Pwn2Own 解碼

廠商視角的弱點反思

Synology Product Developer

吳勃興

Synology

whoami

- 吳勃興
- Synology Product Developer
- Security Incident Response Team

為什麼會有這個議程

Pwn2Own

- 全球頂尖攻防競賽
  - Pre-auth RCE
- Synology 自 2020 年起便持續參與
  - Tokyo 2020
  - Austin 2021
  - Toronto 2022
  - Toronto 2023
  - Ireland 2024

Pwn2Own Ireland 2024

不同於往年

- 新產品線加入競賽
- 讓 scope 變得更大

For the Synology DiskStation target, the following packages will be installed and are in scope for contest:

- MailPlus
- Drive
- Virtual Machine Manager
- Snapshot Replication
- Surveillance Station
- Photos

Pwn2Own 2024 Result

收穫良多的一年

		SUCCESS	COLLISION	FAILURE	WITHDRAWN
Network Attached Storage (NAS)	**DiskStation**	3	0	1	0
	BeeStation	3	1	1	0
Surveillance Systems		1	0	2	1
Small Office / Home Office (SOHO) Smash-up		0	0	1	0

Pwn2Own 2024 Result

收穫良多的一年

研究者如何發現？ 我們如何改進？

		SUCCESS	COLLISION	FAILURE	WITHDRAWN
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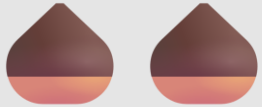
案例探討

Synology

來點例子 

- Off-by-one Error
- Improper Encoding of Output

Off-by-one Error

Replication Service

Synology

Replication Service

- 將拍攝的快照從來源複寫至目的地
- 無法單獨運作，必須依附其他提供快照功能的套件

For the Synology DiskStation target, the following packages will be installed and are in scope for contest:

- MailPlus
- Drive
- Virtual Machine Manager
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- Surveillance Station
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Synology

Off-by-one Error

1. 尋找入口
2. 了解過程
3. 發現漏洞
4. Exploit

Off-by-one Error

1. 尋找入口
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開了哪些 port

```
tcp6       0      0 :::3261                 :::*                    LISTEN      -
tcp6       0      0 :::445                  :::*                    LISTEN      12153/smbd
tcp6       0      0 :::5566                 :::*                    LISTEN      14331/synobtrfsrepl
tcp6       0      0 :::3263                 :::*                    LISTEN      -
tcp6       0      0 :::3264                 :::*                    LISTEN      -
tcp6       0      0 :::3265                 :::*                    LISTEN      13156/scsi_plugin_s
tcp6       0      0 :::2049                 :::*                    LISTEN      -
tcp6       0      0 :::5000                 :::*                    LISTEN      9553/nginx: master
tcp6       0      0 :::5001                 :::*                    LISTEN      9553/nginx: master
tcp6       0      0 :::139                  :::*                    LISTEN      12152/smbd
```

Off-by-one Error

1. 尋找入口
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逆起來

```
struct ReplicaCmdHeader {
    uint32_t cmd;
    uint32_t seq;
    uint32_t len;
};

struct ReplicaCmd {
    struct ReplicaCmdHeader header;
    char *data;
};
```

Off-by-one Error

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```
int recvCmd(struct ReplicaCmd &xxx) {
    int retval = SNAPREPLICA_ERR_GENERIC;

    if (SNAPREPLICA_ERR_NONE != (retval = receiveMessage(xxx))) {
        goto Exit;
    }
    if (xxx.header.len > RECV_BUF_SIZE) {
        goto Exit;
    }
    // Read data
}

int runCmdLoop(bool &xxx) {
    int retval = SNAPREPLICA_ERR_GENERIC;

    while (xxx) {
        if (SNAPREPLICA_ERR_NONE != (retval = recvCmd(xxx))) {
            goto Exit;
        }
        if (CMD_SEND != xxx.header.cmd) {
            xxx.data[xxx.header.len] = '\0';
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Off-by-one Error

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```
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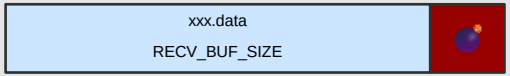


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- Create information leak
  - Defeat ASLR
  - Leak BSS address
- Hijack control flow
  - Overwrite GOT entry

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Off-by-one Error

關鍵疏漏

- 函數返回值不夠準確
- 記憶體管理不夠嚴謹

Off-by-one Error

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Off-by-one Error

關鍵疏漏

- 函數返回值不夠準確
- 記憶體管理不夠嚴謹

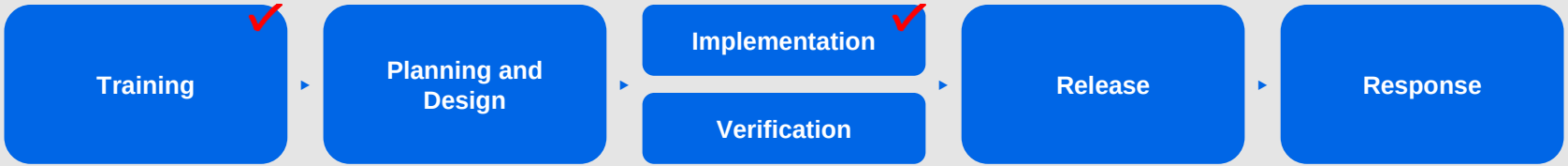
修復方式

- 重新審閱相關實作
  - 緩衝區大小
  - 函數返回值

Off-by-one Error

改進方式

- Internal Training
- SAST
- Full RELRO



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Off-by-one Error

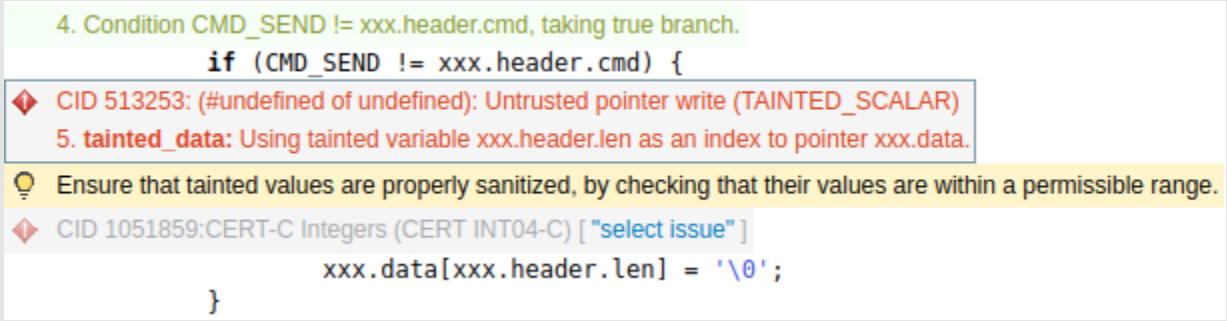
改進方式

- Internal Training
  - Newbie training (e.g. CTF style lab)
  - Regular sharing talk
- SAST
- Full RELRO

Off-by-one Error

改進方式

- Internal Training
- SAST
  - Medium issue
- Full RELRO



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Off-by-one Error

改進方式

- Internal Training
- SAST
- Full RELRO
  - Bye, GOT hijacking

```
$ checksec file -l ./libc.so.6 synobtrfsreplicad -o json | jq .
[
  {
    "checks": {
      "canary": "Canary Found",
      "fortified": "1",
      "fortify_source": "Yes",
      "fortifyable": "1",
      "nx": "NX enabled",
      "pie": "PIE Enabled",
      "relro": "Partial RELRO",
      "rpath": "RPATH",
      "runpath": "No RUNPATH",
      "symbols": "61 symbols"
    },
    "name": "synobtrfsreplicad"
  }
]
```

Off-by-one Error

評估中的改進方式

- libc++ hardening mode
- Rust

Improper Encoding of Output

Plugin Framework

Synology®

Improper Encoding of Output

1. 尋找入口
2. 了解過程
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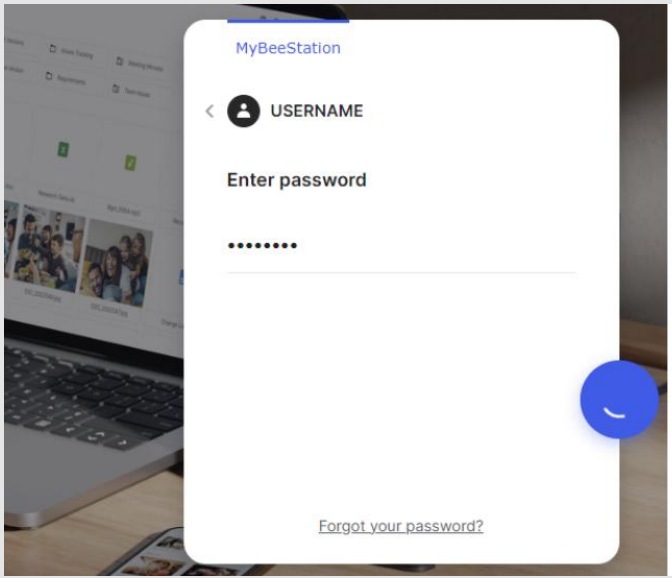
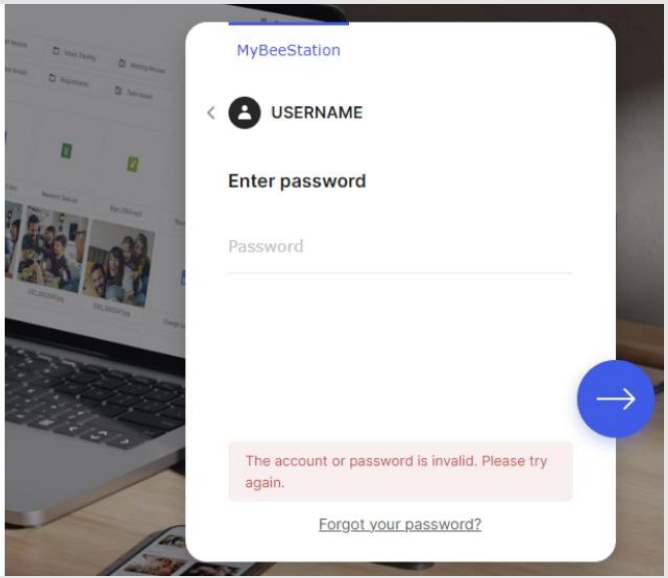
最直覺的入口





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Improper Encoding of Output

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bpftrace 追蹤發生的事情

```
# bpftrace --unsafe /follow_syscall_activity.bt
Attaching 1 probe…

PID: 22515 CMD: NULL #[0]
PID: 22515 ENV:
PATH=/sbin:/bin:/usr/sbin:/usr/bin:/usr/syno/sbin:/usr/syno/bin:/usr/local/sbin
:/usr/local/bin
PID: 22515 ENV: SOCKET=/run/synoscgi.sock
PID: 22515 ENV: LD_PRELOAD=openhook.so
PID: 22515 ENV: CONTENT_LENGTH=1309
PID: 22515 ENV: REWRITE_APP=SYNO.SDS.Bee.Instance
PID: 22515 ENV: SCRIPT_FILENAME=/usr/syno/synoman/webapi/entry.cgi
PID: 22515 ENV: SCRIPT_NAME=/webapi/entry.cgi
PID: 22515 ENV: REQUEST_METHOD=POST
PID: 22515 ENV: REQUEST_URI=/webapi/entry.cgi?api=SYNO.BEE.API.Auth
PID: 22515 ENV: QUERY_STRING=api=SYNO.BEE.API.Auth
PID: 22515 ENV: CONTENT_TYPE=application/x-www-form-urlencoded; charset=UTF-8
PID: 22515 ENV: DOCUMENT_URI=/webapi/entry.cgi
```

Improper Encoding of Output

1. 尋找入口
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登入前 / 後會做其他事情

```
PID: 22691 CMD: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin --post #[2]
PID: 22691 ENV:
PATH=/sbin:/bin:/usr/sbin:/usr/bin:/usr/syno/sbin:/usr/syno/bin:/usr/local/sbin
:/usr/local/bin
PID: 22691 ENV: USER=USERNAME
PID: 22691 ENV: TYPE=passwd
PID: 22691 ENV: SESSION=webui
PID: 22691 ENV: API_VERSION=7
PID: 22691 ENV: IS_KNOWN_DEVICE=no
PID: 22691 ENV: IP=192.168.50.186
PID: 22691 ENV: AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko) Chrome/128.0.0.0 Safari/537.36
PID: 22691 ENV: STATUS=fail
PID: 22691 ENV: RESULT=-2
PID: 22691 ENV:
SYNO_PLUGIN_ARGS=/run/synoplugind//tmp/env.22249.dd150dfd-ee00-4578-bcb3-f52ed0
f21e12 #[3]
PID: 22691 ENV: SYNO_PLUGIN_UUID=dd150dfd-ee00-4578-bcb3-f52ed0f21e12
PID: 22691 CMDL: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin
PID: 22691 CMDL: --post
```


Synology

Improper Encoding of Output

1. 尋找入口
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環境變數有使用者名稱

```
PID: 22691 CMD: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin --post #[2]
PID: 22691 ENV:
PATH=/sbin:/bin:/usr/sbin:/usr/bin:/usr/syno/sbin:/usr/syno/bin:/usr/local/sbin
:/usr/local/bin
PID: 22691 ENV: USER=USERNAME
PID: 22691 ENV: TYPE=passwd
PID: 22691 ENV: SESSION=webui
PID: 22691 ENV: API_VERSION=7
PID: 22691 ENV: IS_KNOWN_DEVICE=no
PID: 22691 ENV: IP=192.168.50.186
PID: 22691 ENV: AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko) Chrome/128.0.0.0 Safari/537.36
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f21e12 #[3]
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PID: 22691 CMDL: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin
PID: 22691 CMDL: --post
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Synology

Improper Encoding of Output

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環境變數有暫存檔路徑

```
PID: 22691 CMD: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin --post #[2]
PID: 22691 ENV:
PATH=/sbin:/bin:/usr/sbin:/usr/bin:/usr/syno/sbin:/usr/syno/bin:/usr/local/sbin
:/usr/local/bin
PID: 22691 ENV: USER=USERNAME
PID: 22691 ENV: TYPE=passwd
PID: 22691 ENV: SESSION=webui
PID: 22691 ENV: API_VERSION=7
PID: 22691 ENV: IS_KNOWN_DEVICE=no
PID: 22691 ENV: IP=192.168.50.186
PID: 22691 ENV: AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko) Chrome/128.0.0.0 Safari/537.36
PID: 22691 ENV: STATUS=fail
PID: 22691 ENV: RESULT=-2
PID: 22691 ENV:
SYNO_PLUGIN_ARGS=/run/synoplugind//tmp/env.22249.dd150dfd-ee00-4578-bcb3-f52ed0
f21e12 #[3]
PID: 22691 ENV: SYNO_PLUGIN_UUID=dd150dfd-ee00-4578-bcb3-f52ed0f21e12
PID: 22691 CMDL: /usr/syno/plugin/weblogin/synocgi-plugin-weblogin
PID: 22691 CMDL: --post
```


Synology

Improper Encoding of Output

1. 尋找入口
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暫存檔內容

```
USER=USERNAME
TYPE=passwd
SESSION=webui
API_VERSION=7
IS_KNOWN_DEVICE=no
IP=192.168.50.186
AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like
Gecko) Chrome/128.0.0.0 Safari/537.36
STATUS=fail
RESULT=-2
```

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有種可以 injection 的感覺

```
▼ dsmForm: Object
    OTPcode: ""
    SSOToken: ""
    password: ""
    username: "USERNAME\nNEXTLINE"
```

```
USER=PLUGIN_VALUE_START
USERNAME
NEXTLINE
PLUGIN_VALUE_END
TYPE=passwd
SESSION=webui
API_VERSION=7
IS_KNOWN_DEVICE=no
IP=192.168.50.186
AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like
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Synology

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戳戳看

```
USER=PLUGIN_VALUE_START
USERNAME
PLUGIN_VALUE_END
NEWVAR=PLUGIN_VALUE_START
TEST
PLUGIN_VALUE_END
TYPE=passwd
SESSION=webui
API_VERSION=7
IS_KNOWN_DEVICE=no
IP=192.168.50.186
AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like
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STATUS=fail
RESULT=-2
```

Improper Encoding of Output

1. 尋找入口
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Bingo!

```
Args=[USER=USERNAME,NEWVAR=TEST,TYPE=passwd,SESSION=webui,API_VERSION=7,IS_KNOW
N_DEVICE=no,IP=192.168.50.186,AGENT=Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko) Chrome/128.0.0.0
Safari/537.36,STATUS=fail,RESULT=-2]
```

Improper Encoding of Output

1. 尋找入口
2. 了解過程
3. 發現漏洞
4. Exploit

- Write to arbitrary file
  - `ld` related environ variables
- Understand cron daemon
  - Ignore malformed lines

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    - LD_PRELOAD
    - LD_DEBUG
    - LD_DEBUG_OUTPUT
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Improper Encoding of Output

關鍵疏漏

- 過度信任輸入的資料

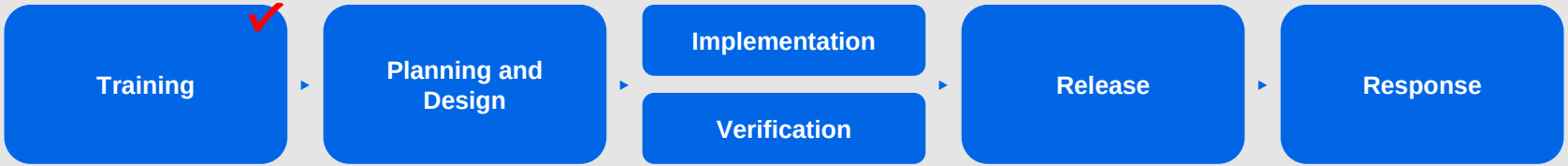
修復方式

- 輸出環境變數前先做編碼

Improper Encoding of Output

改進方式

- Internal Training
  - Newbie training
  - Regular sharing talk



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總結

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Summary

- 想提昇整體安全性
  - SAST
    - Coverity 需要花時間與人力 fine-tune
  - Toolchain hardening flag
    - Full RELRO
  - Memory-safe language
    - Rust
- 但 internal training 仍然不能少

Q & A

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