Algorithm Validation Testing

Larry Bassham
and
Sharon Keller
Validation Testing for Cryptographic Algorithms

• Prerequisite to FIPS 140 Validation Testing
Validation Process

• NIST and CSE develop validation suite consisting of validation tests
• Accreditation Laboratory supplies data and applicable validation tests required to validate a vendor’s Implementation Under Test (IUT)
• Vendor runs the specified validation tests on the IUT and returns the results to the laboratory
• Laboratory verifies results and sends the IUT’s results and a request for validation to NIST
Validation Process (Continued)

• NIST reviews the results
  – Adds the vendor algorithm IUT information to NIST’s algorithm validation database
  – Creates an algorithm validation certificate which NIST and CSE sign and send to the laboratory to be sent to the vendor
  – Adds an entry to the appropriate validation list which is accessible via http://csrc.nist.gov/cryptval
Cryptographic Algorithms for Which NIST Currently Has Standards and Validation Tests

• FIPS 197 – *Advanced Encryption Standard (AES)*
• FIPS 46-3 and FIPS 81 – *Data Encryption Standard (DES)* and *DES Modes of Operation* – specifies the DES and Triple DES algorithms
• FIPS 186-2 and FIPS 180-1 – *Digital Signature Standard (DSS)* and *Secure Hash Standard (SHS)*
• FIPS 185 – *Escrowed Encryption Standard (EES)* – specifies the Skipjack algorithm
Cryptographic Algorithms for Which NIST Is Developing Standards and Validation Tests

- HMAC
- SHA-256, SHA-384, SHA-512
- Key Establishment using Diffie-Hellman and MQV
Validation Tests
(TDES, DES, and Skipjack)

- 3 types of cryptographic algorithm validation tests
  - Known Answer tests
    - Variable Plaintext/Ciphertext Known Answer Test
    - *Inverse Permutation Known Answer Test
    - Variable Key Known Answer Test
    - *Permutation Operation Known Answer Test
    - *Substitution Table Known Answer Test
  - *Multi-block Message test
  - Monte Carlo test

(* Not run for Skipjack)
Validation Tests (TDES, DES, and Skipjack) (Continued)

- A separate set of Known Answer Tests and a corresponding Monte Carlo test and (if applicable) a Multi-block Message Test exist for every state in every mode of operation.
Validation Tests
(TDES, DES, and Skipjack)
(Continued)

• States
  – Encrypt
  – Decrypt
Validation Tests (TDES, DES, and Skipjack) (Continued)

<table>
<thead>
<tr>
<th>Modes of Operation per Algorithm</th>
<th>DES</th>
<th>Triple DES</th>
<th>Skipjack</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECB</td>
<td>ECB</td>
<td>ECB</td>
<td>ECB</td>
</tr>
<tr>
<td>CBC</td>
<td>CBC</td>
<td>CBC-Interleaved</td>
<td>CBC</td>
</tr>
<tr>
<td>CFB - 1,8,64 bit</td>
<td>CFB - 1,8,64 bit</td>
<td>CFB - 1,8,64 bit</td>
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</tr>
<tr>
<td>OFB</td>
<td>CFB-Pipelined - 1,8,64 bit</td>
<td>OFB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OFB</td>
<td>OFB-Interleaved</td>
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</tr>
</tbody>
</table>
Known Answer Tests
(Triple DES and DES)

- Verifies that the implementation correctly performs the algorithm
- Provides conformance testing for components of the algorithm
  - Initial permutation IP
  - Expansion matrix E
  - Inverse permutation IP⁻¹
  - Key permutation PC1 and PC2
  - Data permutation P
  - Substitution tables S₁, S₂, …, S₈
Known Answer Tests (Skipjack)

- Verifies that, given known inputs, the correct results are produced.
Known Answer Tests

• Test procedures:
  – Lab supplies known values for key(s), plaintext, and, if applicable, IV(s) for every Known Answer Test
  – Vendor runs each known value through the IUT of the TDES, DES, or Skipjack algorithms
  – The results are recorded and compared to the known answers
Multi-block Message Test

- Tests the ability to properly process multi-block messages, requiring the chaining of information from one block to the next.
- Lab supplies the IUT with pseudorandom values for key(s), messages that are integral numbers of blocks in length, and, if applicable, IV(s).
- Evaluates the resulting ciphertext.
Monte Carlo Test

- Tests for implementation flaws
- Lab supplies pseudorandom values for key(s), plaintext, and, if applicable, IV(s)
- Test consists of 4 million cycles through the TDES, DES, or Skipjack algorithms
- The results of every 10,000th encryption or decryption cycle are recorded and evaluated
Validation Tests (AES)

- Same three test types as DES and 3DES
  - Know Answer Tests
  - Multi-block Message Test
  - Monte Carlo Test

- Known Answer Tests differ
  - Variable Plaintext/Ciphertext Test
  - Variable Key Test
  - GFSbox Test (stress math operations and Sbox used in round function)
  - Key Sbox Test (stresses Sbox used in key schedule)

- Separate tests required for each of three key sizes as well as each state (encrypt/decrypt)
SHA-1

- Three Tests
  - Short Messages
  - Selected Long Messages
  - Monte Carlo
- Two modes: bit-oriented and byte-oriented
SHA-1: Short Messages

- Tests the ability of the IUT to generate digests for messages of arbitrary length
- Generates messages of length $0 \leq i \leq 1024$
- Calculates message digests of messages
- Compares message digest calculated with those supplied by the tool
SHA-1: Selected Long Messages

• Tests the ability of the IUT to generate digests for messages that span multiple blocks
• Generates messages of length:
  – Byte-oriented: 1032+i*1024, 0 ≤ i < 100
  – Bit-oriented: 1025+i*1024, 0 ≤ i < 100
• Calculates message digests of messages
• Compares messages digests calculated with those supplied by the IUT
SHA-1: Monte Carlo

- Tests for implementation flaws by providing pseudo-random input
- Generates 100 message digests, using previous digests as input
- Compares messages digests calculated by the IUT with the expected values
DSS

- Primality
- Domain Parameter Generation
- Domain Parameter Validation
- Key Pair Generation
- Signature Generation
- Signature Validation
Primality

• Tests the ability of the implementation to determine whether large numbers are prime
• Generates several large numbers, some of which are prime and some of which are not
• Compares the determination of the IUT regarding primality with the expected value
Domain Parameter Generation

- Tests the ability of the IUT to generate Domain Parameters
- Requests the IUT to generate a specific number of Domain Parameter sets (P, Q, G, Seed, Counter, H)
- Recalculates the Domain Parameters using the same Seed and verifies the remaining values in the set
Domain Parameter Validation

• Tests the ability of the IUT to recognize valid vs. invalid Domain Parameters
• Generates several sets of Domain Parameters
• Modifies components of some parameters
• Compares the IUT’s results with the expected values
Key Pair Generation

- Tests the ability of the IUT to generate pair-wise consistent keys
- Provides seed values to the IUT to use to generate key pairs
- Verifies the consistency of key pair or performs public key validation on the public key
Signature Generation

• Tests the ability of the IUT to derive correct signatures for messages
• Generates several messages to be signed by the IUT
• If the IUT can output the private key, compares the derived signatures with the expect signatures
• Otherwise, runs signature verification
Signature Verification

• Tests the ability of the IUT to recognize valid vs. invalid signatures
• Generates several messages and signatures
• Alters some signatures or messages to introduce errors
• Compares the IUT’s results with the expected values
Questions??