

# Speak of the Devil: Runtime Disassembly and a Live Demo

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Back when I was using Windows 7, I was gamehacking with Cheat Engine.

I made a cheat table that wrote integers to `[400000+f59f00]+184` which was the address that stored game currency.

The Entertainment Software Association (ESA) (used to) target Cheat Engine and forums with copyright infringement claims.

Cheat Engine :: View topic - what happened

<https://archive.is/suleX>

## About the game

Devil May Cry 4 is a singleplayer action game written in C++ and released for Windows (x86).

- ▶ There is no in-game economy that ordinarily justifies real-money transactions.
- ▶ Offline except for Steam achievements.
- ▶ No sign of an interpreter such as Lua or Python.

## The weird notation I am using

Cheat Engine uses a notation for pointer paths that look like

`[[0x400000 + base offset] + offset1] + offset2`

In this case `[400000+f59f00]+184` equals

```
; ecx is the game mediator
; uchar** base_address = (uchar**)0x1359F00;
; uchar* ecx = *base_address;
```

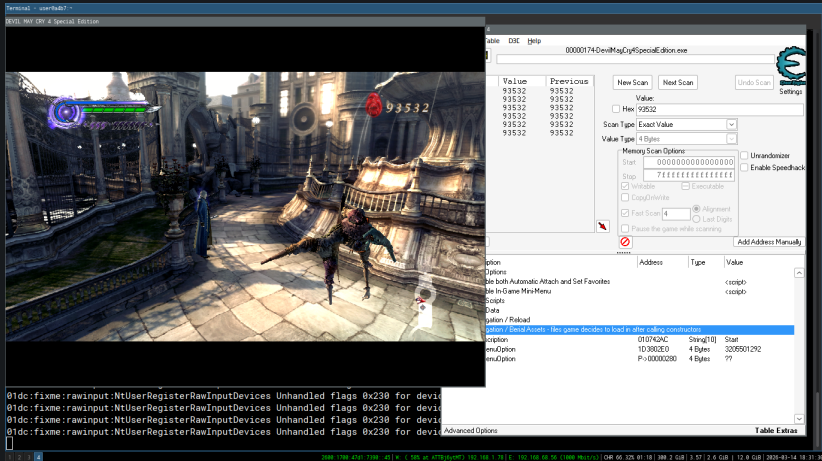
```
mov ecx, [400000+f59f00]
```

```
; ebx is the address of mediator -> currency
; int *ebx = ecx + 184;
```

```
lea ebx, [ecx+184]
```

# Gamehacking Basics

1. Scan memory for a value such as currency (Red Orbs, top right).
  - ▶ Check for increase when the player character collects.
  - ▶ Repeat until the results narrow down to one or a few results.



The screenshot displays a gamehacking tool interface. On the left, a game window shows a character in a fantasy setting with a red orb icon and the number '93532' above it. The game title bar reads 'DEVIL MAY CRY 4 Special Edition'. Below the game window, a terminal window shows the following text:

```
01dc:fxime:rawinput:NtUserRegisterRawInputDevices Unhandled flags 0x230 for device
01dc:fxime:rawinput:NtUserRegisterRawInputDevices Unhandled flags 0x230 for device
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01dc:fxime:rawinput:NtUserRegisterRawInputDevices Unhandled flags 0x230 for device
```

On the right, the memory scanner interface is shown. The title bar reads '00000174-DevilMayCry4SpecialEdition.exe'. The scanner has a table of results:

Value	Previous
93532	93532
93532	93532
93532	93532
93532	93532
93532	93532
93532	93532

The scanner also has a 'Value' field set to '93532', a 'Scan Type' of 'Exact Value', and a 'Value Type' of '4 Bytes'. The 'Memory Scan Options' section includes checkboxes for 'Unrandomizer', 'Enable Speedhack', 'Writable', and 'Executable'. The 'Fast Scan' option is checked and set to '4'. The 'Pause the game while scanning' option is unchecked. The 'Advanced Options' section is visible at the bottom right.

## Gamehacking Basics: Step Two

Find out what writes to this address

F6

```
# watch for writes at (-l)ocation
```

```
(gdb) watch -l *0xADDRESS
```

```
rsi=0x1ae38d60
```

Dump of assembler code from 0x59a4f0 to 0x59a518:

```
0x...59a4f0: add    DWORD PTR [rsi+0x184],edi
0x...59a4f6: add    DWORD PTR [rsi+0x188],edi
0x...59a4fc: cmp    DWORD PTR [rsi+0x184],0x98967f
0x...59a506: jle    0x59a512
0x...59a508: mov    DWORD PTR [rsi+0x184],0x98967f
0x...59a512: cmp    BYTE PTR [rsi+0x1c],0x0
0x...59a516: jne    0x59a521
```

End of assembler dump.

## Quick x86-64 register reference

64-bit	32-bit	16-bit	8-bit	Purpose
rax	eax	ax	ah,al	General
rbx	ebx	bx	bh,bl	General
rcx	ecx	cx	ch,cl	General
rdx	edx	dx	dh,dl	General
rsi	esi	si	sil	“Source Index”
rdi	edi	di	dil	“Destination Index”
rbp	ebp	bp	bpl	Frame Pointer
rsp	esp	sp	spl	Stack Pointer

# Memory Scanning Can Only Take You So Far

Memory scanning becomes less effective for booleans and floating point values between 0 and 1.

- ▶ If you're playing a game that needs 8 GB of RAM, the amount of bytes set to 0 at a given time will be in the hundreds of thousands at least.
- ▶ Scanning also stops being effective for variables that will only change once or a few times.
- ▶ Example: skipping a cutscene that will only play once in a mission.

# Mediator?

**Mediator** is a software design pattern where an object (“the mediator”, typically a singleton) handles interactions between subcomponents and subordinate objects, typically to reduce dependencies and coupling.

- ▶ If a game uses this software design pattern and you find the address of the Mediator, setting a watchpoint will reveal instructions that handle collision, cutscene, event flags, etc.

## In C++ something may have looked like

```
class Mediator {
    // can't tell public or private from disassembler
public:
    // ...
    GameEntity *camera;
    GameEntity *player_character;
    GameEntity *boss;
    List *enemies;
    // ...
    uint red_orbs;           // +184
    uint red_orbs2;         // +188
    uint red_orbs_collected; // +18c
    uint red_orbs_spawned;  // +190
    // ...
}
```

## Writing to addresses

When you have pointer paths, you can modify values stored in addresses.

```
newmem:
```

```
; esi = mediator
```

```
originalcode:
```

```
; add edi = currency_spawned
```

```
; to mediator.total_currency_spawned
```

```
add [esi+00000190],edi
```

```
newcode:
```

```
push eax ; save eax to stack
```

```
mov eax, [esi+190] ; eax = ...total_currency_spawned
```

```
mov [esi+18c], eax ; mediator.currency_collected = eax
```

```
pop eax ; restore eax from stack
```

# Writing New Instructions

But when you inject code, your new instruction must have the same number of bytes as the code you are replacing.

```
[disable]
```

```
DevilMayCry4SpecialEdition.exe+4CD933:
```

```
; FE 81 60 24 00 00 (little endian!)
```

```
inc byte ptr [ecx+00002460]
```

```
[enable]
```

```
DevilMayCry4SpecialEdition.exe+4CD933:
```

```
; do nothing instead of
```

```
; counting double jumps
```

```
db 90 90 90 90 90 90
```

## Code Injection continued

If the size of your new code exceeds the size of the original code, either use a **code cave** or allocate new memory.

```
[enable]
alloc(newmem,289)
registersymbol(next_stage)
alloc(next_stage, 2)

next_stage:
db 0 ; initialization, this will update per stage

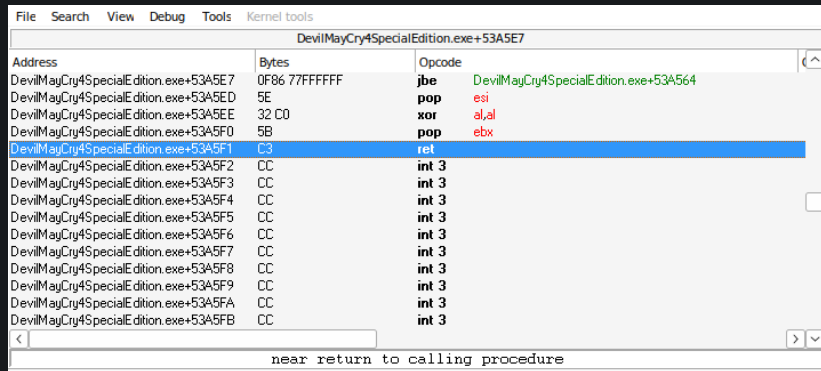
originalcode:
mov [eax+00000088],edx

"DevilMayCry4SpecialEdition.exe"+152461:
jmp newmem
nop
returnhere:
```

## If you're wondering what a code cave is

Compilers typically add padding between functions such as `nop` (90) or `int3` (CC).

A jump to this unused space can be done instead of allocating new memory.



Address	Bytes	Opcode
DevilMayCry4SpecialEdition.exe+53A5E7	0F86 77FFFFFF	<b>jbe</b> DevilMayCry4SpecialEdition.exe+53A564
DevilMayCry4SpecialEdition.exe+53A5E8	5E	<b>pop</b> esi
DevilMayCry4SpecialEdition.exe+53A5E9	32 C0	<b>xor</b> al,al
DevilMayCry4SpecialEdition.exe+53A5EA	5B	<b>pop</b> ebx
DevilMayCry4SpecialEdition.exe+53A5F1	C3	<b>ret</b>
DevilMayCry4SpecialEdition.exe+53A5F2	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F3	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F4	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F5	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F6	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F7	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F8	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5F9	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5FA	CC	<b>int 3</b>
DevilMayCry4SpecialEdition.exe+53A5FB	CC	<b>int 3</b>

near return to calling procedure

Any questions?

## Before moving onto the live demo

I am currently running Linux and playing the game through Wine.

Everything I wrote in x86 assembly works as it did before.

Some scripts I wrote in Lua do not work, especially D3Dhooks.

Attaching the Cheat Engine debugger within Wine causes a crash.

The CE-like frontend for gdb and libscanmem is kind of janky.

# Cheat Table Features

Basic cheats:

- ▶ Infinite double jumps, health, “mana”
- ▶ Disable timed events

The cool scripts:

- ▶ Auto-skip cutscenes
- ▶ Disable collision
- ▶ Kill everything in 1-hit
- ▶ Add boss rush mode

Unusual hacks:

- ▶ Rescale player or enemy models & hitboxes
- ▶ Instant enemy Devil Trigger
- ▶ Custom difficulty (more spawns + highest difficulty setting)

And more.