



# **RSA Security's Official Guide to** **CRYPTOGRAPHY**

**Keller Graduate School of Management of DeVry University**

Learn how secure data-encryption  
techniques work

Protect confidential information  
on your network

Get access to the latest  
cryptography standards

**Steve Burnett & Stephen Paine**

# RSA Security's Official Guide to Cryptography

**Keller Graduate School of Management of DeVry University Edition**

Steve Burnett and Stephen Paine

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# Foreword

Welcome to the second book from RSA Press, RSA Security's Official Guide to Cryptography!

As the Internet becomes a more pervasive part of daily life, the need for e-security becomes even more critical. Any organization engaged in online activity must assess and manage the e-security risks associated with this activity. Effective use of cryptographic techniques is at the core of many of these risk-management strategies. This book provides a practical guide for the use of cryptographic e-security technologies to provide for privacy, security, and integrity of an organization's most precious asset: data.

It is an exciting time for cryptography, with important technical, business, and legal events occurring in quick succession. This book can help the reader better understand the technology behind these events.

In January 2000, the United States Government announced a significant relaxation in restrictions on the export of strong cryptography. This decision has permitted U.S. companies to now compete for cryptographic business on a worldwide basis. Previously, many of the algorithms discussed in this book were treated as munitions and were subject to severe restrictions on their export from the U.S.

In September 2000, the patent on the RSA algorithm, arguably the most important patent in cryptography, expired. Now any firm or individual can create implementations of this algorithm, further increasing the pervasiveness of one of the most widespread technologies in the history of computing.

In October 2000, the United States National Institute of Standards and Technology announced its selection of the winner of the *Advanced Encryption Standard* (AES) selection process, an algorithm called Rijndael developed by two Belgian researchers. The AES algorithm is intended to replace the venerable, and increasingly vulnerable *Data Encryption Standard* (DES) algorithm. AES is expected to become the most widely used algorithm of its type in a short time.

The security technology industry has undergone explosive growth in a short period of time, with many new options emerging for the deployment of e-security techniques based on cryptography. Ranging from new developments in cryptographic hardware to the use of personal smart cards in public key infrastructures, the industry continues to increase the range of choices available to address e-security risks. This book provides the

reader with a solid foundation in the core cryptographic techniques of e-security—including RSA, AES, and DES mentioned previously, and many others—and then builds on this foundation to discuss the use of these techniques in practical applications and cutting-edge technologies.

While this book does discuss the underlying mathematics of cryptography, its primary focus is on the use of these technologies in familiar, real-world settings. It takes a systems approach to the problems of using cryptographic techniques for e-security, reflecting the fact that the degree of protection provided by an e-security deployment is only as strong as the weakest link in the chain of protection.

We hope that you will enjoy this book and the other titles from RSA Press. We welcome your comments as well as your suggestions for future RSA Press books. For more information on RSA Security, please visit our web site at [www.rsasecurity.com](http://www.rsasecurity.com); more information on RSA Press can be found at [www.rsapress.com](http://www.rsapress.com).

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—Steve Burnett

The first person I'd like to thank is Steve Burnett. I am positive that if he had not agreed to co-author this book with me, I might have given up before I began.

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I especially want to thank Jerry Mansfield, a great friend who taught me to take life as it comes. Finally, I would like to thank my family for their support.

—*Stephen Paine*



# Preface

Application developers never used to add security to their products because the buying public didn't care. To add security meant spending money to include features that did not help sales. Today, customers demand security for many applications. The Federal Bureau of Investigation published the following Congressional Statement on February 16, 2000:

"There were over 100 million Internet users in the United States in 1999. That number is projected to reach 177 million in United States and 502 million worldwide by the end of 2003. Electronic commerce has emerged as a new sector of the American economy, accounting for over \$100 billion in sales during 1999; by 2003 electronic commerce is projected to exceed \$1 trillion."

At the same time, the *Computer Security Institute* (CSI) reported an increase in cybercrime, "55% of the respondents to our survey reported malicious activity by insiders." Knowing this, you can be sure growing corporations need security products.

The most important security tool is cryptography. Developers and engineers need to understand crypto in order to effectively build it into their products. Sales and marketing people need to understand crypto in order to prove the products they are selling are secure. The customers buying those products, whether end users or corporate purchasing agents, need to understand crypto in order to make well-informed choices and then to use those products correctly. IT professionals need to understand crypto in order to deploy it properly in their systems. Even lawyers need to understand crypto because governments at the local, state, and national level are enacting new laws defining the responsibilities of entities holding the public's private information.

This book is an introduction to crypto. It is not about the history of crypto (although you will find some historical stories). It is not a guide to writing code, nor a math book listing all the theorems and proofs of the underpinnings of crypto. It does not describe everything there is to know about crypto; rather, it describes the basic concepts of the most widely used crypto in the world today. After reading this book, you will know

what computer cryptography does and how it's used today. For example, you will

- Understand the difference between a block cipher and a stream cipher and know when to use each (if someone tries to sell you an application that reuses a stream cipher's key, you will know why you shouldn't buy it).
- Know why you should not implement key recovery on a signing-only key.
- Understand what SSL does and why it is not the security magic bullet solving all problems, which some e-commerce sites seem to imply.
- Learn how some companies have effectively implemented crypto in their products.
- Learn how some companies have used crypto poorly (smart people learn from their own mistakes; brilliant people learn from other people's mistakes).

There are, of course, many more things you will learn in this book.

Chapter 1 delves into why cryptography is needed today; Chapters 2 through 5 describe the basic building blocks of crypto, such as symmetric keys and public keys, password-based encryption, and digital signatures. In Chapters 6 through 8, you will see how these building blocks are used to create an infrastructure through certificates and protocols. In Chapter 9, you will learn how specialized hardware devices can enhance your security. Chapter 10 explores the legal issues around digital signatures. Finally, Chapters 11 and 12 show you some real-world examples of companies doing it wrong and doing it right.

Throughout this book we use some standard computer hexadecimal notation. For instance, we might show a cryptographic key such as the following:

```
0x14C608B9 62AF9086
```

Many of you probably know what that means, but if you don't, read Appendix A. It's all about how the computer industry displays bits and bytes in hexadecimal. It also describes ASCII, the standard way letters, numerals, and symbols are expressed in computers.

In Chapter 6, you'll find a brief description of ASN.1 and BER/DER encoding. If you want to drill down further into this topic, read Appendix B.

In Appendix C, you will find further detailed information about many of the topics discussed in the book. These details are not crucial to understanding the concepts presented in the main body of the book; but for those who wish to learn more about the way crypto is used today, this appendix will offer interesting reading.

Appendix D contains a handy summary for each chapter. You'll also find a list of key terms, a key terms quiz, a multiple-choice quiz, and an essay quiz to test your knowledge of each chapter's content, as well as one or two lab projects per chapter.

At the end of the book there is a list of additional online resources and a page devoted to the contents of the CD.

## About the Authors

**Steve Burnett** With degrees in math from Grinnell College in Iowa and The Claremont Graduate School in California, Steve Burnett has spent most of his career converting math into computer programs, first at Intergraph Corporation and now with RSA Security. He is currently the lead crypto engineer for RSA's BSAFE Crypto-C and Crypto-J products, which are general purpose crypto software development kits in C and Java. Burnett is also a frequent speaker at industry events and college campuses.

**Stephen Paine** Stephen Paine has worked in the security field throughout most of his career—formerly for the United States Marine Corps and SUN Microsystems. He is currently a systems engineer for RSA Security, where he explains security concepts to corporations and developers worldwide and provides training to customers and RSA employees.

## About the Reviewers

**Blake Dournaee** Blake Dournaee joined RSA Security's developer support team in 1999, specializing in support and training for the BSAFE cryptography toolkits. Prior to joining RSA Security, he worked at NASA-Ames Research Center in their security development group. He has a B.S. in Computer Science from California Polytechnic State University in San Luis Obispo and is currently a graduate student at the University of Massachusetts.

**Jessica Nelson** Jessica Nelson comes from a strong background in computer security. As an officer in the United States Air Force, she spearheaded the 12 Air Force/Southern Command Defensive Information Warfare division. She built programs that integrated computer and communications security into the DoD's Information Warfare. She graduated from UCSD with a degree in physics and has worked with such astrophysicists as Dr. Kim Griest and Dr. Sally Ride. She currently acts as technical sales lead in the western division of a European security company.

# Contents

|   |      |
|---|------|
| Credits   | xiii |
| Foreword  | xv   |
| Acknowledgments                                   | xvii |
| Preface   | xix  |
| About the Authors                                 | xxii |
| <br>  |      |
| <b>Chapter 1</b> Why Cryptography?                | 1    |
| Security Provided by Computer Operating Systems   | 2    |
| How Operating Systems Work                        | 2    |
| Default OS Security: Permissions                  | 3    |
| Attacks on Passwords                              | 4    |
| Attacks That Bypass Operating Systems             | 6    |
| Data Recovery Attack                              | 6    |
| Memory Reconstruction Attack                      | 9    |
| Added Protection Through Cryptography             | 11   |
| The Role of Cryptography in Data Security         | 12   |
| <br>  |      |
| <b>Chapter 2</b> Symmetric-Key Cryptography       | 15   |
| Some Crypto Jargon                                | 18   |
| What Is a Key?                                    | 20   |
| Why Is a Key Necessary?                           | 22   |
| Generating a Key                                  | 22   |
| A Random Number Generator                         | 27   |
| A Pseudo-Random Number Generator                  | 28   |
| Attacks on Encrypted Data                         | 30   |
| Attacking the Key                                 | 30   |
| Breaking the Algorithm                            | 36   |
| Measuring the Time It Takes to Break Your Message | 37   |
| Symmetric Algorithms: The Key Table               | 37   |
| Symmetric Algorithms: Block Versus Stream Ciphers | 38   |
| Block Ciphers                                     | 38   |
| Stream Ciphers                                    | 41   |
| Block Versus Stream: Which Is Better?             | 45   |
| Digital Encryption Standard                       | 46   |
| Triple DES  | 47   |
| Commercial DES Replacements                       | 49   |
| Advanced Encryption Standard                      | 50   |

---

|   |     |
|---|-----|
| Summary   | 51  |
| Real-World Example: Oracle Databases                                      | 51  |
| <b>Chapter 3</b> Symmetric-Key Management                                 | 53  |
| Password-Based Encryption   | 54  |
| Programming Convenience   | 59  |
| Breaking PBE  | 63  |
| Slowing Down an Attack on a Password                                      | 64  |
| Good Passwords  | 65  |
| Password Generators   | 67  |
| Hardware-Based Key Storage  | 69  |
| Tokens  | 69  |
| Crypto Accelerators   | 73  |
| Hardware Devices and Random Numbers                                       | 75  |
| Biometrics  | 75  |
| Summary   | 76  |
| Real-World Examples   | 76  |
| Keon Desktop  | 77  |
| Other Products  | 79  |
| <b>Chapter 4</b> The Key Distribution Problem and Public-Key Cryptography | 81  |
| Sharing Keys in Advance   | 83  |
| Problems With This Scheme   | 84  |
| Using a Trusted Third Party   | 85  |
| Problems With This Scheme   | 86  |
| Public-Key Cryptography and the Digital Envelope                          | 88  |
| Security Issues   | 91  |
| Breaking a Public-Key Algorithm   | 92  |
| Some History of Public-Key Cryptography                                   | 93  |
| How Public-Key Cryptography Works   | 94  |
| The RSA Algorithm   | 98  |
| The DH Algorithm  | 105 |
| The ECDH Algorithm  | 111 |
| Comparing the Algorithms  | 117 |
| Security  | 117 |
| Key Sizes   | 119 |
| Performance   | 120 |
| Transmission Size   | 122 |
| Interoperability  | 122 |

---

|  |         |
|--|---------|
| Protecting Private Keys  | 122     |
| Using the Digital Envelope for Key Recovery                            | 123     |
| Key Recovery via a Trusted Third Party                                 | 124     |
| Key Recovery via a Group of Trustees                                   | 126     |
| Key Recovery via Threshold Schemes                                     | 127     |
| How a Threshold Scheme Works   | 130     |
| Summary  | 132     |
| Real-World Example   | 133     |
| <br><b>Chapter 5</b> The Digital Signature                             | <br>137 |
| The Uniqueness of a Digital Signature                                  | 138     |
| Message Digests  | 141     |
| Collisions   | 145     |
| The Three Important Digest Algorithms                                  | 148     |
| A Representative of Larger Data  | 149     |
| Data Integrity   | 153     |
| Back to Digital Signatures   | 154     |
| Trying to Cheat  | 156     |
| Implementing Authentication, Data Integrity, and Nonrepudiation        | 159     |
| Understanding the Algorithms   | 159     |
| RSA  | 160     |
| DSA  | 161     |
| ECDSA  | 163     |
| Comparing the Algorithms   | 163     |
| Security   | 163     |
| Performance  | 164     |
| Transmission Size  | 165     |
| Interoperability   | 165     |
| Protecting Private Keys  | 166     |
| Introduction to Certificates   | 166     |
| Key Recovery   | 169     |
| Summary  | 169     |
| Real-World Example   | 170     |
| <br><b>Chapter 6</b> Public-Key Infrastructures and the X.509 Standard | <br>171 |
| Public-Key Certificates  | 172     |
| Unique Identifiers   | 174     |
| Standard Version 3 Certificate Extensions                              | 175     |
| Entity Names   | 177     |

---

|  |     |
|--|-----|
| ASN.1 Notation and Encoding                                | 179 |
| The Components of a PKI                                    | 179 |
| Certification Authority                                    | 180 |
| Registration Authority                                     | 180 |
| Certificate Directory                                      | 181 |
| Key Recovery Server  | 182 |
| Management Protocols                                       | 182 |
| Operational Protocols                                      | 184 |
| Registering and Issuing Certificates                       | 184 |
| Revoking a Certificate                                     | 185 |
| Certificate Revocation Lists                               | 186 |
| Suspending a Certificate                                   | 190 |
| Authority Revocation Lists                                 | 190 |
| Trust Models   | 191 |
| Certificate Hierarchies                                    | 192 |
| Cross-Certification  | 193 |
| X.509 Certificate Chain                                    | 194 |
| The Push Model Versus the Pull Model                       | 195 |
| Managing Key Pairs   | 196 |
| Generating Key Pairs                                       | 197 |
| Protecting Private Keys                                    | 197 |
| Managing Multiple Key Pairs                                | 198 |
| Updating Key Pairs   | 199 |
| Keeping a History of Key Pairs                             | 200 |
| Deploying a PKI  | 201 |
| The Future of PKI  | 201 |
| Roaming Certificates                                       | 201 |
| Attribute Certificates                                     | 203 |
| Certificate Policies and Certification Practice Statements | 204 |
| Summary  | 206 |
| Real-World Examples  | 206 |
| Keon Certificate Server                                    | 207 |
| Keon Web PassPort  | 207 |
| <b>Chapter 7</b> Network and Transport Security Protocols  | 209 |
| Internet Protocol Security                                 | 209 |
| IP Security Architecture                                   | 210 |
| IPSec Services   | 211 |
| The Authentication Header Protocol                         | 211 |
| Integrity Check Value Calculation                          | 212 |



---

|   |     |
|---|-----|
| Transport and Tunnel Modes                            | 213 |
| The Encapsulating Security Payload Protocol           | 215 |
| Encryption Algorithms                                 | 216 |
| ESP in Transport and Tunnel Modes                     | 217 |
| Security Associations                                 | 218 |
| Combining Security Associations                       | 219 |
| Security Databases                                    | 220 |
| Security Policy Database                              | 222 |
| Security Association Database                         | 222 |
| Key Management  | 223 |
| Internet Key Exchange                                 | 224 |
| Secure Sockets Layer                                  | 227 |
| The History of SSL                                    | 227 |
| Session and Connection States                         | 228 |
| The Record Layer Protocol                             | 230 |
| The Change Cipher Spec Protocol                       | 231 |
| The Alert Protocol                                    | 232 |
| The Handshake Protocol                                | 233 |
| The Client Hello Message                              | 234 |
| The Server Hello Message                              | 235 |
| The Server Certificate Message                        | 236 |
| The Server Key Exchange Message                       | 236 |
| The Certificate Request Message                       | 237 |
| The Server Hello Done Message                         | 237 |
| The Client Certificate Message                        | 237 |
| The Client Key Exchange Message                       | 238 |
| The Certificate Verify Message                        | 238 |
| The Finished Message                                  | 239 |
| Ending a Session and Connection                       | 239 |
| Resuming Sessions                                     | 240 |
| Cryptographic Computations                            | 240 |
| Encryption and Authentication Algorithms              | 240 |
| Summary   | 241 |
| Real-World Examples                                   | 242 |
| <b>Chapter 8</b> Application-Layer Security Protocols | 243 |
| S/MIME  | 243 |
| Overview  | 244 |
| S/MIME Functionality                                  | 245 |
| Cryptographic Algorithms                              | 245 |