BLACK HAT C

LOW-LEVEL EXPLOITATION AND MALWARE ENGINEERING

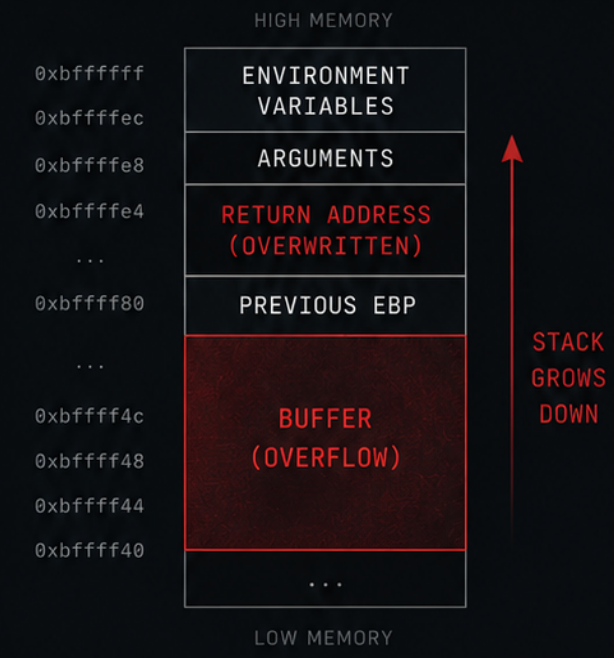
FROM BUFFER OVERFLOWS TO ROOTKITS:
A PRACTITIONER'S GUIDE

```c
#include <stdio.h>
#include <string.h>

void vuln(char *input) {
   char buf[64];
   strcpy(buf, input);
}

int main(int argc, char **argv) {
   vuln(argv[1]);
   return 0;
}
```

```
0x080484b6 <vuln+0>:    push   ebp
0x080484b7 <vuln+1>:    mov    ebp, esp
0x080484b9 <vuln+3>:    sub    esp, 0x50
...
0x080484e9 <vuln+83>:   ret
          // Control Over EIP
```



HANDS-ON CODE EXAMPLES

OFFENSIVE TECHNIQUES AND DEFENSIVE COUNTERMEASURES

EXPLOITATION, MALWARE, AND ROOTKITS

ETHICAL. LEGAL. ISOLATED LAB ENVIRONMENT.

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Black Hat C

Low-Level Exploitation and Malware Engineering

Steve T. Publications

This book is available at https://leanpub.com/blackhatc

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Contents

Low-Level Exploitation and Malware Engineering

This content is not available in the sample book. The book can be purchased on Leanpub at https://leanpub.com/blackhatc.

From Buffer Overflows to Rootkits: A Practitioner's Guide

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Introduction

The most useful perspective you can adopt as a security professional is the attacker's view of memory.

Most developers think about their code at the level of functions and data structures. The attacker has to think one layer lower: bytes on the stack, return addresses, process mappings, system call tables. If you want to understand modern exploits, rootkits, and malware patterns, you must be fluent in that lower-level view.

This book is an end-to-end treatment of how attacks are implemented in C and assembly on real systems. The through-line is simple:

- Start with a vulnerable program.
- Understand the underlying OS and hardware mechanics.
- Show exactly how control flow is hijacked.
- Add evasion, persistence, and stealth.
- For each technique, state the corresponding defenses clearly.

You will encounter concrete C code examples, annotated assembly snippets, and step-by-step walkthroughs that show how vulnerabilities are triggered and exploited in a controlled environment. The goal is not to impress with clever tricks; the goal is to make sure you can look at unfamiliar binary behavior and explain what it is doing and why.

How to use this book

- Prerequisites:
  - Working knowledge of C, including pointers, structs, and memory layout.
  - Comfort with a Linux command line and basic tools (gcc, gdb, objdump).
  - Familiarity with x86/x86_64 assembly is helpful but not required; key concepts are explained.

- Environment:
  - Use an isolated lab: a VM or container running a deliberately vulnerable target.
  - Do not run these examples on production systems.
  - Ensure your use is legal and authorized.
- Reading strategy:
  - Read Chapters 1–3 straight through to establish fundamentals.
  - Use later chapters as reference when encountering specific vulnerability classes, evasion techniques, or malware patterns in real work.

Ethical note

Several examples in this book demonstrate potentially risky behavior: shellcode execution, privilege escalation, kernel hooking, process injection, and stealth techniques. All are provided for educational and defensive engineering purposes. Every chapter that contains such material includes an explicit reminder to use it only in isolated, legal, ethical environments. If you are unsure whether your use is appropriate, assume it is not.

The rest of the book now moves from fundamentals to advanced topics: memory layout and calling conventions, stack overflows, format string bugs, heap exploitation and use-after-free, shellcoding, bypassing ASLR/DEP/canaries, position-independent code, anti-analysis tricks, kernel rootkits, and modern malware development patterns. Each chapter closes with a defensive summary so you can translate what the attacker can do into what your systems should enforce.

Chapter 1: The Attacker's View of Memory and Execution

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A Minimal Vulnerable Program

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Process Layout: Text, Data, Heap, Stack

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ELF Format and Why It Matters

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x86/x64 Registers and the Call Stack

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How a Function Call Really Works (Calling Conventions)

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From Source to Assembly: Tracing One Example

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Segmentation, Paging, and Virtual Memory

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Defensive Note: Why You Must Know This

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Chapter 2: Buffer Overflows–The Classic Weapon

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Anatomy of a Stack Buffer Overflow

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Controlling the Return Address

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Finding the Offset: Fuzzing with Patterns

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NOP Sleds and Shellcode Placement

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A Complete Exploit Walkthrough (Linux, x86)

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Return-to-libc: Exploitation Without Shellcode

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Defensive Note: Stack Canaries, ASLR, and Hardening Trade-offs

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Chapter 3: Format String Vulnerabilities

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How printf Parses Its Arguments

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Leaking the Stack with %x and %p

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Overwriting Arbitrary Memory with %n

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A Realistic Exploit Example

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Chained Format String Attacks

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Real-World Example: CVE-2024-29510 in Ghostscript

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Defensive Note: Safe Formatting and Static Analysis

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Chapter 4: Heap Exploitation and Use-After-Free

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How the Heap Is Managed (ptmalloc / glibc Basics)

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Off-by-One and Heap Overflows

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Use-After-Free: The Concept

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Exploiting UAF via Struct Overwrite

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Fastbin Attacks: A Concrete Walkthrough

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Defensive Note: Hardened Allocators and Sanitizers

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Chapter 5: Shellcoding–Code That Runs Anywhere

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Constraints of Shellcode (No Null Bytes, No Fixed Addresses)

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Writing a Simple execve("/bin/sh") on Linux (x86)

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Writing a Simple execve("/bin/sh") on Linux (x86_64)

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Reverse TCP Shellcode: Connecting Back

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Position-Independent Tricks (Self-Referencing RIP, Syscall Stubs)

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Encoding and Decoding Payloads

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Embedding Shellcode in C Exploits

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Defensive Note: DEP/NX, CFG, and Sandboxing

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Chapter 6: Bypassing Protections–ASLR, DEP, Canaries

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ASLR: How It Works and Where It Leaks

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Information Leaks via Pointers and CRT

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ROP Chaining (Return-Oriented Programming)

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Bypassing DEP with ROP

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Defeating Stack Canaries (Leak + Reuse)

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Defensive Note: Full Mitigation Stacks and SECCOMP

Chapter 7: Position-Independent Code and Exploit Engineering

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Static vs Dynamic Linking

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Position-Independent Executables (PIE)

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GOT/PLT Overwrites as an Attack Vector

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Leveraging libc Offsets in Exploits

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Combining Leaks, ROP, and GOT Hijacking

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Defensive Note: RELRO, BindsNow, and Full Hardening

Chapter 8: Anti-Analysis Techniques

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Detecting Sandboxes and VMs (CPUID, Timing, Artifacts)

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String Obfuscation and Encrypted Payloads

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Packed Binaries and Custom Unpackers

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Anti-Debugging Tricks (PTRACE, Timing, sysenter tricks)

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Flow Obfuscation and Control Integrity

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Defensive Note: Dynamic Analysis Strategies

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Chapter 9: Rootkits–Hiding in the Kernel

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Userland vs Kernel Rootkits

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Inline Hooking System Calls (Linux Example)

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Modifying the System Call Table (Conceptual)

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Hiding Processes, Files, and Network Sockets

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Driver-Based Persistence on Windows (Conceptual)

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Defensive Note: Integrity Checking, eBPF, and PatchGuard

Chapter 10: Malware Development Patterns

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Process Injection Techniques (CreateRemoteThread, APC Injection)

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Reflective DLL Loading

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Living Off the Land (LOLBins and Scripts)

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Command and Control (C2) Channel Design

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Fileless Persistence and Memory-Only Techniques

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Defensive Note: EDR, Telemetry, and Behavioral Detection

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Chapter 11: Putting It All Together–A Controlled Case Study

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The Lab: Dockerized, Isolated Test Environment

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Target Service with Multiple Flaws

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Step-by-Step Exploit Development

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Adding Evasion and Persistence Layers

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Post-Exploitation View

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Defensive Note: How a Hardened System Would Resist This

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Defensive Note: How a Hardened System Would Resist This

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Conclusion

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