

Foreword	xiii
-----------------------	-------------

Preface	xvii
----------------------	-------------

1. Safe Initialization	1
-------------------------------------	----------

1.1 Sanitizing the Environment	1
1.2 Restricting Privileges on Windows	7
1.3 Dropping Privileges in setuid Programs	16
1.4 Limiting Risk with Privilege Separation	20
1.5 Managing File Descriptors Safely	23
1.6 Creating a Child Process Securely	26
1.7 Executing External Programs Securely	28
1.8 Executing External Programs Securely	33
1.9 Disabling Memory Dumps in the Event of a Crash	35

2. Access Control	38
--------------------------------	-----------

2.1 Understanding the Unix Access Control Model	38
2.2 Understanding the Windows Access Control Model	41
2.3 Determining Whether a User Has Access to a File on Unix	43
2.4 Determining Whether a Directory Is Secure	45
2.5 Erasing Files Securely	47
2.6 Accessing File Information Securely	53
2.7 Restricting Access Permissions for New Files on Unix	55
2.8 Locking Files	57
2.9 Synchronizing Resource Access Across Processes on Unix	60
2.10 Synchronizing Resource Access Across Processes on Windows	63
2.11 Creating Files for Temporary Use	65
2.12 Restricting Filesystem Access on Unix	68
2.13 Restricting Filesystem and Network Access on FreeBSD	69

3. Input Validation	71
3.1 Understanding Basic Data Validation Techniques	71
3.2 Preventing Attacks on Formatting Functions	75
3.3 Preventing Buffer Overflows	78
3.4 Using the SafeStr Library	85
3.5 Preventing Integer Coercion and Wrap-Around Problems	88
3.6 Using Environment Variables Securely	92
3.7 Validating Filenames and Paths	97
3.8 Evaluating URL Encodings	99
3.9 Validating Email Addresses	101
3.10 Preventing Cross-Site Scripting	103
3.11 Preventing SQL Injection Attacks	107
3.12 Detecting Illegal UTF-8 Characters	110
3.13 Preventing File Descriptor Overflows When Using select()	112
4. Symmetric Cryptography Fundamentals	116
4.1 Representing Keys for Use in Cryptographic Algorithms	117
4.2 Generating Random Symmetric Keys	119
4.3 Representing Binary Keys (or Other Raw Data) as Hexadecimal	120
4.4 Turning ASCII Hex Keys (or Other ASCII Hex Data) into Binary	121
4.5 Performing Base64 Encoding	123
4.6 Performing Base64 Decoding	125
4.7 Representing Keys (or Other Binary Data) as English Text	128
4.8 Converting Text Keys to Binary Keys	130
4.9 Using Salts, Nonces, and Initialization Vectors	133
4.10 Deriving Symmetric Keys from a Password	136
4.11 Algorithmically Generating Symmetric Keys from One Base Secret	141
4.12 Encrypting in a Single Reduced Character Set	146
4.13 Managing Key Material Securely	149
4.14 Timing Cryptographic Primitives	150
5. Symmetric Encryption	155
5.1 Deciding Whether to Use Multiple Encryption Algorithms	155
5.2 Figuring Out Which Encryption Algorithm Is Best	156
5.3 Selecting an Appropriate Key Length	160
5.4 Selecting a Cipher Mode	162
5.5 Using a Raw Block Cipher	171
5.6 Using a Generic CBC Mode Implementation	175
5.7 Using a Generic CFB Mode Implementation	186

5.8	Using a Generic OFB Mode Implementation	192
5.9	Using a Generic CTR Mode Implementation	197
5.10	Using CWC Mode	202
5.11	Manually Adding and Checking Cipher Padding	205
5.12	Precomputing Keystream in OFB, CTR, CCM, or CWC Modes (or with Stream Ciphers)	207
5.13	Parallelizing Encryption and Decryption in Modes That Allow It (Without Breaking Compatibility)	208
5.14	Parallelizing Encryption and Decryption in Arbitrary Modes (Breaking Compatibility)	212
5.15	Performing File or Disk Encryption	213
5.16	Using a High-Level, Error-Resistant Encryption and Decryption API	217
5.17	Performing Block Cipher Setup (for CBC, CFB, OFB, and ECB Modes) in OpenSSL	221
5.18	Using Variable Key-Length Ciphers in OpenSSL	226
5.19	Disabling Cipher Padding in OpenSSL in CBC Mode	227
5.20	Performing Additional Cipher Setup in OpenSSL	228
5.21	Querying Cipher Configuration Properties in OpenSSL	229
5.22	Performing Low-Level Encryption and Decryption with OpenSSL	230
5.23	Setting Up and Using RC4	233
5.24	Using One-Time Pads	236
5.25	Using Symmetric Encryption with Microsoft's CryptoAPI	237
5.26	Creating a CryptoAPI Key Object from Raw Key Data	244
5.27	Extracting Raw Key Data from a CryptoAPI Key Object	246

6. Hashes and Message Authentication 249

6.1	Understanding the Basics of Hashes and MACs	249
6.2	Deciding Whether to Support Multiple Message Digests or MACs	253
6.3	Choosing a Cryptographic Hash Algorithm	254
6.4	Choosing a Message Authentication Code	258
6.5	Incrementally Hashing Data	262
6.6	Hashing a Single String	267
6.7	Using a Cryptographic Hash	269
6.8	Using a Nonce to Protect Against Birthday Attacks	270
6.9	Checking Message Integrity	274
6.10	Using HMAC	276
6.11	Using OMAC (a Simple Block Cipher-Based MAC)	280
6.12	Using HMAC or OMAC with a Nonce	285
6.13	Using a MAC That's Reasonably Fast in Software and Hardware	286

6.14	Using a MAC That's Optimized for Software Speed	287
6.15	Constructing a Hash Function from a Block Cipher	291
6.16	Using a Block Cipher to Build a Full-Strength Hash Function	294
6.17	Using Smaller MAC Tags	298
6.18	Making Encryption and Message Integrity Work Together	298
6.19	Making Your Own MAC	300
6.20	Encrypting with a Hash Function	301
6.21	Securely Authenticating a MAC (Thwarting Capture Replay Attacks)	303
6.22	Parallelizing MACs	304
7.	Public Key Cryptography	307
7.1	Determining When to Use Public Key Cryptography	309
7.2	Selecting a Public Key Algorithm	311
7.3	Selecting Public Key Sizes	312
7.4	Manipulating Big Numbers	315
7.5	Generating a Prime Number (Testing for Primality)	323
7.6	Generating an RSA Key Pair	327
7.7	Disentangling the Public and Private Keys in OpenSSL	329
7.8	Converting Binary Strings to Integers for Use with RSA	330
7.9	Converting Integers into Binary Strings for Use with RSA	331
7.10	Performing Raw Encryption with an RSA Public Key	332
7.11	Performing Raw Decryption Using an RSA Private Key	336
7.12	Signing Data Using an RSA Private Key	338
7.13	Verifying Signed Data Using an RSA Public Key	340
7.14	Securely Signing and Encrypting with RSA	343
7.15	Using the Digital Signature Algorithm (DSA)	347
7.16	Representing Public Keys and Certificates in Binary (DER Encoding)	352
7.17	Representing Keys and Certificates in Plaintext (PEM Encoding)	355
8.	Authentication and Key Exchange	362
8.1	Choosing an Authentication Method	362
8.2	Getting User and Group Information on Unix	372
8.3	Getting User and Group Information on Windows	375
8.4	Restricting Access Based on Hostname or IP Address	379
8.5	Generating Random Passwords and Passphrases	387
8.6	Testing the Strength of Passwords	391
8.7	Prompting for a Password	392
8.8	Throttling Failed Authentication Attempts	398
8.9	Performing Password-Based Authentication with crypt()	400

8.10	Performing Password-Based Authentication with MD5-MCF	402
8.11	Performing Password-Based Authentication with PBKDF2	408
8.12	Authenticating with PAM	411
8.13	Authenticating with Kerberos	414
8.14	Authenticating with HTTP Cookies	419
8.15	Performing Password-Based Authentication and Key Exchange	422
8.16	Performing Authenticated Key Exchange Using RSA	429
8.17	Using Basic Diffie-Hellman Key Agreement	432
8.18	Using Diffie-Hellman and DSA Together	436
8.19	Minimizing the Window of Vulnerability When Authenticating Without a PKI	438
8.20	Providing Forward Secrecy in a Symmetric System	444
8.21	Ensuring Forward Secrecy in a Public Key System	445
8.22	Confirming Requests via Email	447

9. Networking 454

9.1	Creating an SSL Client	455
9.2	Creating an SSL Server	457
9.3	Using Session Caching to Make SSL Servers More Efficient	460
9.4	Securing Web Communication on Windows Using the WinInet API	463
9.5	Enabling SSL without Modifying Source Code	468
9.6	Using Kerberos Encryption	470
9.7	Performing Interprocess Communication Using Sockets	475
9.8	Performing Authentication with Unix Domain Sockets	482
9.9	Performing Session ID Management	486
9.10	Securing Database Connections	487
9.11	Using a Virtual Private Network to Secure Network Connections	490
9.12	Building an Authenticated Secure Channel Without SSL	491

10. Public Key Infrastructure 502

10.1	Understanding Public Key Infrastructure (PKI)	502
10.2	Obtaining a Certificate	513
10.3	Using Root Certificates	519
10.4	Understanding X.509 Certificate Verification Methodology	522
10.5	Performing X.509 Certificate Verification with OpenSSL	525
10.6	Performing X.509 Certificate Verification with CryptoAPI	530
10.7	Verifying an SSL Peer's Certificate	535
10.8	Adding Hostname Checking to Certificate Verification	539
10.9	Using a Whitelist to Verify Certificates	544

10.10	Obtaining Certificate Revocation Lists with OpenSSL	547
10.11	Obtaining CRLs with CryptoAPI	556
10.12	Checking Revocation Status via OCSP with OpenSSL	562
11.	Random Numbers	568
11.1	Determining What Kind of Random Numbers to Use	568
11.2	Using a Generic API for Randomness and Entropy	573
11.3	Using the Standard Unix Randomness Infrastructure	575
11.4	Using the Standard Windows Randomness Infrastructure	580
11.5	Using an Application-Level Generator	581
11.6	Reseeding a Pseudo-Random Number Generator	591
11.7	Using an Entropy Gathering Daemon—Compatible Solution	594
11.8	Getting Entropy or Pseudo-Randomness Using EGADS	599
11.9	Using the OpenSSL Random Number API	603
11.10	Getting Random Integers	605
11.11	Getting a Random Integer in a Range	606
11.12	Getting a Random Floating-Point Value with Uniform Distribution	608
11.13	Getting Floating-Point Values with Nonuniform Distributions	609
11.14	Getting a Random Printable ASCII String	611
11.15	Shuffling Fairly	612
11.16	Compressing Data with Entropy into a Fixed-Size Seed	613
11.17	Getting Entropy at Startup	614
11.18	Statistically Testing Random Numbers	615
11.19	Performing Entropy Estimation and Management	621
11.20	Gathering Entropy from the Keyboard	630
11.21	Gathering Entropy from Mouse Events on Windows	638
11.22	Gathering Entropy from Thread Timings	643
11.23	Gathering Entropy from System State	644
12.	Anti-Tampering	647
12.1	Understanding the Problem of Software Protection	648
12.2	Detecting Modification	653
12.3	Obfuscating Code	658
12.4	Performing Bit and Byte Obfuscation	664
12.5	Performing Constant Transforms on Variables	667
12.6	Merging Scalar Variables	667
12.7	Splitting Variables	669
12.8	Disguising Boolean Values	670
12.9	Using Function Pointers	671

12.10	Restructuring Arrays	672
12.11	Hiding Strings	678
12.12	Detecting Debuggers	681
12.13	Detecting Unix Debuggers	682
12.14	Detecting Windows Debuggers	685
12.15	Detecting SoftICE	685
12.16	Countering Disassembly	688
12.17	Using Self-Modifying Code	693
13.	Other Topics	700
13.1	Performing Error Handling	700
13.2	Erasing Data from Memory Securely	704
13.3	Preventing Memory from Being Paged to Disk	707
13.4	Using Variable Arguments Properly	709
13.5	Performing Proper Signal Handling	712
13.6	Protecting against Shatter Attacks on Windows	716
13.7	Guarding Against Spawning Too Many Threads	718
13.8	Guarding Against Creating Too Many Network Sockets	724
13.9	Guarding Against Resource Starvation Attacks on Unix	727
13.10	Guarding Against Resource Starvation Attacks on Windows	730
13.11	Following Best Practices for Audit Logging	734
Index		739