Say hello to Baldr, a new stealer on the market

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By William Tsing, Vasilios Hioureas, and Jérôme Segura

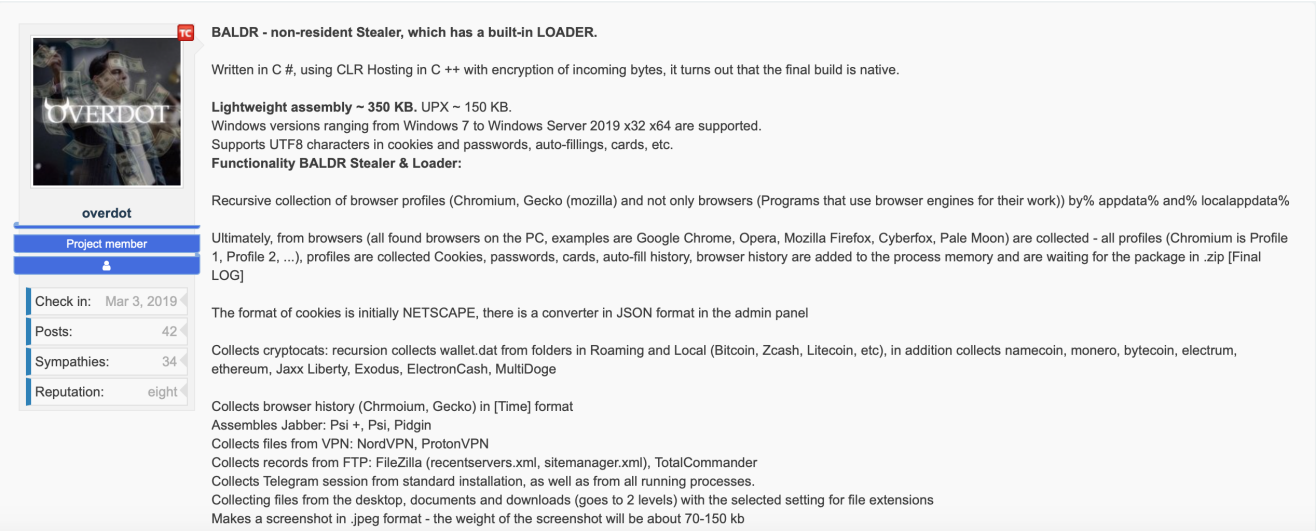
Over the past few months, we have noticed increased activity and development of new stealers. Unlike many banking Trojans that wait for the victim to log into their bank's website, stealers typically operate in grab-and-go mode. This means that upon infection, the malware will collect all the data it needs and exfiltrate it right away. Because such stealers are often non-resident (meaning they have no persistence mechanism) unless they are detected at the time of the attack, victims will be none-the-wiser that they have been compromised.

This type of malware is popular among criminals and covers a greater surface than more specialized bankers. On top of capturing browser history, stored passwords, and cookies, stealers will also look for files that may contain valuable data.

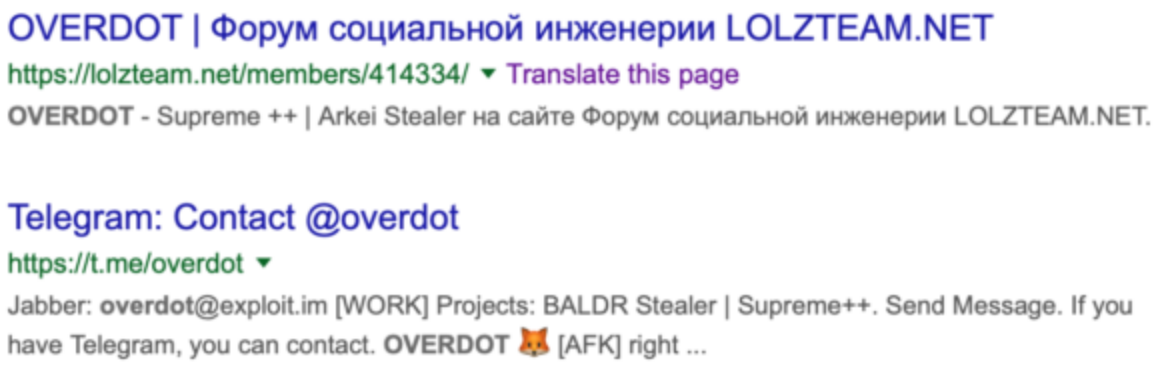
In this blog post, we will review the Baldr stealer which first appeared in underground forums in January 2019, and was later seen in the wild by Microsoft in February.

Baldr on the market

Baldr is likely the work of three threat actors: Agressor for distribution, Overdot for sales and promotion, and LordOdin for development. Appearing first in January, Baldr quickly generated many positive reviews on most of the popular clearnet Russian hacking forums.

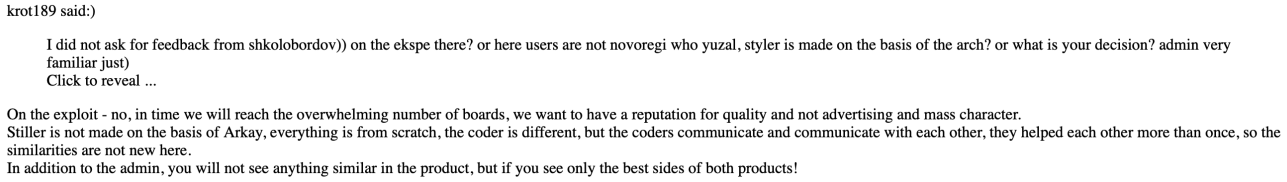


Previously associated with the Arkei stealer (seen below), Overdot posts a majority of advertisements across multiple message boards, provides customer service via Jabber, and addresses buyer complaints in the reputational system used by several boards.

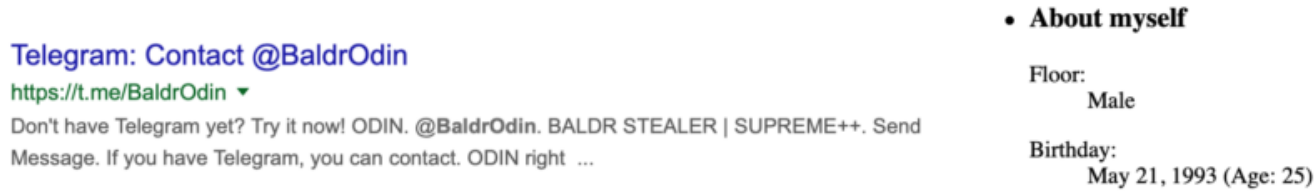


Of interest is a forums post referencing Overdot's previous work with Arkei, where he claims that the developers of both Baldr and Arkei are in contact and collaborate on occasion.

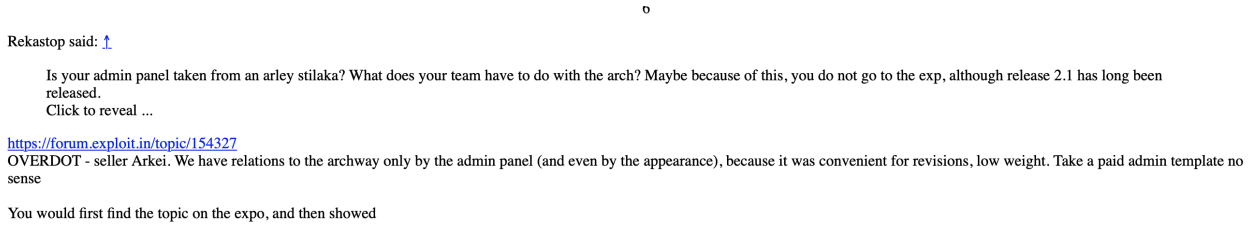
Unlike most products posted on clearnet boards, Baldr has a reputation for reliability, and it also offers relatively good communication with the team behind it.



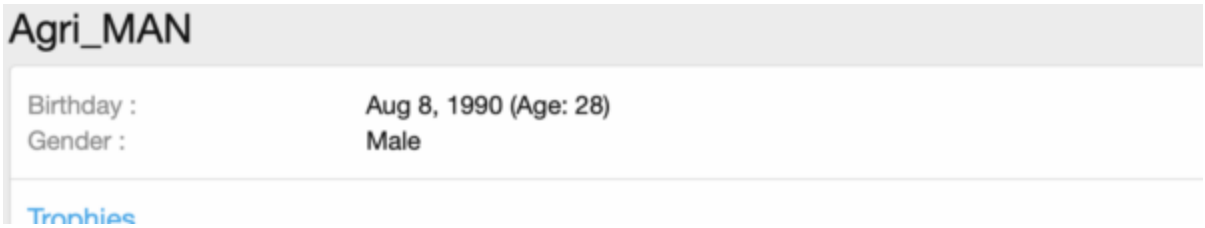
LordOdin, also known as BaldrOdin, has a significantly lower profile in conjunction with Baldr, but will monitor and like posts surrounding it.

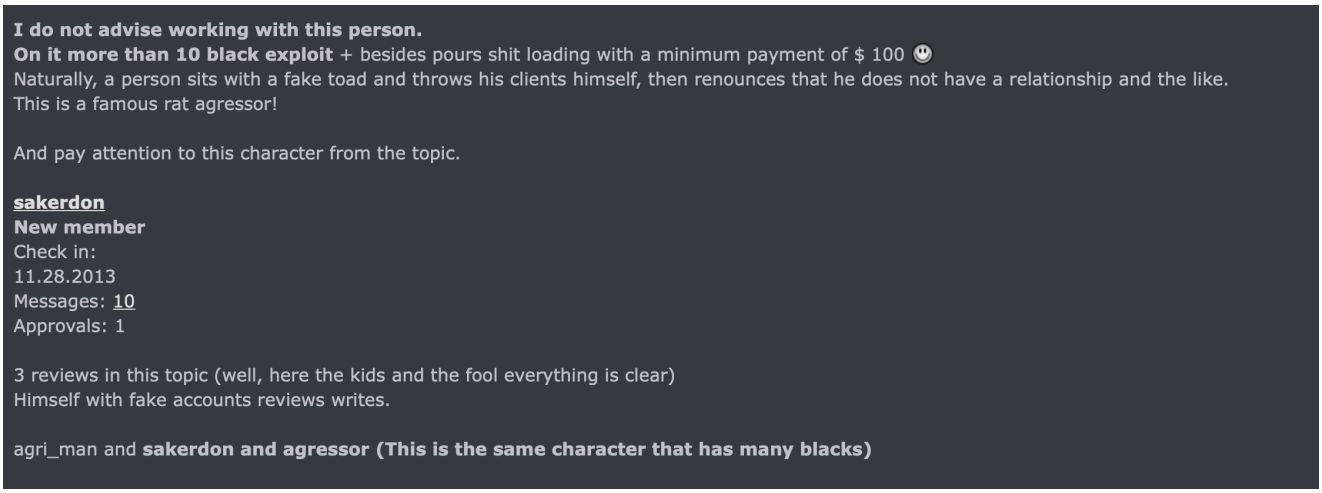


He primarily posts to differentiate Baldr from competitor products like Azorult, and vouches that Baldr is not simply a reskin of Arkei:



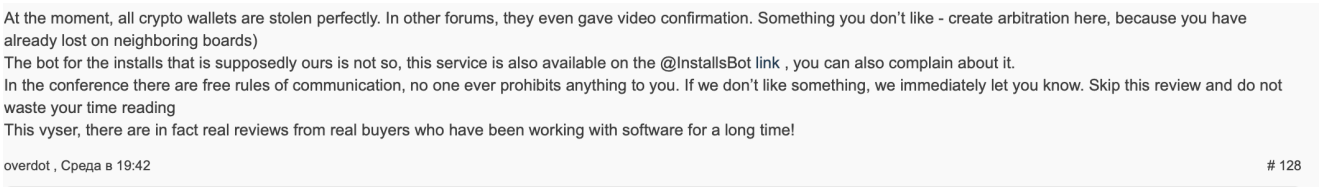
Agressor/Agri_MAN is the final player appearing in Baldr's distribution:





Agri_MAN has a history of selling traffic on Russian hacking forums dating back roughly to 2011. In contrast to LordOdin and Overdot, he has a more checkered reputation, showing up on a blacklist for chargebacks, as well as getting called out for using sock puppet accounts to generate good reviews.

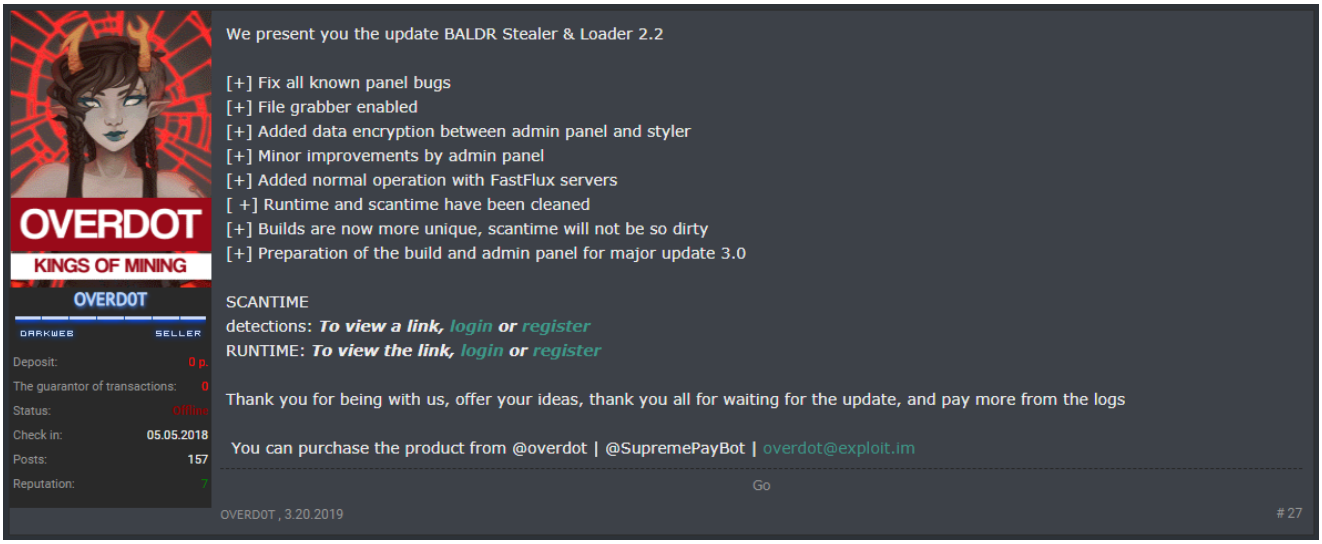
Using the alternate account Agressor, he currently maintains an automated shop to generate Baldr builds at *service-shop[.]ml*. Interestingly, Overdot makes reference to an automated installation bot that is not connected to them, and is generating complaints from customers:



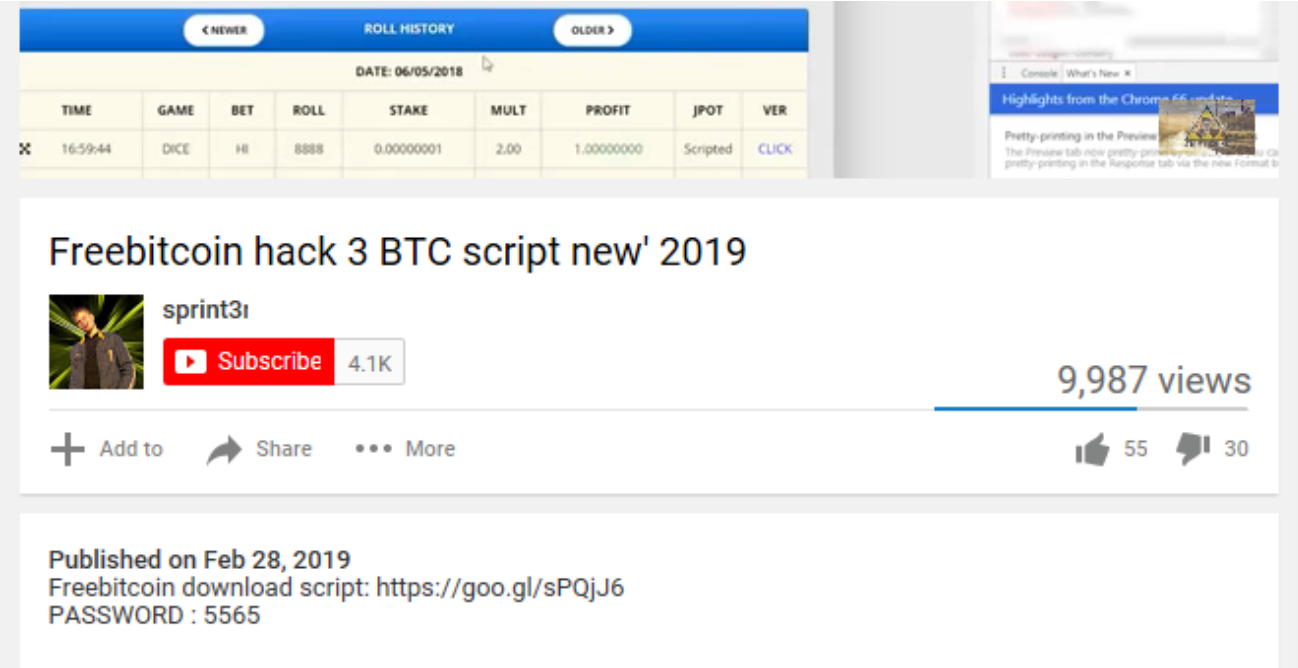
This may indicate Agressor is an affiliate and not directly associated with Baldr development. At presstime, Overdot and LordOdin appear to be the primary threat actors managing Baldr.

Distribution

In our analysis of Baldr, we collected a few different versions, indicating that the malware has short development cycles. The latest version analyzed for this post is version 2.2, announced March 20:



We captured Baldr via different distribution chains. One of the primary vectors is the use of Trojanized applications disguised as cracks or hack tools. For example, we saw a video posted to YouTube offering a program to generate free Bitcoins, but it was in fact the Baldr stealer in disguise.



We also caught Baldr via a drive-by campaign involving the Fallout exploit kit:

Host	URL	Body	Comments
notmyshop4you.world	/JeHHfq/oxyhalide_Stomate_Rasenna/bDEK?C...	5,406	Fallout EK
notmyshop4you.world	/Rxki/nighties_finagles/7270/cmaAJ.shtml	12,144	Fallout EK
raw.githubusercontent.com	/ajblane/CVE-2018-8174/master/index.html	11,757	CVE-2018-8174
notmyshop4you.world	/9765/3637/17430-prunably?6te6Q=pulpily&a...	4,677	Fallout EK
notmyshop4you.world	/7640-Movings/TsYy/Catspaw_8361.jsp?zgtv=...	568,324	Fallout EK
[redacted]	/baldr/gate.php?hwid=[redacted]...	0	Baldr C2

Technical analysis (Baldr 2.2)

Baldr's high level functionality is relatively straight forward, providing a small set of malicious abilities in the version of this analysis. There is nothing ground breaking as far as what it's trying to do on the user's computer, however, where this threat differentiates itself is in its extremely complicated implementation of that logic.

Typically, it is quite apparent when a malware is thrown together for a quick buck vs. when it is skillfully crafted for a long-running campaign. Baldr sits firmly in the latter category—it is not the work of a script kiddie. Whether we are talking about its packer usage, payload code structure, or even its backend C2 and distribution, it's clear Baldr's authors spent a lot of time developing this particular threat.

Functionality overview

Baldr's main functionality can be broken down into five steps, which are completed in chronological order.

Step 1: User profiling

Baldr starts off by gathering a list of user profiling data. Everything from the user account name to disk space and OS type is enumerated for exfiltration.

Step 2: Sensitive data exfiltration

Next, Baldr begins cycling through all files and folders within key locations of the victim computer. Specifically, it looks in the user *AppData* and *temp* folders for information related to sensitive data. Below is a list of key locations and application data it searches:

```
AppData\Local\Google\Chrome\User Data\Default
AppData\Local\Google\Chrome\User Data\Default\Login Data
AppData\Local\Google\Chrome\User Data\Default\Cookies
AppData\Local\Google\Chrome\User Data\Default\Web Data
AppData\Local\Google\Chrome\User Data\Default\History
AppData\Roaming\Exodus\exodus.wallet
AppData\Roaming\Ethereum\keystore
AppData\Local\ProtonVPN
Wallets\Jaxx
Liberty\
NordVPN\
Telegram
Jabber
TotalCommander
Ghisler
```

Many of these data files range from simple sqlite databases to other types of custom formats. The authors have a detailed knowledge of these target formats, as only the key data from these files is extracted and loaded into a series of arrays. After all the targeted data has been parsed and prepared, the malware continues onto its next functionality set.

Step 3: ShotGun file grabbing

DOC, DOCX, LOG, and TXT files are the targets in this stage. Baldr begins in the Documents and Desktop directories and recursively iterates all subdirectories. When it comes across a file with any of the above extensions, it simply grabs the entire file's contents.

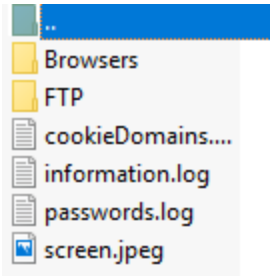
Step 4: ScreenCap

In this last data-gathering step, Baldr gives the controller the option of grabbing a screenshot of the user's computer.

Step 5: Network exfiltration

After all of this data has been loaded into organized and categorized arrays/lists, Baldr flattens the arrays and prepares them for sending through the network.

One interesting note is that there is no attempt to make the data transfer more inconspicuous. In our analysis machine, we purposely provided an extreme number of files for Baldr to grab, wondering if the malware would slowly exfiltrate this large amount of data, or if it would just blast it back to the C2.



The result was one large and obvious network transfer. The malware does not have built-in functionality to remain resident on the victim's machine. It has already harvested the data it desires and does not care to re-infect the same machine. In addition, there is no spreading mechanism in the code, so in a corporate environment, each employee would need to be manually targeted with a unique attempt.

Packer code level analysis

We will begin with the payload obfuscation and packer usage. This version of Baldr starts off as an AutoIt script built into an exe. Using a freely available AIT decompiler, we got to the first stage of the packer below.

```
FUNC AHLBFEOCCYDEOXM ( $STRING , $SHIFTS_STRING )
LOCAL $S = STRINGTOASCIIARRAY ( $STRING )
LOCAL $TPR = $S
LOCAL $I = STRINGSPLIT ( $SHIFTS_STRING , CHR ( 44 ) )
FOR $P = 0 TO UBOUND ( $S ) + -1
$S [ $I [ $P + 1 ] ] = $TPR [ $P ]
NEXT
RETURN STRINGFROMASCIIARRAY ( $S )
ENDFUNC
FUNC AXAAWRPXFYPPXPE ( $SSTRING , $SSHIFT )
RETURN STRINGMID ( $SSTRING , STRINGLEN ( $SSTRING ) - $SSHIFT + 1 ) & STRINGMID ( $SSTRING , 1 , STRINGLEN ( $SSTRING ) - $SSHIFT )
ENDFUNC
$NXRSGVYOFB = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "ctxueeE" , "5,0,3,6,1,4,2" ) , 5 ) )
$JWNEAVXYLN = $NXRSGVYOFB ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "igonSnraByitrT" , "11,13,7,2,8,12,4,3,0,5,1,9,10,6" ) , 0 ) )
$LHJNSZKNGSHXPQMKFMNGYPAKZFBSUAWIIKODNRINLARPXDCWLNQXLRAVGYO = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "epm@TDir" , "5,7,6,3,4,0,1,2" ) , 5 ) )
$KNACMNIQAXORRWHIGJZKXFAMVNYHFBRMYXWKZX = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "tSmsrD@eiy" , "2,9,4,1,7,5,8,3,6,0" ) , 2 ) )
$LGNRNWDEIHUYAWTQZYTBGVFQDVEGXZALYPZOPNCFDZQEYQX = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "EHDISW_@" , "1,6,0,7,3,4,5,2" ) , 6 ) )
$NFHPTENUJKTRJSTIKAZBQOFKVCEPBHDYLTPXEEDZAFP = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "trai@DtSrpu" , "0,5,9,4,6,3,8,7,10,2,1" ) , 5 ) )
$SCLYCALXJTTJBESYMOVWUEXEPQNFPUZPVGVIFUECDLTWEOAYZEYWKGFOFHI = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "ri@SciDrpt" , "8,3,9,0,1,7,6,2,4,5" ) , 1 ) )
$JQPEOIHSDPGVXLDHMCNSQYTFLUZGOKRTGCOICPYXBDSDLLFD = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "O@eSsVinro" , "3,2,6,4,8,5,9,1,7,0" ) , 8 ) )
$WQJCZGOTBMUMXRXOIOAEFBSYZRTMGJVWTSGDPCZPNLU = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "@remieHDvo" , "4,0,8,7,1,3,5,9,2,6" ) , 6 ) )
$MLDDWNXBOVABUSNNNWHLXVCBEPYDZCAODCUYEYWCFWCECMVMXQGDU = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "CR@" , "1,2,0" ) , 0 ) )
$JOZKOYOJWBPLELWRCQYXWPOXOUMCFTECODWAQAWGKICSPDXRZDOPEKDUACW = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "pe@mCocS" , "4,5,7,2,0,1,6,3" ) , 1 ) )
$UIISLHOCDWNPICCWPYAKLFWDGPPLLEYRZTFOCDWVRGCI = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "tAIItPo@Du" , "3,8,2,5,0,4,1,7,6,9" ) , 3 ) )
$DPULBRGMRZXSLCGGAXKVHCFJGFNZWBNLOMKH = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "@toxtAEIue" , "6,2,0,4,9,7,3,1,8,5" ) , 4 ) )
$TJCNDVKEOTZSNWHGKZZXZNAWIQWOCAHL = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "rpa@DpiaADt" , "5,8,0,6,10,9,4,2,7,3,1" ) , 5 ) )
$HIJZAHFWZXUARZJVMOWKFDSFLUZVBUVBROMFZBJIRGLFIENPVCWWNQSEP = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "sEinstxiW" , "1,5,3,4,8,0,6,7,2" ) , 7 ) )
$GTDTXENYMHIOVJRYOAYEFLSMUOIBKQXCL = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "UnuoBd" , "1,5,4,3,2,0" ) , 5 ) )
$ZKGDATQHXDABOICSQSBRJMCXPFKZIIDBXIWJGWD = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "getrSlnciepaR" , "12,6,8,9,7,3,11,5,10,1,2,4,0" ) , 6 ) )
$EEWFRWOZQGLSUWZVFSTHCQVUMAEMHGTJVF = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "teLgnSinr" , "2,8,7,6,5,1,4,0,3" ) , 8 ) )
$LUFNRPYUSKRRVDRSOHUFBHPBQLYBGTTKFCJVTTC = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "SIntrSitnrg" , "3,1,2,4,8,6,9,7,10,5,0" ) , 5 ) )
$RXUWSXPTFSWROMNWMVFYTRVAMQPEVVFFBQSUMVHKUOZGTRKOXTXNUCOM = EXECUTE ( AXAAWRPXFYPPXPE ( AHLBFEOCCYDEOXM ( "Seeln" , "4,2,1,0,3" ) , 1 ) )
```

As you can see, this code is heavily obfuscated. The first two functions are the main workhorse of that obfuscation. What is going on here is simply reordering of the provided string, according to the indexes passed in as the second parameter. This, however, does not pose much of a problem as we can easily extract the strings generated by simply modifying this script to *ConsoleWrite* out the deobfuscated strings before returning:

```
FUNC SECOND_FUNC ( $SSTRING , $SSHIFT )
    ConsoleWrite (STRINGMID ( $SSTRING , STRINGLEN ( $SSTRING ) - $SSHIFT + 1 ) & STRINGMID ( $SSTRING , 1 , STRINGLEN ( $SSTRING ) - $SSHIFT ) & @CRLF)
    RETURN STRINGMID ( $SSTRING , STRINGLEN ( $SSTRING ) - $SSHIFT + 1 ) & STRINGMID ( $SSTRING , 1 , STRINGLEN ( $SSTRING ) - $SSHIFT )
ENDFUNC
```

The resulting strings extracted are below:

```
Execute
BinaryToString
@TempDir
@SystemDir
@SW_HIDE
@StartupDir
@ScriptDir
@OSVersion
@HomeDrive
@CR
@ComSpec
@AutoItPID
@AutoItExe
@AppDataDir
WinExists
UBound
StringReplace
StringLen
StringInStr
Sleep
ShellExecute
RegWrite
Random
ProcessExists
ProcessClose
IsAdmin
FileWrite
FileSetAttrib
FileRead
FileOpen
FileExists
FileDelete
FileClose
DriveGetDrive
DllStructSetData
DllStructGet
DllStructGetData
DllStructCreate
DllCallAddress
DllCall
DirCreate
BinaryLen
TrayIconHide
:Zone.Identifier
kernel32.dll
handle
CreateMutexW
struct*
FindResourceW
kernel32.dll
dword
SizeofResource
kernel32.dll
LoadResource
kernel32.dll
```

```
LockResource
byte[
VirtualAlloc
byte shellcode [
```

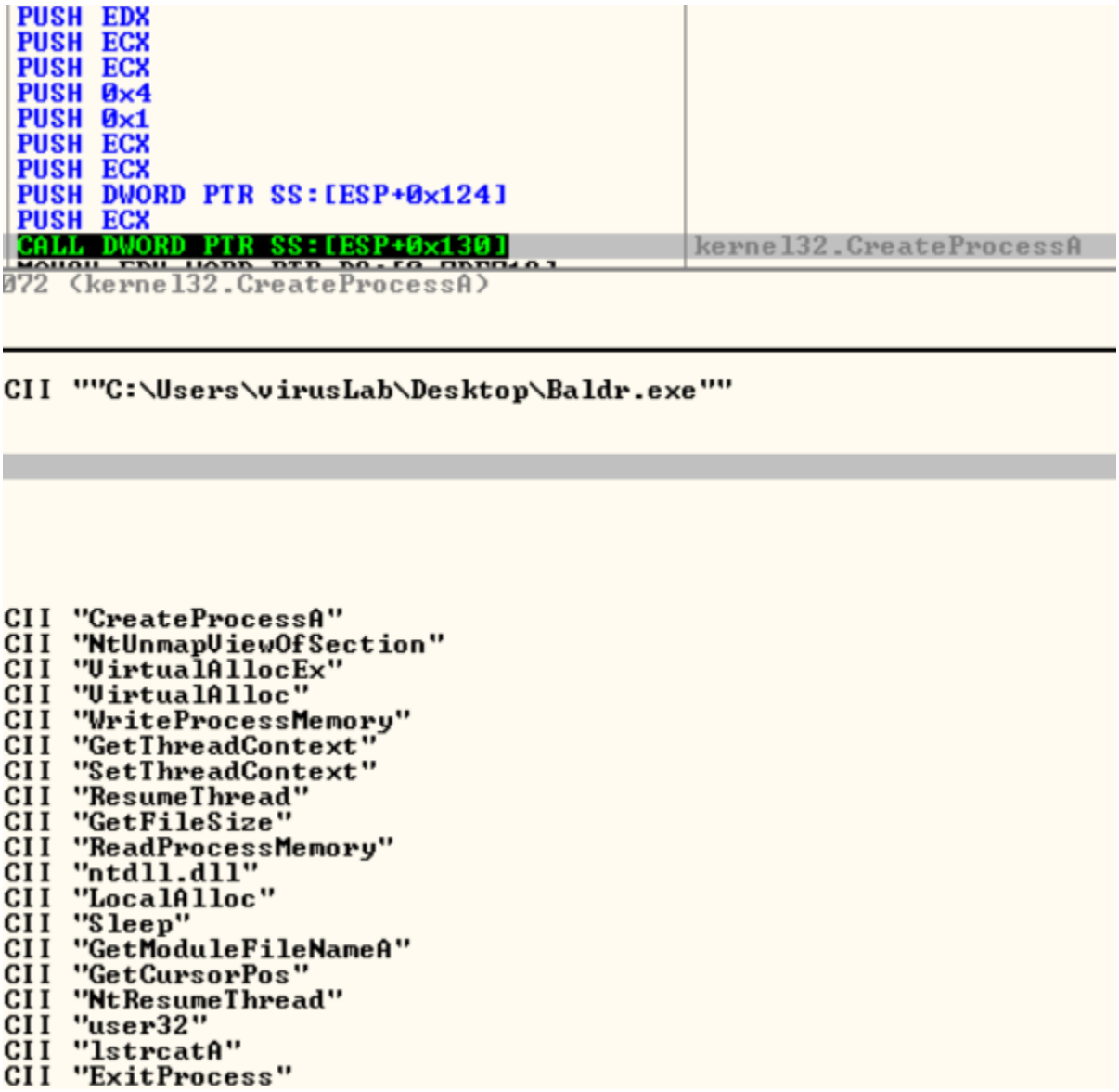
In addition to these obvious function calls, we also have a number of binary blobs which get deobfuscated. We have included only a limited set of these strings as to not overload this analysis with long sets of data.

We can see that it is pulling and decrypting a resource DLL from within the main executable, which will be loaded into memory. This makes sense after analyzing a previous version of Baldr that did not use AIT as its first stage. The prior versions of Baldr required a secondary file named *Dulciana.* So, instead of using AIT, the previous versions used this file containing the encrypted bytes of the same DLL we see here:

Dulciana **OVERWRITE MODE**

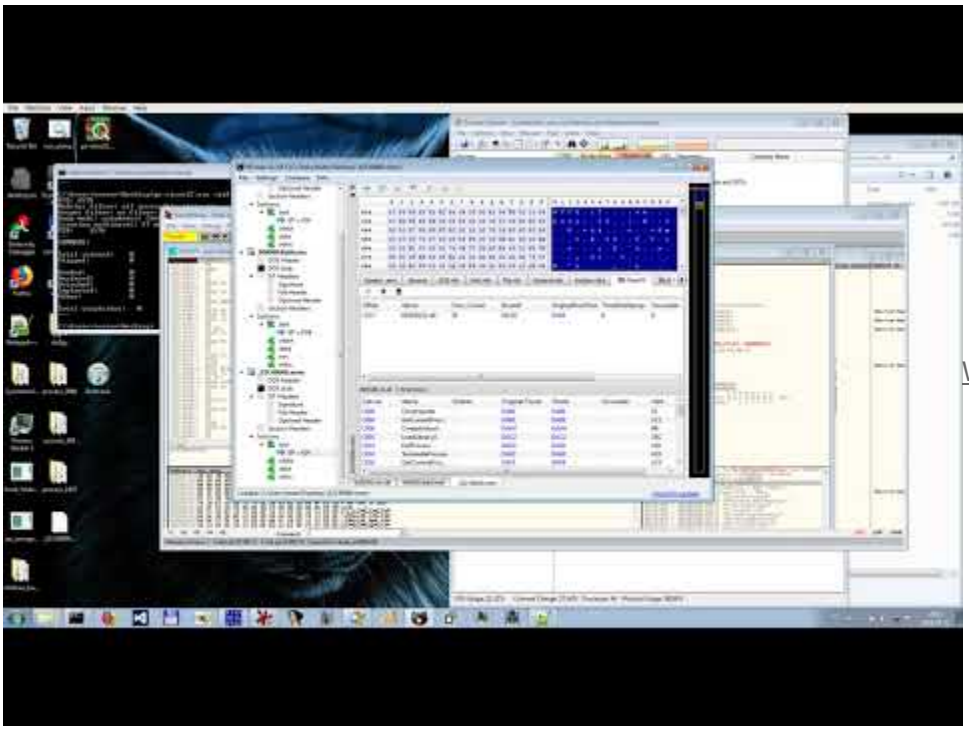
040BC88B 63039AB8 95E1B0E4 FE41A495 61D3F99C	ŸB õ K=–45 @õ»Æß≠/ußBÀï° »ãc öˆ∏ï·∞%˛A§ïa”˘ú
983455BD D2DDADBE EB45D00F 64843F66 CB0B50C7	ô7˜úœB zã±àµØ7ÎŸõÉ# a ò4UΩ“›≠œÎE– dÑ?fÀ P«
DB5F8C0D 67A5EA57 CA46F39E 0A270D1C 6373A2E3	2©Yi≈ `z Z’fi2Ãπ \!ëÜð(D@€_å g●ÍW FÛû ' cs¢„
4693D77A 35FA00D4 B91D00E4 26A210E6 1EC9984B	˙ò4°˛™ CflMO% {U Ì? JÅ„●#Fi◊z5˙ ‘π %&¢ Ê …òK
63CED8CC 13521B48 CD7E76D1 AD338A5A 3BEE05D5	€%5`˚°YÁßCÕe<L- úisbÿl cŒÿÃ R HÕ~v–≠3äZ;Ó ’
39B0CC6C 5ECCA10D 6144FCC3 5B9848C7 53CBF413	Rˆ,b≠NV +ü`ø/ΩôflˈhQ m≈ 9∞Ãl^Ã° aD˛√[òH«SÀÙ
D565D2F9 549F6BAD 9298F55A 02ECDFD2 68D4412F	„1"‡î?"@bj36»Ö§, ’’`"PV ’e“˘Tük≠íòıZ Ïfl“hˈA/
F4C32962 CB9864A3 E8C95600 FF6BB0C9 B8F6C0A5	3Ò Û`îDÄGIè~/:ê˛€ªfië°±ïÙ√)bÀòdf£Ë…V ˘k∞…∏ˆ¿●
8073797D 2D937118 DF32B702 C1BFE8A3 8451CE4F	L[o:Ìhõ Œ/qú°˛●<”π”ÿ“@ EÄsy}-ìq fl2∑ ¡øË£ÑQŒO
A86F440F 5A1E84E5 110563EB AEE42E6D 5A71054C	¿! ªíÿ§èÿ´0ŸMÒW È‹ªMØ5nì®oD Z ÑÂ cÎÆ%.mZq L
C5905F09 4EC2C3CE 017F67DA 0243C08E 177D8B8F	ÒX–m˛à´D¬Kv8 .{_ fiqáÈ6◊∞≈ê_ N¬√Œ g/ C¿é }ãè
4CBBB173 1A6FE923 018AFBB2 08C6F91E 99A9889B	6ë…„œëk¢®%Õ [Ø??Õ'Õ¯L§ âLª±s oÈ# ä°≤ Δ˘ ô©àõ

Moving forward to stage two, all things essentially remain equal throughout all versions of the Baldr packer. We have the DLL loaded into memory, which creates a child process of the main Baldr executable in a suspended state and proceeds to hollow this process, eventually replacing it with the main .NET payload. This makes manually unpacking with ollyDbg nice because after we break on child Baldr.exe load, we can step through the remaining code of the parent, which writes to process memory and eventually calls *ResumeThread()*.



As you can see, once the child process is loaded, the functions that it has set up to call contain *VirtualAlloc, WriteProcessMemory,* and *ResumeThread,* which gives us an idea what to look out for. If we dump this written memory right before resume thread is called, we can then easily extract the main payload.

Our colleague @hasherezade has made this step-by-step video of unpacking Baldr:



Watch Video At:

https://youtu.be/E2V4kB_gtcQ

Payload code analysis

Now that we have unpacked the payload, we can see the actual malicious functionality. However, this is where our troubles began. For the most part, malware written in any interpreted language is a relief for a reverse engineer as far as ease of analysis goes. Baldr, on the other hand, managed to make the debugging and analysis of its source code a difficult task, despite being written in C#.

```
da471cba arg_2C1_0 = <Module>.x,æØ;
int num = -487978463 + (int)Math.Floor(0.20884692673983377);
int num2 = ((int)Math.Sqrt(0.85618871257462947) == -487978463) ? ((i
int num3 = 1243834968 + (int)Math.Floor(0.32713996759948316);
int num4 = ((int)Math.Tanh(0.85618871257462947) == 1243834968) ? ((i
int num5 = -890862818 - (int)Math.Floor(0.37742677064492691);
int num6 = ((int)Math.Cos(0.85618871257462947) == -890862818) ? ((in
int num7 = 692661293 - (int)Math.Floor(0.1433449093454261);
int num8 = ((int)Math.Log10(0.85618871257462947) == 692661293) ? ((i
int num9 = 1430155919 - (int)Math.Floor(0.13792638314791322);
int num10 = ((int)Math.Floor(0.85618871257462947) == 1430155919) ? (
int num11 = 127191041 + (int)Math.Floor(0.17903493907257681);
int num12 = ((int)Math.Truncate(0.85618871257462947) == 127191041) ?
int num13 = -1192098763 + (int)Math.Floor(0.35518656031004459);
int num14 = ((int)Math.Atan(0.85618871257462947) == -1192098763) ? (
int num15 = -491114841 - (int)Math.Floor(0.36429729287712709);
int num16 = ((int)Math.Exp(0.85618871257462947) == -491114841) ? ((i
if (arg_2C1_0(0de672fa.f301b9ff, <Module>.85a8ba6d<string>(380385245
{
    string[] array = 66576fa6.a1e702d4(0de672fa.f301b9ff, new char[]
    {
```

The code base of this malware is not straight forward. All functionality is heavily abstracted, encapsulated in wrapper functions, and utilizes a ton of utility classes. Going through this code base of around 80 separate classes and modules, it is not easy to see where the key functionality lies. Multiple static passes over the code base are necessary to begin making sense of it all. Add in the fact that the function names have been mangled and junk instructions are inserted throughout the code, and the next step would be to start debugging the exe with DnSpy.

Now we get to our next problem: threads. Every minute action that this malware performs is executed through a separate thread. This was obviously done to complicate the life of the analyst. It would be accurate to say that there are over 100 unique functions being called inside of threads throughout the code base. This does not include the threads being called recursively, which could become thousands.

```
case 3:
    191ed1e5.74b80c40.5ae7fc6c = 191ed1e5.74b80c40.ef9ea488;
    arg_C8_0 = (num5 * 691511557 ^ 1968371167);
    continue;
case 4:
{
    Thread expr_187 = <Module>.oc¶Õ(new ThreadStart(191ed1e5.02c9b121));
    611140ae.a18ab42a(expr_187, true);
    Thread thread6 = expr_187;
    Thread expr_1A6 = <Module>.oc¶Õ(new ThreadStart(191ed1e5.068454af));
    611140ae.a18ab42a(expr_1A6, true);
    Thread thread7 = expr_1A6;
    Thread expr_1C5 = <Module>.oc¶Õ(new ThreadStart(191ed1e5.0151b121));
    611140ae.a18ab42a(expr_1C5, true);
    Thread thread8;
    <Module>.j¾?È(thread8);
    Thread thread9;
    <Module>.j¾?È(thread9);
    Thread thread10;
    <Module>.j¾?È(thread10);
    Thread thread4;
    <Module>.j¾?È(thread4);
    Thread thread5;
    <Module>.j¾?È(thread5);
    Thread thread2;
    <Module>.j¾?È(thread2);
    Thread thread;
    <Module>.j¾?È(thread);
    Thread thread3;
    <Module>.j¾?È(thread3);
    <Module>.j¾?È(thread6);
    <Module>.j¾?È(thread7);
    0c646f75.d6d80dde(expr_1C5);
    <Module>.¿³\þe(thread8);
    <Module>.¿³\þe(thread9);
    <Module>.¿³\þe(thread10);
    <Module>.¿³\þe(thread4);
    <Module>.¿³\þe(thread5);
    <Module>.¿³\þe(thread2);
    <Module>.¿³\þe(thread);
```

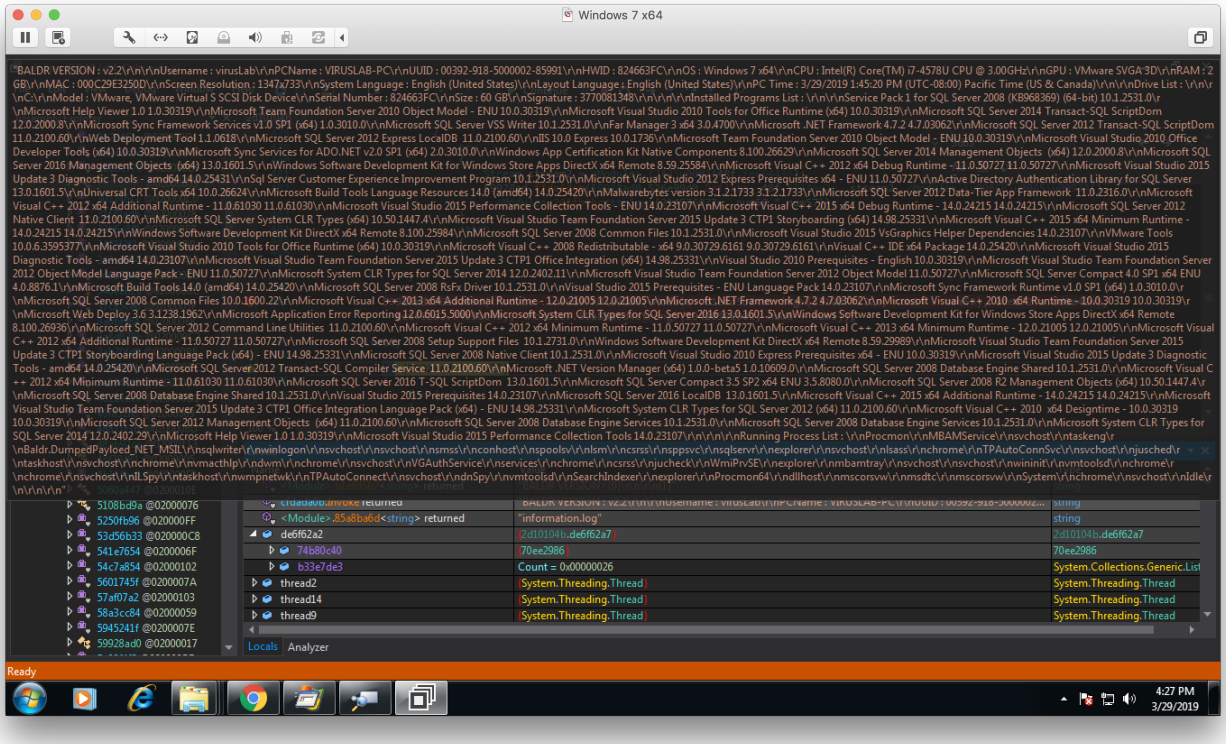
Luckily, we can view local data as it is being written, and eventually we are able to locate the key sections of code:

```
private static void ebb82042()
{
string ef9ea = <Module>.b1efd5b2<string>(arg_8AA_0, num52 + num51);
string string_ = <Module>.smethod_23<string>(3737841071u, num50 * num49);
string text = <Module>.smethod_23<string>(3737841071u, num48 * num47);
try
{
    ManagementObject expr_8E9 = <Module>.e4e70648_0(<Module>.b1efd5b2<string>(207135629u, num44 + num43));
    ef9ea = b200af0a.fee0a694(Delegate47.f509de3b(expr_8E9, <Module>.smethod_24<string>(246472369u, num42 + num41)));
    string_ = b200af0a.fee0a694(Delegate47.f509de3b(expr_8E9, <Module>.b1efd5b2<string>(1107098930u, num46 + num45)));
    text = b200af0a.fee0a694(Delegate47.f509de3b(expr_8E9, <Module>.b1efd5b2<string>(1635233314u, num40 + num39)));
    if (<Module>.da471cba_0(string_, <Module>.b1efd5b2<string>(735270013u, num38 * num37)))
    {
        goto IL_9C5;
    }
    goto IL_C94;
    int arg_C2B_0;
    while (true)
    {
```

The function pictured above gathers the user's profile, as mentioned previously. This includes the CPU type, computer name, user accounts, and OS.

text	"824663FC"
list	Count = 0x00000001
[0]	{74fe0123}
06eccc24	"60 GB"
3764ac2a	"C:"
4197e83c	"3770081348"
4f118dad	"824663FC"
a35445a7	"VMware, VMware Virtual S SCSI Disk Device"
Raw View	
managementObjectEnumerator	{System.Management.ManagementObjectCollection.ManagementObjectEnumerator}
managementObject	{\\VIRUSLAB-PC\root\cimv2:Win32_DiskDrive.DeviceID="\\\\.\\PHYSICALDRIVE0"}
managementObjectEnumerator2	{System.Management.ManagementObjectCollection.ManagementObjectEnumerator}
managementBaseObject	{\\VIRUSLAB-PC\root\cimv2:Win32_DiskPartition.DeviceID="Disk #0, Partition #1"}
managementObject2	{\\VIRUSLAB-PC\root\cimv2:Win32_DiskPartition.DeviceID="Disk #0, Partition #1"}
managementObjectEnumerator3	{System.Management.ManagementObjectCollection.ManagementObjectEnumerator}
managementBaseObject2	{\\VIRUSLAB-PC\root\cimv2:Win32_LogicalDisk.DeviceID="C:"}
managementObject3	{\\VIRUSLAB-PC\root\cimv2:Win32_LogicalDisk.DeviceID="C:"}
text3	"C:"

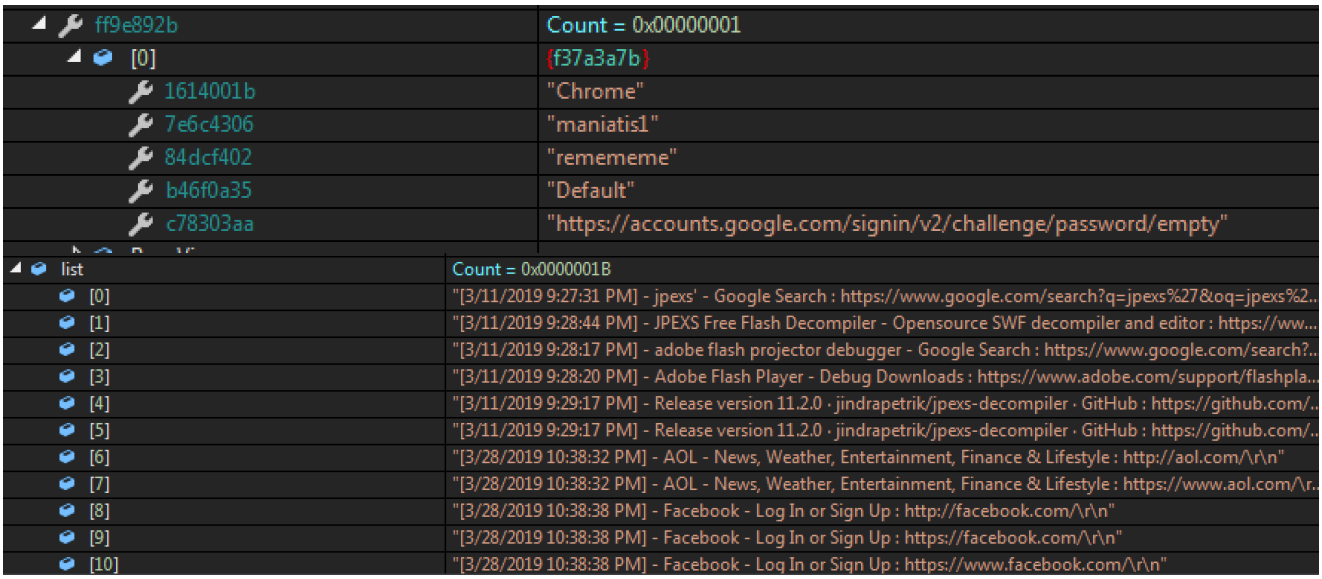
After the entire process is complete, it flattens the arrays storing this data, resulting in a string like this:



The next section of code shows one of the many enumerator classes used to cycle directories, looking for application data, such as stored user accounts, which we purposely saved for testing.

```
public static void 3881f4dc()
using (List<8448a8d0>.Enumerator enumerator = arg_FF5_0.GetEnumerator())
{
    IL_29EB:
    while (enumerator.MoveNext())
    {
        8448a8d0 current;
        while (true)
        {
            IL_1027:
            current = enumerator.Current;
            int arg_100A_0 = 977494244;
            while (true)
            {
                int num97;
                switch ((num97 = (arg_100A_0 ^ 848596064)) % 4)
                {
                case 0:
                    if (current.e2324d0b == b0eb3715.Chromium)
                    {
                        arg_100A_0 = (num97 * -354014648 ^ 964306117);
                        continue;
                    }
                    goto IL_29EB;
                case 2:
                    arg_100A_0 = 586619503;
                    continue;
                case 3:
                    goto IL_1027;
                }
                goto Block_51;
            }
        }
        IL_1051:
```

The data retrieved was saved into lists in the format below:



In the final stage of data collection, we have the threads below, which cycle the key directories looking for txt and doc files. It will save the filename of each txt or doc it finds, and store the file's contents in various arrays.

```
foreach (DirectoryInfo current in new List<DirectoryInfo>
{
    <Module>.  x[è(<Module>.SSAVëEPA§(<Module>.ý$-tó(<Module>.85a8ba6d<string>(3102868533u, num14 - num13)),
    <Module>.  x[è(<Module>.WÇÒ|ÿ(Environment.SpecialFolder.CommonDocuments)),
    <Module>.  x[è(<Module>.WÇÒ|ÿ(Environment.SpecialFolder.DesktopDirectory))
})
    case 8:
    {
        FileInfo fileInfo;
        list.Add(new 48f70484
        {
            fe664438 = <Module>.ªl
            /(<Module>.&fqÍ(fileInfo)),
            3764ac2a = 7399ef3e.9e61f6d3(new string[]
            {
                <Module>.e5131c6b<string>(692661293u, num8 + num7),
                <Module>.SS3#;Q<(current),
                <Module>.201fb1bc<string>(1243834968u, num4 + num3),
                <Module>.SS3#;Q<(directoryInfo),
                <Module>.b1efd5b2<string>(3806988833u, num2 + num),
                <Module>.SS3#;Q<(fileInfo)
            })
        });
        arg_5FC_0 = (num17 * -1085783678 ^ 338587260);
        continue;
```

array	{string[0x00000005]}
[0]	".doc"
[1]	".docx"
[2]	".log"
[3]	".txt"
[4]	""

list	Count = 0x00000003
[0]	{48f70484}
[1]	{48f70484}
[2]	{48f70484}
3764ac2a	@"Files\Desktop\ChimpRec\aaa.docx"
fe664438	{byte[0x00000056]}

Finally, before we proceed to the network segment of the malware, we have the code section performing the screen captures:

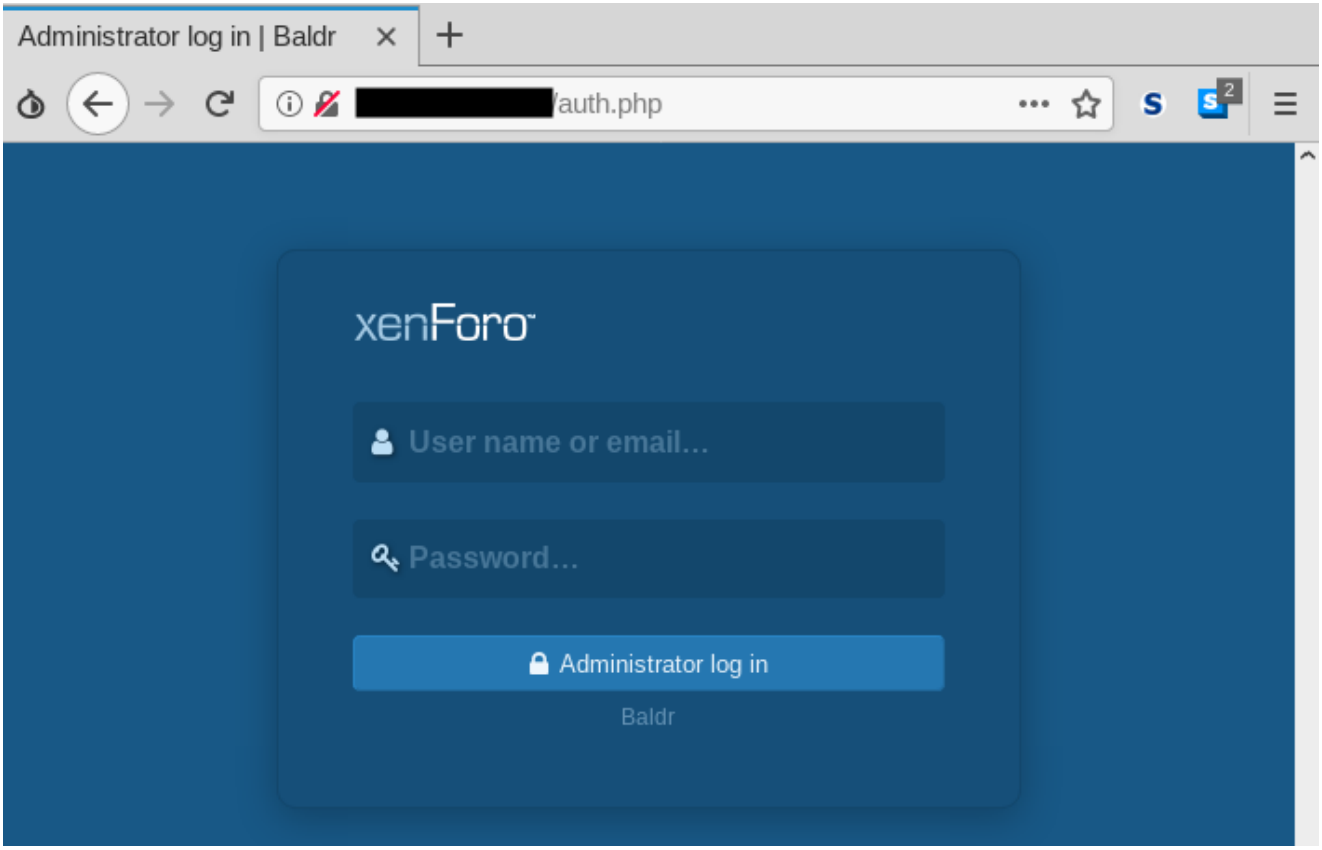
```
// Token: 0x06000049 RID: 73 RVA: 0x0001A55C File Offset: 0x0001875C
private static void 02c9b121()
{
    uint num = 3737841071u;
    int num2 = 316830955 + (int)Math.Floor(0.25480818569418429);
    int num3 = ((int)Math.Tanh(0.66100397271150912) == 316830955) ? ((int)Math.Truncate(1292.26
      Math.Cosh(0.66100397271150912));
    int num4 = 1616532161 - (int)Math.Floor(0.38982956087674459);
    int num5 = ((int)Math.Log10(0.66100397271150912) == 1616532161) ? ((int)Math.Sqrt(957.79475
      Math.Log10(0.66100397271150912));
    int num6 = -557126225 + (int)Math.Floor(0.10605824776275934);
    int num7 = ((int)Math.Tanh(0.66100397271150912) == -557126225) ? ((int)Math.Tan(2548.831318
      (0.66100397271150912));
    string str = <Module>.85a8ba6d<string>(num, num7 + num6);
    string str2 = <Module>.24a84f73<string>(1616532161u, num5 + num4);
    try
    {
        str = <Module>.\u008E\u00A5o\u00A7K(<Module>.\u0007Ó\u00BEu\u0091()).Width.ToString();
        Rectangle bounds = Screen.PrimaryScreen.Bounds;
```

Class 2d10104b function 1b0b685() is one of the main modules that branches out to do the majority of the functionality, such as looping through directories. Once all data has been gathered, the threads converge and the remaining lines of code continue single threaded. It is then that the network calls begin and all the data is sent back to the C2.

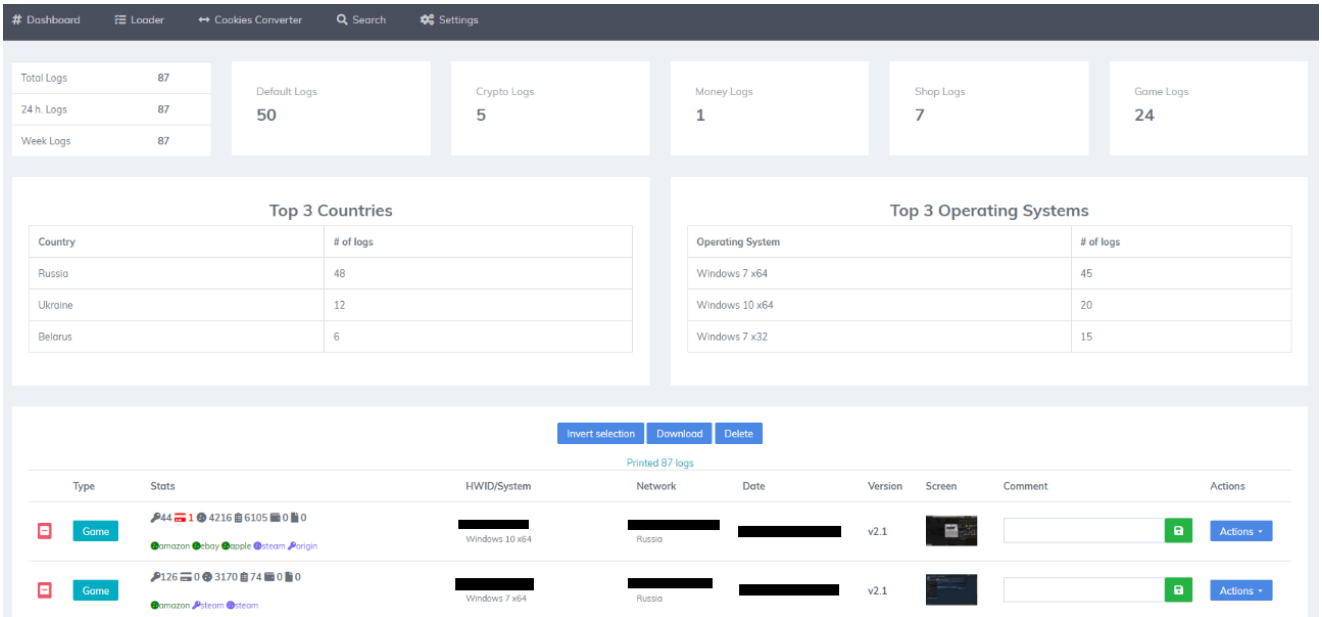
The zipped data is encrypted via XOR with a 4 byte key and version number obtained from contacting the C2 via a first network request. The second request sends the cyphered data back to the C2.

Panel

Like other stealers, Baldr comes with a panel that allows the customers (criminals that buy the product) to see high-level stats, as well as retrieve the stolen information. Below is a panel login page:



And here, in a screenshot posted by the threat actor on a forum, we see the inside of the panel:



Final analysis

Baldr is a solid stealer that is being distributed in the wild. Its author and distributor are active in various forums to promote and defend their product against critics. During a short time span of only a few months, Baldr has gone through many versions, suggesting that its author

is fixing bugs and interested in developing new features.

Baldr will have to compete against other stealers and differentiate itself. However, the demand for such products is high, so we can expect to see many distributors use it as part of several campaigns.

Malwarebytes users are protected against this threat, detected as Spyware.Baldr.

Thanks to S!Ri for additional contributions.

Indicators of compromise

Baldr samples

```
5464be2fd1862f850bdb9fc5536eceafb60c49835dd112e0cd91dabef0ffcec5 -> version 1.2
1cd5f152cde33906c0be3b02a88b1d5133af3c7791bcde8f33eefed3199083a6 -> version 2.0
7b88d4ce3610e264648741c76101cb80fe1e5e0377ea0ee62d8eb3d0c2decb92 > version 2.2
8756ad881ad157b34bce011cc5d281f85d5195da1ed3443fa0a802b57de9962f (2.2 unpacked)
```

Network traces

```
hwid=
{redacted}&os=Windows%207%20x64&file=0&cookie=0&pswd=0&credit=0&autofill=0&wallets=0&i

hwid=
{redacted}&os=Windows%207%20x64&file=0&cookie=0&pswd=0&credit=0&autofill=0&wallets=0&i
```