Cisco Common Cryptographic Module (C3M)

FIPS 140-2 Non Proprietary Security Policy
Level 1 Validation

Version 0.3

November, 11
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1 Introduction

1.1 Purpose
This document is the non-proprietary Cryptographic Module Security Policy for the Cisco Common Cryptographic Module (C3M). This security policy describes how the Cisco Common Cryptographic Module (C3M) (Software Version: 0.9.8r.1.1) meets the security requirements of FIPS 140-2, and how to operate it in a secure FIPS 140-2 mode. This policy was prepared as part of the Level 1 FIPS 140-2 validation of the Cisco Common Cryptographic Module (C3M).


1.2 Module Validation Level
The following table lists the level of validation for each area in the FIPS PUB 140-2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Area Title</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cryptographic Module Specification</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Cryptographic Module Ports and Interfaces</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Roles, Services, and Authentication</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Finite State Model</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Physical Security</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>Operational Environment</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Cryptographic Key management</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Electromagnetic Interface/Electromagnetic Compatibility</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Self-Tests</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Design Assurance</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Mitigation of Other Attacks</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Overall module validation level</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1 Module Validation Level

1.3 References
This document deals only with operations and capabilities of the Cisco Common Cryptographic Module (C3M) in the technical terms of a FIPS 140-2 cryptographic module security policy. More information is available from the following sources:

For answers to technical or sales related questions please refer to the contacts listed on the Cisco Systems website at www.cisco.com.

The NIST Validated Modules website (http://csrc.nist.gov/groups/STM/cmvp/validation.html) contains contact information for answers to technical or sales-related questions for the module.
1.4 Terminology
In this document, the Cisco Common Cryptographic Module (C3M) is referred to as C3M, the library, or the module.

1.5 Document Organization
The Security Policy document is part of the FIPS 140-2 Submission Package. In addition to this document, the Submission Package contains:

- Vendor Evidence document
- Finite State Machine
- Other supporting documentation as additional references

This document provides an overview of the Cisco Common Cryptographic Module (C3M) and explains the secure configuration and operation of the module. This introduction section is followed by Section 2, which details the general features and functionality of the module. Section 3 specifically addresses the required configuration for the FIPS-mode of operation.

With the exception of this Non-Proprietary Security Policy, the FIPS 140-2 Validation Submission Documentation is Cisco-proprietary and is releasable only under appropriate non-disclosure agreements. For access to these documents, please contact Cisco Systems.
2 Cisco Common Cryptographic Module (C3M)

The Cisco Common Cryptographic Module (C3M) is a software library that provides cryptographic services to a vast array of Cisco’s networking and collaboration products. The module provides FIPS validated cryptographic algorithms for services such as sRTP, SSH, TLS, 802.1x etc. The module does not implement any of the protocols directly. Instead, it provides the cryptographic primitives and functions to allow a developer to implement various protocols.

The module is based on OpenSSL FIPS canister with additions to support Suite B algorithms.

2.1 Cryptographic Module Physical Characteristics

![Figure 1 C3M logical block diagram](image)

FEC: Fundamental Elliptical Curve cryptography

Figure 1 C3M logical block diagram
The module is a multiple-chip standalone cryptographic module. For the purposes of the FIPS 140-2 level 1 validation, the C3M module is a single object module file named fipscanister.o (Linux/Unix/OS X) or fipscanister.lib (Microsoft Windows).

The module’s logical block diagram is shown in Figure 1 above. The red border denotes the logical cryptographic boundary of the module. The physical cryptographic boundary of the module is the enclosure of the system on which it is executing.

This module was tested on the following platforms for the purposes of this FIPS validation:

<table>
<thead>
<tr>
<th>#</th>
<th>Operating System</th>
<th>Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FreeBSD 8.2 (x86)</td>
<td>Intel Core i5</td>
</tr>
<tr>
<td>2</td>
<td>FreeBSD 8.2 (x64)</td>
<td>Intel Core i5</td>
</tr>
<tr>
<td>3</td>
<td>Red Hat Enterprise Linux v5 (x86)</td>
<td>Intel Xeon</td>
</tr>
<tr>
<td>4</td>
<td>Red Hat Enterprise Linux v5 (x64)</td>
<td>Intel Xeon</td>
</tr>
<tr>
<td>5</td>
<td>Linux Kernel 2.6.27.7</td>
<td>Cavium Octeon</td>
</tr>
<tr>
<td>6</td>
<td>Yellow Dog Linux 6.2</td>
<td>IBM PowerPC G4</td>
</tr>
<tr>
<td>7</td>
<td>Windows 7 SP1 (x86)</td>
<td>Intel Pentium 4</td>
</tr>
<tr>
<td>8</td>
<td>Windows 7 SP1 (x64)</td>
<td>Intel Core i5</td>
</tr>
<tr>
<td>9</td>
<td>Mac OS X 10.6 (x86)</td>
<td>Intel Core 2 Duo</td>
</tr>
<tr>
<td>10</td>
<td>Mac OS X 10.6 (x64)</td>
<td>Intel Core 2 Duo</td>
</tr>
</tbody>
</table>
2.2 Module Interfaces

The physical ports of the Module are the same as the system on which it is executing. The logical interface is a C-language application program interface (API).

The Data Input interface consists of the input parameters of the API functions. The Data Output interface consists of the output parameters of the API functions. The Control Input interface consists of the actual API functions. The Status Output interface includes the return values of the API functions.

The module provides a number of physical and logical interfaces to the device, and the physical interfaces provided by the module are mapped to the following FIPS 140-2 defined logical interfaces: data input, data output, control input, status output, and power. The logical interfaces and their mapping are described in the following table:

<table>
<thead>
<tr>
<th>Module Interface</th>
<th>FIPS 140-2 Logical Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>API input parameters</td>
<td>Data Input Interface</td>
</tr>
<tr>
<td>API output parameters</td>
<td>Data Output Interface</td>
</tr>
<tr>
<td>API function calls</td>
<td>Control Input Interface</td>
</tr>
<tr>
<td>API return codes</td>
<td>Status Output Interface</td>
</tr>
<tr>
<td>N/A</td>
<td>Power Interface</td>
</tr>
</tbody>
</table>

Table 3 – FIPS 140-2 Logical Interfaces

2.3 Roles and Services

The Module meets all FIPS 140-2 level 1 requirements for Roles and Services, implementing both Crypto-User and Crypto-Officer roles. As allowed by FIPS 140-2, the Module does not support user authentication for those roles. Only one role may be active at a time and the Module does not allow concurrent operators.

The User and Crypto Officer roles are implicitly assumed by the entity accessing services implemented by the Module. The Crypto Officer can install and initialize the Module. The Crypto Officer role is implicitly entered when installing the Module or performing system administration functions on the host operating system.

- User Role: Loading the Module and calling any of the API functions. This role has access to all of the services provided by the Module.
• Crypto-Officer Role: Installation of the Module on the host computer system. This role is assumed implicitly when the system administrator installs the Module library file.

<table>
<thead>
<tr>
<th>Service</th>
<th>Role</th>
<th>CSP</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetric encryption/decryption</td>
<td>User, Crypto Officer</td>
<td>Symmetric keys AES, Triple-DES</td>
<td>Execute</td>
</tr>
<tr>
<td>Key transport</td>
<td>User, Crypto Officer</td>
<td>Asymmetric private key RSA</td>
<td>Execute</td>
</tr>
<tr>
<td>Key agreement</td>
<td>User, Crypto Officer</td>
<td>DH and ECDH private key</td>
<td>Execute</td>
</tr>
<tr>
<td>Digital signature</td>
<td>User, Crypto Officer</td>
<td>Asymmetric private key RSA, DSA, ECDSA</td>
<td>Execute</td>
</tr>
<tr>
<td>Symmetric key generation</td>
<td>User, Crypto Officer</td>
<td>Symmetric key AES, Triple-DES</td>
<td>Write/execute</td>
</tr>
<tr>
<td>Keyed Hash (HMAC)</td>
<td>User, Crypto Officer</td>
<td>HMAC SHA-1 key, HMAC-SHA-1</td>
<td>Execute</td>
</tr>
<tr>
<td>Message digest (SHS)</td>
<td>User, Crypto Officer</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Random number generation</td>
<td>User, Crypto Officer</td>
<td>Seed key, seed</td>
<td>Write/execute</td>
</tr>
<tr>
<td>Show status</td>
<td>User, Crypto Officer</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Module initialization</td>
<td>User, Crypto Officer</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Self-test</td>
<td>User, Crypto Officer</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Zeroize</td>
<td>User, Crypto Officer</td>
<td>Symmetric key, asymmetric key, HMAC-SHA-1 key, seed key AES</td>
<td>Zeroize</td>
</tr>
</tbody>
</table>

Table 4 Roles, Services and Keys

2.4 Physical Security
The module is comprised of software only and thus does not claim any physical security.

2.5 Cryptographic Algorithms
The module implements a variety of approved and non-approved algorithms.

2.5.1 Approved Cryptographic Algorithms
The routers support the following FIPS 140-2 approved algorithm implementations:
2.5.2 Non-FIPS Approved Algorithms Allowed in FIPS Mode

The module supports the following non-FIPS approved algorithms which are permitted for use in the FIPS approved mode:

- Diffie-Hellman (key agreement; key establishment methodology provides between 80 and 152 bits of encryption strength)
- EC Diffie-Hellman (key agreement; key establishment methodology provides between 80 and 256 bits of encryption strength)
- RSA (key wrapping; key establishment methodology provides between 80 and 152 bits of encryption strength)

2.5.3 Non-Approved Cryptographic Algorithms

The module does not implement any non-approved cryptographic algorithms.

2.6 Cryptographic Key Management

2.6.1 Key Generation

The Module supports generation of DH, ECDH, DSA, RSA, and ECDSA public-private key pairs. The Module employs an ANSI X9.31 compliant random number generator for creation of asymmetric and symmetric keys.

The developer shall use entropy sources that contain at least 128 bits of entropy to seed the RNG as the module is not capable of detecting randomness or quality of the seeding material provided.
2.6.2 Key Storage

Public and private keys are provided to the Module by the calling process, and are destroyed when released by the appropriate API function calls. The Module does not perform persistent storage of keys.

2.6.3 Key Access

An authorized application as user (the Crypto-User) has access to all key data generated during the operation of the Module.

2.6.4 Key Protection and Zeroization

Keys residing in internally allocated data structures can only be accessed using the Module defined API. The operating system protects memory and process space from unauthorized access. Zeroization of sensitive data is performed automatically by API function calls for intermediate data items, and on demand by the calling process using Module provided API function calls provided for that purpose.

Only the process that creates or imports keys can use or export them. No persistent storage of key data is performed by the Module. All API functions are executed by the invoking process in a non-overlapping sequence such that no two API functions will execute concurrently.

The calling process can perform key zeroization of keys by calling an API function. Additionally keys can be zeroized by power-cycling the module.

The module supports the following keys and critical security parameters (CSPs):
<table>
<thead>
<tr>
<th>ID</th>
<th>Algorithm</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNG Seed key</td>
<td>X9.31</td>
<td>128, 192 and 256 bits</td>
<td>This is the seed key used for X9.31 RNG</td>
</tr>
<tr>
<td>Keyed Hash key</td>
<td>HMAC</td>
<td>All supported key sizes for HMAC</td>
<td>Used for keyed hash</td>
</tr>
</tbody>
</table>

Table 6 Cryptographic Keys and CSPs

### 2.7 Self-Tests

The Module performs both power-up self-tests at module initialization\(^1\) and continuous condition tests during operation. Input, output, and cryptographic functions cannot be performed while the Module is in a self-test or error state as the module is single threaded and will not return to the calling application until the power-up self-tests are complete. If the power-up self tests fail subsequent calls to the module will fail and thus no further cryptographic operations are possible.

#### 2.7.1 Self-tests performed

- **POST tests**
  - AES Known Answer Test
  - AES-CCM Known Answer Test
  - AES-GCM Known Answer Test
  - AES-CMAC Known Answer Test
  - Triple-DES Known Answer Test
  - DSA Sign/Verify Test
  - RSA Signature Known Answer Test
  - ECDSA Sign/Verify Test
  - RNG Known Answer Test
  - HMAC Known Answer Test (performed for each supported SHA)
  - SHA-1 Known Answer Test
  - SHA-2 Known Answer Test (includes SHA-224, SHA-256, SHA-384 and SHA-512)
  - Software Integrity Test
- **Conditional tests**
  - Pairwise consistency test for RSA, DSA, and ECDSA signature keys
  - Continuous random number generation test for approved

---
\(^1\) The FIPS mode initialization is performed when the application invokes the FIPS\_mode\_set() call which returns a “1” for success and “0” for failure

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A single initialization call, \texttt{FIPS\_mode\_set()}, is required to initialize the Module for operation in the FIPS 140-2 Approved mode. When the Module is in FIPS mode all security functions and cryptographic algorithms are performed in Approved mode.

The FIPS mode initialization is performed when the application invokes the \texttt{FIPS\_mode\_set()} call which returns a “1” for success and “0” for failure. Interpretation of this return code is the responsibility of the host application. Prior to this invocation the Module is uninitialized in the non- FIPS mode by default.

The \texttt{FIPS\_mode\_set()} function verifies the integrity of the runtime executable using a HMAC-SHA-1 digest computed at build time. If this computed HMAC-SHA-1 digest matches the stored known digest then the power-up self-tests, consisting of the algorithm specific Pairwise Consistency and Known Answer tests, are performed. If any component of the power-up self-test fails an internal global error flag is set to prevent subsequent invocation of any cryptographic function calls. Any such power-up self-test failure is a hard error that can only be recovered by reinstalling the Module\(^2\). If all components of the power-up self-test are successful then the Module is in FIPS mode. This function call also returns a “1” for success and “0” for failure, and interpretation of this return code is the responsibility of the host application.

A power-up self-test failure can only be cleared by a successful \texttt{FIPS\_mode\_set()} invocation. No operator intervention is required during the running of the self-tests.

3 Secure Operation

The tested operating systems segregate user processes into separate process spaces. Each process space is an independent virtual memory area that is logically separated from all other processes by the operating system software and hardware. The Module functions entirely within the process space of the process that invokes it, and thus satisfies the FIPS 140-2 requirement for a single user mode of operation.

The Module is installed using one of the set of instructions in CiscoSSL\_DeveloperGuide.pdf appropriate to the target system. A complete revision history of the source code from which the Module was generated is maintained in a version control database\(^3\). The HMAC-SHA-1 of the Module distribution file as tested by the CMT Laboratory is verified during installation of the Module file as described in CiscoSSL\_DeveloperGuide.

The HMAC fingerprint of the validated distribution file is d592c5af90566c18fca75b0d8883e92f65b0aa97

\(^2\) The \texttt{FIPS\_mode\_set()} function could be re-invoked but such re-invocation does not provide a means from recovering from an integrity test or known answer test failure.

\(^3\) This database is internal to Cisco since the intended use of this crypto module is by Cisco dev teams

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Upon initialization of the Module, the module will run its power-up self tests. Successful completion of the power-up self tests ensures that the module is operating in the FIPS mode of operation.

The self-tests can be called on demand by reinitializing the module using the FIPS_mode_set() function call, or alternatively using the FIPS_selftest() function call.
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