       iQsetup_static1.asp   mobilestatic1.asp       syspasswd.asp         wlcontrol.asp
fwdmz.asp           iQsetup_static.asp    mobilestatic.asp        sysrm.asp             wlencrypt.asp
fwdos.asp           iQsetup_wireless.asp  mobilewireless.asp      systimezone.asp       wlschedule.asp
fwmain.asp          javascript.js         mp.asp                  tlcon.asp             wlstatbl.asp
fwurlb.asp          lan.asp               natalg.asp              tlreset.asp           wlsurvey2.asp
iQsetup.asp         language.asp          natmain.asp             tlreset_inner.htm     wlsurvey.asp
iQsetup_check.asp   mobilecheck.asp       natpfw.asp              tlupgrade.asp         wlwdsenp3.asp
iQsetup_detect.asp  mobiledetect.asp      natupnp.asp             tlupgrade_inner.asp   wlwdsenp4.asp
iQsetup_dhcp.asp    mobiledhcp.asp        natvser.asp             wait.gif              wlwdsenp5.asp
iQsetup_direct.asp  mobiledirect.asp      probe.asp               wan.asp               wol.asp
iQsetup_dns.asp     mobiledns.asp         quick_timezone.asp      wanddns.asp           wpsconfig.asp
iQsetup_end.asp     mobileend.asp         quick_wan.asp           wandns.asp
iQsetup_error.asp   mobileerror.asp       stadhcptbl_lanpage.asp  wanqosadd.asp
iQsetup_main.asp    mobilemain.asp        staslog.asp             wanqos.asp
```

# Real world case

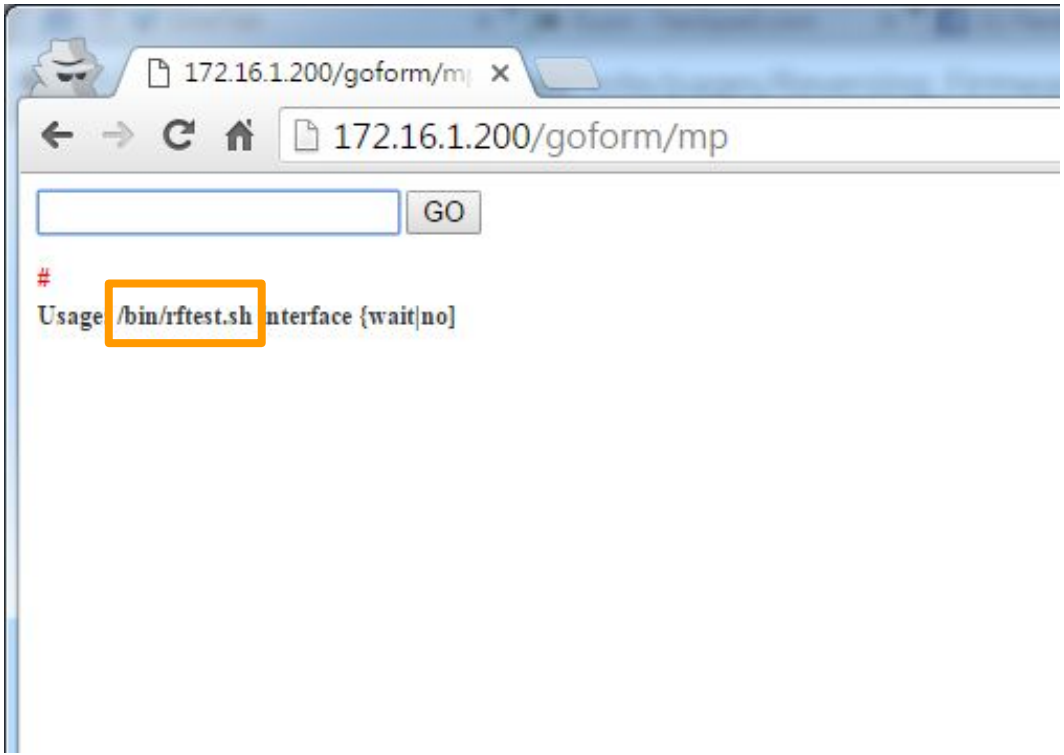


# Real world case

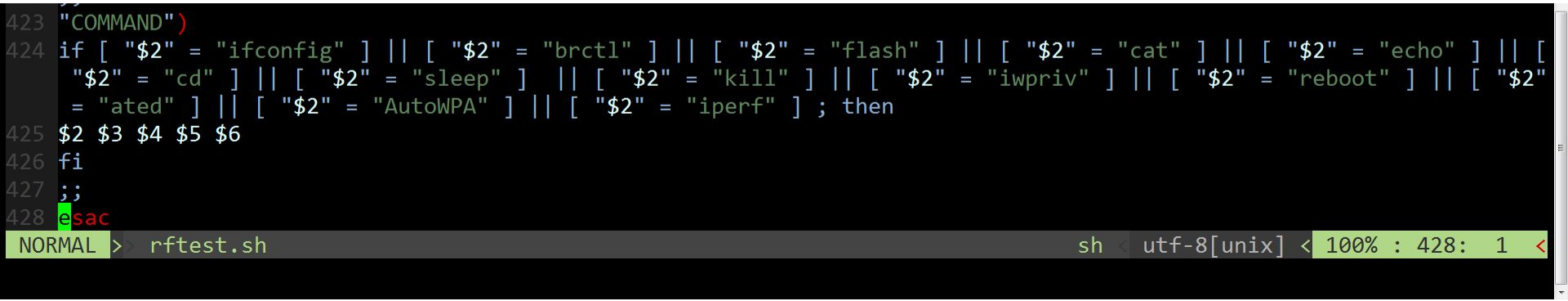


# Real world case

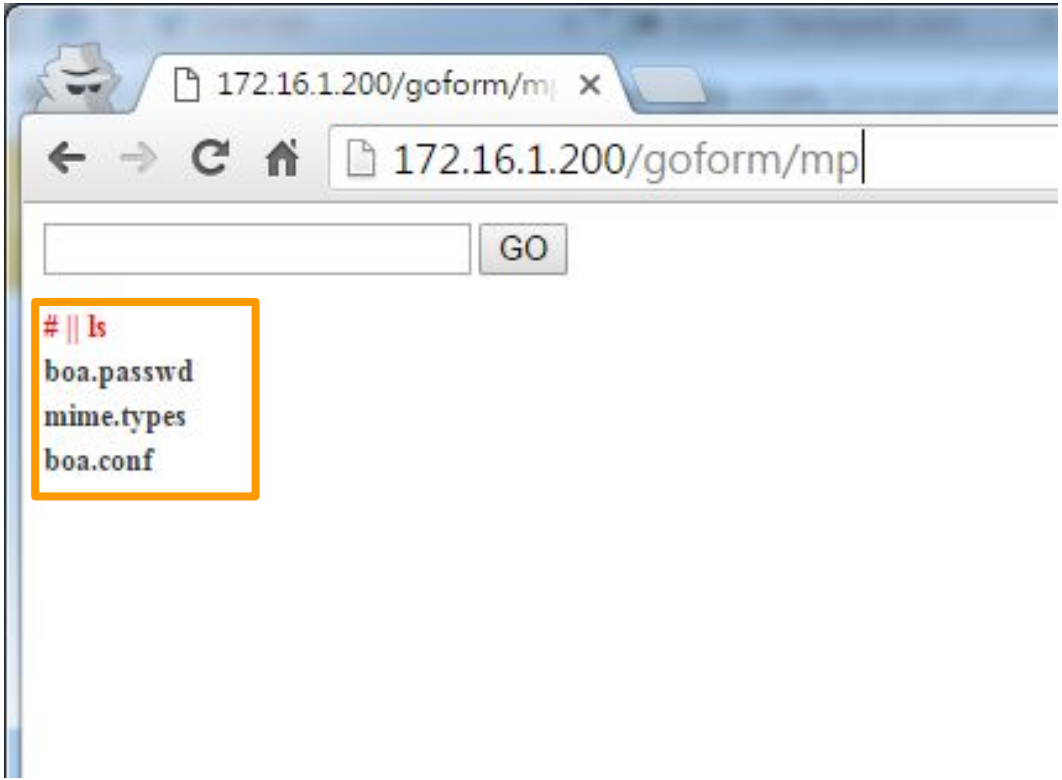
# Real world case



# Real world case



# Real world case



# Real world case

# BusyBox

GPL　Linux內核　軟件版本週期

維基百科，自由的百科全書

**BusyBox** 是一個遵循GPL協議、以自由軟體形式發行的應用程式。Busybox在單一的執行檔中提供了精簡的Unix工具集，可執行於多款POSIX環境的作業系統，例如Linux（包括Android[6][7][8][9]）、Hurd[10]、FreeBSD[11][12]等等。由於BusyBox執行檔尺寸小、並通常使用 Linux內核，這使得它非常適合使用於嵌入式系統。此外，由於BusyBox功能強大，因此有些人將 BusyBox 稱為「嵌入式Linux的瑞士軍刀」。[13]

# Real world case

## 範例

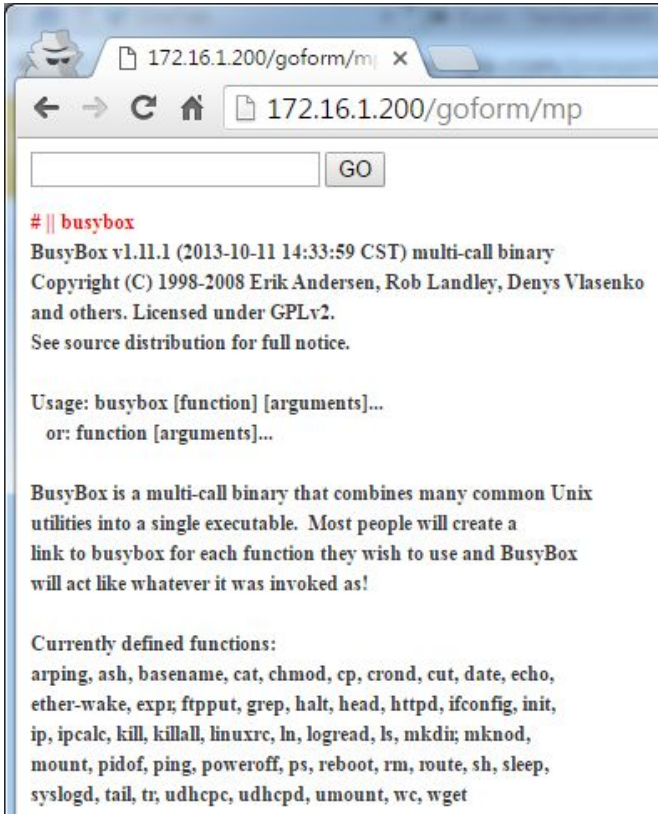
BusyBox 所包含的程式只需要簡單的將名稱附加在第一個參數即可執行：

```
/bin/busybox ls
```

更常見的作法是，這些指令會以連結 (使用硬連結（英語：hard link）或者符號連結) 至 BusyBox 可執行檔，BusyBox 會偵測其被連結時的名稱，並執行對應的指令。舉例來說，只要將 */bin/ls* 連結到 */bin/busybox*，即可執行

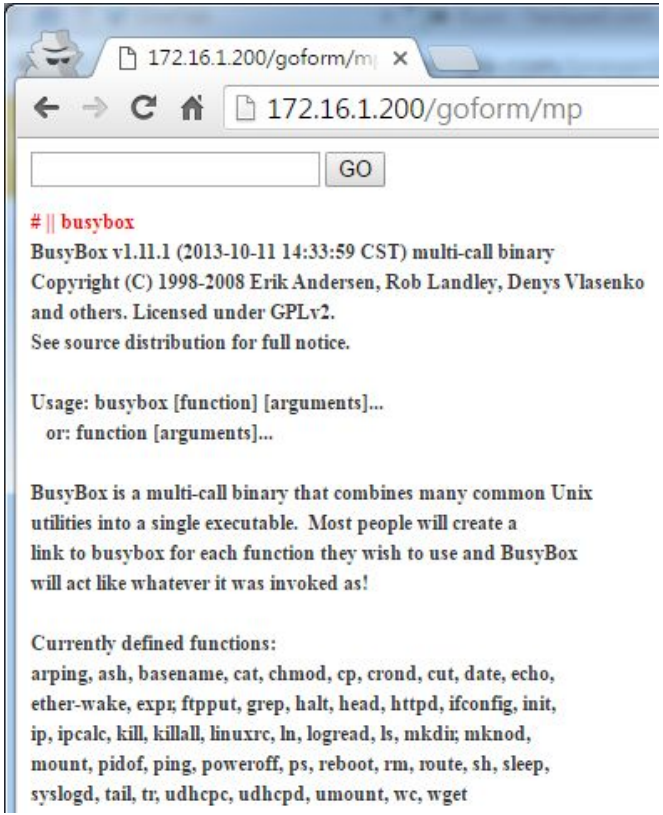
```
/bin/ls
```

# Real world case



# Real world case

Currently defined functions:
arping, ash, basename, cat, chmod,
cp, crond, cut, date, echo,ether-wake,
expr, ftpput, grep, halt, head, httpd,
ifconfig, init, ip, ipcalc, kill,
Killall, linuxrc, ln, logread, ls,
mkdir, mknod, mount, pidof, ping,
poweroff, ps, reboot, rm, route,
sh, sleep, syslogd, tail, tr,
udhcpc, udhcpd, umount, wc, wget



# Real world case

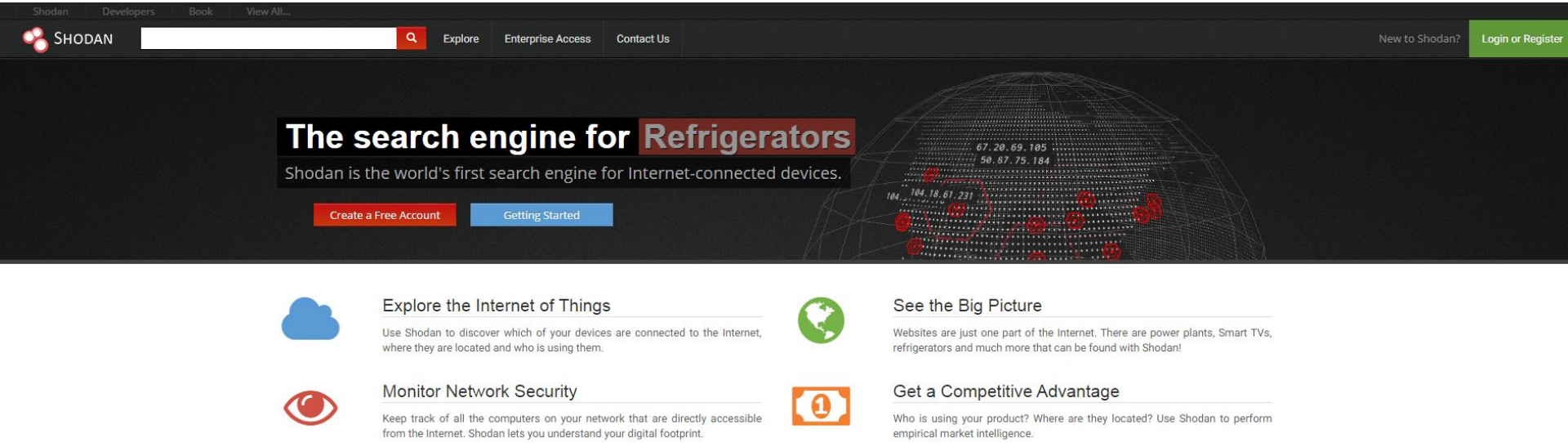
- For debug == For hacker

# Real world case

- For debug == For hacker
- After that ?

# Real world case

## Shodan

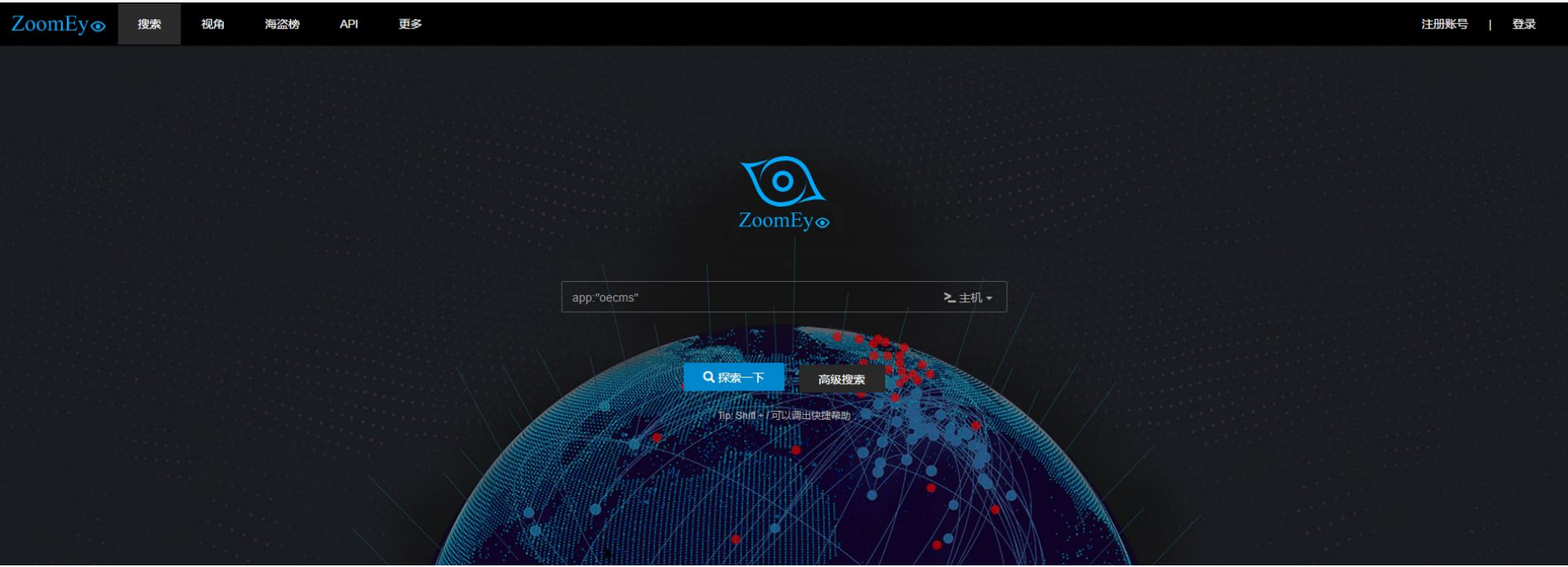


# Real world case

## Censys

# Real world case

## Zoomeye



What is SOHO Router

Firmware overview

Reversing engineering

Common vulnerabilities

Real world case

UCCU

# UCCU

problems you may encounter

# UCCU

problems you may encounter

- different version, different output ?

# UCCU

problems you may encounter

- different version, different output ?
- new stuff or old stuff ?

# You may have heard about ...

# You may have heard about ...

This is just beginning ...


IoT is coming

# IoT is coming ...

- SOHO Router

# IoT is coming ...

- SOHO Router
- Web Cam

# IoT is coming ...

- SOHO Router
- Web Cam
- Car

# IoT is coming ...

- SOHO Router
- Web Cam
- Car
- anything smart device

# IoT is coming ...

- SOHO Router
- Web Cam
- Car
- anything smart device
- anything Internet-connected


# Questions ?