Solution to zaas's Old_KeygenMe_2010

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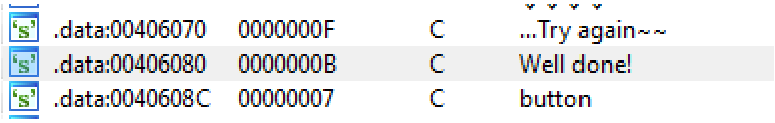
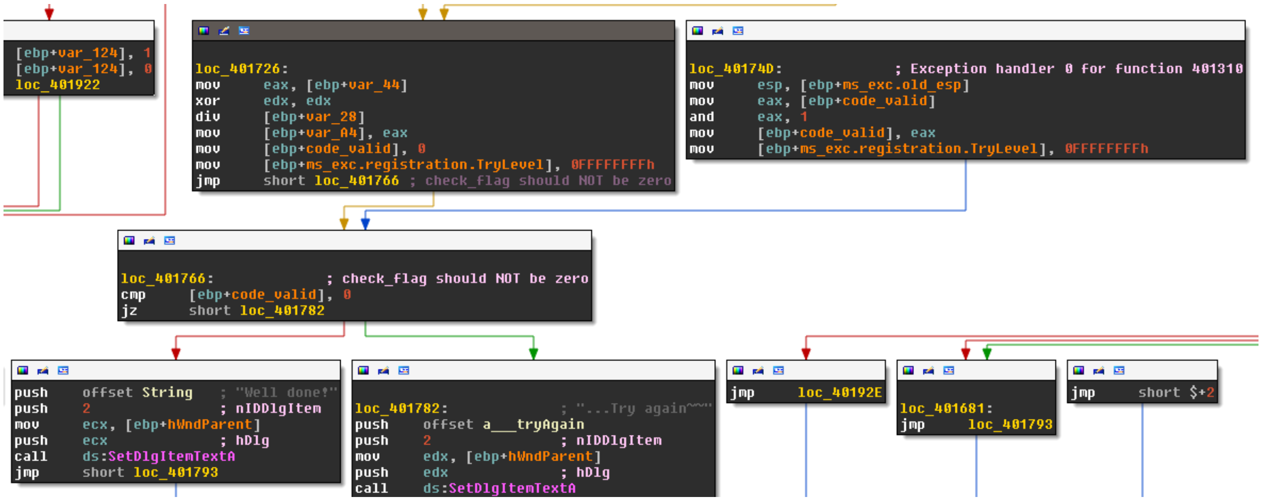
An Exceptional Path



```
.data:00406070    0000000F    C    ...Try again~~
.data:00406080    0000000B    C    Well done!
.data:0040608C    00000007    C    button
```

Figure 1: Bad boy and Good boy message

I used IDA Pro to solve this crackme. First I searched for the good boy message by looking at the strings, see Figure 1. There is one reference to the good boy message "Well done!", see Figure 2.



```
[ebp+var_124], 1
[ebp+var_124], 0
loc_401922
```

```
loc_401726:
mov     eax, [ebp+var_44]
xor     edx, edx
div     [ebp+var_28]
mov     [ebp+var_A4], eax
mov     [ebp+code_valid], 0
mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
jmp     short loc_401766 ; check_flag should NOT be zero
```

```
loc_40174D:                 ; Exception handler 0 for function 401310
mov     esp, [ebp+ms_exc.old_esp]
mov     eax, [ebp+code_valid]
and     eax, 1
mov     [ebp+code_valid], eax
mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
```

```
loc_401766:                 ; check_flag should NOT be zero
cmp     [ebp+code_valid], 0
jz      short loc_401782
```

```
push    offset String   ; "Well done!"
push    2               ; nIDDlgItem
mov     ecx, [ebp+hWndParent]
push    ecx             ; hDlg
call    ds:SetDlgItemTextA
jmp     short loc_401793
```

```
loc_401782:             ; "...Try again~~"
push    offset a___tryAgain
push    2               ; nIDDlgItem
mov     edx, [ebp+hWndParent]
push    edx             ; hDlg
call    ds:SetDlgItemTextA
```

```
jmp     loc_40192E
```

```
loc_401681:
jmp     loc_401793
```

```
jmp     short $+2
```

Figure 2: Final check to decide between success and failure

A simple check of the stack variable `[ebp-0B0h]`, which I renamed to `code_valid`, decides whether we failed (`code_valid` is False), or succeeded (`name_valid` is True):

```
.text:00401766                cmp     dword ptr [ebp+name_valid], 0
```

Two paths lead up to the check. The left path in Figure 2 ends with the following lines:

```
.text:00401726                mov     eax, [ebp+var_44]
.text:00401729                xor     edx, edx
.text:0040172B                div     [ebp+var_28]
```

```
.text:0040172E                 mov     [ebp+var_A4], eax
.text:00401734                 mov     [ebp+name_valid], 0
.text:0040173E                 mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
.text:00401745                 jmp     short loc_401766 ; check_flag should NOT be zero
```

In Line `.text:00401734` the variable `name_valid` is set to `False`, so this path can't be it. The right path looks better:

```
.text:0040174D loc_40174D:                             ; DATA XREF: .rdata:stru_405118o
.text:0040174D           mov    esp, [ebp+ms_exc.old_esp] ; Exception handler 0 for function 401310
.text:00401750                 mov     eax, [ebp+name_valid]
.text:00401756                 and     eax, 1
.text:00401759                 mov     [ebp+name_valid], eax
.text:0040175F                 mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
```

Line `.text:00401759` sets `name_valid` to True. The problem with this block is that seemingly no path, i.e., arrows in IDA's graph view, lead to to those lines. That is because it is an "Exception handler 0 for function 401310" as IDA Pro recognized and commented in line `.text:0040174D`. The exception handler takes care of all exception thrown inside the first level try block inside the routine `401310`. We find the start of this try block a couple of lines backwards from the good boy check:

```
.text:00401686            mov    [ebp+ms_exc.registration.TryLevel], 0 ; start of try block
```

The try block ends here:

```
.text:0040173E                 mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
```

To get to the good boy message, we need to trigger an exception inside the try block.

Valid Names

Let's see what happens with the name and code after we hit `OK`. Going back a few block inside the subroutine `401310` we find the characteristic lines that read the values of the two input boxes::

```
.text:00401639                 push    32h             ; cchMax
.text:0040163B                 lea     edx, [ebp+name]
.text:00401641                 push    edx             ; lpString
.text:00401642                 push    1               ; nIDDlgItem
.text:00401644                 mov     eax, [ebp+hWndParent]
.text:00401647                 push    eax             ; hDlg
.text:00401648                 call    ds:GetDlgItemTextA
.text:0040164E                 mov     [ebp+name_length], eax ; name_length
.text:00401654                 push    32h             ; cchMax
.text:00401656                 lea     ecx, [ebp+code]
.text:0040165C                 push    ecx             ; lpString
.text:0040165D                 push    2               ; nIDDlgItem
.text:0040165F                 mov     edx, [ebp+hWndParent]
.text:00401662                 push    edx             ; hDlg
.text:00401663                 call    ds:GetDlgItemTextA
.text:00401669                 mov     [ebp+code_length], eax ; code_length
.text:0040166F                 cmp     [ebp+name_length], 0
.text:00401676                 jz      short loc_401681
.text:00401678                 cmp     [ebp+code_length], 0
```

This snippet fetches the content of both input boxes and checks if they contain text. If they do, the code enters the `try`-block (so any exception thrown from now on gives us the good boy message)::

```
.text:00401686 ; ---------------------------------------------------------------------------
.text:00401686
.text:00401686 loc_401686:                             ; CODE XREF: sub_401310+36Fj
.text:00401686            mov    [ebp+ms_exc.registration.TryLevel], 0 ; start of try block
.text:0040168D                 cmp     [ebp+name_length], 4
.text:00401694                 jb      short loc_40169F
.text:00401696                 cmp     [ebp+code_length], 4
.text:0040169D                 jnb     short loc_4016B1
.text:0040169F
.text:0040169F loc_40169F:                             ; CODE XREF: sub_401310+384j
.text:0040169F                 xor     eax, eax
.text:004016A1                 cmp     [ebp+name_valid], 0
.text:004016A8                 setz    al
.text:004016AB                 mov     [ebp+name_valid], eax ; check_flag = 0
.text:004016B1
.text:004016B1 loc_4016B1:                             ; CODE XREF: sub_401310+38Dj
.text:004016B1                 mov     [ebp+i], 0
.text:004016BB                 jmp     short loc_4016CC
.text:004016BD ; ---------------------------------------------------------------------------
```

The code checks if the length of the `name` field is at least 4 characters. If not, it sets the variable `[ebp+name_valid]` to `False`. Otherwise, the variable stays at `True` as set in line `40162F`::

```
.text:0040162F                 mov     [ebp+name_valid], 1
```

If the name has at least four characters we enter a loop::

```
.text:004016B1 loc_4016B1:                             ; CODE XREF: sub_401310+38Dj
.text:004016B1                 mov     [ebp+i], 0
.text:004016BB                 jmp     short loc_4016CC
.text:004016BD ; ---------------------------------------------------------------------------
.text:004016BD
.text:004016BD loc_4016BD:                             ; CODE XREF: sub_401310+3EEj
.text:004016BD                 mov     ecx, [ebp+i]    ; increment
.text:004016C3                 add     ecx, 1
.text:004016C6                 mov     [ebp+i], ecx
.text:004016CC
.text:004016CC loc_4016CC:                             ; CODE XREF: sub_401310+3ABj
.text:004016CC                 mov     edx, [ebp+i]
.text:004016D2                 cmp     edx, [ebp+name_length]
.text:004016D8                 jnb     short loc_401700
.text:004016DA                 mov     eax, [ebp+i]
.text:004016E0                 mov     cl, [ebp+eax+name] ; name[i]
.text:004016E7                 push    ecx
.text:004016E8                 call    sub_4019A0
.text:004016ED                 add     esp, 4
.text:004016F0                 mov     edx, [ebp+name_valid]
.text:004016F6                 and     edx, eax
.text:004016F8           mov    [ebp+name_valid], edx ; if not sub_4019A0(c): check_flag = False
.text:004016FE                 jmp     short loc_4016BD ; increment
```

This code snippet iterates over all characters in `name`. It calls a routine `sub_4019A0` for all characters in `name`, and updates the `name_valid` flag based on the return value of `sub_4019A0`:

```
name_valid = name_valid && sub_4019A0(name[i])
```

So `sub_4019A0` is most likely a check for valid characters. If one of the characters in name is invalid, the flag `name_valid` becomes False (and stays False). The routine `sub_4019A0` is::

```
.text:004019A0 sub_4019A0      proc near               ; CODE XREF: sub_401310+3D8p
.text:004019A0
.text:004019A0 character       = byte ptr  4
.text:004019A0
.text:004019A0 c = al
.text:004019A0                 mov     c, [esp+character]
.text:004019A4                 cmp     c, '/'
.text:004019A6                 jle     short no_numbers ; jump if below numbers
.text:004019A8                 cmp     c, ':'
.text:004019AA                 jl      short loc_4019BC ; jump if number
.text:004019AC
.text:004019AC no_numbers:                             ; CODE XREF: sub_4019A0+6j
.text:004019AC                 cmp     c, 'A'
.text:004019AE                 jl      short loc_4019B4 ; jump if not letter
.text:004019B0                 cmp     c, 'Z'
.text:004019B2                 jle     short loc_4019BC ; jump if capital letter
.text:004019B4
.text:004019B4 loc_4019B4:                             ; CODE XREF: sub_4019A0+Ej
.text:004019B4                 cmp     c, 'a'
.text:004019B6                 jl      short loc_4019C2 ; jump if special
.text:004019B8                 cmp     c, 'z'
.text:004019BA                 jg      short loc_4019C2 ; jump if lower case letter
.text:004019BC
.text:004019BC loc_4019BC:                             ; CODE XREF: sub_4019A0+Aj
.text:004019BC                                         ; sub_4019A0+12j
.text:004019BC                 mov     eax, 1          ; return True
.text:004019C1                 retn
.text:004019C2 ; ---------------------------------------------------------------------------
.text:004019C2
.text:004019C2 loc_4019C2:                             ; CODE XREF: sub_4019A0+16j
.text:004019C2                                         ; sub_4019A0+1Aj
.text:004019C2                 xor     eax, eax        ; return False
.text:004019C4                 retn
.text:004019C4 sub_4019A0      endp
```

The routine checks if the character is one of the following:

- a digit
- an uppercase letter
- a lowercase letter

In other words, this is the C function isalnum. After checking all characters in name we get to::

```
.text:00401700                 cmp     [ebp+name_valid], 0
.text:00401707                 jz      short loc_401726 ; if name invalid -> failed
```

If the name has at least four characters, and all characters of the name are alpha numeric, then the flag name_valid is still True and we continue, otherwise we jump to loc_401726 and the bad boy message is shown.

The Key Validation

If the name is valid, the following lines are executed::

```
.text:00401709                  lea     eax, [ebp+code]
.text:0040170F                  push    eax
.text:00401710                  lea     ecx, [ebp+name]
.text:00401716                  push    ecx
.text:00401717                  lea     edx, [ebp+var_28]
.text:0040171A                  push    edx
.text:0040171B                  call    sub_401960      ; ecx = code
.text:00401720                  add     esp, 0Ch
.text:00401723                  mov     [ebp+var_44], eax
```

They boil down to:

```
var_44 = sub_401960(var_28, name, code)
```

The routine sub_401960 calculates a value based on the name and code. The first argument of the function var_28 was initialized to 0 before and will probably hold a second return value of sub_401960 (besides the one in <eax>):

```
.text:00401353                  mov     [ebp+var_28], 0
```

So let's have a look at sub_401960::

```
.text:00401960 sub_401960      proc near               ; CODE XREF: sub_401310+40Bp
.text:00401960
.text:00401960 result          = dword ptr  4
.text:00401960 name            = dword ptr  8
.text:00401960 code            = dword ptr  0Ch
.text:00401960
.text:00401960                  mov     ecx, [esp+code]
.text:00401964                  mov     edx, [esp+result] ; starts at 0
.text:00401968                  push    ebx
.text:00401969                  push    ebp
.text:0040196A                  push    esi
.text:0040196B                  mov     esi, [esp+0Ch+name] ; esi = name
.text:0040196F                  push    edi
.text:00401970                  xor     eax, eax        ; sum=0
.text:00401972                  sub     esi, ecx
.text:00401974                  mov     edi, 4          ; repeat four times
.text:00401979
.text:00401979 loc_401979:                             ; CODE XREF: sub_401960+2Cj
.text:00401979                  movsx   ebx, byte ptr [esi+ecx] ; name[i]
.text:0040197D                  mov     ebp, [edx]      ; result
.text:0040197F                  add     eax, ebx        ; sum = sum + name[i]
```

```
.text:00401981                 movsx   ebx, byte ptr [ecx] ; code[i]
.text:00401984                 add     ebx, eax        ; ebx = sum + code[i]
.text:00401986                 add     ebp, ebx        ; result = result + ebx
.text:00401988                 inc     ecx
.text:00401989                 dec     edi
.text:0040198A                 mov     [edx], ebp
.text:0040198C                 jnz     short loc_401979 ; name[i]
.text:0040198E                 mov     ecx, added_to_weighted_sum
.text:00401994                 mov     esi, ebp
.text:00401996                 add     esi, ecx        ; add constant
.text:00401998                 pop     edi
.text:00401999                 mov     [edx], esi
.text:0040199B                 pop     esi
.text:0040199C                 pop     ebp
.text:0040199D                 pop     ebx
.text:0040199E                 retn
.text:0040199E sub_401960      endp
```

The code boils down to the following pseudocode:

```
FUNCTION sub_401960(int* result, char* name, char* code)
    rv = 0
    FOR i = 0 TO 3
        rv += name[i]
        result += sum + code[i]
    END FOR
    result += added_to_weighted_sum
    RETURN rv
END
```

Let n_i, c_i be the ith character of the name and code respectively, and let C be the constant `added_to_weighted_sum`, then the above code calculates:

$$result = \left(\sum_{i=0}^{3} c_i\right) + 4n_3 + 3n_2 + 2n_1 + n_0 + C$$

$$rv = \sum_{i=0}^{3} n_i$$

The return value of `sub_401960` is stored in `[ebp+rv]`.

```
.text:0040171B                 call    sub_401960      ; ecx = code
.text:00401720                 add     esp, 0Ch
.text:00401723                 mov     [ebp+rv], eax
```

Next follow the last lines of our try block::

```
.text:00401726 loc_401726:                             ; CODE XREF: sub_401310+3F7j
.text:00401726                 mov     eax, [ebp+rv]
.text:00401729                 xor     edx, edx
.text:0040172B                 div     [ebp+var_28]
.text:0040172E                 mov     [ebp+var_A4], eax
.text:00401734                 mov     [ebp+code_valid], 0
.text:0040173E                 mov     [ebp+ms_exc.registration.TryLevel], 0FFFFFFFFh
```

Finally we've got an instruction that can throw an exception (the division by zero exception):

```
.text:0040172B                  div     [ebp+var_28]
```

The `div` statement divides what is in `edx:eax` by `var_28`. `edx` is set to zero, and `eax` holds the return value of `sub_401960`. We don't care about these values, because a division by zero exception only occurs when the divisor is zero, regardless of the dividend. The divisor `var_28` was the first argument passed to `sub_401960`, i.e., the `result` of the routine `sub_401960`. **If a name/code pair leads to `result` being 0, an exception is thrown and we solved the crackme**. With the mathematical notation introduced before this means:

$$result = \left(\sum_{i=0}^{3} c_i \right) + 4n_3 + 3n_2 + 2n_1 + n_0 + C \overset{!}{=} 0$$

What is the value of C? If you check the value of `added_to_weighted_sum` with a debugger it is 0 as set in this line::

```
.data:00408570 added_to_weighted_sum dd 0             ; DATA XREF: .text:0040112Ar
```

So how can we get the variable `result` to become zero? The values of n_0 to n_3 are alpha numeric ASCII codes and therefore greater than 0. The values of c_i are the ASCII codes of the code and also positive. So with C being zero there is no way to get the sum in `result` to zero. We need to find a way to change C aka `added_to_weighted_sum`.

A Secret Key Combination

To see how we can change `added_to_weighted_sum` let's check the references to this variable. Outside of `sub_401960` the only other references are inside the following code snippet:

```
.text:00401102                  cmp     pressed_shift_3_before, 0
.text:00401109                  jnz     short loc_40113C
.text:0040110B                  cmp     dword ptr [ebp+pressed_key], '3' ; 3 pressed
.text:0040110F                  jnz     short loc_40113C
.text:00401111                  push    10h
.text:00401113                  call    ds:GetKeyState
.text:00401119                  movsx   eax, ax
.text:0040111C                  test    eax, eax
.text:0040111E                  jge     short loc_40113C
.text:00401120                  mov     pressed_shift_3_before, 1
.text:0040112A                  mov     ecx, added_to_weighted_sum
.text:00401130                  sub     ecx, 586h
.text:00401136                  mov     added_to_weighted_sum, ecx
```

The whole snippet is inside the callback that registers key presses. I renamed some variables to make clearer what the snippet does. It boils down to this:

```
IF NOT pressed_shift_3_before THEN
    IF pressed_key == '3' THEN
        key_state = GetKeyState()
        IF key_state != 0 THEN
            pressed_shift_3_before = True
            added_to_weighted_sum = -0x586
        END IF
    END IF
END IF
```

This means that the first time we press key `3` together with `Shift` (which will give a non zero `KeyState`), the value `added_to_weighted_sum` is set to -586h. On an US keyboard layout this means our code needs to contain the `#` character. We can enter this character at any point before hitting `OK`, we can also enter it more than once. As long as there is the letter `#` somewhere in our code, the constant `added_to_weighted_sum`, i.e., C, becomes 0x586h.

The Keygenerator

We know two things about our code now. First of, it needs to contain `Shift+3` (the hash character on US keyboards, the star `*` on Swiss keyboards and the `§` on German keyboards). Secondly, the following equation must hold:

$$\left(\sum_{i=0}^{3} c_i\right) + 4n_3 + 3n_2 + 2n_1 + n_0 + C \overset{!}{=} 0$$

So with $C = -586h$ we have:

$$\left(\sum_{i=0}^{3} c_i\right) \overset{!}{=} 586h - 4n_3 - 3n_2 - 2n_1 - n_0$$

This condition can be met by many different codes for each name. Here is a simple keygenerator that picks four characters that satisfy the sum, then adds the `#` character to trigger the code to set the `added_to_weighted_sum` alias C value::

```
import string
import argparse

def keygen(name):
    code_sum = 0x586
    for i in range(4):
        code_sum -= (4-i)*ord(name[i])

    nice_ascii = string.ascii_letters + string.digits
    nice_ascii_nr = [ord(c) for c in nice_ascii]
    code_list = 4*[0]
    for i in  range(3):
        avg = (code_sum - sum(code_list)) // (4-i)
        code_list[i] = min(nice_ascii_nr, key=lambda x: abs(x-avg))
    code_list[3] = code_sum - sum(code_list)
    code = "".join([chr(c) for c in code_list] )
    return code

parser = argparse.ArgumentParser("Keygen for Old_KeygenMe.exe")
parser.add_argument("name")
args = parser.parse_args()
if len(args.name) < 4:
    print("Name must have at least 4 characters")
    quit()
code = keygen(args.name)
print("enter the following code: {}".format(code))
print("next enter SHIFT+3 and hit OK")
print("-> so on US keyboards enter: {}".format(code+"#"))
```

Here's a test::

```
> keygen.py sheldon
enter the following code: SSSS
next enter SHIFT+3 and hit OK
-> so on US keyboards enter: SSSS#
```