JACKPOT!
Sbancare un ATM con Ploutus.D

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$whoami

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- Phrack Author
  - http://www.phrack.org/papers/dotnet_instrumentation.html
- Owasp Italy Board since 2006
- Passionate F# developer
  - https://github.com/enkomio
  - https://github.com/taipan-scanner/Taipan

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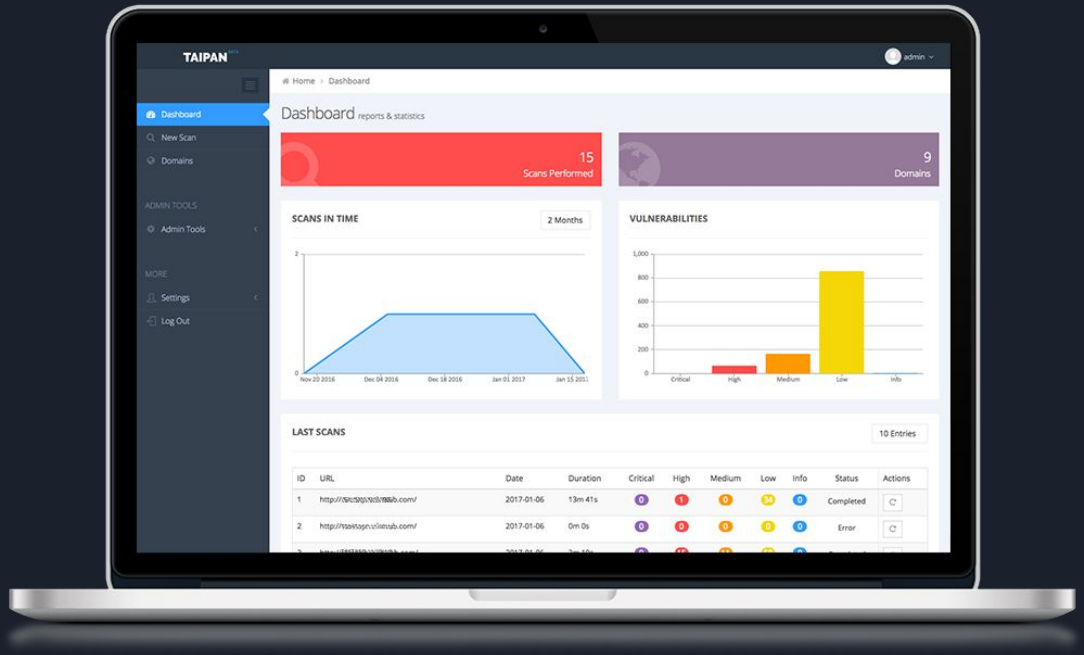
Global	Specific	Accessible
Trends & Threats	Scaling your capability	STIX / TAXII
Who & how	Analyst availability	Customisable output
Actors, victims & attribution	Malware & MO's	API Portal access
Knowledge base & reporting	Credential & card recovery	Alerting

Real-time contextual threat intelligence

www.fox-it.com/intell/

Taipan Web Application Security Scanner



https://github.com/taipan-scanner/Taipan

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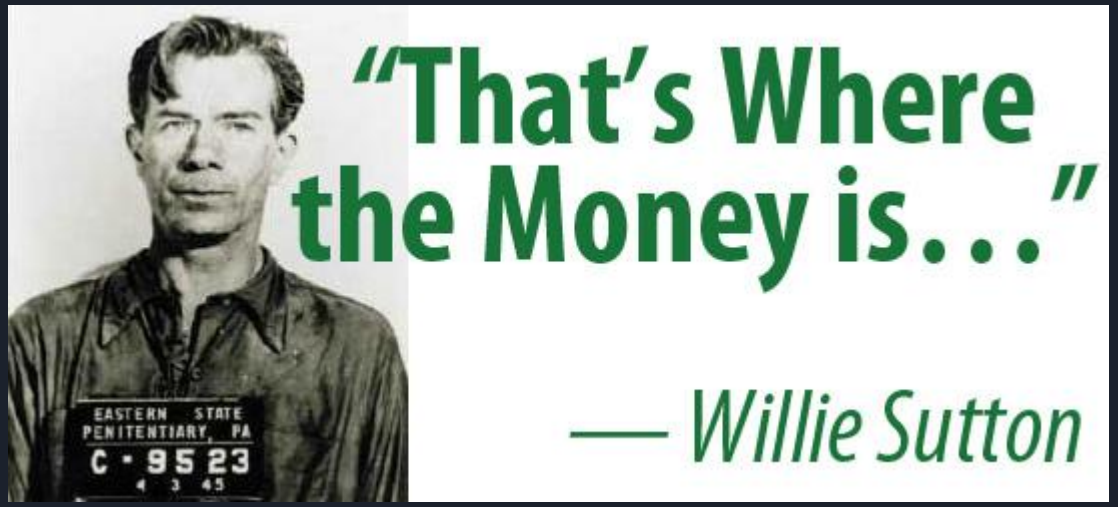
Why target ATMs?



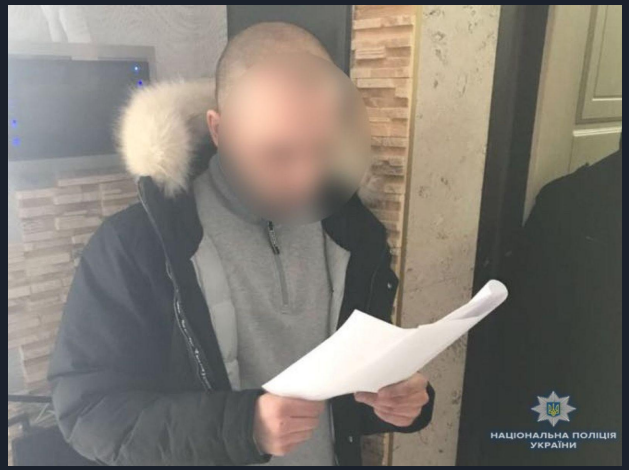
* FAKE: http://scobbs.blogspot.it/2015/01/why-willie-sutton-robbed-banks-real.html

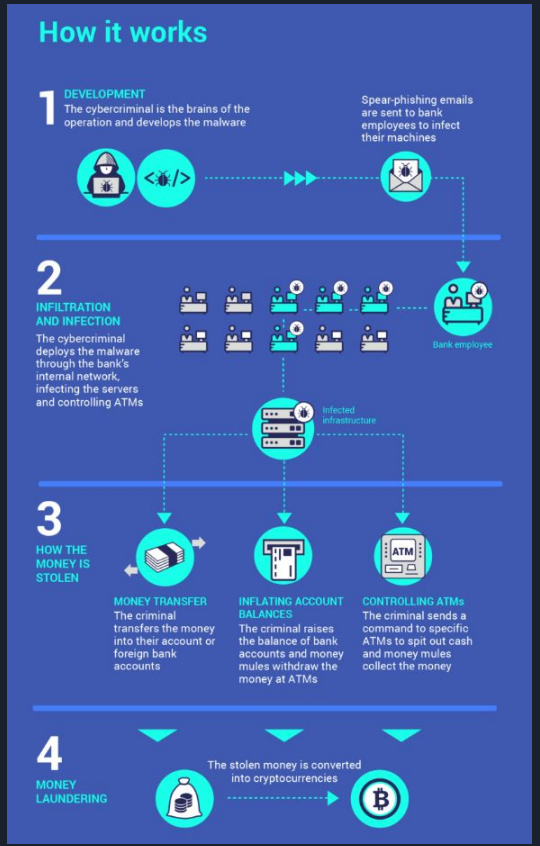
Are ATMs a real target for criminals?

MASTERMIND BEHIND EUR 1 BILLION CYBER BANK ROBBERY ARRESTED IN SPAIN

26 March 2018

Press Release





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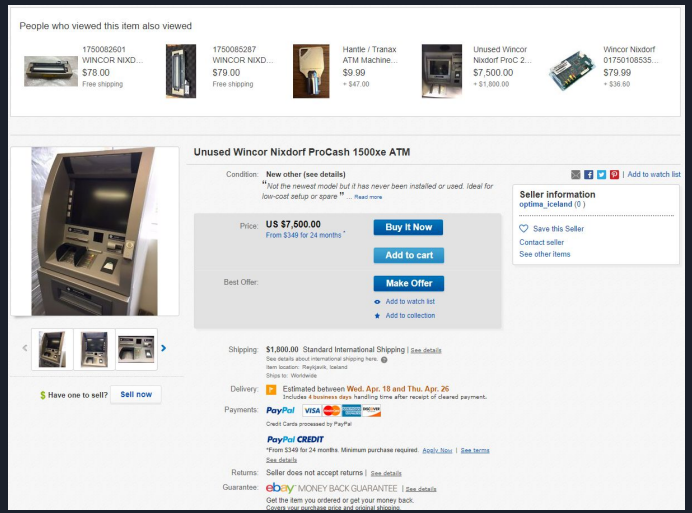
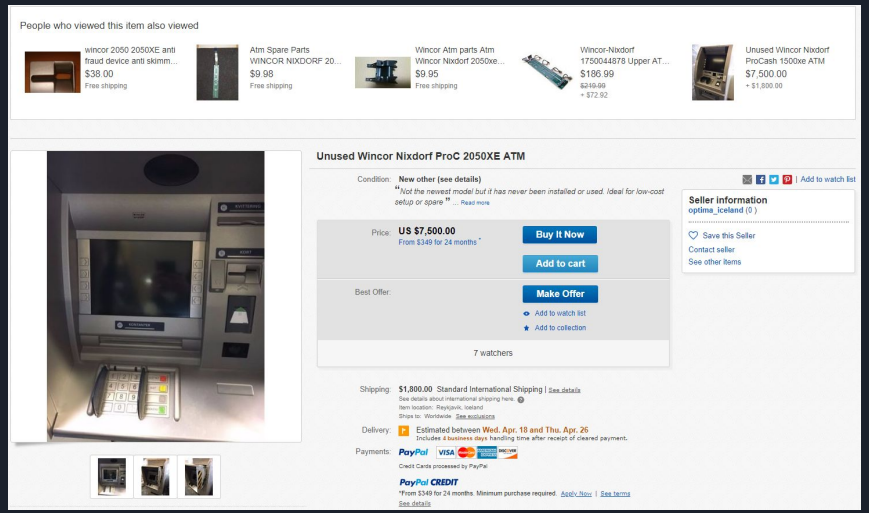
What is an ATM?

“An automated teller machine (ATM) is an electronic telecommunications device that enables customers of financial institutions to perform financial transactions, such as cash withdrawals, deposits, transfer funds, or obtaining account information, at any time and without the need for direct interaction with bank staff.” -

How to test an ATM?

- ATMs are like regular computers with custom hardware and software
  - ATM file list https://dokumen.tips/documents/ejemplodeimagennorton-ghosttxt.html
- One of the most difficult parts is to obtain an ATM for testing purpose
- If you have the money you can buy one on e-bay :)





ATM Internals

Ploutus.D ATM Malware

- During the past years various malwares were created in order to attack ATM in order to force the ejection of all the bills stored inside the various dispensers
  - This kind of attack is known as Jackpotting, after the seminal talk done at BH USA 2010 by Barnaby Jack
- In 2013 FireEye discovered a new ATM malware, dubbed Ploutus ([1])
  - At the time it was known as Ploutus (without D) and targeting Mexican banks
- In 2017 FireEye released a new article about a new Ploutus variant, dubbed Ploutus.D ([2])
  - The D suffix was added due to the fact that it targets Diebold ATM vendor

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[1] https://www.symantec.com/connect/blogs/criminals-hit-atm-jackpot
[2] https://www.fireeye.com/blog/threat-research/2017/01/new_ploutus_variant.html

Ploutus.D ATM Malware

- March 2017: ZingBox published an article about a new version of Ploutus.D which added the capability to be controlled remotely ([3])
- January 2018: the reporter Brian Krebs published an article about Ploutus.D infecting also US ATMs ([4]). This new variant was described by ZingBox in [5] and named as *Piolin*.

[3] https://www.zingbox.com/blog/ploutus-d-malware-turns-atms-into-iot-devices/
[4] https://krebsonsecurity.com/tag/ploutus-d/
[5] https://www.zingbox.com/blog/piolin-the-first-atm-malware-jackpotting-atms-in-usa/

Is the DIEBOLD brand used in Italy?

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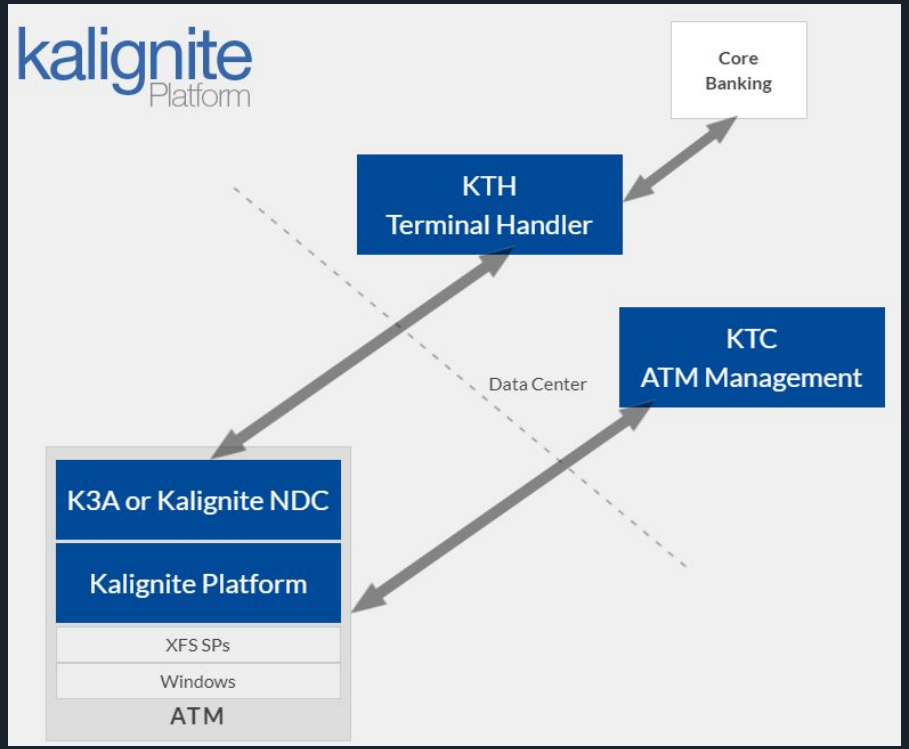
Interaction with the ATM

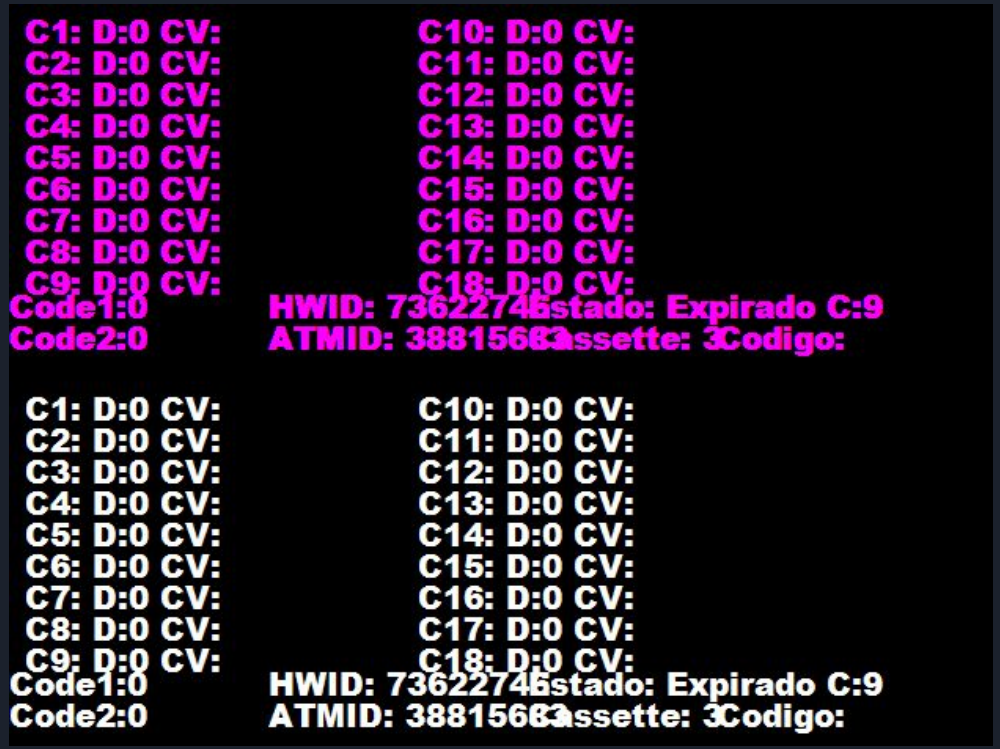
- According to FE ([1]) interactions with the ATM are done through the Kalignite Platform
- This framework is an abstraction level above the XFS middleware
- The usage of this framework implies that the author(s) has a good understanding of how an ATM works

UPDATE: Recent Ploutus.D samples seem to have moved from Kalignite framework to Diebold Agilis Power middleware (based on INvolve middleware platform from Nexus Software [2]), this according to the name of the referenced files.



Src: http://www.kal.com/en/kal-products
[1] https://www.fireeye.com/blog/threat-research/2017/01/new_ploutus_variant.html
[2] https://www.finextra.com/newsarticle/6822/diebold-releases-agilis-power-platform-for-multi-vendor-atm-upgrades

Hello Ploutus.D



Reading user input

```
// Token: 0x0600003A RID: 58 RVA: 0x000034C4 File Offset: 0x000016C4
private static IntPtr smethod_2(Class7.Delegate0 delegate0_1)
{
    IntPtr result;
    using (Process currentProcess = Process.GetCurrentProcess())
    {
        using (ProcessModule mainModule = currentProcess.MainModule)
        {
            result = Class7.SetWindowsHookEx(13, delegate0_1, Class7.GetModuleHandle
              (mainModule.ModuleName), 0u);
        }
    }
    return result;
}
```

Set Keyboard Hook in order to intercept all keyboard keys

```
// Token: 0x0600003B RID: 59 RVA: 0x00003528 File Offset: 0x00001728
private static IntPtr smethod_3(int int_0, IntPtr intptr_1, IntPtr intptr_2)
{
    if (int_0 >= 0 && intptr_1 == (IntPtr)256)
    {
        int int_ = Marshal.ReadInt32(intptr_2);
        Class11.smethod_0(int_);
    }
    return Class7.CallNextHookEx(Class7.intptr_0, int_0, intptr_1, intptr_2);
}
```

Dispatch the pressed key to the handler

User Interface

```
37      // Token: 0x0600000F RID: 15 RVA: 0x00002F84 File Offset: 0x00001184
38      private static void smethod_1()
39      {
40          try
41          {
42              IntPtr intPtr = Class2.CreateDC("\\\\.\\DISPLAY1", "", "", IntPtr.Zero);
43              Graphics graphics = Graphics.FromHdc(intPtr);
44              SolidBrush brush = new SolidBrush(Color.Magenta);
45              SolidBrush brush2 = new SolidBrush(Color.Black);
46              Font font = new Font("Arial Black", 12f);
47              new Font("Arial Black", 20f);
48              short num = 10;
49              while (Class7.bool_7)
50              {
51                  if (num < 1)
52                  {
53                      num = 10;
54                      graphics.FillRectangle(brush2, 0, 0, 800, 300);
55                      graphics.DrawRectangle(new Pen(new SolidBrush(Color.White)), 0, 0, 799, 299);
```

Write directly to DISPLAY1 device

Loop forever until the UI is active

Ploutus.D Framework

- Ploutus.D is a full framework
  - Some of these file are used to encrypt content or to interact with dispenser. Relevant file to interact with the ATM are:
    - *AxInterop.CASHDISPENSER3Lib.dll*
    - *AxInterop.PINPAD3Lib.dll*
    - *Interop.CASHDISPENSER3Lib.dll*
    - *Interop.PINPAD3Lib.dll*

Ploutus.D Framework

- Some of the identified files are:
  - *Launcher*: it is the initial launcher, the one which use the attacker to install the malware
  - *XFSConsole.exe*: it allows to interact with XFS Middleware
  - *NewAge.exe*: it allows to connect remotely to the ATM (more on this later)
  - *AgilisConfigurationUtility.exe*: it allows to interact with the ATM in order to dispense money

How to access the ATM computer

- Accessing the ATM via software vulnerability
  - Exploit some vulnerability in the user interaction software (sticky keys…)
  - AFAIK never use in real attack
- Accessing the ATM through internal network compromise
  - Accessing the ATM through an internal network which was previously compromised
- Physically access the ATM
  - Physically accessing the ATM by compromising the case or by opening it

How to access the ATM computer

LECCEPRIMA ≡ Sezioni Cronaca ACCEDI

Cronaca / Tuglie / Via Tito Schipa

Fiamma ossidrica per aprire la cassa automatica: ladri "prelevano" 70mila euro dalle poste

Ancora un furto, nella notte, ai danni di un postamat. L'episodio a Tuglie, dove i malviventi hanno scardinato lo sportello, e arraffato il denaro custodito all'interno. Sul posto, per i rilievi, carabinieri della compagnia di Gallipoli e del reparto di Investigazioni scientifiche. Meno di una settimana addietro, colpo identico a Santa Maria al Bagno

V.Murr.
05 GENNAIO 2016 10:21

30 Commenti 233 Condivisioni

L'ufficio derubato nella notte, a Tuglie

TUGLIE - Ennesimo assalto al bancomat, alla vigilia dell'Epifania. La solita modalità per un nuovo maxi furto: malviventi, nella notte, hanno preso di mira l'ufficio postale in via Tito Schipa, a **Tuglie.** Hanno raggiunto lo sportello automatico e, servendosi della fiamma ossidrica, hanno aperto il deposito dopo averlo praticamente scardinato.

La cassa è rimasta sul posto, ma i ladri sono riusciti ad estrarre tutto il denaro caricato nella giornata di ieri, in vista delle maggiori

I più letti di oggi

1 Il cavallo s'imbizzarrisce, allevatore precipita con il calesse e muore

2 Si ribalta con l'auto mentre si reca al lavoro: resta ferita una 22enne

3 Guida senza patente e a bordo eroina: arrestata una coppia

4 Scontro tra Vespa e pulmino con un disabile: ferito al capo un ragazzo

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How Ploutus.D works?

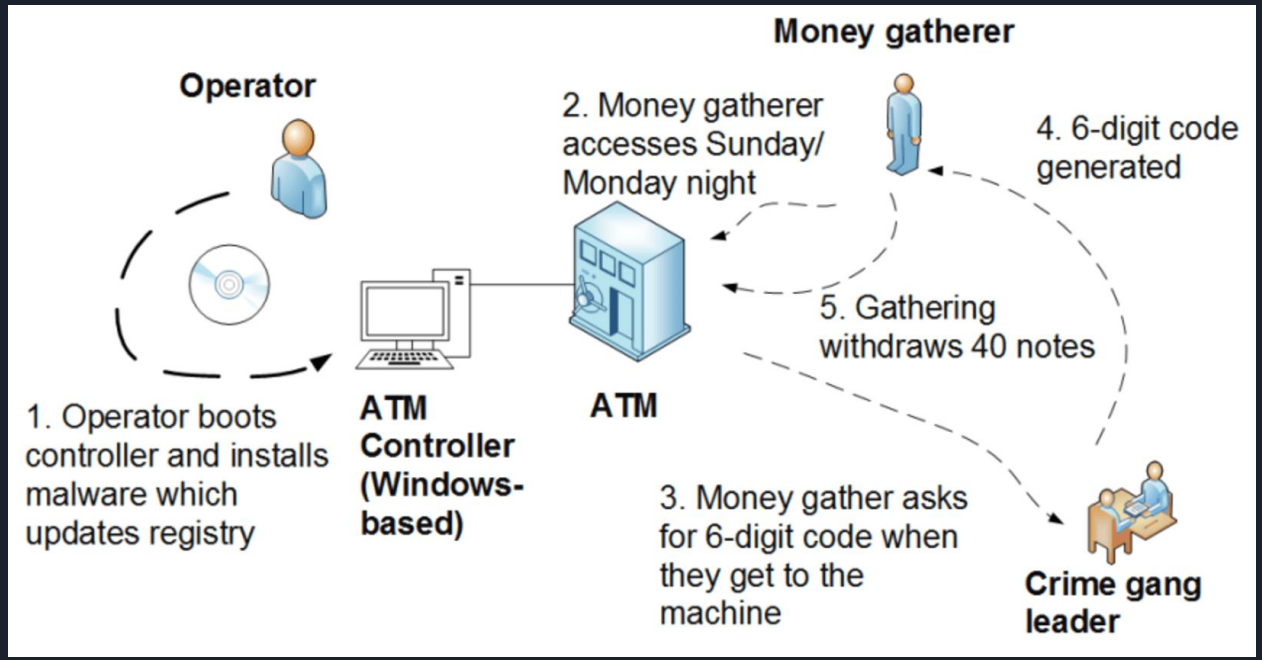


Image not strictly related to Ploutus.D, but same process.
Source: https://phys.org/news/2014-10-atm-windows-safe-money.html

Ploutus.D initialization

- Once the malware is installed and initialized, it creates a new configuration file (P.bin) where it stores, among other info, the ATMID pseudo-random value

```
70          Class6.smethod_5("APPStart");
71          if (Class9.smethod_52())
72          {
73              string text = string.Empty;
74              Class6.smethod_5("Generando ID");
75              Random random = new Random(DateTime.Now.Millisecond);
76              for (int i = 1; i <= 4; i++)
77              {
78                  text += random.Next(0, 10).ToString();
79              }
80              Random random2 = new Random(DateTime.Now.Second);
81              for (int j = 1; j <= 4; j++)
82              {
83                  text += random2.Next(0, 10).ToString();
84              }
85              Class9.smethod_7(uint.Parse(text));
86              Class9.smethod_47(0.0);
87              Class9.smethod_53(false);
88              Class7.string_3 = Class6.smethod_1(text);
89          }
90          else
91          {
92              Class7.string_3 = Class6.smethod_1(Class9.smethod_6().ToString());
93          }
94          if (Class9.smethod_4() == 0u)
95          {
96              Random random3 = new Random(DateTime.Now.Millisecond);
97              int uint_ = random3.Next(1, 99999999);
98              Class9.smethod_5((uint)uint_);
99              Class7.string_4 = Class6.smethod_1(uint_.ToString());
100         }
```

Generate HWID

Generate *ATMID* (this info is needed for activation)

Ploutus.D activation

- The activation step needs two data
  - ATMID a pseudo-random number generated during the first execution of the malware
  - The current day number (1-31)
  - The current month number (1-12)
- The encryption is done by three external libraries:
  - *EncryptD.dll*: It is in charge for “encrypt” the day number
  - *EncryptM.dll*: It is in charge for “encrypt” the month number
  - *EncryptID.dll*: It is in charge for “encrypt” the ATM ID number
- The activation holds for one day only, then it needs to be activated again

Ploutus.D activation

ATMID

```
Class6.smethod_5("Activate");
string b = Class6.smethod_1(Class4.smethod_1(Class9.smethod_6().ToString(), now.Day, now.Month));
if (Class7.string_5 == b)
{
```

1

```
public static string smethod_1(string string_0, int int_0, int int_1)
{
    ulong num = 0UL;
    int num2 = ClassEncryptID.EncryptID(string_0);
    int num3 = ClassEncryptD.EncryptDay(int_0);
    int num4 = ClassEncryptM.EncryptMoth(int_1);
```

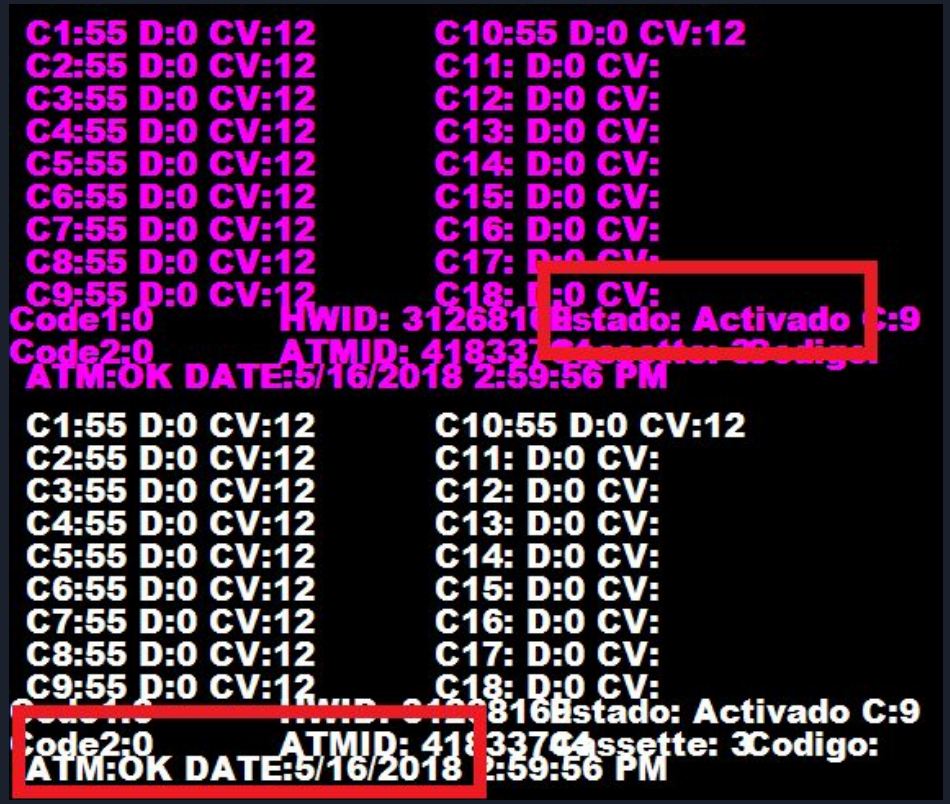
2

```
private static byte[] Calculate(byte[] Value)
{
    uint num = uint.MaxValue;
    for (int i = 0; i < Value.Length; i++)
    {
        num = (num >> 8 ^ ClassEncryptM.CRCTable[(int)((UIntPtr)((num & 255u) ^ (uint)Value[i]))]);
    }
    num ^= uint.MaxValue;
    return new byte[]
    {
        (byte)(num >> 24),
        (byte)(num >> 16),
        (byte)(num >> 8),
        (byte)num
    };
}
```

3

Is the computed value (**b** variable) equals to the inserted activation code?

Ploutus.D activation



Ploutus.D activation

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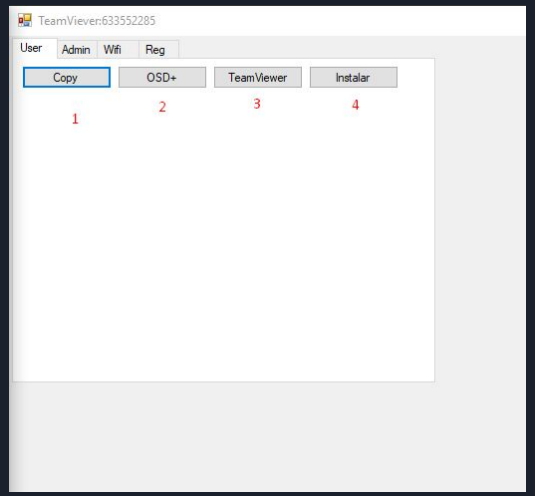
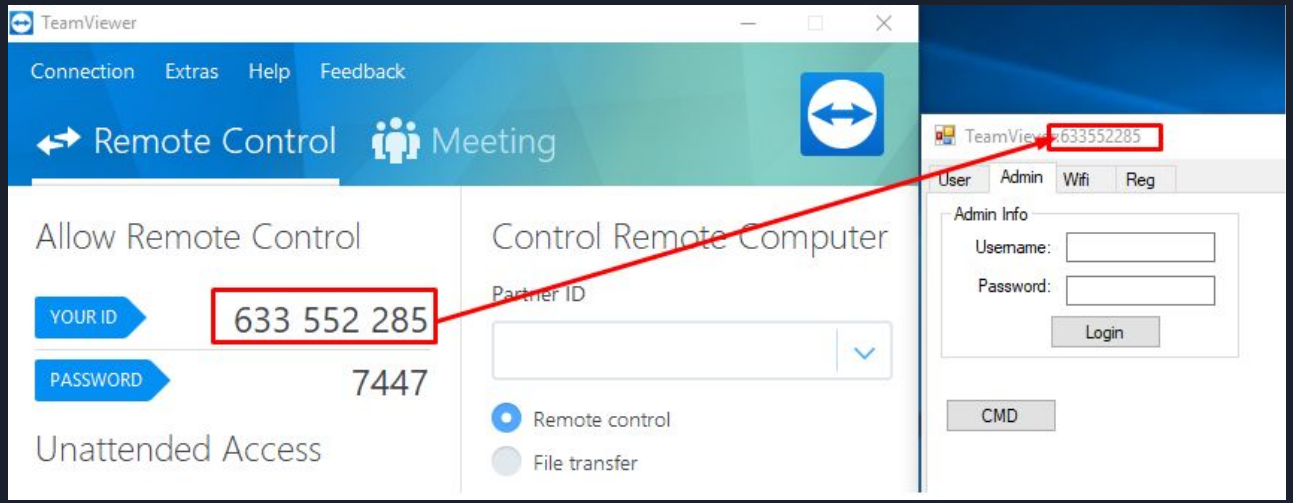
Remote ATM connection

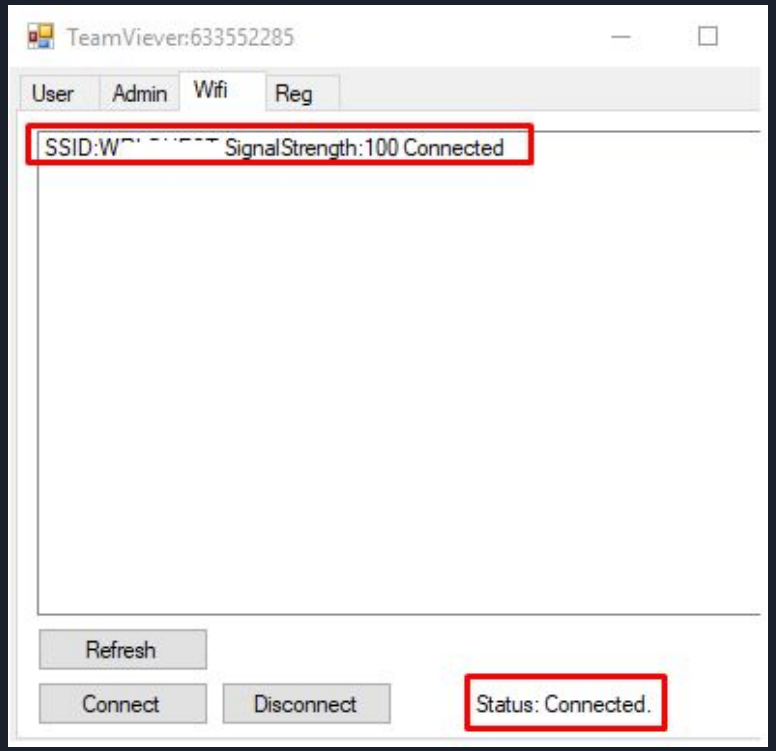
- Ploutus.D in its initial releases, only supported a physical connection to the ATM in order to plug a keyboard and interacts with it
- Latest version added a new feature that allows to connect via WiFi to the ATM
  - It uses a legit SimpleWifi.dll library
  - It is necessary to connect a WiFi dongle to the ATM
- This version is protected in a different way than the previous one, which makes the usage of de4dot not valid.
  - For more info on how to bypass this protection take a look at my article: http://antonioparata.blogspot.it/2018/02/analyzing-nasty-net-protection-of.html

Remote ATM connection





Remote ATM connection



Software Obfuscation

- Ploutus.D uses .NET Reactor a commercial .NET code protector to obfuscate its code
  - *NecroBit is a powerful protection technology which provides complete protection for your sensitive intellectual property by replacing the CIL code within methods with encrypted code. This way it is not possible to decompile/reverse engineer your method source code.*
- Luckily for us the ATM component can be deobfuscated with the open source software de4dot
- The *main.exe* (the one in charge for remote connection) seems to crash de4dot so a manual unpacking process is necessary
  - The most difficult aspect to reverse is to obtains the real MSIL code

Software Obfuscation

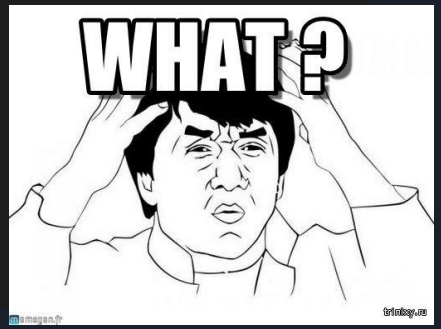
```
// Token: 0x06000125 RID: 293 RVA: 0x00004054 File Offset: 0x00002454
[MethodImpl(MethodImplOptions.NoInlining)]
public N7RHghwy3wqnyoITO7()
{
}

// Token: 0x06000131 RID: 305 RVA: 0x0000418C File Offset: 0x0000258C
[MethodImpl(MethodImplOptions.NoInlining)]
internal static void AsiwGGJ1gM2wCYu0AAM(object obj, object obj2, object obj3, object obj4, PointF pointF)
{
}

// Token: 0x0600012F RID: 303 RVA: 0x00004178 File Offset: 0x00002578
[MethodImpl(MethodImplOptions.NoInlining)]
internal static void BN7S0RJVllOKAkZhMS6(object obj, object obj2, int num, int num2, int num3, int num4)
{
}

// Token: 0x06000127 RID: 295 RVA: 0x00004130 File Offset: 0x00002530
[MethodImpl(MethodImplOptions.NoInlining)]
internal static void Cg0BMbJ9uuGjwseXwSh(object obj)
{
}

// Token: 0x06000122 RID: 290 RVA: 0x00003FD0 File Offset: 0x000023D0
[MethodImpl(MethodImplOptions.NoInlining)]
private static void cnVoE1FS2w()
{
}
```



Software Obfuscation

- The compile method is in charge for compiling MSIL code to machine specific code. This can be (ab)used by obfuscators.

```
class ICorJitCompiler
{
public:
    // compileMethod is the main routine to ask the JIT Compiler to create native code for a method. The
    // method to be compiled is passed in the 'info' parameter, and the code:ICorJitInfo is used to allow the
    // JIT to resolve tokens, and make any other callbacks needed to create the code. nativeEntry, and
    // nativeSizeOfCode are just for convenience because the JIT asks the EE for the memory to emit code into
    // (see code:ICorJitInfo.allocMem), so really the EE already knows where the method starts and how big
    // it is (in fact, it could be in more than one chunk).
    //
    // * In the 32 bit jit this is implemented by code:CILJit.compileMethod
    // * For the 64 bit jit this is implemented by code:PreJit.compileMethod
    //
    // Note: Obfuscators that are hacking the JIT depend on this me[illegible]ving __stdcall calling convention
    virtual CorJitResult __stdcall compileMethod (
            ICorJitInfo                 *comp,              /* IN */
            struct CORINFO_METHOD_INFO  *info,              /* IN */
            unsigned /* code:CorJitFlag */   flags,         /* IN */
            BYTE                        **nativeEntry,      /* OUT */
            ULONG                       *nativeSizeOfCode   /* OUT */
            ) = 0;
```

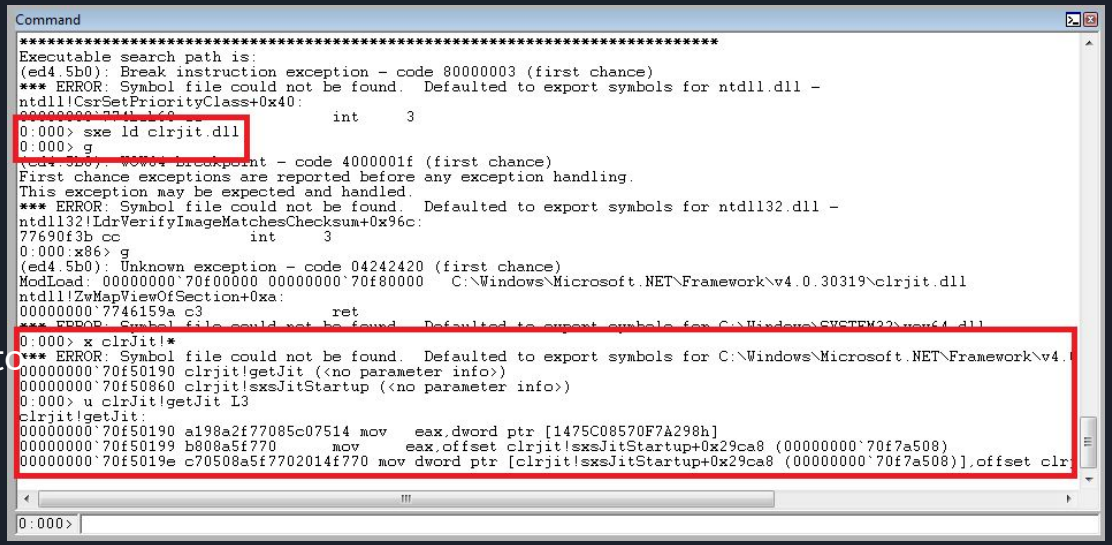
```
1225
1226  struct CORINFO_METHOD_INFO
1227  {
1228      CORINFO_METHOD_HANDLE       ftn;
1229      CORINFO_MODULE_HANDLE       scope;
1230      BYTE *                      ILCode;
1231      unsigned                    ILCodeSize;
1232      unsigned                    maxStack;
1233      unsigned                    EHcount;
1234      CorInfoOptions              options;
1235      CorInfoRegionKind           regionKind;
1236      CORINFO_SIG_INFO            args;
1237      CORINFO_SIG_INFO            locals;
1238  };
```

Software Obfuscation

- Let's use WinDBG with SOS extension to see if the *compileMethod* is hooked

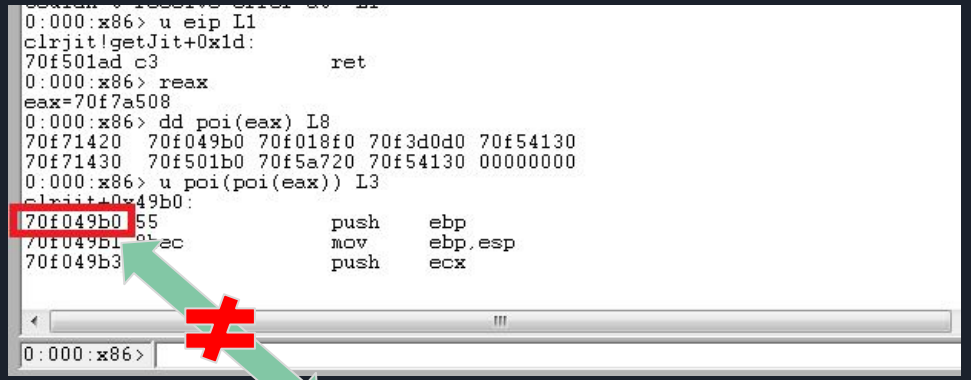
Set breakpoint on *clrjit.dll* load

Set breakpoint on *clrJit!getJit* to get the address of the *compileMethod* method

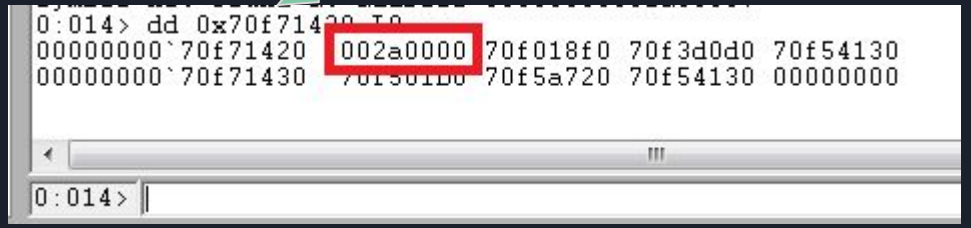


Software Obfuscation

By executing the *getJit* method we obtain the address of *compileMethod* which is 0x70f049b0



Let's execute the program a bit and then check again the address in the VTable of the *compileMethod*



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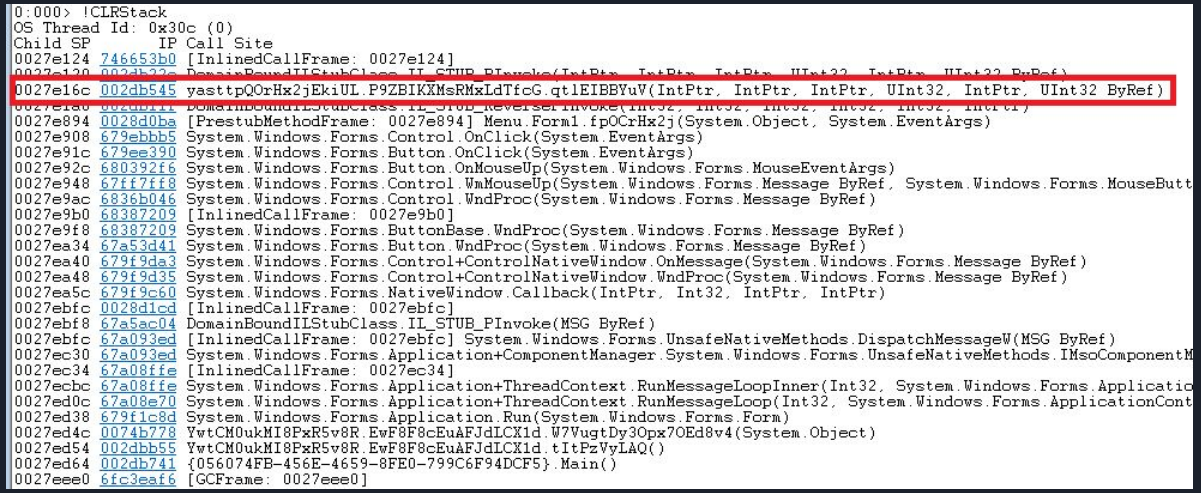
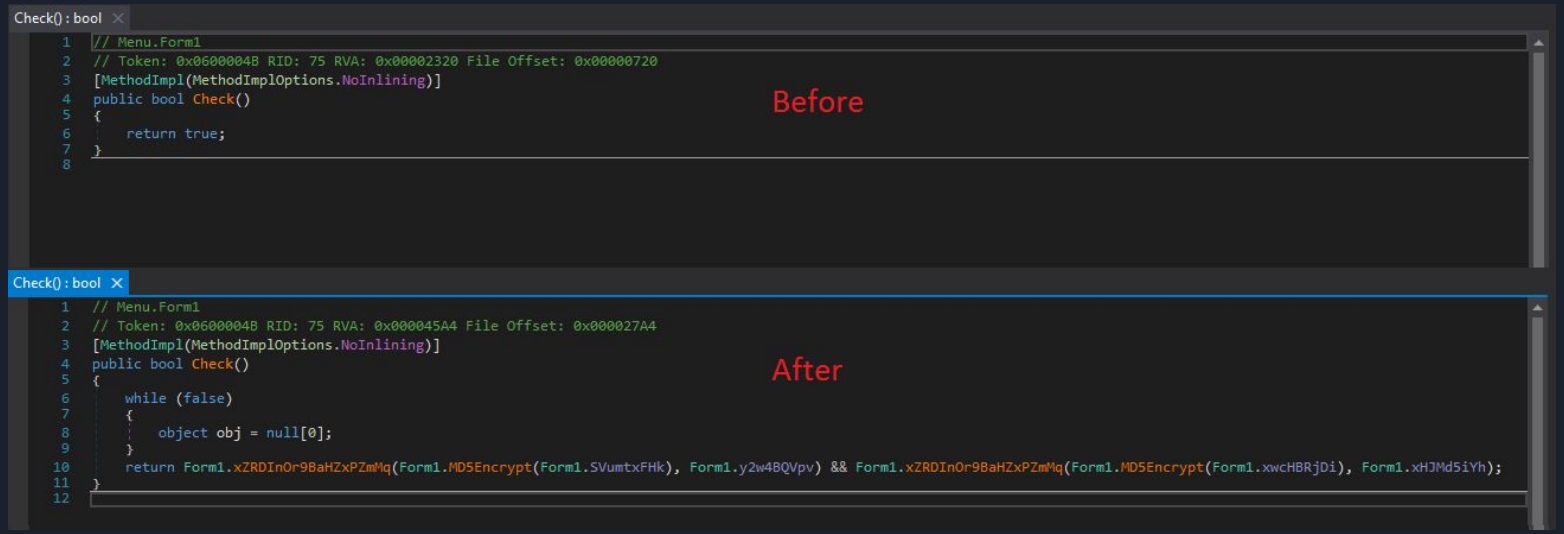
Software Obfuscation

- Let's identify which one is the replacement function. By inspecting the call stack we can identify who called the real *compileMethod*.
- With this information we can now rebuild the the assembly with the real method body



Software Protection



Q&A

Thanks!

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References

- Analyzing the nasty .NET protection of the Ploutus.D malware.
  - http://antonioparata.blogspot.it/2018/02/analyzing-nasty-net-protection-of.html
- .NET Instrumentation via MSIL bytecode injection
  - http://www.phrack.org/papers/dotnet_instrumentation.html
- MASTERMIND BEHIND EUR 1 BILLION CYBER BANK ROBBERY ARRESTED IN SPAIN
  - https://www.europol.europa.eu/newsroom/news/mastermind-behind-eur-1-billion-cyber-bank-robbery-arrested-in-spain
- New Variant of Ploutus ATM Malware Observed in the Wild in Latin America
  - https://www.fireeye.com/blog/threat-research/2017/01/new_ploutus_variant.html
- Ploutus-D Malware turns ATMs into IoT Devices
  - https://www.zingbox.com/blog/ploutus-d-malware-turns-atms-into-iot-devices/