SIGPwny

General SP2026 • 2026-04-05

Game Hacking II

Tyler Mercado

Announcements

- DiceCTF 2025 Quals on 3/28, the Friday after spring break!
  - Starts at 4:00 pm, come in person!

ctf.sigpwny.com

sigpwny{v4ngu4rd_c4n7_c47ch_m3}

Last time on Game Hacking

Game Hacking I covered how cheats work:

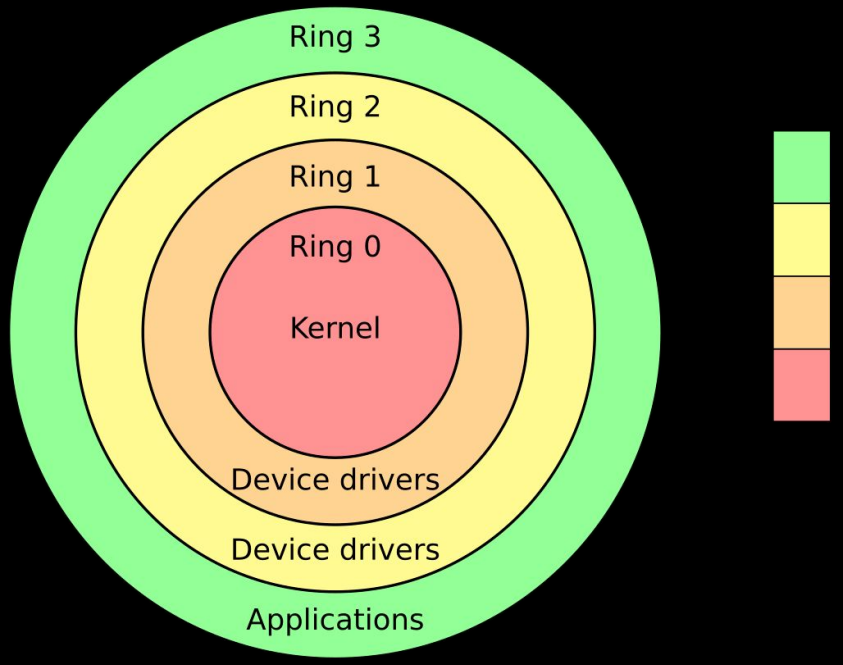
- Memory patching & manipulation
- DLL injection (traditional + manual mapping)
- Function hooking (inline + JIT)
- External vs. Internal cheats
- Reversing structs & vtables

But how do they get caught?

The Privilege Ring Ladder

- Ring 3 (User Mode): Vac
- Ring 0 (Kernel Mode): EAC, BattleEye
- Ring 0 + Boot: Vanguard
- Ring -1/-2: Covered in GH-I (hypervisors, SMM)

We’re climbing this ladder today.



VAC: The Classic Anti-Cheat

- Valve Anti-Cheat: purely user-mode (Ring 3)
- Gabe Newell: prefers security through obscurity combined with delayed ban waves
- No BSODs. No driver conflicts. Cross-platform.

- Trade off: can’t see kernel-level cheats.

VAC Architecture

Three-tier design:

- Valve Servers -> steam encrypted modules
- steamservice.dll -> orchestrator (32-bit)
- VAC Modules -> run in dedicated threads

Notes:

- Modules are not embedded in steam binaries
- Streamed dynamically at runtime
- Each module owns its own thread
- All VAC code is 32-bit (x86)

The VAC Module System

Modules encrypted with RSA + ICE cipher

- ICE key derived from LCG seeded by __rdtsc()
- Custom VLV PE header format
- All modules export _runfunc@20

4 known modules types:

- SystemInfo - hardware fingerprinting
- ProcessHandleList - handle enumeration
- ProcessMonitor - process scanning
- DriverInfo - driver inspection

VAC Module Loader

- VAC_LoadModule @ 0x1005bab0
- Two loading paths:
  - Manual mapping (anti-dump)
  - Standard LoadLibrary
- Both resolve “__runfunc@20” via GetProcAddress

- steamservice.dll - 3.6MB, thousands of imports, no obfuscation

PE ▾ Linear ▾ High Level IL ▾

```
void* __stdcall VAC_LoadModule(char* arg1, char arg2)
1005bbf3                        var_28 = nullptr
1005bbf3
1005bbfa                    int32_t var_24_1 = 0
1005bbfa
1005bc01                sub_100efe50()
1005bc0f                (*(data_10475bf8 + 0x1c))(arg1, 0)
1005bb60            else
1005bb69                int32_t* eax_7 = VAC_ManualMapModule(*(esi + 0x18), 0, 1)
1005bb71                *(esi + 8) = eax_7
1005bb71
1005bb76                if (eax_7 == 0)
1005bb9d                    *(esi + 0x10) = 0x16
1005bb76                else
1005bb7e                    int32_t eax_8 = VAC_ManualMap_GetExport(eax_7, "_runfunc@20")
1005bb86                    *(esi + 0xc) = eax_8
1005bb86
1005bb8b                    if (eax_8 == 0)
1005bb91                        *(esi + 0x10) = 0x19
1005bb91
1005bce8            if (*(esi + 0xc) == 0)
1005bced                sub_1005c0d0(esi)
1005bcf3                void* eax_17
1005bcf3                eax_17.b = 0
1005bcf9                return eax_17
1005bcf9
1005bcfc            bool cond:4_1 = *(esi + 0x18) == 0
1005bd05            int32_t ecx_9 = data_10471f6c
1005bd0b            *(esi + 0x20) = data_10471f68
1005bd0e            *(esi + 0x24) = ecx_9
1005bd0e
1005bd11            if (not(cond:4_1))
1005bd13                sub_100efe50()
1005bd21                (*(data_10475bf8 + 0x1c))(*(esi + 0x18), 0)
1005bd24                *(esi + 0x18) = 0
1005bd24
1005bd2c        eax.b = 1
1005bd32        return eax
```

VAC Detection Techniques

- Signature scanning of known cheats in process memory
- Process handle enumeration
- IAT/VMT hook detection
- File hash checking
- ConVr manipulation detection (CS2-specific)
- DNS cache scanning (yes, really - more on this next)

The DNS Cache incident (2014)

- VAC scanned DNS cache to check if players visited known cheat DRM servers.
- Public outcry. Privacy concerns.
- Worked for ~13 days before cheat devs adapted
- Even user-mode scanning has privacy implications

Why VAC is “Weak”

- No kernel access = can’t see kernel-level cheats
- Modules can be blocked from loading
- Known bypasses at steamservice.dll + 0x590DE
- Delayed bans (3-4 weeks): cheats play free

But: catching up!

- VACnet - ML-powered detection (2017)
- VAC Live - real-time, cancels matches mid-game (2024)

EAC: The Industry Standard

- EasyAntiCheat: kernel-level (Ring 0)
- Finnish origin -> acquired by Epic Games (2018)
- Free via Epic online Services (200+ games)
- Fortnite, Apex Legends, Rust, Elden Ring, The Finals, …
- Most widely deployed kernel anti-cheat

EAC Architecture

Three-tier kernel design:

- Ring 0: EasyAntiCheat.sys (kernel driver)
  - Callbacks, memory scanning, driver validation
- Ring 3: EasyAntiCheat_EOS.exe (SYSTEM)
  - Bridge between driver and EAC servers
- Ring 3: EasyAntiCheat.dll (injected into game)
  - Game integration, user-mode checks

- Bootstrapper downloads fresh client modules from CDN on every launch

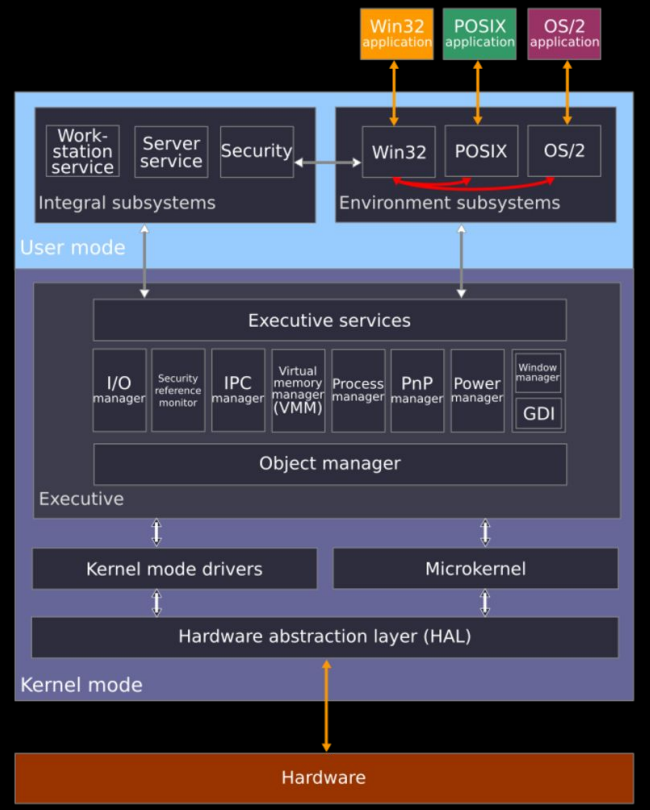
Kernel Callbacks: The Big Six

- PsSetCreateProcessNotifyRoutine
  - sees every process creation
- PsSetLoadImageNotifyRoutine
  - sees every DLL/driver load
- PsSetCreateThreadNotifyRoutine
  - sees every thread creation
- ObRegisterCallbacks
  - intercepts handle operations!
- Minifilter
  - filesystem monitoring
- CmRegisterCallbackEX
  - registry monitoring

ObRegisterCallbacks: Handle Stripping

The most important anti-cheat mechanism

- Cheat calls OpenProcess(game)
- Kernel sends request to ObRegisterCallbacks
- EAC's callback strips access rights:
  - PROCESS_VM_READ -> removed
  - PROCESS_VM_WRITE -> removed
  - PROCESS_CREATE_THREAD -> removed
- Cheat gets a useless handle



Result: ReadProcessMemory / WriteProcessMemory fail.

- External cheats are dead.

EAC Detections

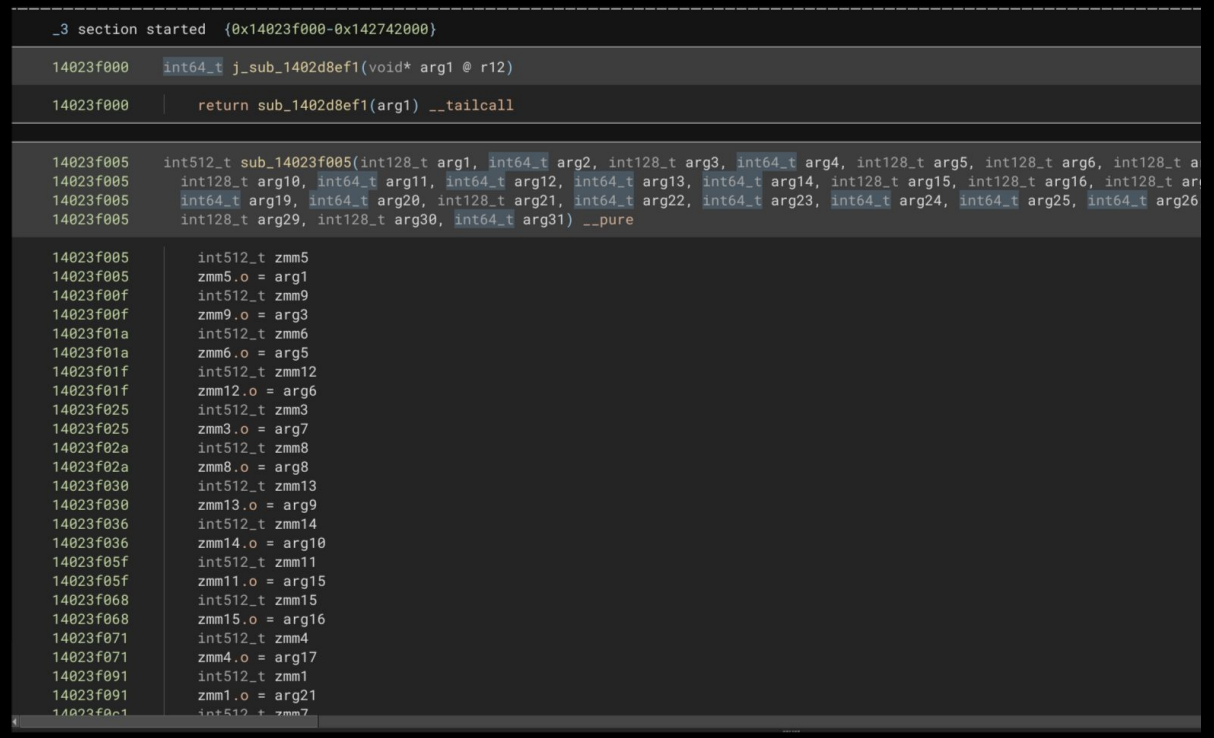
- Memory integrity:
  - Copies own driver to pool, compares every 10-40s
- DLL injection detection:
  - Scans for PE headers + compiler patterns (FF 25 stubs)
- Stack walking via RtlVirtualUnwind:
  - Checks 32 frames for suspicious return addresses
- SSDT integrity via IA32_LSTAR MSR:
  - Verified syscall table hasn’t been hooked
- Driver enumeration:
  - PiDDBCacheTable, MmUnloadedDrivers, pool tag ‘SldT’

Custom VM Obfuscation

- EAC uses custom virtual machine obfuscation
- Only 2 imports: FtlRegisterFilter + __chkstk
- 100+ APIs resolved at runtime

- .text section: 1.3MB (real code)
- _3 section: 38MB (VM bytecode)

- No public deobfuscation tooling exists



HWID Collection & The ALGS Incident

- EAC collects hardware IDs from 10+ registry paths
- Hardware bans
  - New account + same hardware = banned again
- HWID spoofers vs. EAC adding more fingerprint sources
- ALGS Tournament Incident
  - Pro players got aimbot mid-match on live stream. RCE was in Apex itself, not EAC

BattlEye: The Veteran

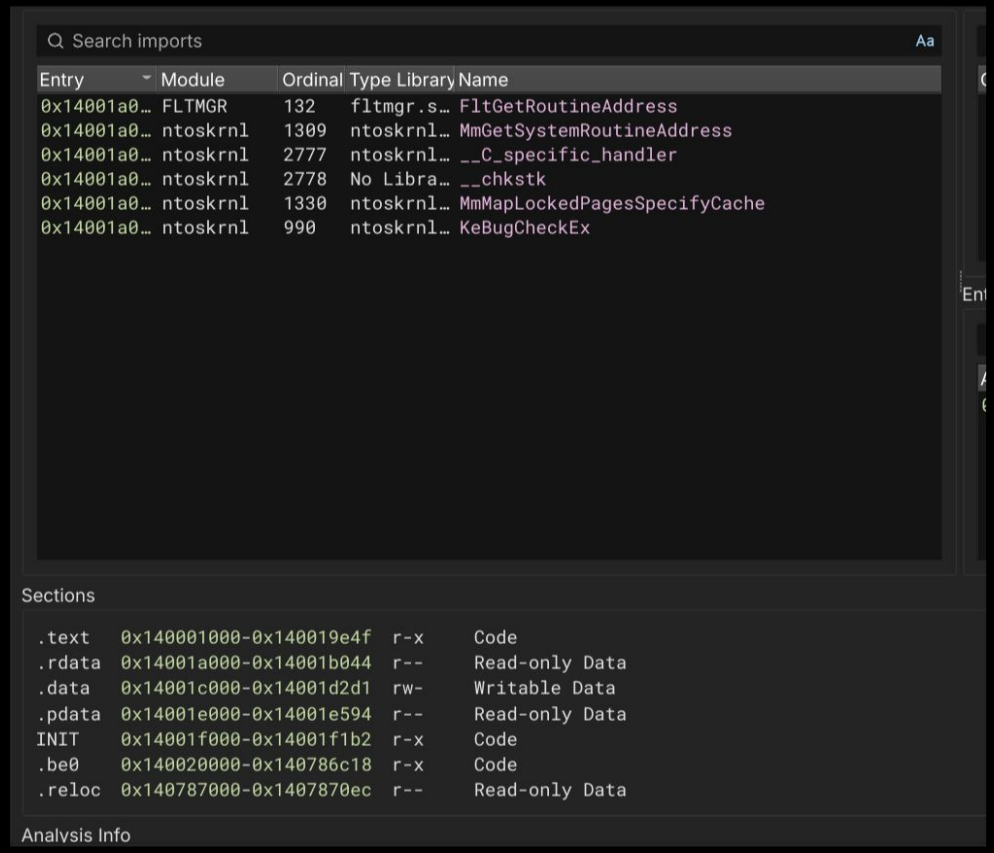
- Created by Bastian Suter (2004)
- Kernel Driver since 2014-2015
- PUBG, Escape from Tarkov, R6 Siege, DayZ, Arma3, GTA Online

The Four Components

- BEService.exe (NT service, SYSTEM)
  - Orchestrator, server comms, loads driver
- BEDaisy.sys (Ring 0)
  - Preventative: kernel callbacks, blocks access
- BEClient.dll (injected into game)
  - Offensive: the actual scanner
- BEServer (cloud)
  - Telemetry, signatures, bans

BEDaisy.sys Internals

- Same kernel callbacks as EAC, plus:
- 80+ runtime-resolved API imports
  - Not in IAT (uses MmGetSystemRoutineAddress)
- VMProtect obfuscation
  - .text: 100KB, .be0: 7.7MB
- Injects shellcode into lsass.exe and csrss.exe
  - For monitoring from privileged system processes
- Device: \\Device\\BattlEye
- IOCTLs: 0x222000, 0x2D1400, 0x7C088 (HWIDs)



BEClient: The Real Scanner

- Memory pattern scanning with report IDs
- Window/process enumeration with blacklists
- Shellcode scanning in game process memory
- Module validation
- Guard page detection
- Screenshot capture and upload
- Server pushes new scan patterns dynamically

- Blacklisted:
  - nvToolsExt64_1.dll -> 0x5A8
  - ws2detour_x96.dll -> 0x5B5

BattlEye: Historical Vulnerabilities

- CVE-2022-27095
  - Privilege escalation vulnerability
- FakeEye
  - Emulated launcher elevation to obtain unstripped process handle
- badeye
  - Handle elevation exploit
- ObRegisterCallbacks disable
  - Technique to remove callback protection (patched)

Vanguard: Boot or Don’t Play

- Riot Games: Valorant + League of Legends
- The most invasive mainstream anti-cheat
- Loads at BOOT TIME. Runs 24/7.
- The one that made gamers actually angry.
- Cannot run under Virtual Machine

Why Boot-Time?

- EAC / BattlEye:
  - Load when game launches
  - Cheat driver could already be loaded
- Vanguard:
  - Loads at Windows boot
    - Sees every driver load from the start
- Writes VGKbootstatus.dat to C:\Windows\ during DriverEntry to prove clean boot.
- Disable it = must reboot
  - Chain of trust is broken

The Component Triad

- vgk.sys (Ring 0, boot)
  - Kernel driver, passive monitoring always-on
- vgc.exe (Ring 3, SYSTEM)
  - User-mode service, issues scan commands
- vgtray.exe (Ring 3)
  - System tray icon
- vgk.sys has no network access.
  - All server comms go through vgc.exe
  - Driver only answers binary true/false queries

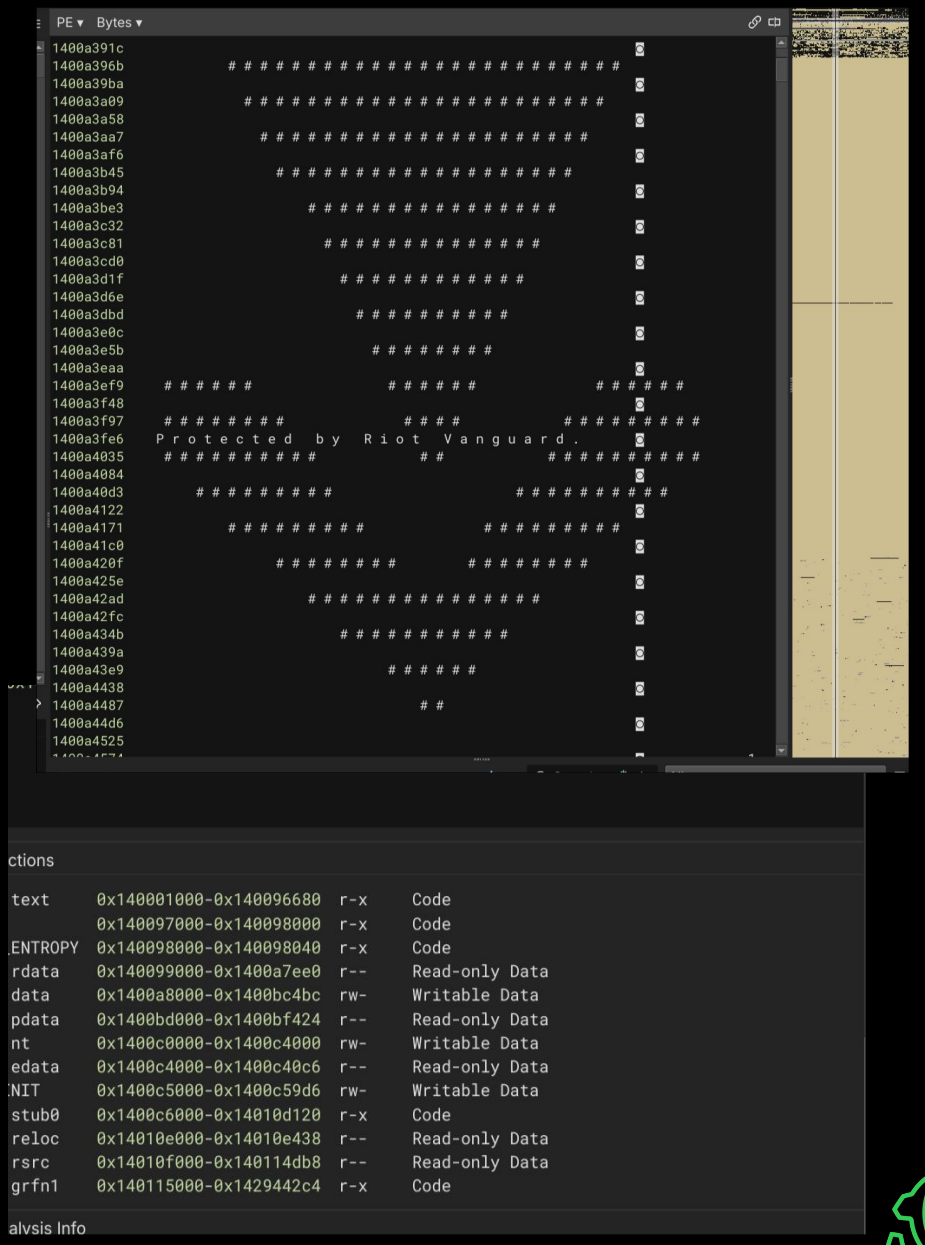
Kernel Callbacks + Hooks

Standard callbacks (same as EAC/BE) Plus:

- HalPrivateDispatchTable hooks:
  - +0x400 -> SwapContext (context switch monitor)
  - +0x248 -> Syscall hooking
- IAT hooks MmCopyVirtualMemory:
  - Intercepts ALL memory copy operations
- Device: \\Device\\VGK_PLZNOHACK
  - (yes, really)

vgk.sys

- 42MB driver. 22 imports
- .text: 600KB (real code)
- .grfn1: 42MB (Packman + VMProtect 3)
- .stub0: 291KB (hook stubs)
- _ENTROPY: 64B (randomness seed)
- Pool tag: VGKT
- HAL.dll import in INIT section



Guarded Regions

- Clones CR3/PML4 page table entries to create shadow memory regions
- Game memory mapped into alternate address space only Vangaurd controls
- External cheats using ReadProcessMemory see FAKE DATA (e.g., fake UWorld Pointer)
- Even kernel-level reads get the decoy unless you know the real mapping

Anti-Everything

- Debuggers:
  - Clears DR7 via IPI across ALL cores, RDTSC timing
- Hypervisors:
  - MSR analysis, CPUID checks (refuses to run in VMs)
- DMA:
  - PCIe device scanning, chipset analysis
  - HalpDmaGetIommuInterface import
- Screen capture:
  - Win32k syscall hooks block overlay/capture tools

Self-Protection

- Packman packer + VMProtect 3 virtualization on critical code sections
- stub.dll API hooking with return address verification (calling from unexpected location = flagged)
- Heartbeat:
  - vgk.sys <-> vgc.exe <-> Riot servers
- BCrypt imports for signature verification of all loaded code.

Vanguard Exploits

- Van1338: Handle leak via callback timing race
  - $6k bug bounty
- Sleeping Bouncer: UEFI vulnerability
  - 4 CVEs across ASUS/Gigabyte/MSI/ASRock
  - Attackers load before Vangaurd at BIOS level
- DMA evolution: PCIe cards reading physical memory
  - Vanguard now scans for them

What Actually Works?

- User-mode (VAC):
  - Catches skids, misses kernel cheats
- Kernel (EAC/BE):
  - Stops most cheats, vulnerable to BYOVD + DMA
- Boot (Vanguard):
  - Hardest to bypass, most invasive
- The real trend:
  - Server-side detection + ML
  - Client-side is always an arms race
  - Sadly, you eventually lose

The Privacy Question

- These are rootkits that millions of gamers voluntarily install
- Vanguard runs 24/7 from boot
- EAC collects 10+ hardware fingerprints
- VAC scanned DNS caches
- BattlEye takes screenshots

- Where’s the line?

Next Meetings

2026-02-19 • This Thursday

- Password Cracking
- Learn how to store passwords securely and crack them hashed with insecure algorithms!

2026-02-22 • Next Sunday

- Elliptic Curves and Sigs
- Learn some newer forms of cryptography and their benefits.

ctf.sigpwny.com

sigpwny{v4ngu4rd_c4n7_c47ch_m3}

Meeting content can be found at sigpwny.com/meetings.

SIGPwny