2025
The Botnet &
Malware Ecosystem
Fighting Conference

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Unveiling the DVR Ecosystem

A 3-Year Investigation into Global IoT Bot Recruitment Campaigns

UMEMURA Yuki*
MORI Yoshiki
FURUKAWA Hideyuki
OKUGAWA Kanta
KUBO Masaki*

Cybersecurity Research Institute (CSRI), NICT

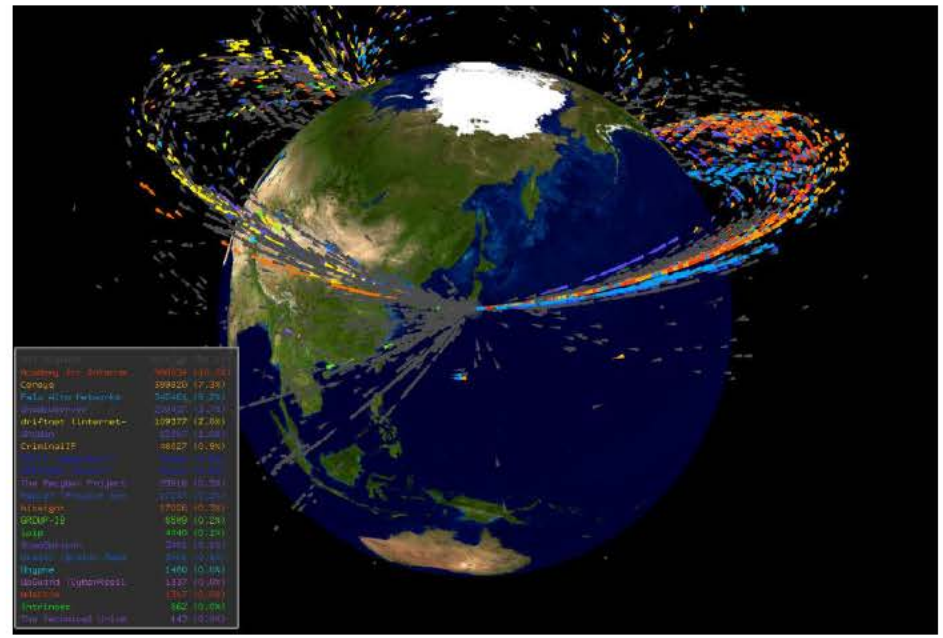
NICT National Institute of Information and Communications Technology

CYBERSECURITY Research Institute

About Us

- **Cybersecurity Research Institute (CSRI), NICT**

- A team of experts dedicated to:
  - Monitoring and analyzing darknet traffic
  - Tracking Internet-wide scanners
  - Discovering and analyzing zero-day vulnerabilities in IoT ecosystem
  - Analyzing malware



Real-time visualization packets arriving at 'NICTER' darknet sensors (300,000 unused IP addresses)

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Three Key Challenges in IoT Botnet Research

Challenge 1.
Tracking infected hosts

Challenge 2.
Identifying infection vectors

x ***RapperBot***

Challenge 3.
Analyzing the Evolution and Operation of a Bot Family

Challenge #1: Tracking infected hosts

Methods for Tracking and Profiling Infected Hosts

- How to get the IP address of infected hosts?
  - ✓sinkhole C2 traffic
  - ✓flow data analysis
  - ✓**passive monitoring of scan packets**
- How to identify the infected device?
  - ✓passive scan data (Shodan/Censys)
  - ✓**active scan-back the source**

Our Approach to Tracking Infected Hosts

- **Passive monitoring of scan packets with bot-specific signatures:**

```
iph->id = rand_next();
iph->saddr = LOCAL_ADDR;
iph->daddr = get_random_ip();
iph->check = 0;
iph->check = checksum_generic((uint16_t *)iph, sizeof (struct iphdr));

if (i % 10 == 0)
{
    tcph->dest = htons(2323);
}
else
{
    tcph->dest = htons(23);
}
tcph->seq = iph->daddr;
tcph->check = 0;
tcph->check = checksum_tcpudp(iph, tcph, htons(sizeof (struct tcphdr)), sizeof (struct tcphdr));

paddr.sin_family = AF_INET;
paddr.sin_addr.s_addr = iph->daddr;
paddr.sin_port = tcph->dest;
```

TCP SYN packet patterns

AND/OR

{23 26}
{23 67 70 79 80 81 82 83 84 85 88 90 ...}
{80 81 5555 7574 8080 8081 8181 8443 37215 ...}
{80 81 82 8080}
{80 81 82 83 85}

Characteristic scanning port sets

👎 **Non-scanning bots** can't be detected this way

👍 But **loader's infection activity** reveals which malware is being deployed

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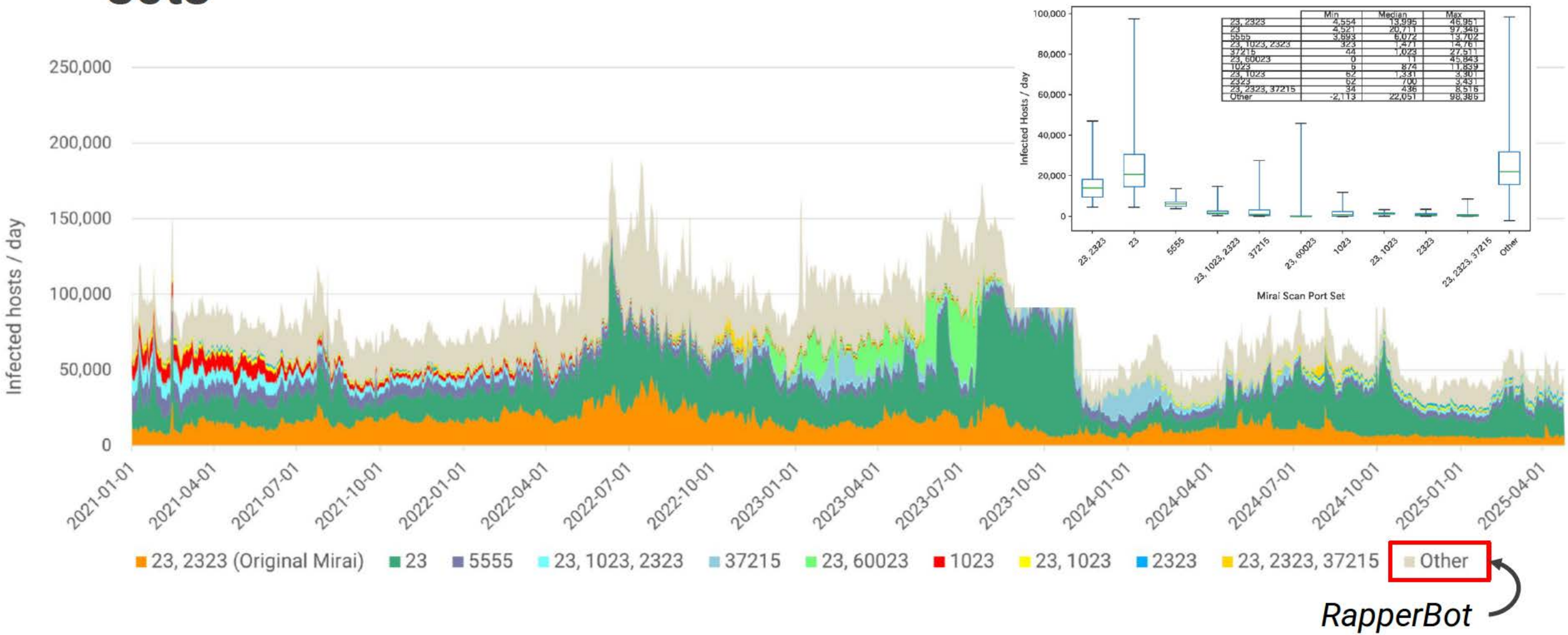
Tracking Bots by Destination Ports (Top 10)

- **Daily unique source IPs, grouped by Mirai scan port sets**



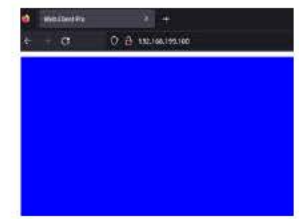
Identifying the Infected Device

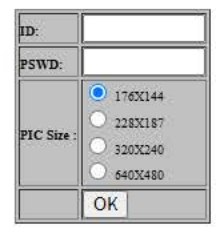
- **Actively scanned-back** bot IPs in **real time** after detecting their scan

No.	Stat	Last Seen[l] v	Src IPaddr[s]	ASNo	ORG	CC	Count[c] v	pps[p]	Proto	Portset
1	Alive	2025/04/27 13:47:57	150	2527	So-net	JP	173	0	S	S:23
2	Alive	2025/04/27 13:47:58	160	2514	NTT PC Communic	JP	139	5	S	S:23
3	Alive	2025/04/27 13:47:55	150	2527	So-net	JP	117	0	S	S:23
4	Alive	2025/04/27 13:47:58	60.1	17676	SoftBank Corp.	JP	82	2	S	S:23,S:2323
5	Alive	2025/04/27 13:47:57	1.3	2514	NTT PC Communic	JP	37	0	S	S:23
6	Alive	2025/04/27 13:47:58	60.3	4713	NTT Communicati	JP	29	2	S	S:23,S:2323
7	Alive	2025/04/27 13:47:58	115	9595	NTT-ME Corporat	JP	27	3	S	S:23
8	Alive	2025/04/27 13:47:34	106	2516	au one net	JP	27	0	S	S:23
9	Alive	2025/04/27 13:47:52	119	17511	K-Opticom Corpo	JP	26	0	S	S:23
10	Alive	2025/04/27 13:47:53	150	4685	Asahi Net	JP	21	0	S	S:23
11	Alive	2025/04/27 13:47:46	126	17676	SoftBank Corp.	JP	19	0	S	S:23
12	Alive	2025/04/27 13:47:58	220	2519	VECTANT	JP	18	1	S	S:23,S:2323
13	Alive	2025/04/27 13:47:58	1.3	2514	NTT PC Communic	JP	15	1	S	S:23
14	Alive	2025/04/27 13:47:58	124	9595	NTT-ME Corporat	JP	15	1	S	S:23
15	Alive	2025/04/27 13:47:52	124	9595	NTT-ME Corporat	JP	14	0	S	S:23,S:60023
16	Alive	2025/04/27 13:47:56	220	2519	VECTANT	JP	13	0	S	S:23
17	Alive	2025/04/27 13:47:52	1.3	2514	NTT PC Communic	JP	11	0	S	S:23
18	Alive	2025/04/27 13:47:56	133	2514	NTT PC Communic	JP	10	0	S	S:23
19	Alive	2025/04/27 13:47:54	219	2514	NTT PC Communic	JP	10	0	S	S:23
20	Alive	2025/04/27 13:47:49	60.1	17676	SoftBank Corp.	JP	10	0	S	S:23
21	Alive	2025/04/27 13:47:47	221	9354	Community Netwo	JP	10	0	S	S:23
22	Alive	2025/04/27 13:47:56	219	2514	NTT PC Communic	JP	9	0	S	S:23
23	Alive	2025/04/27 13:47:52	210	2514	NTT PC Communic	JP	8	0	S	S:23
24	Alive	2025/04/27 13:47:52	117	18081	KCN	JP	8	0	S	S:23
25	Alive	2025/04/27 13:47:40	114	4713	NTT	JP	8	0	S	S:23
26	Alive	2025/04/27 13:47:56	58.1	17511	K-Opticom Corpo	JP	7	0	S	S:23
27	Alive	2025/04/27 13:47:50	58.1	17511	K-Opticom Corpo	JP	7	0	S	S:23,S:2323
28	Alive	2025/04/27 13:47:50	118	4713	NTT	JP	7	0	S	S:9530
29	Alive	2025/04/27 13:47:24	61.1	18081	KCN	JP	7	0	S	S:23
30	Alive	2025/04/27 13:47:58	128	2514	NTT PC Communic	JP	6	1	S	S:23
31	Alive	2025/04/27 13:47:51	124	9595	NTT-ME Corporat	JP	6	0	S	S:23
32	Alive	2025/04/27 13:47:58	125	2518	Biglobe	JP	5	1	S	S:23
33	Alive	2025/04/27 13:47:58	180	4713	NTT	JP	5	1	S	S:23
34	Alive	2025/04/27 13:47:56	153	18013	freebit	JP	5	0	S	S:23
35	Alive	2025/04/27 13:47:55	180	4713	NTT	JP	5	0	S	S:23
36	Alive	2025/04/27 13:47:54	210	2519	VECTANT	JP	5	0	S	S:23
37	Alive	2025/04/27 13:47:48	220	9595	NTT-ME Corporat	JP	5	0	S	S:23
38	Alive	2025/04/27 13:47:46	153	4713	NTT	JP	5	0	S	S:23,S:2323
39	Alive	2025/04/27 13:47:41	210	2514	NTT PC Communic	JP	5	0	S	S:23
40	Alive	2025/04/27 13:47:41	118	18126	Chubu Telecommu	JP	5	0	S	S:23
41	Alive	2025/04/27 13:47:24	36.3	2519	VECTANT	JP	5	0	S	S:23

20,000 packets/sec

- **Around 70% of hosts were DVRs**
  - 527 out of 602 hosts (87.5%) responded
    - HITRON DVR: 63%
    - Rifatron DVR: 7%
    - Other devices: 17%





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What is DVR?

- Digital Video Recorder：A device that records, stores and streams camera recordings

- Linux based OS
- Web UI (HTTP)
- RTSP/ONVIF server
- Telnet/SSH access
- Dynamic DNS
- Internal HDD for recording storage

CPU: HiSilicon 3531
ARM Cortex-A9(Dual-Core)
Memory: 384MB
NAND Flash: 128MB
HDD: 2TB
NIC: 1Gbps

Camera input:
BNC/IP

LAN port

User

- This 1080p 16-channel DVR from 2016 (around $1000) comes with these specs
- Newer models supporting 4K video often include upgraded CPUs, including some with quad-core processors

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Challenge #2: Identifying infection vectors

Common Infection Vectors

A) Brute-force login (default credentials)

B) Management interface exploits

- Known CVEs
- Zero-day attacks

A）Brute-force logins

- Original Mirai hard-coded 60 ID/password pairs
- **40%** of them are linked to **DVR**, over **70%** are **surveillance** equipment

Username	Password	Manufacturer (vendor)	Device Model / Type (if known)
666666	**666666**	Dahua Technology	Default user account on Dahua DVRs/IP cams
888888	**888888**	Dahua Technology	Default admin account on Dahua standalone DVR/NVRs
admin	**12345**	Hikvision	IP Cameras/DVRs (older Hikvision models)
(snip)			
root	**1111**	Merit LiLin (Pinetron)	Digital video recorders
root	**juantech**	Guangzhou Juan Optical	DVR device (Juan CCTV DVR/NVR equipment)
root	**jvbzd**	Hangzhou Xiongmai (XM)	IP Camera/DVR (Xiongmai firmware)

A) Brute-force logins

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B) Management Interface Exploits

- **Exploits (zero-day) are sent only if the host returns a valid banner**
  - No banner → No payload
  - Honeypot can't capture the exploit
- **Real hardware is required for observation**
- **But how do we know which device models are being targeted in the first place?**

If infected device spread scans	If infected device doesn't spread scan
✅ Active scan-back	❌ Wait for a incident report
fingerprint device type	From the user or ISP notice

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- OEM: ITX Security (Korea)

- Distributed in Japan and overseas
- Vulns reported via JP distributor; patch released
- Patch status via overseas distributors unknown

- Discovered **four previously uknov vulnerabilities**

- **Two were being exploited as zero-days**:
  - ✓Hardcoded backdoor account (CWE-287)
  - ✓OS command injection (CWE-78)

Two Zero-days Exploited by Attackers

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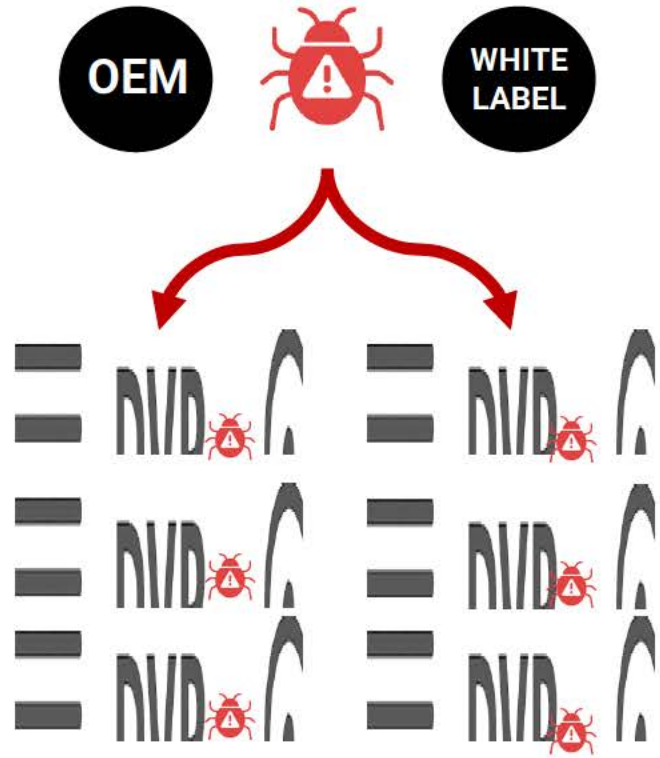
DVRs Keep Getting Targeted: Vulnerable ecosystem

Easy to Hack, Rarely Patched

- **User context**
  - **24/7 online** and **exposed to the internet**
  - Security is often ignored — “if it works, it’s fine”
- **Default Design**
  - **Weak credentials**; **Telnet/HTTP enabled** by default
- **Operational Reality**
  - **Firmware rarely updated**; vulnerabilities left unpatched

Botnets Exploit the Ecosystem

- OEM and white-label DVRs **share common firmware**
- One exploit can impact many vendors across regions
- Patching is fragmented and hard to coordinate



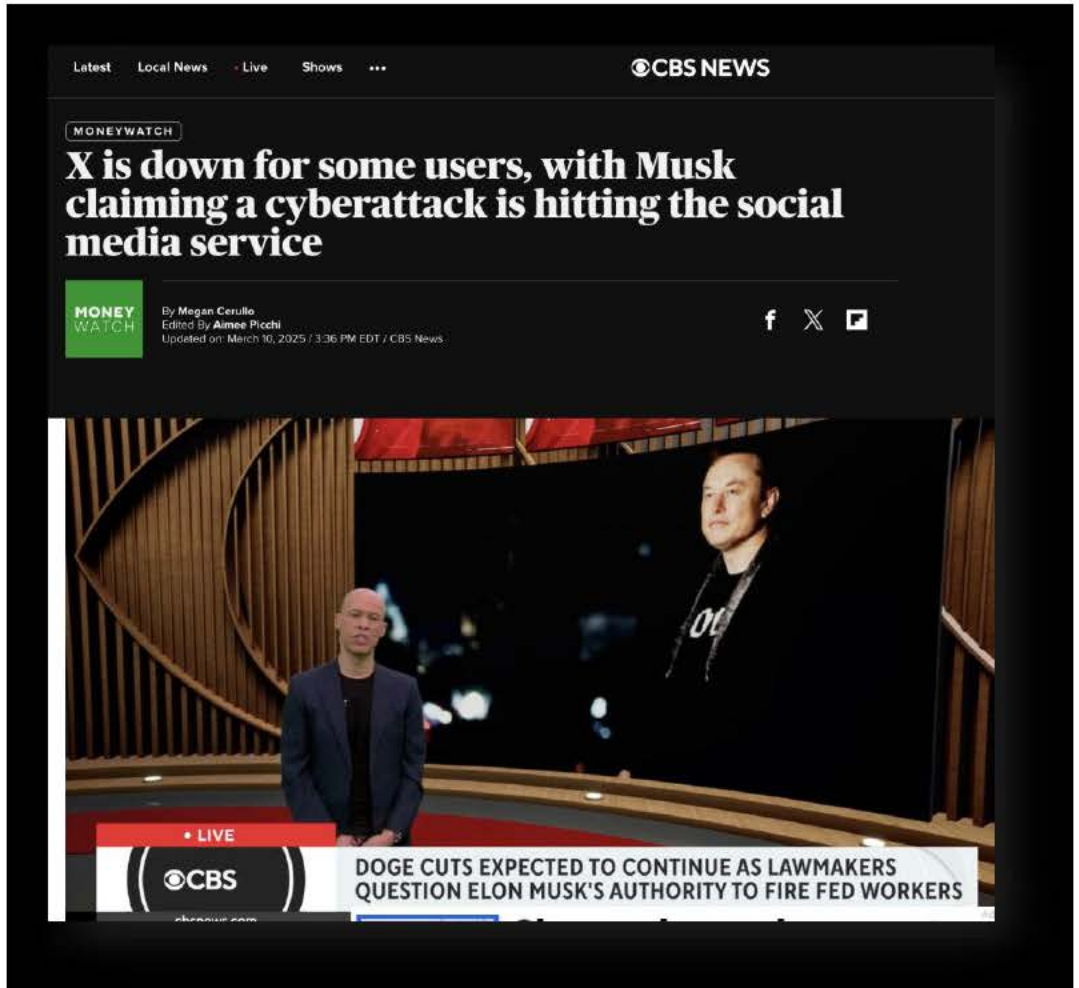
Challenge #3： Analyzing the Evolution and Operation of a Bot Family

Why We Focused on RappeBot

- **Exclusive Targeting Strategy**
  - Only RapperBot exploits ITX/CTRing DVRs
- **Detection-Avoidant Behavior**
  - Avoid spraying payloads; target confirmed devices only
- **Variant-Based Functional Evolution**
  - Multiple variants for different targets and infection vector
- **Infection Trends and Abuse**
  - Persistent infections in Japan, with active use in DDoS campaigns

RapperBot in a Confirmed Attack

- **RapperBot was used in the March 10 DDoS attack on X, confirmed through our C2 monitoring**



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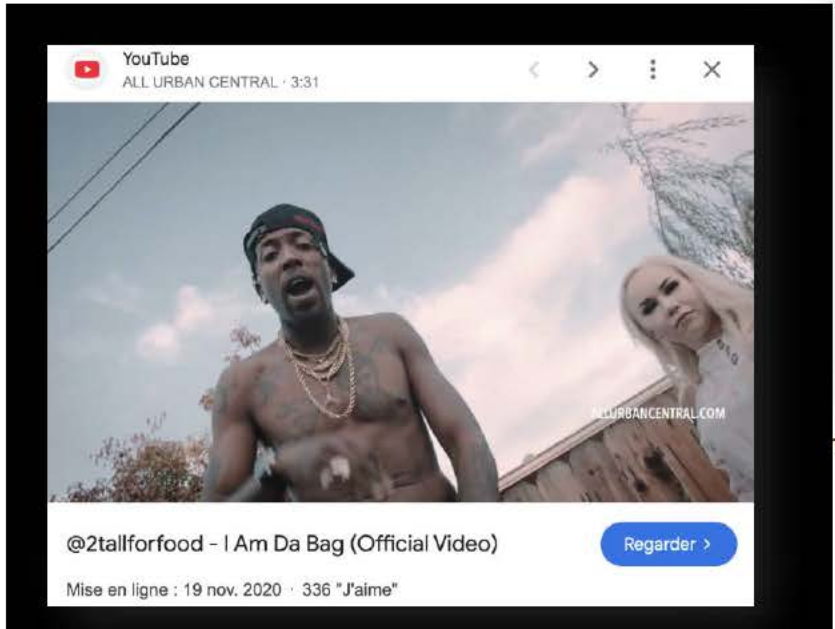
Emergence of RapperBot

- Discovered in June 2022 by CNCERT
- Named derived from a **YouTube video of rappers**
- Based on Mirai source code
- Targets Linux-based IoT devices
- Propagates via SSH brute-force (not Telnet)
- C2 infrastructure overlaps with Fbot, linked to Rippr group



原创 | 预警：新僵尸网络家族正在利用IoT设备构建攻击网络

来源：网络安全应急技术国家工程实验室　时间：2022-07-05　阅读次数：1

作者 | 本报告由CNCERT物联网威胁研究团队与绿盟科技伏影实验室共同发布

一. 概述

1.1 新僵尸网络家族预警

2022年6月22日，我们监测发现一个新的僵尸网络正在利用IoT设备的弱口令构建僵尸网络。根据僵尸网络恶意代码中的url、youtube视频内容以及通信命令特征，我们将这个僵尸网络家族分别命名为RapperBot。截止目前，已发现失陷主机已经超过5000台，但是未监测到攻击者下发任何攻击指令，这说明该僵尸网络仍在持续构建中。

此外，我们注意到RapperBot僵尸网络连接过C2地址2.58.149.116，曾经有一个历史解析域名：dota.lwishiwashappy.eu，该域名在Rippr团伙运营的僵尸网络Fbot中也曾使用过。根据相关威胁情报，Rippr团伙运营着Fbot在内多个僵尸网络家族，该团伙拥有极其丰富的0DAY/NDAY武器库，且参与过针对"北京健康宝攻击事件"以及针对"乌克兰DDoS攻击"在内的多起攻击活动。

以上迹象表明，由RapperBot家族构建的僵尸网络已经成为一个重要的潜在威胁源。

1.2 IoT僵尸网络总体情况

根据CNCERT的监控数据，最近一个月内共监测发现了超过3000个活跃的IoT类僵尸网络C2控制地址，其中有161个级度活跃的C&C地址，控制了大量的失陷主机。其中控制数超过5000台控制主机的C&C占6%，控制数在1000至5000台主机的C&C占21%少于1000台主机的C&C占73%。

https://www.ics-cert.org.cn/portal/page/112/1208496c5e164aceb8dadd08ab993dd2.html

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RapperBot – 3-Year Attack Campaign Details

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RapperBot and Mirai: Similarities and Differences

Identical to Mirai

```
void attack_udp_generic(uint8_t targs_len,attack_target *targs,uint8_t opts_len,attack_option *opts)
```

1. Attack function arguments are identical to Mirai

```
#define ATK_OPT_PAYLOAD_SIZE    0   // What should the size of the packet data be?
#define ATK_OPT_PAYLOAD_RAND    1   // Should we randomize the packet data contents?
#define ATK_OPT_IP_TOS          2   // tos field in IP header
#define ATK_OPT_IP_IDENT        3   // ident field in IP header
#define ATK_OPT_IP_TTL          4   // ttl field in IP header
#define ATK_OPT_IP_DF           5   // Dont-Fragment bit set
#define ATK_OPT_SPORT           6   // Should we force a source port? (0 = random)
#define ATK_OPT_DPORT           7   // Should we force a dest port? (0 = random)
```

2. Same option structure as Mirai

- Option 0 = packet data size
- Option 1 = data content
- Option 7 = destination port number

Modified from Mirai

Obfuscated string struct with per-string keys

```
struct table_value {
    char *val;
    uint16_t val_len;
    BOOL locked;
};
```

```
struct table_value {
    uint32_t key;
    char *val;
    uint16_t val_len;
    BOOL locked;
};
```

Password list struct nested by banner

```
struct scanner_auth {
    char *username;
    char *password;
    uint16_t weight_min;
    uint16_t weight_max;
    uint8_t username_len;
    uint8_t password_len;
};
```

```
struct scanner_auth {
    bool_t regular_expression;
    char *banner;
    struct {
        char *username;
        char *password;
    } credentials[100];
    uint32_t entry_count;
};
```

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Functional Comparison: RapperBot vs Original Mirai

Function	**RapperBot (ver.2025.02.recon)**	Original Mirai
Scan Target Ports	**36 ports, scan result reporting**	2 ports, scan result reporting
String Obfuscation Method	Per-string single-byte XOR keys	Single global XOR key
Collected Host Data	**Global IP Address*, Hostname, Current directory, Network interface name, MAC address, etc**	N/A
C2 Resolution Method	**TXT record via OpenNIC DNS**	Standard DNS (A record)
C2 Protocol	Structured, XOR-encoded payload	Fixed-format binary, unencrypted
Supported DDoS Methods	11	10

*: RapperBot uses **STUN/3478** to obtain a global ip address

RapperBot Variants by Scanning Behavior

Variant Type	Scanning Behavior	Infection Method	Scan Ports	ID/Password Combos	Target Devices
No-scan	None	external loader	N/A	None	• **ITX DVR** • **CTRing DVR**
Telnet Scanner	Brute-force	Malware installed after successful login	32 (1 random port)	895	• **Huawei HG659 Router** • **Nokia G-010S-A GPON SFP**
SSH Scanner	Brute-force		5	508	• **Hikvison DVR** • **WiMAX Router**
Recon Scanner	Scans for device types only	Sends device info to loader for exploitation	36	N/A	• **Rifatron DVR** • **Shenzhen TVT DVR NVMS-9000**

RapperBot Exploit Arsenal

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Tracking DVRs via Predictable DDNS Hostname

- If the DDNS hostname is derived from the MAC address, attackers can brute-force valid hostnames and track active devices

If your DVR's host name

is Y559469, Your DVR's remote address

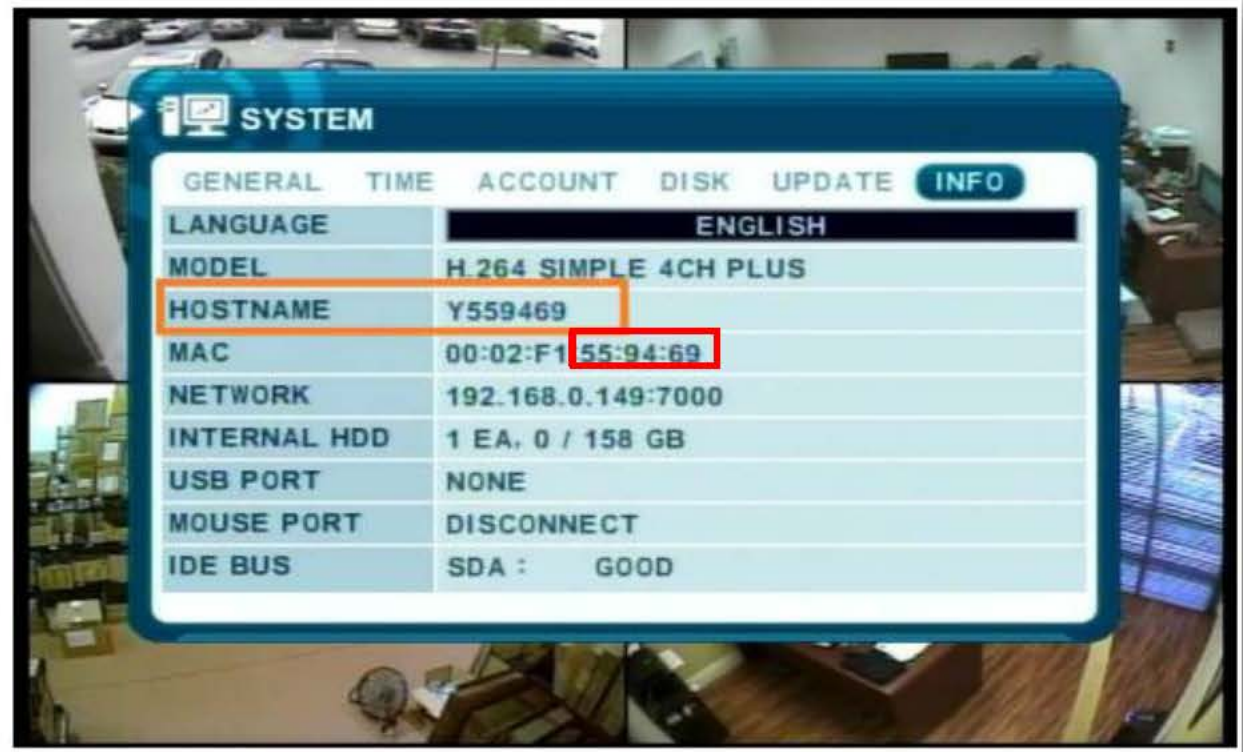
address is **http://Y559469.dvrhost.com:7000**

MAC address **DDNS domain**

BE SURE TO SUBSTITUTE YOUR HOSTNAME FOR THE ADDRESS USED IN THIS EXAMPLE

The remote address will be used in place of **"Host/IP"** in your mobile app and /or web browser.

Port 7000 is the **DEFAULT** port for the iDVR-E series, if you have changed the port to ***any other number***, please use that instead



DVR manual (https://videos.cctvcamerapros.com/pdf/surveillance-dvrs/iDVR/iDVR-DDNS-Setup.pdf)

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C2 Resolution via OpenNIC and TXT Records

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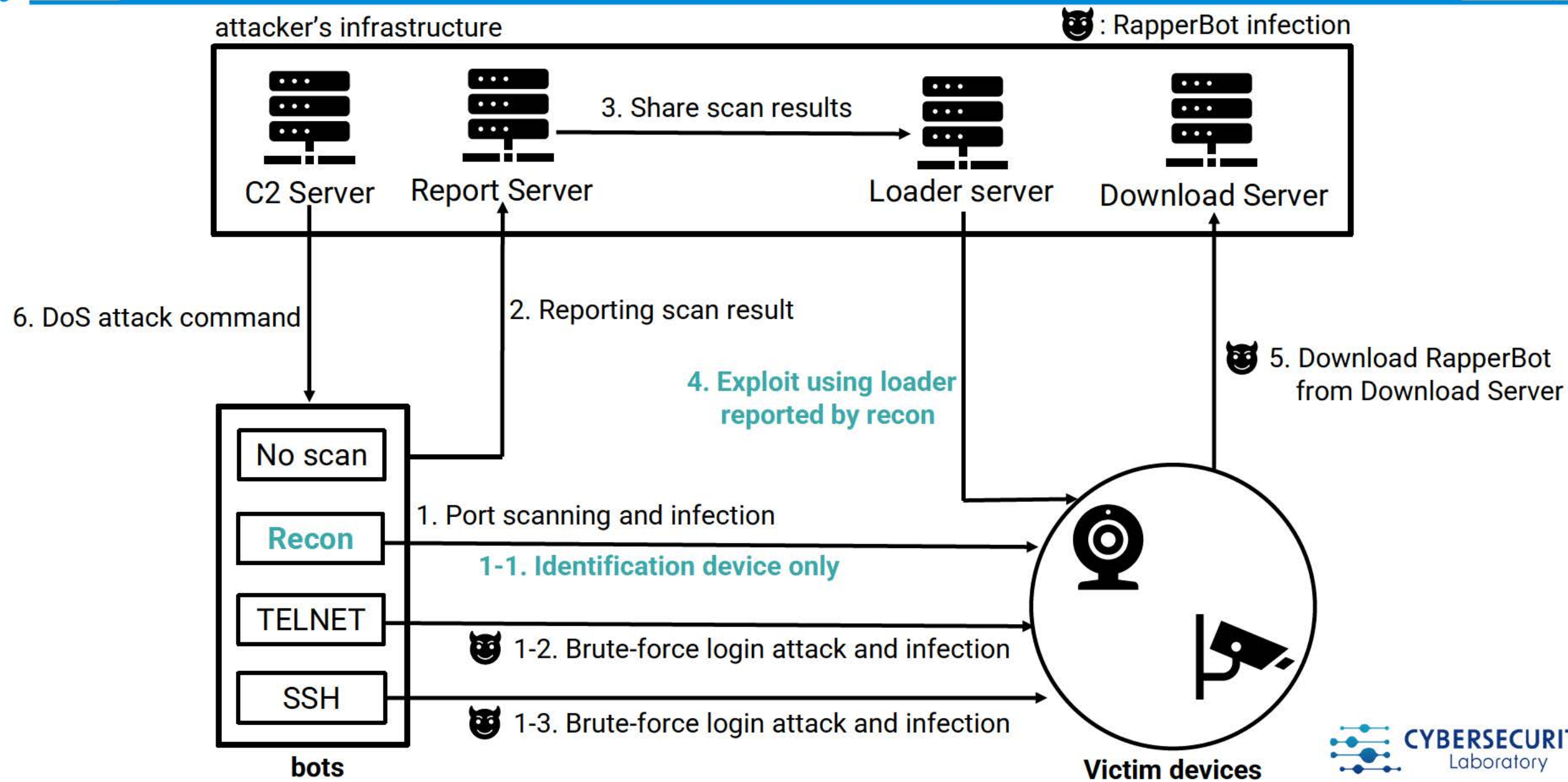
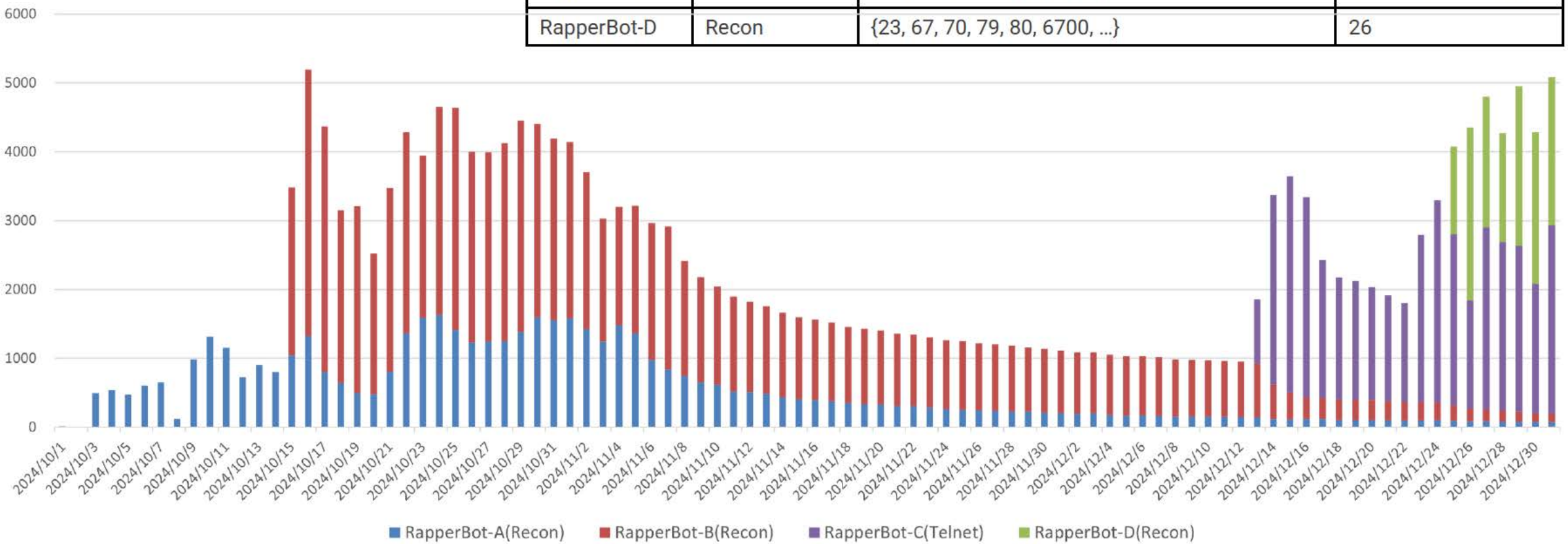
RapperBot infection strategy



RapperBot Botnet: Infection Timeline

Lable	Variant Type	Scan Ports	Ports
RapperBot-A	Recon	{67, 80, 6700, 8291, 501000, ...}	14
RapperBot-B	Recon	{23, 80, 2051, 34567, 345678, ...}	16
RapperBot-C	Telnet	{23, 26, 254, 523, 1023, ...}	31 + 1 random port
RapperBot-D	Recon	{23, 67, 70, 79, 80, 6700, ...}	26



NOTE: Hosts infected with the No-scan variant are not reflected in this count.

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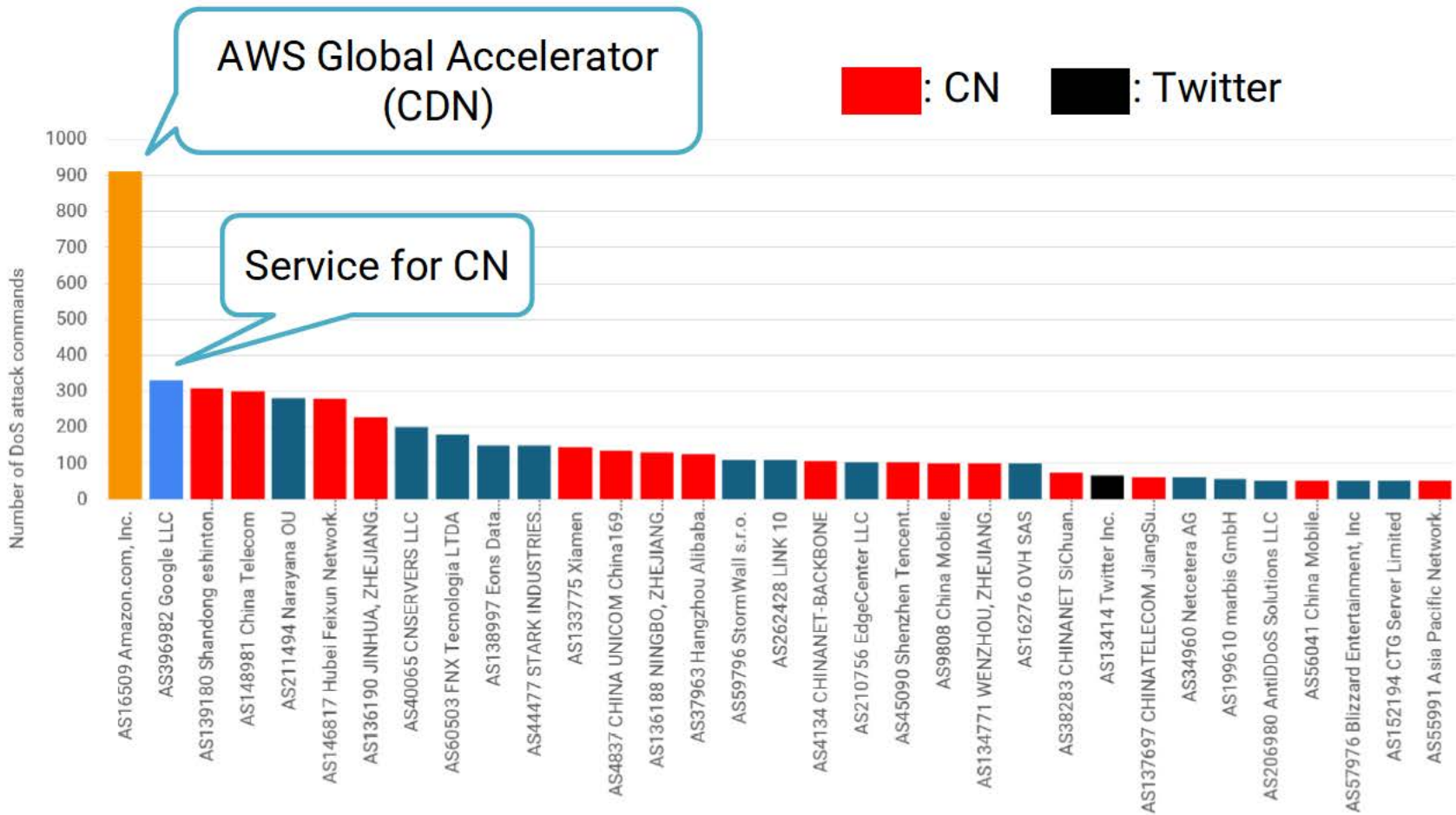
Target Distribution of DDoS Commands (Mar-Apr 2025)



- **Majority of targets were Chinese ASNs**
- **Includes AWS Global Accelerator (Amazon ASN)**
- **GCP infrastructure serving China (confirmed via TLS certs)**
- **Targets run diverse services with no consistent pattern**
  - ✓ e.g., CDN, web, mail, SSH-only

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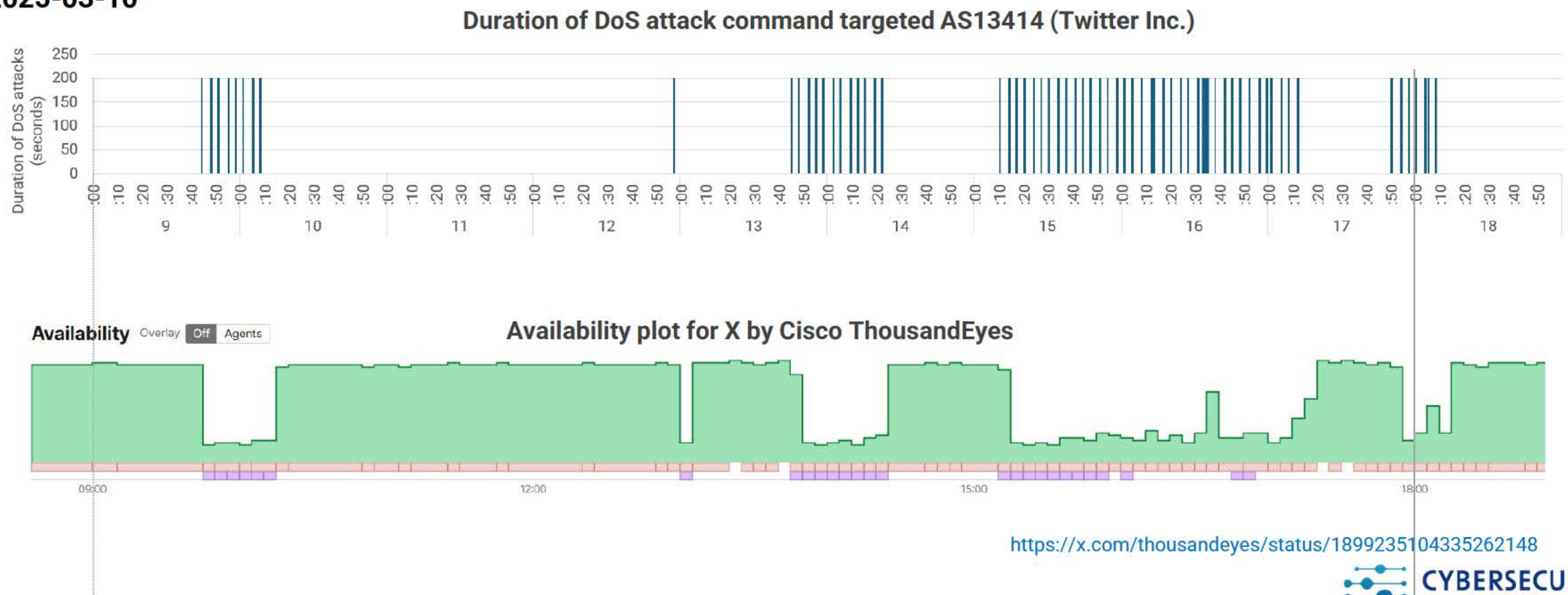
Correlating RapperBot C2 Commands with X Downtime

- RapperBot C2 attack timing exactly aligns with observed outage in ThousandEyes

2025-03-10



https://x.com/thousandeyes/status/1899235104335262148

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Conclusion

Vulnerable DVR ecosystem	Vulnerability impacts 28+ vendors
	No fix for distributors, end users
RapperBot's Changing TTPs	C2, recon targets, new zero-days
Toward Mitigation	**Track and analyze RapperBot's new target**
	Global coordinator to reach distributors

Thank you!

Questions?

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NICTER Analysis Team
@nicter_jp

REFERENCES

Partial IOCs

- Download servers :
  - 95[.]214[.]27[.]202
  - 194[.]180[.]48[.]105
  - zyb[.]ac
  - rppr[.]cc
  - vzxv[.]me
  - 4v[.]wtf
  - o0s[.]cc
  - 6sz[.]ru
- Command and Control servers:
  - ozxxb[.]eu
  - h[.]vzxv[.]me
  - qiap[.]cc
  - helloworld[.]libre
  - dbovmix[.]xyz txt
  - tvoewev[.]link txt
  - keipyeb[.]africa txt
  - dfubdf[.]click txt
  - 194[.]180[.]48[.]105
  - 193[.]32[.]162[.]174
  - nexuszeta[.]lib txt
  - iranistrash[.]libre txt
  - iguessimhere[.]libre txt
  - churchofhollywood[.]libre txt
  - 167[.]99[.]0.202

OpenNIC

- Scan report servers:
  - 158[.]255[.]213[.]225
  - 193[.]31[.]6[.]57
  - 80[.]66[.]77[.]235
  - pool[.]rentcheapcars[.]sbs
  - pool3[.]rentcheapcars[.]sbs
- Monero wallets:
  - 48SFiWgbAaFf75KsRSEEr4i DcxrevFzVmhgfb6Qudss52J K8cCR8bwmUxNBPN2Vmq DTucJL3eabiZc5XRYVGkbh 6BH58Ytk
- Email address:
  - horse@riseup[.]net