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Flare-On 6 CTF WriteUp (Part 8)

16.OCT.2019 . 4 MIN READ

This is the eighth part of the Flare-On 6 CTF WriteUp Series.

8 - snake

The challenge reads

> *The Flare team is attempting to pivot to full-time twitch streaming video games instead of reverse engineering computer software all day. We wrote our own classic NES game to stream content that nobody else has seen and watch those subscribers flow in. It turned out to be too hard for us to beat so we gave up. See if you can beat it and capture the internet points that we failed to collect.*

Different from others, challenge 8 deals with reversing a NES Rom named *snake.nes*. We will be using the Mesen emulator for running the Rom. Among other features, Mesen

Barun

Reverse Engineer with an interest in low level stuff and anything about security.

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will be using the Mesen emulator for running the Rom. Among other features, Mesen supports debugging the assembly code which is integral for our purpose. The processor on the NES runs 6502 assembly. Without further ado, let's give the game a try.

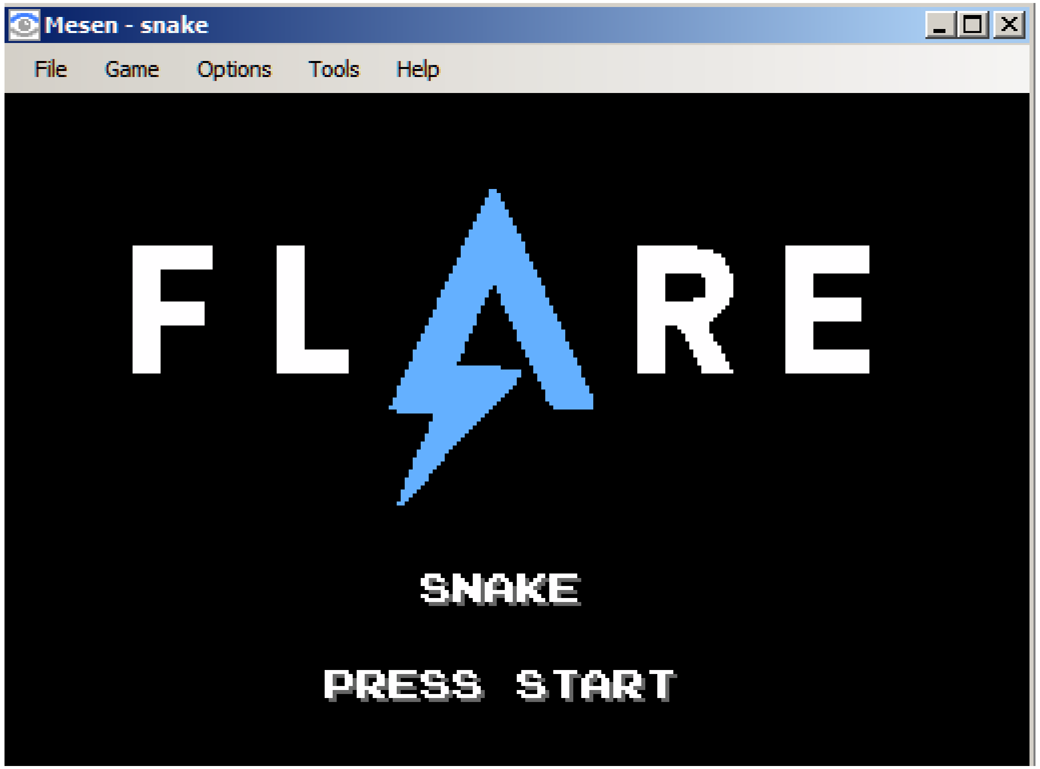

Figure 1: The starting window

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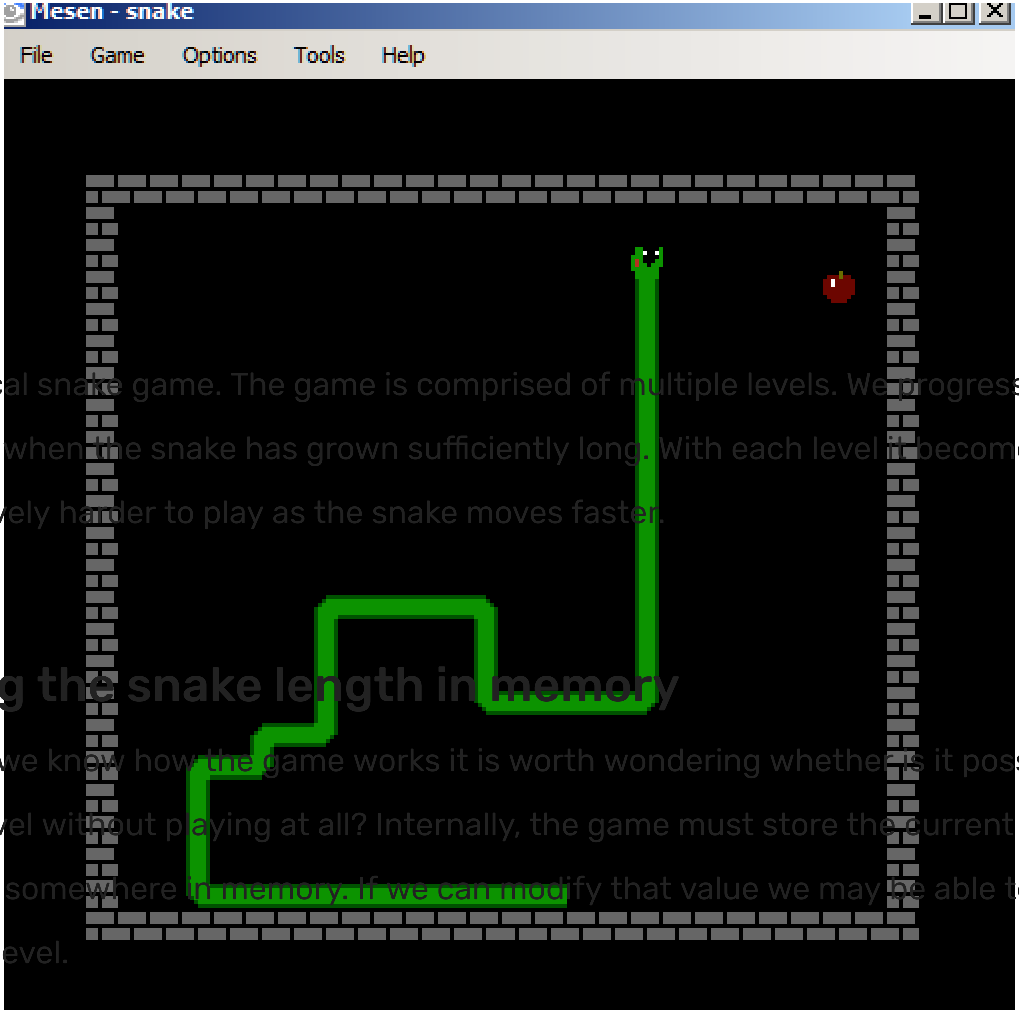

It's a typical snake game. The game is comprised of multiple levels. We progress to the next level when the snake has grown sufficiently long. With each level it becomes progressively harder to play as the snake moves faster.

Finding the snake length in memory

Now that we know how the game works it is worth wondering whether is it possible to finish a level without playing at all? Internally, the game must store the current length of the snake somewhere in memory. If we can modify that value we may be able to bypass playing a level.

5.

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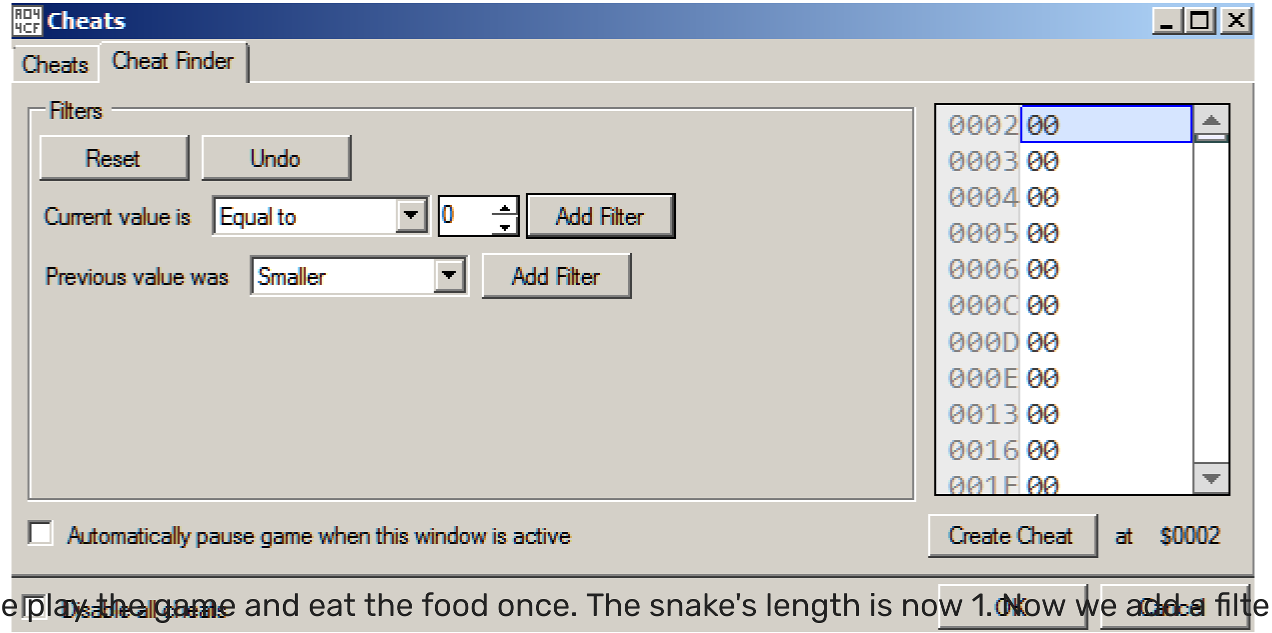
Figure 2: A typical snake game

Mesen offers cheating functionality like the venerable Cheat Engine. Start a new Game and pause it immediately. Now go to Tools -> Cheats. Initially, the length of the snake is 0. In the Cheat Finder tab, we add a filter for Current value is Equal to 0.



Cheats

Cheats | Cheat Finder

Filters

Reset | Undo

Current value is: Equal to, 0 — Add Filter

Previous value was: Smaller — Add Filter

```
0002 00
0003 00
0004 00
0005 00
0006 00
000C 00
000D 00
000E 00
0013 00
0016 00
001F 00
```

☐ Automatically pause game when this window is active

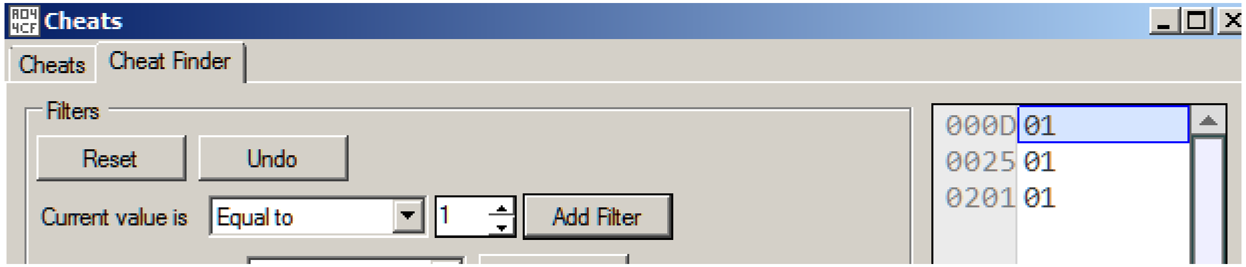
Create Cheat at $0002

☐ Disable all cheats

OK | Cancel

Figure 3: Using Cheat Finder

We play the game and eat the food once. The snake's length is now 1. Now we add a filter for current value is equal to 1. We get three possible memory locations.



Cheats

Cheats | Cheat Finder

Filters

Reset | Undo

Current value is: Equal to, 1 — Add Filter

```
000D 01
0025 01
0201 01
```

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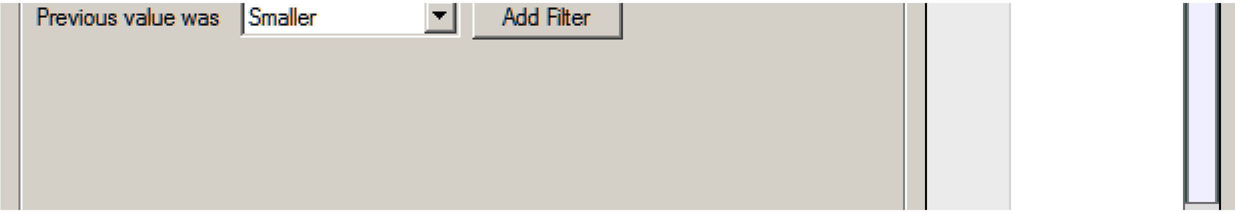
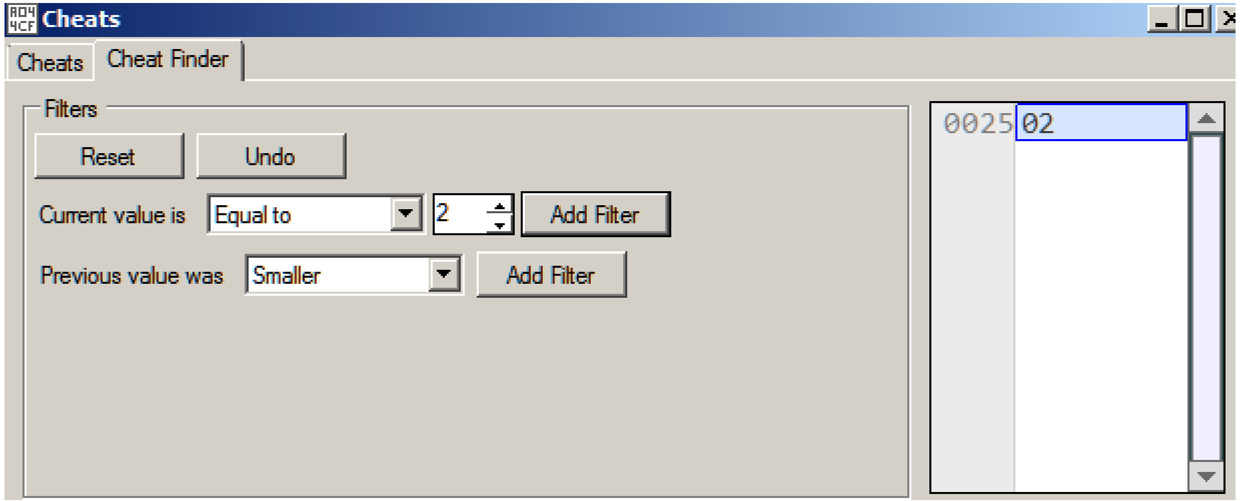

Previous value was Smaller

Figure 4: Three possible locations

Continuing in the same way, we just get a single hit when the snake's length is 2.



Current value is Equal to 2

Previous value was Smaller

```
0025 02
```

Figure 5: Snake length is stored at address 0x25

Thus 0x25 is the address of the memory where the length of the snake is stored. Now we need to locate the code that writes to this address. This can be done in Mesen by setting a Write Breakpoint. Open the Memory viewer in Debug view and navigate to address 0x25 where the snake length is stored.

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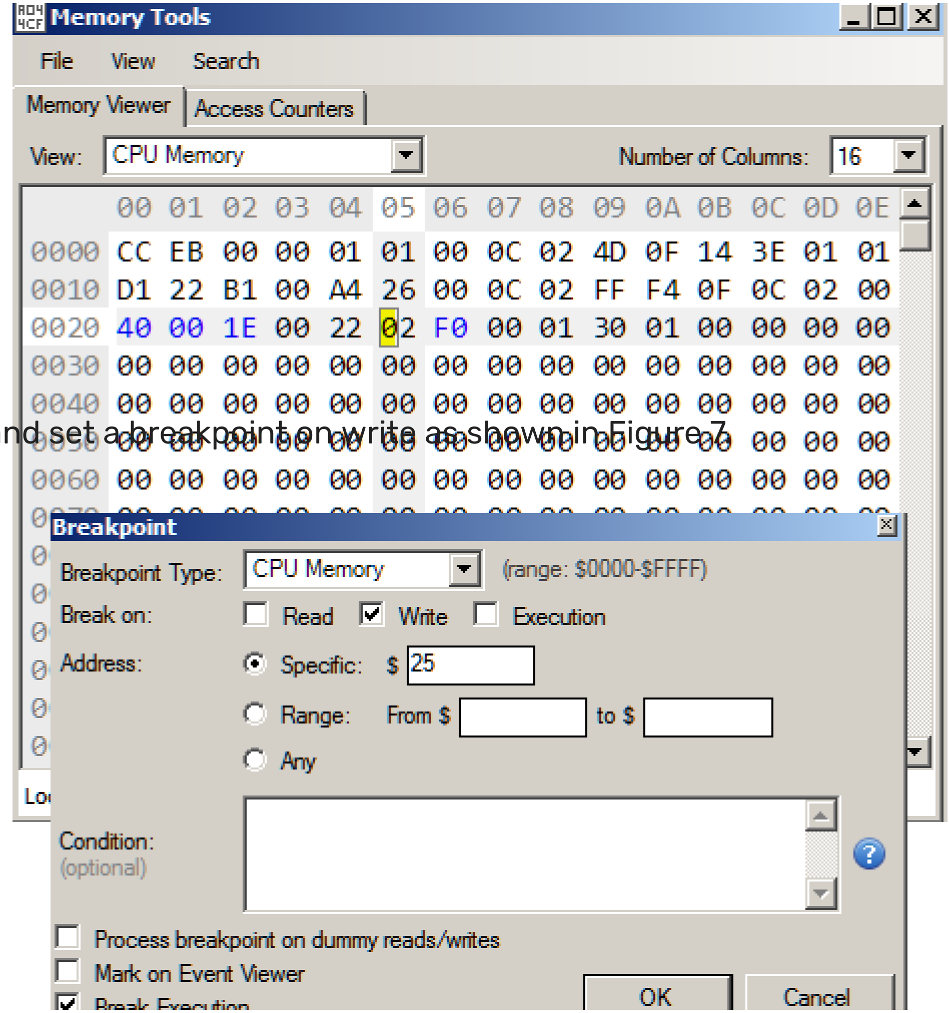

View: CPU Memory Number of Columns: 16

```
      00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E
0000  CC EB 00 00 01 01 00 0C 02 4D 0F 14 3E 01 01
0010  D1 22 B1 00 A4 26 00 0C 02 FF F4 0F 0C 02 00
0020  40 00 1E 00 22 02 F0 00 01 30 01 00 00 00 00
0030  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0040  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0050  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0060  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Breakpoint Type: CPU Memory (range: $0000-$FFFF)

Break on: □ Read ☑ Write □ Execution

Address: ● Specific: $ 25

○ Range: From $ to $

○ Any

Condition: (optional)

□ Process breakpoint on dummy reads/writes

□ Mark on Event Viewer

☑ Break Execution

Right click and set a breakpoint on write as shown in Figure 7.

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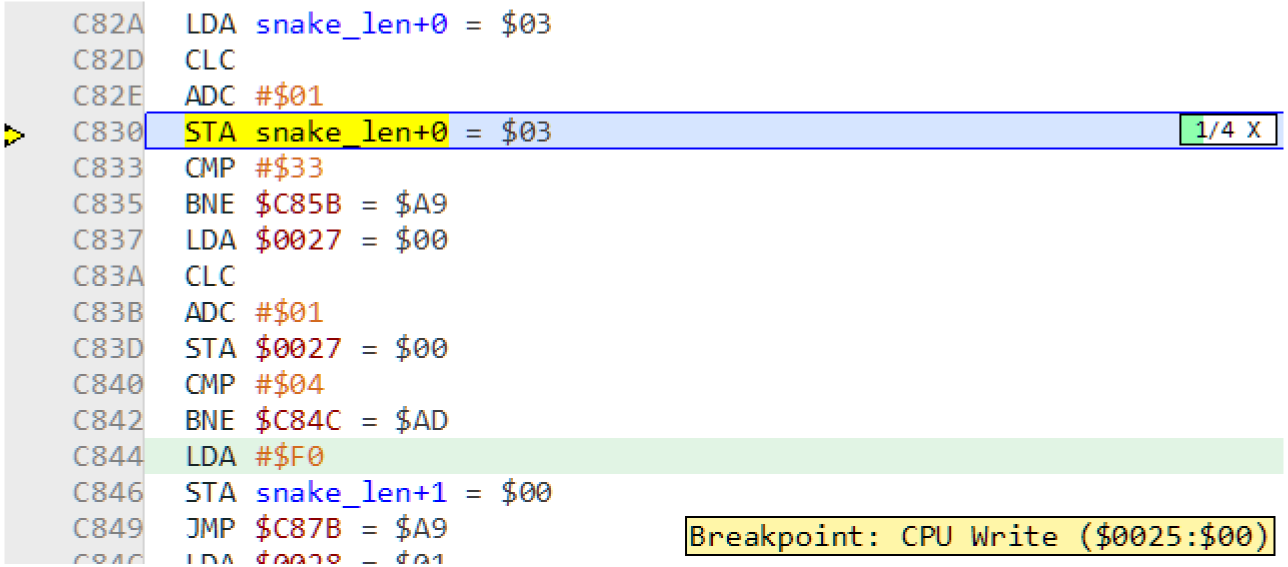
Figure 7: Setting a memory write breakpoint

We continue playing the game and just after the snake eats the food the breakpoint triggers.



```
 C82A  LDA snake_len+0 = $03
 C82D  CLC
 C82E  ADC #$01
>C830  STA snake_len+0 = $03                                    1/4 X
 C833  CMP #$33
 C835  BNE $C85B = $A9
 C837  LDA $0027 = $00
 C83A  CLC
 C83B  ADC #$01
 C83D  STA $0027 = $00
 C840  CMP #$04
 C842  BNE $C84C = $AD
 C844  LDA #$F0
 C846  STA snake_len+1 = $00
 C849  JMP $C87B = $A9             Breakpoint: CPU Write ($0025:$00)
 C84C  LDA $0028 = $01
```

Figure 8: The breakpoint hits

The code at C830 tried to write to the address at 0x25 which triggered the breakpoint. After incrementing the length it goes on to check if it equals 0x33. If not it jumps to C85B. Thus our snake has to be 0x33 units long in order to progress to the next level. We can set the memory to 0x33 to cheat our way to the next level, but there is an even easier way.

Recall, that the game is comprised of multiple levels. The code from C837 to C840

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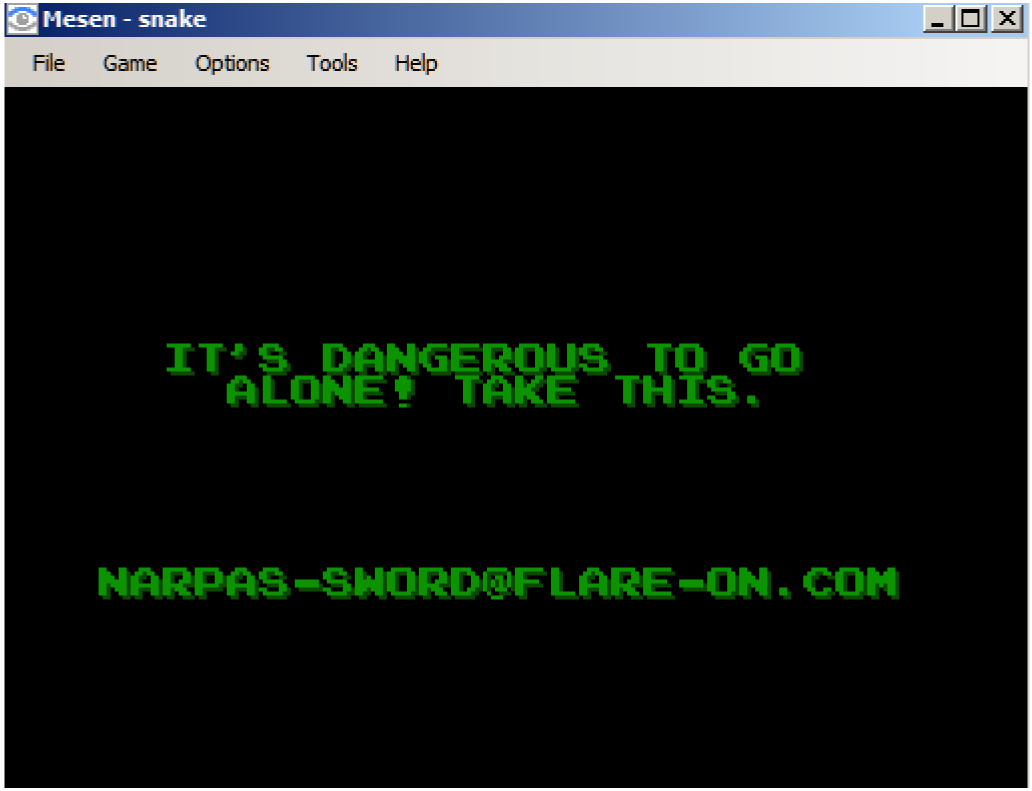
increments the current level when our snake is of length 0x33. At C840 the current level number is compared with 4 which implies there are that many levels. If our current level number is not 4, we jump to C84C or else we continue normally to C844.

Winning the game

If we set the Instruction Pointer to C844 we can bypass playing the game totally. This can be done in Mesen using "Set Next Statement" in the right click pop up menu. Jumping to the address and resuming execution we are pleasantly greeted with the flag.



IT'S DANGEROUS TO GO
ALONE! TAKE THIS.

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Figure 9: The flag!

Flag: `NARPAS-SWORD@FLARE-ON.COM`

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