

# **Report on the Development of the Advanced Encryption Standard (AES)**

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## **Abstract:**

In 1997, the National Institute of Standards and Technology (NIST) initiated a process to select a symmetric-key encryption algorithm to be used to protect sensitive (unclassified) Federal information in furtherance of NIST's statutory responsibilities. In 1998, NIST announced the acceptance of fifteen candidate algorithms and requested the assistance of the cryptographic research community in analyzing the candidates. This analysis included an initial examination of the security and efficiency characteristics for each algorithm. NIST reviewed the results of this preliminary research and selected MARS, RC6™, Rijndael, Serpent and Twofish as finalists. Having reviewed further public analysis of the finalists, NIST has decided to propose **Rijndael** as the Advanced Encryption Standard (AES). The research results and rationale for this selection are documented in this report.

**Key words:** Advanced Encryption Standard (AES), cryptography, cryptanalysis, cryptographic algorithms, encryption, Rijndael.

# Report On The Development Of The Advanced Encryption Standard Aes

**Máire McLoone, John V. McCanny**



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**Report on the Development of the Advanced Encryption Standard (AES).** ,2000 In 1997 the National Institute of Standards and Technology NIST initiated a process to select a symmetric key encryption algorithm to be used to protect sensitive unclassified Federal information in furtherance of NIST's statutory responsibilities In 1998 NIST announced the acceptance of fifteen candidate algorithms and requested the assistance of cryptographic research community in analyzing the candidates This analysis included an initial examination of the security and efficiency characteristics for each algorithm NIST reviewed the results of this preliminary research and selected MARS RC6 TM Rijndael Serpent and Twofish as finalists Having reviewed further public analysis of the finalist NIST has decided to propose Rijndael as the Advance Encryption Standard AES The research results and rationale for this selection are documented in this report [Report on the](#)

[Development of the Advanced Encryption Standard \(AES\)](#) James Nechvatal,2001-12-01 In 1997 NIST initiated a process to select a symmetric key encryption algorithm to be used to protect sensitive unclass Fed info In 1998 NIST announced the acceptance of 15 candidate algorithms and requested the assistance of the cryptographic research community in analyzing the candidates This analysis included an initial exam of the security and efficiency characteristics for each algorithm NIST reviewed the results of this research and selected MARS RC Rijndael Serpent and Twofish as finalists After further public analysis of the finalists NIST has decided to propose Rijndael as the AES The research results and rationale for this selection are documented here

**System-on-Chip Architectures and Implementations for Private-Key Data Encryption** Máire McLoone,John V. McCanny,2012-12-06 In System on Chip Architectures and Implementations for Private Key Data Encryption new generic silicon architectures for the DES and Rijndael symmetric key encryption algorithms are presented The generic architectures can be utilised to rapidly and effortlessly generate system on chip cores which support numerous application requirements most importantly different modes of operation and encryption and decryption capabilities In addition efficient silicon SHA 1 SHA 2 and HMAC hash algorithm architectures are described A single chip Internet Protocol Security IPSec architecture is also presented that comprises a generic Rijndael design and a highly efficient HMAC SHA 1 implementation In the opinion of the authors highly efficient hardware implementations of cryptographic algorithms are provided in this book However these are not hard fast solutions The aim of the book is to provide an excellent guide to the design and development process involved in the translation from encryption algorithm to silicon chip implementation

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algorithms A selected number of future directions such as post quantum security or design of ciphers for modern needs and particular applications are also discussed We believe that the two volumes of this work will be of interest to researchers to master s and PhD students studying or working in the field of cryptography as well as to all professionals working in the field of cybersecurity

**Topics in Cryptology - CT-RSA 2001** David Naccache,2003-06-29 You are holding the rst in a hopefully long and successful series of RSA Cryptographers Track proceedings The Cryptographers Track CT RSA is one of the many parallel tracks of the yearly RSA Conference Other sessions deal with government projects law and policy issues freedom and privacy news analysts opinions standards ASPs biotech and healthcare nance telecom and wireless security developers new products implementers threats RSA products VPNs as well as cryptography and enterprise tutorials RSA Conference 2001 is expected to continue the tradition and remain the largest computer security event ever staged 250 vendors 10 000 visitors and 3 000 class going attendees are expected in San Francisco next year I am very grateful to the 22 members of the program committee for their hard work The program committee received 65 submissions one of which was later withdrawn for which review was conducted electronically almost all papers had at least two reviews although most had three or more Eventually we accepted the 33 papers that appear in these proceedings Revisions were not checked on their scientific aspects and some authors will write final versions of their papers for publication in refereed journals As is usual authors bear full scientific and paternity responsibilities for the contents of their papers

**Data and Applications Security XXII** Vijay Atluri,2008-07 This book constitutes the refereed proceedings of the 22nd Annual IFIP WG 11.3 Working Conference on Data and Applications Security held in London UK in July 2008 The 22 revised full papers presented together with 1 keynote lecture and 1 invited talk were carefully reviewed and selected from 56 submissions The papers are organized in topical sections on access control audit and logging privacy systems security certificate management trusted computing platforms security policies and metrics as well as Web and pervasive systems

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**The Mathematics of Secrets** Joshua Holden,2018-10-02 Explaining the mathematics of cryptography The Mathematics of Secrets takes readers on a fascinating tour of the mathematics behind cryptography the science of sending secret messages Using a wide range of historical anecdotes and real world examples Joshua Holden shows how mathematical principles underpin the ways that different codes and ciphers work He focuses on both code making and code breaking and discusses most of the ancient and modern ciphers that are currently known He begins by looking at substitution ciphers and then discusses how to introduce flexibility and additional notation Holden goes on to explore polyalphabetic substitution ciphers transposition ciphers connections between ciphers and computer encryption stream ciphers public key ciphers and ciphers involving exponentiation He concludes by looking at the future of ciphers and where cryptography might be headed The Mathematics of Secrets reveals the mathematics working stealthily in the science of coded messages A blog describing new developments and historical discoveries in cryptography related to the material in this book is accessible at <http://press.princeton.edu/titles/10826.html>

*Proceedings of the 12th National Technical Seminar on Unmanned System Technology 2020* Khalid Isa,Zainah Md. Zain,Rosmiwati Mohd-Mokhtar,Maziyah Mat Noh,Zool H. Ismail,Ahmad Anas Yusof,Ahmad Faisal Mohamad Ayob,Syed Saad Azhar Ali,Herdawatie Abdul Kadir,2021-09-24 This book comprises the proceedings of the 12th National Technical Symposium on Unmanned System Technology 2020 NUSYS 20 held on October 27 28 2020 It covers a number of topics including intelligent robotics novel sensor technology control algorithms acoustics signal processing imaging techniques biomimetic robots green energy sources and underwater communication backbones and protocols and it appeals to researchers developing marine technology solutions and policy makers interested in technologies to facilitate the exploration of coastal and oceanic regions

**Field-Programmable Logic and Applications** Gordon Brebner,2001-08-15 This book constitutes the refereed proceedings of the 11th International Conference on Field Programmable Logic and Application FPL 2001 held in Belfast Northern Ireland UK in August 2001 The 56 revised full papers and 15 short papers presented were carefully reviewed and selected from a total of 117 submissions The book offers topical sections on architectural framework place and route architecture DSP synthesis encryption runtime reconfiguration graphics and vision networking processor interaction applications methodology loops and systolic image processing faults and arithmetic

## **Cryptographic Hardware and Embedded Systems - CHES 2002** Burton S. Jr. Kaliski, Cetin K. Koc, Christof

Paar, 2003-08-02 These are the proceedings of CHES 2002 the Fourth Workshop on Cryptographic Hardware and Embedded Systems After the first two CHES Workshops held in Massachusetts and the third held in Europe this is the first Workshop on the West Coast of the United States There was a record number of submissions this year and in response the technical program was extended to 3 days As is evident by the papers in these proceedings there have been again many excellent submissions Selecting the papers for this year's CHES was not an easy task and we regret that we could not accept many contributions due to the limited availability of time There were 101 submissions this year of which 39 were selected for presentation We continue to observe a steady increase over previous years 42 submissions at CHES 99 51 at CHES 2000 and 66 at CHES 2001 We interpret this as a continuing need for a workshop series that combines theory and practice for integrating strong security features into modern communications and computer applications In addition to the submitted contributions Jean Jacques Quisquater UCL Belgium Sanjay Sarma MIT USA and a panel of experts on hardware random number generation gave invited talks As in the previous years the focus of the Workshop is on all aspects of cryptographic hardware and embedded system security Of special interest were contributions that describe new methods for

efficient hardware implementations and high speed software for embedded systems e.g. smart cards microprocessors DSPs etc CHES also continues to be an important forum for new theoretical and practical findings in the important and growing field of side channel attacks

## **UMTS Security** Valtteri Niemi, Kaisa Nyberg, 2006-02-08 Can you afford not to read this book The Universal Mobile Telecommunication System UMTS offers a consistent set of services to mobile computer and phone users and numerous different radio access technologies will co exist within the UMTS system's core network security is therefore of the utmost importance UMTS Security focuses on the standardized security features of UMTS and brings together material previously only available in specifications design documents and presentations in one concise form In addition this unique volume also covers non standard implementation specific features that allow differentiation between operators and manufacturers Describes the security solutions specified for UMTS Provides a comprehensive presentation of the UMTS security specifications and explains the role of the security functionality in the UMTS system Presents the UMTS security system in its totality from the theoretical background through to the design process Discusses the new security features included in Release 4 and 5 By providing a unified treatment of the security services provided by the UMTS system this volume will provide invaluable information and have instant appeal to planners constructors and implementers of UMTS networks and developers and analysts of application oriented security services that make use of UMTS communication networks It will also be of considerable interest to postgraduates and researchers of modern communication security technology

*Cryptographic Hardware and Embedded Systems - CHES 2001* Cetin K. Koc, David Naccache, Christof

Paar, 2003-06-30 These are the proceedings of CHES 2001 the third Workshop on Cryptographic Hardware and Embedded

Systems The rst two CHES Workshops were held in Massachusetts and this was the rst Workshop to be held in Europe There was a large number of submissions this year and in response the technical program was extended to 2 1 2 days As is evident by the papers in these proceedings many excellent submissions were made Selecting the papers for this year s CHES was not an easy task and were regret that we had to reject several very interesting papers due to the lack of time There were 66 submitted contributions this year of which 31 or 47% were selected for presentation If we look at the number of submitted papers at CHES 99 42 papers and CHES 2001 51 papers we observe a steady increase We interpret this as a continuing need for a workshop series which combines theory and practice for integrating strong security features into modern communications and computer applications In addition to the submitted contributions Ross Anderson from Cambridge University UK and Adi Shamir from The Weizmann Institute Israel gave invited talks As in previous years the focus of the workshop is on all aspects of cryptographic hardware and embedded system design Of special interest were contributions that describe new methods for efficient hardware implementations and high speed software for embedded systems e g smart cards microprocessors DSPs etc CHES also continues to be an important forum for new theoretical and practical findings in the important and growing field of side channel attacks

**Proceedings of the International Conference on Soft Computing for Problem Solving (SocProS 2011) December 20-22, 2011** Kusum Deep, Atulya Nagar, Millie Pant, Jagdish Chand Bansal, 2012-04-13 The objective is to provide the latest developments in the area of soft computing These are the cutting edge technologies that have immense application in various fields All the papers will undergo the peer review process to maintain the quality of work

**Cryptography and Satellite Navigation** Joseph J. Rushanan, James T. Gillis, 2024-12-31 Cryptography and Satellite Navigation is a comprehensive guide that offers a wide ranging yet approachable introduction to the world of cryptography with a particular focus on its role in navigation In an increasingly connected world cryptography serves as the cornerstone of secure communication safeguarding information across countless cyber and navigation applications The book includes a thorough explanation of the three primary cryptographic methods Symmetric ciphers provide confidentiality through shared keys while hashes play a crucial role in ensuring the integrity of information Asymmetric or public key cryptography introduces a level of security through confidentiality and authentication uniquely using private information to establish digital signatures The book contains an insightful exploration of quantum computing and its profound implications for the future of cryptography This book also delves into the practical application of cryptographic methods through cryptographic protocols essential for the seamless functioning of everyday life With real world examples like the Galileo navigation system the book demonstrates how digital signatures safeguard navigation data while symmetric ciphers and hashing extend beyond traditional data protection to ensure the authenticity of navigation signals This book provides valuable insights into the essential role of cryptography in both cyber and navigation domains preparing its reader for the challenges of a rapidly evolving technological landscape whether the reader is a seasoned professional or new to the field Information Security

and Cryptology - ICISC 2002 Pil Joong Lee, Chae Hoon Lim, 2003-02-24 This book constitutes the thoroughly refereed post proceedings of the 5th International Conference on Information Security and Cryptology ICISC 2002 held in Seoul Korea in November 2002 The 35 revised full papers presented together with an invited paper were carefully selected from 142 submissions during two rounds of reviewing and improvement The papers are organized in topical sections on digital signatures Internet security block ciphers and stream ciphers stream ciphers and other primitives efficient implementations side channel attacks cryptographic protocols and biometrics *Advances in Artificial Intelligence and Security* Xingming

Sun, Xiaorui Zhang, Zhihua Xia, Elisa Bertino, 2022-07-08 The 3 volume set CCIS 1586 CCIS 1587 and CCIS 1588 constitutes the refereed proceedings of the 8th International Conference on Artificial Intelligence and Security ICAIS 2022 which was held in Qinghai China in July 2022 The total of 115 full papers and 53 short papers presented in this 3 volume proceedings was carefully reviewed and selected from 1124 submissions The papers were organized in topical sections as follows Part I artificial intelligence Part II artificial intelligence big data cloud computing and security multimedia forensics Part III encryption and cybersecurity information hiding IoT security

**Encyclopedia of Computer Science and Technology, Second Edition (Set)** Phillip A. Laplante, 2017-10-02 With breadth and depth of coverage the Encyclopedia of Computer Science and Technology Second Edition has a multi disciplinary scope drawing together comprehensive coverage of the inter related aspects of computer science and technology The topics covered in this encyclopedia include General and reference Hardware Computer systems organization Networks Software and its engineering Theory of computation Mathematics of computing Information systems Security and privacy Human centered computing Computing methodologies Applied computing Professional issues Leading figures in the history of computer science The encyclopedia is structured according to the ACM Computing Classification System CCS first published in 1988 but subsequently revised in 2012 This classification system is the most comprehensive and is considered the de facto ontological framework for the computing field The encyclopedia brings together the information and historical context that students practicing professionals researchers and academicians need to have a strong and solid foundation in all aspects of computer science and technology



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