



Malicious Cryptography

Exposing Cryptovirology

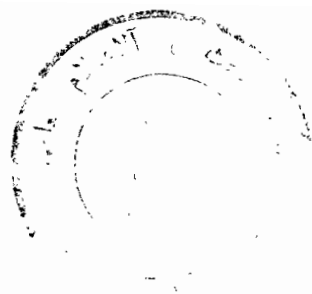
Adam Young

Moti Yung



WILEY

Wiley Publishing, Inc.



*Dedicated to Elisa (A. Y.)
and to Maya (M. Y.)*

Contents



Foreword	xiii
Acknowledgments	xix
Introduction	xxi
1 Through Hacker's Eyes	1
2 Cryptovirology	33
3 Tools for Security and Insecurity	51
3.1 Sources of Entropy	53
3.2 Entropy Extraction via Hashing	54
3.3 Unbiasing a Biased Coin	57
3.3.1 Von Neumann's Coin Flipping Algorithm	57
3.3.2 Iterating Neumann's Algorithm	59
3.3.3 Heuristic Bias Matching	60
3.4 Combining Weak Sources of Entropy	62
3.5 Pseudorandom Number Generators	66
3.5.1 Heuristic Pseudorandom Number Generation	66
3.5.2 PRNGs Based on Reduction Arguments	67
3.6 Uniform Sampling	68
3.7 Random Permutation Generation	71
3.7.1 Shuffling Cards by Repeated Sampling	71
3.7.2 Shuffling Cards Using Trotter-Johnson	73
3.8 Sound Approach to Random Number Generation and Use	76
3.9 RNGs Are the Beating Heart of System Security	77
3.10 Cryptovirology Benefits from General Advances	78
3.10.1 Strong Crypto Yields Strong Cryptoviruses	78
3.10.2 Mix Networks and Cryptovirus Extortion	80

7	Non-Zero Sum Games and Survivable Malware	147
7.1	Survivable Malware	148
7.2	Elements of Game Theory	150
7.3	Attacking a Brokerage Firm	151
7.3.1	Assumptions for the Attack	152
7.3.2	The Distributed Cryptoviral Attack	153
7.3.3	Security of the Attack	158
7.3.4	Utility of the Attack	159
7.4	Other Two-Player Game Attacks	161
7.4.1	Key Search via Facehuggers	161
7.4.2	Catalyzing Conflict Among Hosts	167
7.5	Future Possibilities	167
8	Coping with Malicious Software	171
8.1	Undecidability of Virus Detection	171
8.2	Virus Identification and Obfuscation	172
8.2.1	Virus String Matching	173
8.2.2	Polymorphic Viruses	176
8.3	Heuristic Virus Detection	182
8.3.1	Detecting Code Abnormalities	182
8.3.2	Detecting Abnormal Program Behavior	183
8.3.3	Detecting Cryptographic Code	191
8.4	Change Detection	197
8.4.1	Integrity Self-Checks	197
8.4.2	Program Inoculation	198
8.4.3	Kernel Based Signature Verification	199
9	The Nature of Trojan Horses	201
9.1	Text Editor Trojan Horse	202
9.2	Salami Slicing Attacks	202
9.3	Thompson's Password Snatcher	203
9.4	The Subtle Nature of Trojan Horses	206
9.4.1	Bugs May In Fact Be Trojans	208
9.4.2	RNG Biasing Trojan Horse	208
10	Subliminal Channels	211
10.1	Brief History of Subliminal Channels	212
10.2	The Difference Between a Subliminal and a Covert Channel	214
10.3	The Prisoner's Problem of Gustavus Simmons	215
10.4	Subliminal Channels New and Old	216

12.7.4 SETUP in the Schnorr Signature Algorithm	284
12.8 Rogue Use of DSA for Encryption	285
12.9 Other Work in Kleptography	286
12.10 Should You Trust Your Smart Card?	288
Appendix A: Computer Virus Basics	295
A.1 Origins of Malicious Software	295
A.2 Trojans, Viruses, and Worms: What Is the Difference?	297
A.3 A Simple DOS COM Infector	299
A.4 Viruses Don't Have to Gain Control Before the Host	303
Appendix B: Notation and Other Background Information	307
B.1 Notation Used Throughout the Book	307
B.2 Basic Facts from Number Theory and Algorithmics	309
B.3 Intractability: Malware's Biggest Ally	312
B.3.1 The Factoring Problem	313
B.3.2 The e^{th} Roots Problem	314
B.3.3 The Composite Residuosity Problem	314
B.3.4 The Decision Composite Residuosity Problem	315
B.3.5 The Quadratic Residuosity Problem	315
B.3.6 The Phi-Hiding Problem	315
B.3.7 The Phi-Sampling Problem	317
B.3.8 The Discrete Logarithm Problem	318
B.3.9 The Computational Diffie-Hellman Problem	318
B.3.10 The Decision Diffie-Hellman Problem	318
B.4 Random Oracles and Functions	319
Appendix C: Public Key Cryptography in a Nutshell	321
C.1 Overview of Cryptography	321
C.1.1 Classical Cryptography	322
C.1.2 The Diffie-Hellman Key Exchange	324
C.1.3 Public Key Cryptography	325
C.1.4 Attacks on Cryptosystems	326
C.1.5 The Rabin Encryption Algorithm	330
C.1.6 The Rabin Signature Algorithm	331
C.1.7 The RSA Encryption Algorithm	332
C.1.8 The RSA Signature Algorithm	334
C.1.9 The Goldwasser-Micali Algorithm	335
C.1.10 Public Key Infrastructures	336
C.2 Discrete-Log Based Cryptosystems	337