

# Contents

*Preface*    *xiii*

*Acknowledgments*    *xxi*

*About the Authors*    *xxiii*

## **1 Honeypot and Networking Background**    **1**

1.1	Brief TCP/IP Introduction	1
1.2	Honeypot Background	7
1.2.1	High-Interaction Honeypots	9
1.2.2	Low-Interaction Honeypots	10
1.2.3	Physical Honeypots	11
1.2.4	Virtual Honeypots	11
1.2.5	Legal Aspects	12
1.3	Tools of the Trade	13
1.3.1	Tcpdump	13
1.3.2	Wireshark	15
1.3.3	Nmap	16

## **2 High-Interaction Honeypots**    **19**

2.1	Advantages and Disadvantages	20
2.2	VMware	22
2.2.1	Different VMware Versions	25
2.2.2	Virtual Network with VMware	26
2.2.3	Setting Up a Virtual High-Interaction Honeypot	29
2.2.4	Creating a Virtual Honeypot	33
2.2.5	Adding Additional Monitoring Software	37
2.2.6	Connecting the Virtual Honeypot to the Internet	39
2.2.7	Building a Virtual High-Interaction Honeynet	40
2.3	User-Mode Linux	41
2.3.1	Overview	41
2.3.2	Installation and Setup	42

2.3.3 Runtime Flags and Configuration	46
2.3.4 Monitoring UML-Based Honeypots	50
2.3.5 Connecting the Virtual Honeypot to the Internet	51
2.3.6 Building a Virtual High-Interaction Honeynet	52
2.4 Argos	52
2.4.1 Overview	53
2.4.2 Installation and Setup for Argos Honeypots	54
2.5 Safeguarding Your Honeypots	62
2.5.1 Honeywall	63
2.6 Summary	69
<b>3 Low-Interaction Honeypots</b>	<b>71</b>
3.1 Advantages and Disadvantages	72
3.2 Deception Toolkit	73
3.3 LaBrea	74
3.3.1 Installation and Setup	75
3.3.2 Observations	81
3.4 Tiny Honeypot	81
3.4.1 Installation	82
3.4.2 Capture Logs	83
3.4.3 Session Logs	85
3.4.4 Netfilter Logs	85
3.4.5 Observations	86
3.5 GHH — Google Hack Honeypot	87
3.5.1 General Installation	87
3.5.2 Installing the Transparent Link	91
3.5.3 Access Logging	92
3.6 PHP.HoP — A Web-Based Deception Framework	94
3.6.1 Installation	95
3.6.2 HipHop	96
3.6.3 PhpMyAdmin	97
3.7 Securing Your Low-Interaction Honeypots	98
3.7.1 Chroot Jail	98
3.7.2 Systrace	101
3.8 Summary	103
<b>4 Honeyd — The Basics</b>	<b>105</b>
4.1 Overview	106
4.1.1 Features	107
4.1.2 Installation and Setup	108

4.2	Design Overview	109
4.2.1	Interaction Only via the Network	111
4.2.2	Multiple IP Addresses	111
4.2.3	Deceiving Fingerprinting Tools	111
4.3	Receiving Network Data	112
4.4	Runtime Flags	114
4.5	Configuration	115
4.5.1	create	117
4.5.2	set	117
4.5.3	add	121
4.5.4	bind	123
4.5.5	delete	124
4.5.6	include	125
4.6	Experiments with Honeyd	125
4.6.1	Experimenting with Honeyd Locally	125
4.6.2	Integrating Virtual Honeypots into Production Networks	128
4.7	Services	129
4.8	Logging	131
4.8.1	Packet-Level Logging	131
4.8.2	Service-Level Logging	133
4.9	Summary	134

## 5 Honeyd — Advanced Topics 135

5.1	Advanced Configuration	136
5.1.1	set	136
5.1.2	tarpit	137
5.1.3	annotate	138
5.2	Emulating Services	139
5.2.1	Scripting Languages	139
5.2.2	SMTP	139
5.3	Subsystems	142
5.3.1	Optimizing Subsystems	145
5.4	Internal Python Services	146
5.5	Dynamic Templates	148
5.6	Routing Topology	150
5.7	Honeydstats	154
5.8	Honeydctl	156
5.9	Honeycomb	158
5.10	Performance	160
5.11	Summary	161

**6 Collecting Malware with Honeypots 163**

6.1 A Primer on Malicious Software	164
6.2 Nepenthes — A Honeypot Solution to Collect Malware	165
6.2.1 Architecture of Nepenthes	167
6.2.2 Limitations	176
6.2.3 Installation and Setup	177
6.2.4 Configuration	179
6.2.5 Command Line Flags	181
6.2.6 Assigning Multiple IP Addresses	183
6.2.7 Flexible Deployment	185
6.2.8 Capturing New Exploits	186
6.2.9 Implementing Vulnerability Modules	187
6.2.10 Results	188
6.2.11 Lessons Learned	196
6.3 Honeytrap	197
6.3.1 Overview	197
6.3.2 Installation and Configuration	200
6.3.3 Running Honeytrap	203
6.4 Other Honeypot Solutions for Learning About Malware	204
6.4.1 Multipot	204
6.4.2 HoneyBOT	205
6.4.3 Billy Goat	205
6.4.4 Learning About Malicious Network Traffic	206
6.5 Summary	207

**7 Hybrid Systems 209**

7.1 Collapsar	211
7.2 Potemkin	214
7.3 RolePlayer	220
7.4 Research Summary	224
7.5 Building Your Own Hybrid Honeypot System	224
7.5.1 NAT and High-Interaction Honeypots	224
7.5.2 Honeyd and High-Interaction Honeypot	228
7.6 Summary	230

**8 Client Honeypots 231**

8.1 Learning More About Client-Side Threats	232
8.1.1 A Closer Look at MS04-040	233
8.1.2 Other Types of Client-Side Attacks	236
8.1.3 Toward Client Honeypots	238
8.2 Low-Interaction Client Honeypots	241

8.2.1 Learning About Malicious Websites	241
8.2.2 HoneyC	246
8.3 High-Interaction Client Honeypots	253
8.3.1 Design of High-Interaction Client Honeypots	254
8.3.2 HoneyClient	258
8.3.3 Capture-HPC	260
8.3.4 HoneyMonkey	262
8.4 Other Approaches	263
8.4.1 Studying Spyware on the Internet	264
8.4.2 SpyBye	267
8.4.3 SiteAdvisor	270
8.4.4 Further Research	271
8.5 Summary	272

## 9 Detecting Honeypots 273

9.1 Detecting Low-Interaction Honeypots	274
9.2 Detecting High-Interaction Honeypots	280
9.2.1 Detecting and Disabling Sebek	281
9.2.2 Detecting the Honeywall	285
9.2.3 Circumventing Honeynet Logging	286
9.2.4 VMware and Other Virtual Machines	289
9.2.5 QEMU	297
9.2.6 User-Mode Linux	298
9.3 Detecting Rootkits	302
9.4 Summary	305

## 10 Case Studies 307

10.1 Blast-o-Mat: Using Nepenthes to Detect Infected Clients	308
10.1.1 Motivation	309
10.1.2 Nepenthes as Part of an Intrusion Detection System	311
10.1.3 Mitigation of Infected Systems	312
10.1.4 A Modern Trojan: Haxdoor	316
10.1.5 Lessons Learned with Blast-o-Mat	320
10.1.6 Lightweight IDS Based on Nepenthes	321
10.1.7 SURFnet IDS	325
10.2 Search Worms	327
10.3 Red Hat 8.0 Compromise	332
10.3.1 Attack Summary	334
10.3.2 Attack Timeline	335
10.3.3 Tools Involved	338
10.3.4 Attack Evaluation	343

10.4	Windows 2000 Compromise	343
10.4.1	Attack Summary	344
10.4.2	Attack Timeline	345
10.4.3	Tools Involved	347
10.4.4	Attack Evaluation	350
10.5	SUSE 9.1 Compromise	351
10.5.1	Attack Summary	351
10.5.2	Attack Timeline	352
10.5.3	Tools Involved	354
10.5.4	Attack Evaluation	356
10.6	Summary	357
<b>11</b>	<b>Tracking Botnets</b>	<b>359</b>
11.1	Bot and Botnet 101	360
11.1.1	Examples of Bots	362
11.1.2	Spyware in the Form of Bots	366
11.1.3	Botnet Control Structure	369
11.1.4	DDoS Attacks Caused by Botnets	372
11.2	Tracking Botnets	373
11.2.1	Observing Botnets	375
11.3	Case Studies	376
11.3.1	Mocbot and MS06-040	381
11.3.2	Other Observations	384
11.4	Defending Against Bots	387
11.5	Summary	390
<b>12</b>	<b>Analyzing Malware with CWSandbox</b>	<b>391</b>
12.1	CWSandbox Overview	392
12.2	Behavior-Based Malware Analysis	394
12.2.1	Code Analysis	394
12.2.2	Behavior Analysis	395
12.2.3	API Hooking	396
12.2.4	Code Injection	400
12.3	CWSandbox — System Description	401
12.3.1	Architecture	402
12.4	Results	405
12.4.1	Example Analysis Report	406
12.4.2	Large-Scale Analysis	411
12.5	Summary	413
<b>Bibliography</b>	<b>415</b>	
<b>Index</b>	<b>423</b>	