

NIST
Cryptographic Toolkit

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Toolkit Purpose

- ✓ The NIST Cryptographic Toolkit will provide Federal agencies, and others who choose to use it, with a comprehensive toolkit of standardized cryptographic algorithms, protocols, and security applications that they can use with confidence to protect sensitive information.

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Commercial Off-The-Shelf

- ✓ Agencies can't afford special government cryptographic products
- ✓ Government needs are sometimes more severe than ordinary commercial needs
 - Many users look to government to set cryptographic standards
 - Adopt industry standards wherever possible
 - Work with industry to encourage strong, high assurance cryptographic products

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Industry Participation

- ✓ NIST working with industry to develop a toolkit of high quality cryptographic algorithms
- ✓ Industry interaction & participation
 - Participate in voluntary standards bodies
 - Review draft FIPS
 - AES workshop & participation
 - Key Management workshop
 - Modes of Operation Workshop
 - Algorithm and Cryptographic Module Validation via CMVP

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NIST Cryptographic Toolkit

- ✓ Encryption
- ✓ Encryption modes
- ✓ Authentication
- ✓ Hashing
- ✓ Digital Signatures
- ✓ Key Management
- ✓ Random Number Generation
- ✓ Prime Number Generation

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NIST Cryptographic Toolkit

- ✓ Standardized algorithms
 - Federal Information Processing Standards
 - Often based on ANSI or other voluntary standards
 - Confidence they are secure
 - now and for foreseeable future
 - Wide range of applications
 - Assurance testing
 - Cryptographic Module Validation Program (CMVP)

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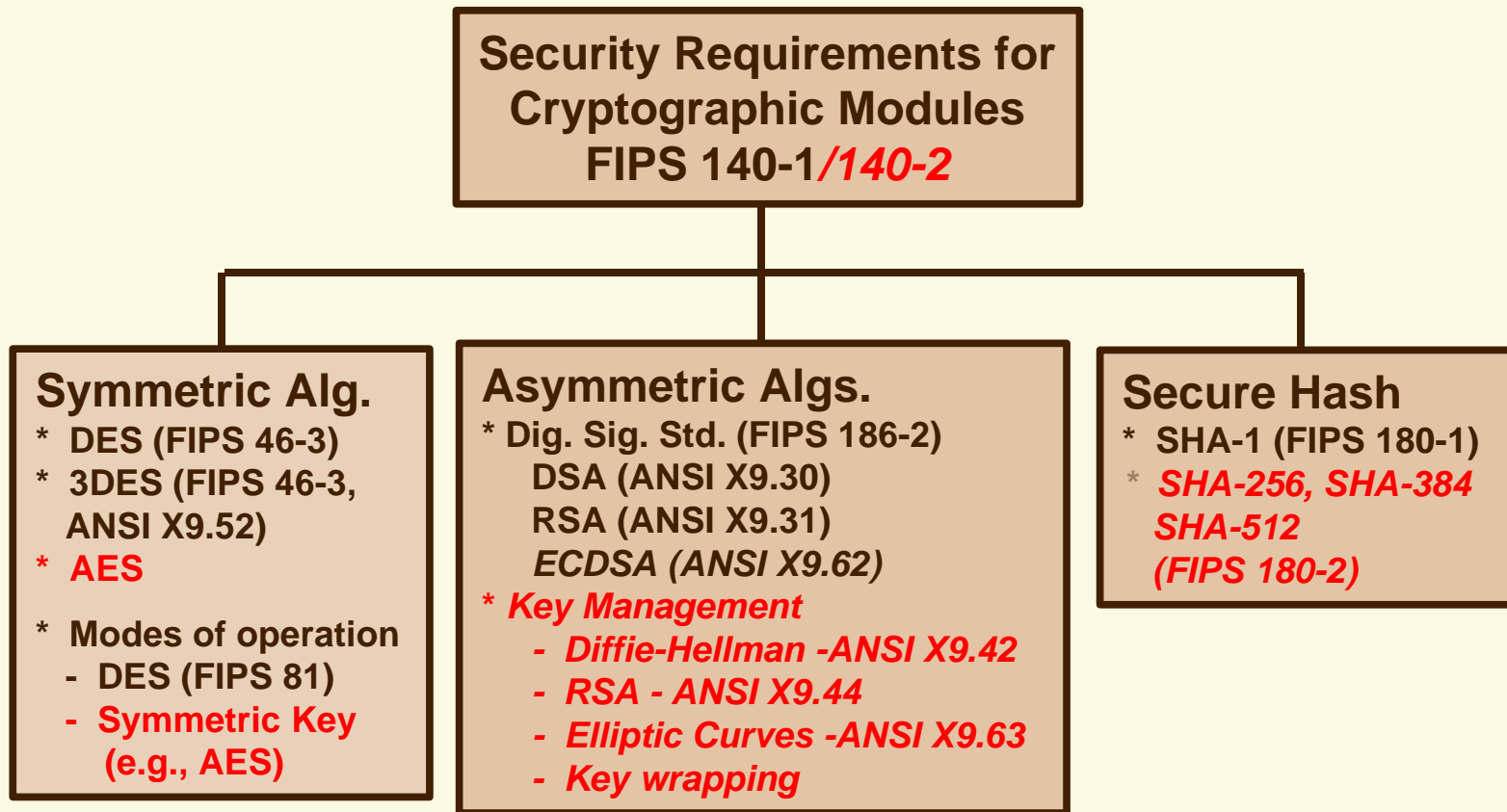
Algorithm Categories

- ✓ Symmetric (secret key cryptography)
 - Encrypt and decrypt using same key
- ✓ Asymmetric (public key cryptography)
 - Two related keys: one public, other private
 - Mainly used for signatures & key establishment
- ✓ Hashing
 - Compute a “cryptographic checksum” or “message digest” of messages or files
 - Used for integrity, authentication & signatures

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Cryptographic Standards



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FIPS Approved Crypto Algorithms

- ✓ Approved for US Government use
 - sensitive/unclassified
- ✓ Subject to 5 year NIST Reviews
- ✓ Analyzed for strength of security
- ✓ Have validation tests & program
- ✓ Coordination / cooperation with voluntary standards bodies
 - ANSI X9F (banking standards body)
 - IETF (major developer of standard apps that use crypto)

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FIPS 140-1/2

- ✓ Joint program with Canadian Security Establishment
- ✓ Umbrella standard for Crypto FIPS
- ✓ Validation testing for algorithms & Crypto Modules
 - Four independent private testing laboratories
 - this number may grow
 - National Voluntary Laboratory Accreditation (NLVAP) accreditation
- ✓ Big increase in validations since 1999
 - About 120 validated modules to date
- ✓ Update (FIPS 140-2) waiting for SoC signature

Data Encryption Standard (DES)

- ✓ FIPS 46-3
- ✓ In wide use
 - First open standard for strong crypto
 - “Kickstarted” open, public discussion and development of cryptographic algorithms
 - Benchmark for everything that has come after
- ✓ 64 bit block
- ✓ 56 bit keys
 - More than 2 decades old
 - now vulnerable to attack by key exhaustion
 - should be moving to Triple DES
 - otherwise still a good algorithm

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DES Modes of Operation

- ✓ FIPS 81
- ✓ Four modes defined
 - Electronic Code Book (ECB)
 - Cipher Block Chaining (CBC)
 - can be used for Message Authentication Code (MAC)
 - Cipher Feedback (CFB)
 - Output Feedback (OFB)
- ✓ Uses 64-bit blocks
- ✓ 56 bit keys

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Triple DES

- ✓ FIPS 46-3 and ANSI X9.52
- ✓ 64 bit block size
- ✓ 112 and 168 bit keys
 - DES repeated 3 times with 2 or 3 different keys
- ✓ Strong protection
- ✓ Easy substitution for DES
 - Main difference is bigger key size & slower performance
- ✓ Expands 4 DES modes into 7 modes

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Advanced Encryption Standard (AES)

- ✓ DES replacement
- ✓ Selected through open competition run by NIST
 - Public evaluation and analysis
 - 21 original submissions, 5 “finalists”
 - Final selection of Rijndael announced Oct. 2, 2000
 - <http://www.nist.gov/aes>
- ✓ Strong encryption with long expected life
 - 128 bit block size
 - 128, 192, & 256 bit key sizes
- ✓ Goal: royalty free worldwide

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Modes of Operation for Symmetric Key Block Ciphers

- ✓ Plan to parameterize 4 DES Modes
 - Could be used with any block encryption algorithm
- ✓ Other modes???

 - Counter
 - MAC
 - Modes combining integrity, authentication & encryption
 - Interleaved CBC
 - Super-encryption (e.g., Triple AES?)

- ✓ Workshop on October 20 (this Friday)
 - <http://www.nist.gov/modes>

SHA-1

- ✓ Secure Hash Algorithm
- ✓ FIPS 180-1; ANSI X9.30 Part 2
- ✓ 160 bit message digest
- ✓ Wide current use
 - Used with DSA, RSA or ECDSA

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SHA-xxx

- ✓ “Birthday” attacks against a hash make make n -bit AES and a $2n$ -bit hash roughly equivalent
 - 128-bit AES \approx SHA-256
 - 192-bit AES \approx SHA-384
 - 256-bit AES \approx SHA-512
- ✓ Available at <http://www.nist.gov/sha>
- ✓ Draft standard available ~ February

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Message. Authentication Code (MAC)

✓ Current DES-MAC

- FIPS 113 & FIPS 81
 - Cipher Block Chaining (CBC)
- 64-bit MAC
 - 2^{32} work factor for birthday attacks
 - Not now strong enough for many applications

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MAC (contd.)

✓ HMAC

- Generalization of RFC 2104 and ANSI X9.71
 - concatenate secret key and message
 - allow different FIPS-approved hash functions and sizes
- Soon available for public comment

✓ AES MAC Needed???

- Modes workshop issue

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Digital Signature Std. (DSS)

✓ FIPS 186-2

- Three algorithms
 - DSA (ANSI X9.30 Part 1)
 - RSA (ANSI X9.31)
 - transition period from PKCS#1
 - ECDSA (ANSI X9.62)
- Use SHA-1 message digest

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DSS Plans

- ✓ Planned modification of FIPS 186-2 → 186-3
- ✓ Need to expand key sizes
 - DSA now limited to 1024 bits
 - 128-bit AES roughly as strong as 3000 bit DSA
 - 1024 bit DSA roughly as strong as 160-bit SHA-1
 - SHA 256, SHA 384 & SHA 512
- ✓ Allow PKCS#1 (RSA)?
- ✓ Draft available ~ February 2001

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Other Areas for New Crypto FIPS

- ✓ Prime Number Generation
 - ANSI X9.80
- ✓ Random Number Generation
 - ANSI X9.82
 - NIST RNG tests (<http://csrc.nist.gov/rng>)

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Key Management

- ✓ Key Management = Key establishment + rules (including protocols)
- ✓ Key establishment = Key Agreement + Key Transport
- ✓ Key Agreement: no key sent; uses asymmetric/public key techniques
- ✓ Key Transport: encrypted key is sent; uses symmetric or public key techniques

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Key Management (contd.)

- ✓ No current FIPS using public key techniques
- ✓ Workshop held Feb. 10 - 11, 2000
- ✓ Multi-level approach
 - Framework document to lay out approach
 - Key establishment schemes
 - Rules/guidance/protocols

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Key Management (contd.)

✓ Draft FIPS in early FY2002?

- ANSI X9.42, DH and MVQ Key Agreement
- ANSI X9.44, Factoring Based (e.g., RSA) Key Agreement & Transport
- ANSI X9.63, EC Key Agreement & TransportKey wrapping
- Key wrapping

✓ <http://www.nist.gov/kms>

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Conclusion

- ✓ NIST is building a comprehensive cryptographic toolkit
 - strong security
 - assurance & validation testing
 - suitable for commercial use and COTS products
 - encourage industry participation

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Further Information

✓ **NIST Computer Security Division Home Page**

<http://www.itl.nist.gov/div893/>

✓ **Points of Contact**

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