THE POWER TO KNOW.

Encryption in SAS® 9.3

Second Edition

SAS® Documentation

The correct bibliographic citation for this manual is as follows: SAS Institute Inc 2012. *Encryption in SAS® 9.3, Second Edition*. Cary, NC: SAS Institute Inc.

Encryption in SAS® 9.3, Second Edition

SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513.

1st electronic book, February 2015

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About This Book

Syntax Conventions for the SAS Language

Overview of Syntax Conventions for the SAS Language

SAS uses standard conventions in the documentation of syntax for SAS language elements. These conventions enable you to easily identify the components of SAS syntax. The conventions can be divided into these parts:

- syntax components
- style conventions
- special characters
- references to SAS libraries and external files

Syntax Components

The components of the syntax for most language elements include a keyword and arguments. For some language elements, only a keyword is necessary. For other language elements, the keyword is followed by an equal sign (=).

keyword
specifies the name of the SAS language element that you use when you write your program. Keyword is a literal that is usually the first word in the syntax. In a CALL routine, the first two words are keywords.

In the following examples of SAS syntax, the keywords are the first words in the syntax:

CHAR (*string, position*)

CALL RANBIN (*seed, n, p, x*);

ALTER (*alter-password*)

BEST *w*.

REMOVE <*data-set-name*>

In the following example, the first two words of the CALL routine are the keywords:

CALL RANBIN(*seed*, *n*, *p*, *x*)

The syntax of some SAS statements consists of a single keyword without arguments:

DO;
... SAS code ...

END;

Some system options require that one of two keyword values be specified:

DUPLEX | **NODUPLEX**

argument
specifies a numeric or character constant, variable, or expression. Arguments follow the keyword or an equal sign after the keyword. The arguments are used by SAS to process the language element. Arguments can be required or optional. In the syntax, optional arguments are enclosed between angle brackets.

In the following example, *string* and *position* follow the keyword CHAR. These arguments are required arguments for the CHAR function:

CHAR (*string, position*)

Each argument has a value. In the following example of SAS code, the argument *string* has a value of 'summer', and the argument *position* has a value of 4:`x=char('summer', 4);`

In the following example, *string* and *substring* are required arguments, while *modifiers* and *startpos* are optional.

FIND(*string, substring* <,*modifiers*> <,*startpos*>

Note: In most cases, example code in SAS documentation is written in lowercase with a monospace font. You can use uppercase, lowercase, or mixed case in the code that you write.

Style Conventions

The style conventions that are used in documenting SAS syntax include uppercase bold, uppercase, and italic:

UPPERCASE BOLD
identifies SAS keywords such as the names of functions or statements. In the following example, the keyword ERROR is written in uppercase bold:

ERROR<*message*>;

UPPERCASE
identifies arguments that are literals.

In the following example of the CMPMODEL= system option, the literals include BOTH, CATALOG, and XML:

CMPMODEL = BOTH | CATALOG | XML

italics
identifies arguments or values that you supply. Items in italics represent user-supplied values that are either one of the following:

- nonliteral arguments In the following example of the LINK statement, the argument *label* is a user-supplied value and is therefore written in italics:

  LINK *label*;

- nonliteral values that are assigned to an argument

  In the following example of the FORMAT statement, the argument DEFAULT is assigned the variable *default-format*:

  FORMAT = *variable-1* <, ..., *variable-nformat*><DEFAULT = *default-format*>;

Items in italics can also be the generic name for a list of arguments from which you can choose (for example, *attribute-list*). If more than one of an item in italics can be used, the items are expressed as *item-1, ..., item-n*.

Special Characters

The syntax of SAS language elements can contain the following special characters:

=
an equal sign identifies a value for a literal in some language elements such as system options.

In the following example of the MAPS system option, the equal sign sets the value of MAPS:

MAPS = *location-of-maps*

< >
angle brackets identify optional arguments. Any argument that is not enclosed in angle brackets is required.

In the following example of the CAT function, at least one item is required:

CAT (*item-1 <, ..., item-n>*)

|
a vertical bar indicates that you can choose one value from a group of values. Values that are separated by the vertical bar are mutually exclusive.

In the following example of the CMPMODEL= system option, you can choose only one of the arguments:

CMPMODEL = BOTH | CATALOG | XML

...
an ellipsis indicates that the argument or group of arguments following the ellipsis can be repeated. If the ellipsis and the following argument are enclosed in angle brackets, then the argument is optional.

In the following example of the CAT function, the ellipsis indicates that you can have multiple optional items:

CAT (*item-1 <, ..., item-n>*)

'*value*' or "*value*"
indicates that an argument enclosed in single or double quotation marks must have a value that is also enclosed in single or double quotation marks.

In the following example of the FOOTNOTE statement, the argument *text* is enclosed in quotation marks:

FOOTNOTE <*n*> <*ods-format-options* '*text*' | "*text*">;

;
a semicolon indicates the end of a statement or CALL routine.

In the following example each statement ends with a semicolon: `data namegame; length color name $8; color = 'black'; name = 'jack'; game = trim(color) || name; run;`

References to SAS Libraries and External Files

Many SAS statements and other language elements refer to SAS libraries and external files. You can choose whether to make the reference through a logical name (a libref or fileref) or use the physical filename enclosed in quotation marks. If you use a logical name, you usually have a choice of using a SAS statement (LIBNAME or FILENAME) or the operating environment's control language to make the association. Several methods of referring to SAS libraries and external files are available, and some of these methods depend on your operating environment.

In the examples that use external files, SAS documentation uses the italicized phrase *file-specification*. In the examples that use SAS libraries, SAS documentation uses the italicized phrase *SAS-library*. Note that *SAS-library* is enclosed in quotation marks:

```
infile file-specification obs = 100;
libname libref 'SAS-library';
```

What's New in Encryption in SAS 9.3

Overview

Encryption in SAS is affected by the following changes and enhancements in SAS:

- FIPS 140-2 is a standard that defines the security requirements that must be satisfied by a cryptographic module used in a security system protecting unclassified information within IT systems. In SAS 9.3, enhancements have been made to support this standard of security. SAS/SECURE and SSL now comply with the FIPS 140-2 standard.
- In the second maintenance release for SAS 9.3, a hot fix is available that updates the UNIX and z/OS OpenSSL version for 0.9.8.
- In the second maintenance release for SAS 9.3, security hot fixes are available that introduce two new environment variables: SAS_SSL_MIN_PROTOCOL, supported on UNIX, Windows, and z/OS, and SAS_SSL_CIPHER_LIST, supported on UNIX and z/OS.

General Enhancements

- SAS/SECURE now supports FIPS 140-2 encryption. See “FIPS 140-2 Standards Compliance” on page 4 for details.
- Secure Sockets Layer (SSL) now supports FIPS 140-2 encryption. See “Secure Sockets Layer (SSL) ” on page 7 for details.
- New option ENCRYPTFIPS specifies that encryption services are using FIPS 140-2 validated algorithms. When specified, a new INFO message is written at server start-up. Refer to “ENCRYPTFIPS System Option” on page 17 for details.
- The process for downloading SSL libraries has changed. See “Secure Sockets Layer (SSL) ” on page 7 for details.
- If using the FIPS 140-2 standard for security, the algorithm used for hashing passwords is SHA-256. The MD5 algorithm continues to be used for all other security technologies.
- Encoded passwords are now supported for SAS data sets.
- In the second maintenance release for SAS 9.3, a hot fix is available that updates the OpenSSL 0.9.8 version on UNIX and z/OS. For more information, see “SSL Software Availability” on page 8.

In the second maintenance release for SAS 9.3, security hot fixes are available that introduce two new environment variables: SAS_SSL_MIN_PROTOCOL, supported on UNIX, Windows, and z/OS, and SAS_SSL_CIPHER_LIST, supported on UNIX and z/OS. For more information, see "SAS_SSL_MIN_PROTOCOL Environment Variable" on page 35 and "SAS_SSL_CIPHER_LIST Environment Variable" on page 37.

Recommended Reading

Here is the recommended reading list for this title:

- *SAS/CONNECT User's Guide*
- *SAS/SHARE User's Guide*
- *SAS Statements: Reference*
- *SAS System Options: Reference*
- *Base SAS Procedures Guide*
- *SAS Language Reference: Concepts*
- *Communications Access Methods for SAS/CONNECT and SAS/SHARE*
- *SAS XML LIBNAME Engine: User's Guide*
- SAS Companion that is specific to your operating environment
- *Configuration Guide for SAS® 9.3 Foundation for Microsoft® Windows® for x64*
- *Configuration Guide for SAS® 9.3 Foundation for Microsoft®Windows®*
- *Configuration Guide for SAS® 9.3 Foundation for z/OS®*
- *Configuration Guide for SAS® 9.3 Foundation for UNIX® Environments*

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Part 1

Encryption in SAS 9.3

Chapter 1

Technologies for Encryption

Encryption: Overview

There is a great need to ensure the confidentiality of business transactions over a network between an enterprise and its consumers, between enterprises, and within an enterprise. SAS products and third-party strategies for protecting data and credentials (user IDs and passwords) are exchanged in a networked environment. This process of protecting data is called *encryption*. Encryption is the transformation of intelligible data (plaintext) into an unintelligible form (ciphertext) by means of a mathematical process. The ciphertext is translated back to plaintext when the appropriate key that is necessary for decrypting (unlocking) the ciphertext is applied.

SAS offers two classes of encryption strength:

- If you do not have SAS/SECURE, only the SASProprietary algorithm is available. SASProprietary uses 32-bit fixed encoding and is appropriate only for preventing accidental exposure of information. SASProprietary is licensed with Base SAS software and is available in all deployments.
- If you have SAS/SECURE, you can use an industry standard encryption algorithm instead of the SASProprietary algorithm. SAS/SECURE is an add-on product that is licensed separately.

Encryption helps protect information on-disk and in-transit as follows:

- Over-the-wire encryption protects data while in transit. Passwords in transit to and from SAS servers are encrypted or encoded.
- On-disk encryption protects data at rest. Passwords in configuration files and the metadata are encrypted or encoded. Configuration files and metadata repository data sets are also host protected.

FIPS 140-2 Standards Compliance

In SAS 9.3, FIPS 140-2 standards are supported for SAS/SECURE and SSL Encryption technologies. FIPS 140-2 is not a technology, but a definition of what security mechanisms should do. FIPS 140-2 is the current version of the Federal Information Processing Standardization 140 (FIPS 140) publication. FIPS 140-2 is a standard that describes US Federal government requirements that IT products should meet for Sensitive,but Unclassified (SBU) use. The standard defines the security requirements that must be satisfied by a cryptographic module used in a security system protecting unclassified information within IT systems. FIPS 140-2 requires organizations that do business with a government agency or department that requires the exchange of sensitive information, to ensure that they meet the FIPS 140-2 security standards. In addition, the financial community increasingly specifies FIPS 140-2 as a procurement requirement.

The National Institute of Standards and Technology (NIST) issued the FIPS 140 Publication Series to coordinate the requirements and standards for cryptography modules that include both hardware and software components. Federal agencies and departments can validate that the module in use is covered by an existing FIPS 140-1 or FIPS 140-2 certificate that specifies the exact module name, hardware, software, firmware, and applet version numbers. For more information, see **SECURITY REQUIREMENTS FOR CRYPTOGRAPHIC MODULES**.

There are four levels of security: from Level 1 (lowest) to Level 4 (highest).The security requirements cover areas related to the secure design and implementation of a cryptographic module. These areas include basic design and documentation, module interfaces, authorized roles and services, physical security, software security, operating system security, key management, cryptographic algorithms, electromagnetic interference/electromagnetic compatibility (EMI/EMC), and self-testing.

For installation and configuration details about FIPS 140-2, see “SAS/SECURE FIPS 140-2 Compliant Installation and Configuration” on page 7, “SSL Installation and Configuration” on page 10, and “ENCRYPTFIPS System Option” on page 17.

Providers of Encryption

SASProprietary

SASProprietary Overview

SASProprietary is a fixed encoding algorithm that is included with Base SAS software. It requires no additional SAS product licenses. The SAS proprietary algorithm is strong enough to protect your data from casual viewing. SASProprietary provides a medium level of security. SAS/SECURE and SSL provide a high level of security.

SASProprietary System Requirements

SAS supports SASProprietary under these operating environments:

- UNIX
- Windows
- z/OS

SASProprietary Installation and Configuration

SASProprietary is part of Base SAS. Separate installation is not required.

For an example of configuring and using SASProprietary in your environment, see "SASProprietary for SAS/SHARE: Example " on page 48.

SAS/SECURE

SAS/SECURE Overview

SAS/SECURE software is an add-on product that provides industry standard encryption capabilities in addition to the SASProprietary algorithm. SAS/SECURE requires a license, and it must be installed on each computer that runs a SAS Foundation client and a server that uses the encryption algorithms.

Note: SAS/SECURE provides encryption of data in transit. It does not provide authentication or authorization capabilities.

SAS/SECURE supports industry-standard encryption algorithms. This affects communications among SAS servers and between SAS servers and SAS desktop clients. On UNIX, z/OS, and Windows, SAS/SECURE supports the following encyrption algorithims:

- SASProprietary
- RC2
- RC4
- DES
- TripleDES
- AES
- SSL

Note: These algorithms are supported by SAS/SECURE on Windows by using the Microsoft Cryptographic API libraries that are included with the operating system.

Refer to "Encryption Algorithms" on page 12 for more information about encryption algorithms supported for use with SAS/SECURE.

SAS/SECURE enables you to provide stronger protection for stored login passwords than is provided by SASProprietary encoding. This affects passwords that are included in configuration files. AES is the encryption algorithm used with the FIPS 140-2 enabled SAS/SECURE software. In the PWENCODE procedure, the METHOD option supports the SAS003 value (AES) only if you have SAS/SECURE. Refer to the Chapter 4, "PWENCODE Procedure," on page 39 for details.

In SAS 9.3, you can instruct SAS/SECURE to use only services that are part of the Federal Information Processing Standard (FIPS) 140-2 standard. When SAS system option ENCRYPTFIPS is configured, SAS/SECURE uses only FIPS 140-2 validated

encryption and hashing algorithms. Refer to "FIPS 140-2 Standards Compliance" on page 4 and "ENCRYPTFIPS System Option" on page 17 for details.

SAS/SECURE also provides greater protection for stored internal account passwords. The SHA-256 hashing algorithm is used with FIPS 140-2 enabled software. Otherwise, the MD5 hashing algorithm is used.

CAUTION:

In SAS 9.2, the password hash list was created using the MD5 hash algorithm. In SAS 9.3 when you are configuring your system to be FIPS 140-2 compliant, you need to reset your hash password five times to clear all previously stored passwords. When you reset the passwords, they use the SHA-256 hashing algorithm.

SAS/SECURE System Requirements

SAS supports SAS/SECURE under these operating environments:

- UNIX
- Windows
- z/OS

SAS/SECURE Software Availability

SAS/SECURE software is an add-on product that provides industry standard encryption capabilities in addition to the SASProprietary algorithm. SAS/SECURE requires a license, and it must be installed on each computer that runs a SAS Foundation client and a server that uses the encryption algorithms.

Export Restrictions for SAS/SECURE

For software licensing and delivery purposes, SAS/SECURE is the product within the SAS System. For U.S. export licensing purposes, SAS designates each product based on the encryption algorithms and the product's functional capability. SAS/SECURE 9.3 is available to most commercial and government users inside and outside the U.S. However, some countries (for example, Russia, China, and France) have import restrictions on products that contain encryption, and the U.S. prohibits the export of encryption software to specific embargoed or restricted destinations.

SAS/SECURE for UNIX and z/OS includes the following encryption algorithms:

- RC2 using up to 128-bit keys
- RC4 using up to 128-bit keys
- DES using up to 56-bit keys
- TripleDES using up to 168-bit keys
- AES using 256-bit keys

SAS/SECURE for Windows uses the encryption algorithms that are available in Microsoft CryptoAPI. The level of the SAS/SECURE encryption algorithms under Windows depends on the level of the encryption support in Microsoft CryptoAPI under Windows.

SAS/SECURE Installation and Configuration

SAS/SECURE must be installed on the SAS server computer, the client computer, and possibly other computers, depending on the SAS software that requires encryption. For installation details, see the SAS documentation for the software that uses encryption.

To use the higher forms of encryption provided by SAS/SECURE for communications and networking, specify the NETENCRYPT system option and set the NETENCRALG= system option to a value of RC2, RC4, DES, TRIPLEDES, AES, or SSL. Refer to "NETENCRYPT System Option" on page 19 and "NETENCRYPTALGORITHM System Option" on page 20.

For examples of configuring and using SAS/SECURE in your environment, see "Encryption Technologies: Examples" on page 48.

SAS/SECURE FIPS 140-2 Compliant Installation and Configuration

To configure a FIPS 140-2 compliant system, you must use SAS/SECURE or SSL (or TLS). When using SAS/SECURE, specify SAS system options ENCRYPTFIPS and NETENCRALG= (set to AES) for UNIX, z/OS, or Windows. When ENCRYPTFIPS is specified, an INFO message is written at server start-up to indicate that FIPS encryption is enabled. Refer to "ENCRYPTFIPS System Option" on page 17 for details.

In the FIPS 140-2 compliant mode, AES or SSL are the only supported encryption algorithms. Refer to "NETENCRYPTALGORITHM System Option" on page 20 for details.

In the FIPS 140-2 compliant mode, the SHA-256 hashing algorithm is used for stored password protection. The data transferred between servers and clients prior to SAS 9.3 uses hashing passwords that are not FIPS 140-2 compliant. Therefore, you can connect only servers and clients that are enabled for FIPS 140-2 using SAS 9.3 and above.

CAUTION:

In SAS 9.2, the password hash list was created using the MD5 hash algorithm. If you are moving from SAS 9.2 to a higher version of SAS and configuring your system to be FIPS 140-2 compliant, you need to clear all previously stored passwords. When you reset the passwords, they use the SHA-256 hashing algorithm.

For information about using FIPS with SSL, refer to "SSL: FIPS 140-2 Compliant Installation and Configuration" on page 10.

There is a Microsoft issue that needs attention before configuring FIPS on Microsoft Windows 2003 servers.

Services that run on a computer that uses Microsoft Windows Server 2003 might not recognize Windows environment variable changes. To resolve this issue, perform these steps:

1. Go to the Microsoft support website and apply the fix located at `http://support.microsoft.com/kb/887693`. This website provides detailed information about the Windows 2003 Server issue.
2. Run the configuration file that specifies the ENCRYPTFIPS system option.

For examples of configuring and using SAS/SECURE in your environment, see "Encryption Technologies: Examples" on page 48.

Secure Sockets Layer (SSL)

Secure Sockets Layer (SSL) Overview

SSL is an abbreviation for Secure Sockets Layer, a protocol that provides network data privacy, data integrity, and authentication. Developed by Netscape Communications, SSL uses encryption algorithms that include RC2, RC4, DES, TripleDES, AES, and others.

SSL uses X.509 certificates and hence asymmetric cryptography to assure the party with whom they are communicating, and to exchange a symmetric key. As a consequence of choosing X.509 certificates, certificate authorities and a public key infrastructure are necessary to verify the relation between a certificate and its owner, as well as to generate, sign, and administer the validity of certificates.

In addition to providing encryption services, SSL performs client and server authentication, and it uses message authentication codes to ensure data integrity. The client requests a certificate from the server, which it compares to the certificate that the client stores locally. The client then verifies the identity of the server and negotiates with the server to select a cipher (encryption method). The cipher that is selected is the first match between the ciphers that are supported on both the client and the server. All subsequent data transfers for the current request are then encrypted with the selected encryption method.

SSL uses encryption algorithms that include RC2, RC4, DES, TripleDES, and AES.

SSL is supported by Internet Explorer and Firefox. Many websites use the protocol to protect confidential user information, such as credit card numbers. The SSL protocol is application independent and allows protocols such as HTTP, FTP, and Telnet to be transparently layered above it. SSL is optimized for HTTP. SSL includes software that was developed by the OpenSSL Project for use in the OpenSSL Toolkit. For more information see **OpenSSL**.

Note: Transport Layer Security (TLS) is the successor to SSL 3.0. The Internet Engineering Task Force (IETF) took SSL 3.0, the de facto standard, modified it, renamed it TLS V1.0, and adopted it as a standard.

In SAS 9.3, you can configure SSL to run in FIPS 140-2 compliant mode. For an overview of FIPS 140-2 compliancy, refer to "FIPS 140-2 Standards Compliance" on page 4. FIPS 140-2 compliant SSL supports the AES encryption algorithm and the SHA-256 hashing algorithm. Refer to "ENCRYPTFIPS System Option" on page 17 and "SSL Installation and Configuration" on page 10 for configuration instructions.

SSL System Requirements

SAS supports SSL under these operating environments:

- UNIX
- Windows
- z/OS

Note: The SSL software is included in the SAS installation software only for countries that allow the importation of encryption software.

Note: The FIPS-2 encryption standard is not supported on z/OS.

SSL Software Availability

Starting in the second maintenance release for SAS 9.3, SAS supports SSL on the Windows, UNIX, and z/OS platforms for the following versions of SSL:

- SSL 3.0
- TLS 1.0

When security hot fixes are applied in the second maintenance release for SAS 9.3, the default minimum protocol for OpenSSL is TLS 1.0. OpenSSL 0.9.8 libraries can use only SSL 3.0 and TLS 1.0. However, it is highly recommended that TLS 1.0 and higher be used.

Note: If you need to override the default protocol, you can set the SAS_SSL_MIN_PROTOCOL environment variable. For information, see "SAS_SSL_MIN_PROTOCOL Environment Variable" on page 35.

OpenSSL is shipped with Base SAS for UNIX and z/OS.

For Windows, SAS uses the SChannel library that comes with the Windows operating system.

To find the OpenSSL code base version that is used to build the SSL and TLS libraries provided by SAS for each release, see **`Mapping Between SAS Version and OpenSSL Version`**.

Note: Different operating systems require the use of different library file extensions. For example, HPUX, Linux, and Solaris use libcrypto.so.0.9.8 and libssl.so.0.9.8. AIX uses libcrypto.so and libssl.so. Refer to your operating system vendor documentation when using the vendor's OpenSSL libraries. There might be additional procedures that need to be followed to make the libraries work properly in your environment.

The SSL version shipped with SAS for Windows is FIPS 140-2 compliant. The SSL version shipped with SAS for UNIX is not FIPS 140-2 compliant. However, you can compile a FIPS 140-2 compliant version of OpenSSL and install it. For more information, see "SSL: FIPS 140-2 Compliant Installation and Configuration" on page 10.

SSL Concepts

The following concepts are fundamental to understanding SSL:

Certification Authorities (CAs)
: Cryptography products provide security services by using digital certificates, public-key cryptography, private-key cryptography, and digital signatures. Certification authorities (CAs) create and maintain digital certificates, which also help preserve confidentiality.

  Various commercial CAs, such as VeriSign and Thawte, provide competitive services for the e-commerce market. You can also develop your own CA by using products from companies such as RSA Security and Microsoft or from the Open-Source Toolkit OpenSSL.

  Note: z/OS provides the PACDCERT command and PKI Services for implementing a CA.

  From a trusted CA, members of an enterprise can obtain digital certificates to facilitate their e-business needs. The CA provides a variety of ongoing services to the business client that include handling digital certificate requests, issuing digital certificates, and revoking digital certificates.

Public and Private Keys
: Public-key cryptography uses a public and a private key pair. The public key can be known by anyone, so anyone can send a confidential message. The private key is confidential and known only to the owner of the key pair, so only the owner can read the encrypted message. The public key is used primarily for encryption, but it can also be used to verify digital signatures. The private key is used primarily for decryption, but it can also be used to generate a digital signature.

Digital Signatures
: A digital signature affixed to an electronic document or to a network data packet is like a personal signature that concludes a hand-written letter or that validates a credit card transaction. Digital signatures are a safeguard against fraud. A unique digital signature results from using a private key to encrypt a message digest. Receipt of a document that contains a digital signature enables the receiver to verify the source of

the document. Electronic documents can be verified if you know where the document came from, who sent it, and when it was sent. Another form of verification comes from Message Authentication Codes (MAC), which ensure that a document has not been changed since it was signed. A MAC is attached to a document to indicate the document's authenticity. Receipt of the document that contains a MAC enables the receiver (who also has the secret key) to know that the document is authentic.

Digital Certificates

Digital certificates are electronic documents that ensure the binding of a public key to an individual or an organization. Digital certificates provide protection from fraud.

Usually, a digital certificate contains a public key, a user's name, and an expiration date. It also contains the name of the Certification Authority (CA) that issued the digital certificate and a digital signature that is generated by the CA. The CA's validation of an individual or an organization allows that individual or organization to be accepted at sites that trust the CA.

SSL Installation and Configuration

SSL for UNIX, z/OS, and Windows is shipped with Base SAS. No additional software installation is required.

The instructions that you use to install and configure SSL at your site depend on whether you use UNIX, Windows, or z/OS. See the appropriate details:

- "Installing and Configuring SSL under UNIX" on page 65
- "Installing and Configuring SSL under Windows" on page 73
- "Installing and Configuring SSL under z/OS" on page 79

For examples of configuring and using SSL in your environment, see "Encryption Technologies: Examples" on page 48.

SSL: FIPS 140-2 Compliant Installation and Configuration

Starting in SAS 9.3, you can configure SSL to run in FIPS 140-2 compliant mode.

To configure a FIPS 140-2 compliant system, specify SAS system options ENCRYPTFIPS and NETENCRALG= (set to AES or SSL). When ENCRYPTFIPS is specified, an INFO message is written at server start-up to indicate that FIPS encryption is enabled. For more information, refer to "ENCRYPTFIPS System Option" on page 17 and "NETENCRYPTALGORITHM System Option" on page 20.

The SSL versions shipped with SAS for Windows are FIPS 140-2 compliant. The SSL version shipped with SAS for UNIX is not FIPS 140-2 compliant. However, you can compile a FIPS 140-2 compliant version of OpenSSL and install it. For more information, see "Building FIPS 140-2 Capable OpenSSL for UNIX" on page 66 and "FIPS 140-2 Capable SSL for Windows" on page 74.

Note: The SSL version shipped with SAS for z/OS is not FIPS 140-2 compliant. However, you can use SAS/SECURE with AES to provide FIPS on z/OS.

For an overview of FIPS 140-2 compliancy, refer to "FIPS 140-2 Standards Compliance" on page 4.

SSH (Secure Shell)

SSH (Secure Shell) Overview

SSH is an abbreviation for Secure Shell. SSH is a protocol that enables users to access a remote computer via a secure connection. SSH is available through various commercial products and as freeware. OpenSSH is a free version of the SSH protocol suite of network connectivity tools.

Although SAS software does not directly support SSH functionality, you can use the tunneling feature of SSH to enable data to flow between a SAS client and a SAS server. Port forwarding is another term for tunneling. The SSH client and SSH server act as agents between the SAS client and the SAS server, tunneling information via the SAS client's port to the SAS server's port.

SSH System Requirements

OpenSSH supports SSH protocol versions 1.3, 1.5, and 2.0.

SAS supports SSH under these operating environments:

- UNIX
- Windows
- z/OS

For additional resources, see

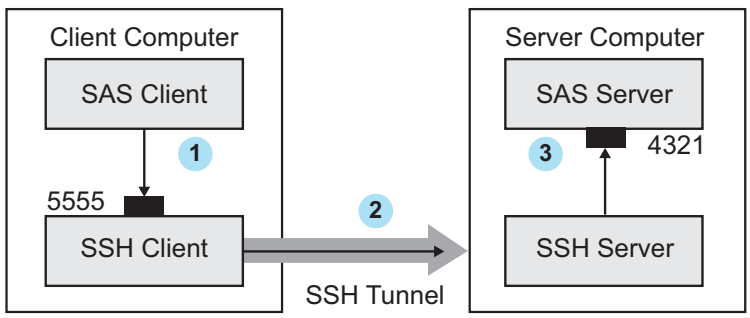
- **`www.openssh.com`**
- **`www.ssh.com`**
- ssh(1) UNIX manual page.

Under z/OS, the IBM Ported Tools for z/OS Program Product must be installed for OpenSSH support. See **`www-03.ibm.com/servers/eserver/zseries/zos/unix/port_tools.html`**.

SSH Tunneling Process

An inbound request from a SAS client to a SAS server is shown as follows:

Figure 1.1 *SSH Tunneling Process*



1. The SAS client passes its request to the SSH client's port 5555.
2. The SSH client forwards the SAS client's request to the SSH server via an encrypted tunnel.

3. The SSH server forwards the SAS client's request to the SAS server via port 4321.

Outbound, the SAS server's reply to the SAS client's request flows from the SAS server to the SSH server. The SSH server forwards the reply to the SSH client, which passes it to the SAS client.

SSH Tunneling: Process for Installation and Setup

SSH software must be installed on the client and server computers. Exact details about installing SSH software at the client and the server depend on the particular brand and version of the software that is used. See the installation instructions for your SSH software.

The process for setting up an SSH tunnel consists of the following steps:

- SSH tunneling software is installed on the client and server computers. Details about tunnel configuration depend on the specific SSH product that is used.
- The SSH client is started as an agent between the SAS client and the SAS server.
- The components of the tunnel are set up. The components are a "listen" port, a destination computer, and a destination port. The SAS client accesses the listen port, which is forwarded to the destination port on the destination computer. SSH establishes an encrypted tunnel that indirectly connects the SAS client to the SAS server.

For examples of setting up and using a tunnel, see "SSH Tunnel for SAS/CONNECT: Example " on page 57 and "SSH Tunnel for SAS/SHARE: Example " on page 58.

Encryption Algorithms

The following encryption algorithms are used by SASProprietary and SAS/SECURE:

RC2
: is a block cipher that encrypts data in blocks of 64 bits. A *block cipher* is an encryption algorithm that divides a message into blocks and encrypts each block. The RC2 key size ranges from 8 to 256 bits. SAS/SECURE uses a configurable key size of 40 or 128 bits. (The NETENCRYPTKEYLEN system option is used to configure the key length.) The RC2 algorithm expands a single message by a maximum of 8 bytes. RC2 is a proprietary algorithm developed by RSA Data Security, Inc.

  Note: RC2 is supported in SAS/SECURE and SSL.

RC4
: is a stream cipher. A *stream cipher* is an encryption algorithm that encrypts data 1 byte at a time. The RC4 key size ranges from 8 to 2048 bits. SAS/SECURE uses a configurable key size of 40 or 128 bits. (The NETENCRYPTKEYLEN system option is used to configure the key length.) RC4 is a proprietary algorithm developed by RSA Data Security, Inc.

  Note: RC4 is supported in SAS/SECURE and SSL.

DES (Data Encryption Standard)
: is a block cipher that encrypts data in blocks of 64 bits by using a 56-bit key. The algorithm expands a single message by a maximum of 8 bytes. DES was originally developed by IBM but is now published as a U.S. Government Federal Information Processing Standard (FIPS 46-3).

  Note: DES is supported in SAS/SECURE and SSL.

TripleDES
: is a block cipher that encrypts data in blocks of 64 bits. TripleDES executes the DES algorithm on a data block three times in succession by using a single, 56-bit key. This has the effect of encrypting the data by using a 168-bit key. TripleDES expands a single message by a maximum of 8 bytes. TripleDES is defined in the American National Standards Institute (ANSI) X9.52 specification.

  Note: TripleDES is supported in SAS/SECURE and SSL.

SASProprietary
: is a cipher that provides basic fixed encoding encryption services under all operating environments that are supported by SAS. Included in Base SAS, SASProprietary does not require additional SAS product licenses. The algorithm expands a single message to approximately one-third by using 32-bit encoding.

  Note: SASProprietary is supported only by the SASProprietary encryption provider.

AES (Advanced Encryption Standard)
: is a block cipher that encrypts data in blocks of 128 bits by using a 256-bit key. AES expands a single message by a maximum of 16 bytes. Based on its DES predecessor, AES has been adopted as the encryption standard by the U.S. Government. It is one of the most popular algorithms that is used in symmetric key cryptography. AES is published as a U.S. Government Federal Information Processing Standard (FIPS 197).

  Note: AES is supported in SAS/SECURE and SSL. AES is the only algorithm that meets the FIPS 140-2 standard.

Here is a summary of the encryption algorithms, by operating environment:

Table 1.1 *Encryption Algorithms Supported by Operating Environments*

	Operating Environments		
Encryption Algorithms	**UNIX**	**Windows**	**z/OS**
SASProprietary	X	X	X
RC2	X	X	X
RC4	X	X	X
DES	X	X	X
TripleDES	X	X	X
SSL	X	X	X
AES	X	X	X

Encryption: Comparison

The following table compares the features of the encryption technologies:

Table 1.2 Summary of SASProprietary, SAS/SECURE, SSL, and SSH Features

Features	SASProprietary	SAS/SECURE	SSL	SSH
License required	No	Yes	No	No
Encryption and authentication	Encryption only	Encryption only	Encryption and authentication	Encryption only
Encryption level	Medium	High	High	High
Algorithms supported	SASProprietary fixed encoding	RC2, RC4, DES, TripleDES, AES	RC2, RC4, DES, TripleDES, AES	Product dependent
Installation required	No (part of Base SAS)	Yes	Yes	Yes
Operating environments supported	UNIX Windows z/OS	UNIX Windows z/OS	UNIX Windows z/OS	UNIX Windows z/OS
SAS version support	8 and later	8 and later	9 and later	8.2 and later

Encryption: Implementation

The implementation of the installed encryption technology depends on the environment that you work in. If you work in a SAS enterprise intelligence infrastructure, encryption might be transparent to you because it has already been configured into your site's overall security plan. After the encryption technology has been installed, the site system administrator configures the encryption method (level of encryption) to be used in all client/server data exchanges. All enterprise activity uses the chosen level of encryption, by default. For an example, see “SAS/SECURE for the IOM Bridge: Examples ” on page 56.

If you work in a SAS session on a client computer that exchanges data with a SAS server, you specify SAS system options that implement encryption for the duration of the SAS session. If you connect a SAS/CONNECT client to a spawner, you need to specify encryption options in the spawner start-up command. For details about SAS system options, see Chapter 2, “SAS System Options for Encryption,” on page 17. For examples, see “Encryption Technologies: Examples” on page 48.

Accessibility Features in SAS Products

For information about accessibility for any of the products mentioned in this book, see the documentation for that product. If you have questions or concerns about the accessibility of SAS products, send e-mail to **accessibility@sas.com**

Encrypting ODS Generated PDF Files

You can use ODS to generate PDF output. When these PDF files are not password protected, any user can use Acrobat to view and edit the PDF files. You can encrypt and password-protect your PDF output files by specifying the PDFSECURITY system option. Two levels of security are available: 40-bit (low) and 128-bit (high). With either of these settings, a password is required to open a PDF file that has been generated with ODS.

You can find information about using the ODS PRINTER and PDF statements in the *SAS Output Delivery System: User's Guide*. The following table lists the PDF system options that are available to restrict or allow users' ability to access, assemble, copy, or modify ODS PDF files. Other SAS system options control whether the user can fill in forms and set the print resolution. These system options are documented in *SAS System Options: Reference*.

Table 1.3 *PDF System Options*

Task	System Option
Specifies whether text and graphics from PDF documents can be read by screen readers for the visually impaired	PDFACCESS | NOPDFACCESS
Controls whether PDF documents can be assembled	PDFASSEMBLY | NOPDFASSEMBLY
Controls whether PDF document comments can be modified	PDFCOMMENT | NOPDFCOMMENT
Controls whether the contents of a PDF document can be changed	PDFCONTENT | NOPDFCONTENT
Controls whether text and graphics from a PDF document can be copied	PDFCOPY | NOPDFCOPY
Controls whether PDF forms can be filled in	PDFFILLIN | NOPDFFILLIN
Specifies the password to use to open a PDF document and the password used by a PDF document owner	PDFPASSWORD
Controls the resolution used to print the PDF document	PDFPRINT
Controls the printing permissions for PDF documents	PDFSECURITY

Note: The SAS/SECURE SSL software is included in the SAS installation software only for countries that allow the importation of encryption software.

Chapter 2

SAS System Options for Encryption

Dictionary

ENCRYPTFIPS System Option

Specifies that the SAS/SECURE and SSL security services use FIPS 140-2 validated algorithms.

Client: optional

Server: optional

Valid in: SAS invocation, configuration file, SAS/CONNECT spawner command line

Categories: Communications: Networking
System Administration: Security

PROC OPTIONS GROUP= Communications
SECURITY

Default: NOENCRYPTFIPS

Restriction: The ENCRYPTFIPS option is not supported on z/OS for SSL

Operating environment: UNIX, Windows, z/OS

See: NETENCRYPTALGORITHM

Syntax

ENCRYPTFIPS

Syntax Description

ENCRYPTFIPS
specifies that SAS/SECURE and SSL services are using FIPS 140-2 compliant encryption algorithms. When this option is specified, a new INFO message is written at server start-up to indicate that FIPS encryption is enabled.

Restriction: When the ENCRYPTFIPS option is specified, the NETENCRYPTALGORITHM system option must be set to AES or SSL. If a different algorithm is specified, an error message is output.

Notes:

When configuring the ENCRYPTFIPS option on a Microsoft Windows 2003 server, refer to "SAS/SECURE FIPS 140-2 Compliant Installation and Configuration" on page 7 for instructions on resolving the environment variable issue.

The ENCRYPTFIPS option is configured only at start-up. However, you can see that the option is configured when you view the OPTIONS statement or the SAS System Options window.

NOENCRYPTFIPS
specifies that the SAS/SECURE and SSL security services are not limited to FIPS 140-2 verified algorithms.

Details

The ENCRYPTFIPS option limits the services provided by SAS/SECURE and SSL to those services that are part of the FIPS 140-2 specification. Read more about Security Requirements for Cryptographic Modules at **`http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf`**. Also refer to Refer to "FIPS 140-2 Standards Compliance" on page 4 for an overview of FIPS 140-2 standards.

There is an interaction between the ENCRYPTFIPS option and the NETENCRYPTALGORITHM option. Only the AES or the SSL algorithm is supported for FIPS 140-2 encryption. An error is logged when an unsupported algorithm is specified.

```
ERROR: When SAS option ENCRYPTFIPS is ON the option value for SAS option
ERROR: NETENCRYPTALGORITHM must be a single value of AES or SSL.
ERROR: Invalid option value.
NOTE: Unable to initialize the options subsystem.
```

When the ENCRYPTFIPS option is specified, a message is logged informing the user that FIPS 140-2 encryption is enabled. This log can be viewed in the log for SAS window at the DEBUG and or TRACE levels. Refer to "Administering Logging for SAS Connect" in *SAS/CONNECT User's Guide* and "The SAS Log" in *SAS Language Reference: Concepts*.

This is an example of a TRACE log that is generated when ENCRYPTFIPS is enabled.

```
2010-12-15T08:37:12,725 TRACE [00000008] :App.tk.eam sasiom1 - Attempting FIPS
mode init
```

This is an example of a DEBUG log generated when ENCRYPTFIPS is enabled.

```
2010-12-15T08:37:12,731 DEBUG [00000008] :App.tk.eam sasiom1 - FIPS 140-2 mode
is enabled
```

Examples

Example 1

Here is an example of configuring the ENCRYPTFIPS option on UNIX:

```
-encryptfips -netencryptalgorithm aes;
```

Example 2

Here is an example of configuring the ENCRYPTFIPS option on z/OS:

```
encryptfips netecryptalgorithm="aes"
```

Example 3

Here is an example of configuring the ENCRYPTFIPS option on Windows:

```
-encryptfips
-netencralg "AES"
```

See Also

- "NETENCRYPTALGORITHM System Option" on page 20
- "FIPS 140-2 Standards Compliance" on page 4

NETENCRYPT System Option

Specifies whether client/server data transfers are encrypted.

Client:	optional
Server:	optional
Valid in:	Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line
Category:	Communications: Networking and Encryption
PROC OPTIONS GROUP=	Communications
Default:	NONETENCRYPT
Operating environment:	UNIX, Windows, z/OS
See:	NETENCRYPTALGORITHM
Example:	"SAS/SECURE for SAS/CONNECT: Example " on page 48

Syntax

NETENCRYPT | **NONETENCRYPT**

Syntax Description

NETENCRYPT
specifies that encryption is required.

NONETENCRYPT
specifies that encryption is not required, but is optional.

Details

The default for this option specifies that encryption is used if the NETENCRYPTALGORITHM option is set and if both the client and the server are capable of encryption. If encryption algorithms are specified but either the client or the server is incapable of encryption, then encryption is not performed.

Encryption might not be supported at the client or at the server in these situations:

- You are using a release of SAS (prior to SAS 8) that does not support encryption.
- Your site (the client or the server) does not have a security software product installed.
- You specified encryption algorithms that are incompatible in SAS sessions on the client and the server.

NETENCRYPTALGORITHM System Option

Specifies the algorithm or algorithms to be used for encrypted client/server data transfers.

Client:	optional
Server:	required
Valid in:	Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line
Category:	Communications: Networking and Encryption
PROC OPTIONS GROUP=	Communications
Alias:	NETENCRALG
Operating environment:	UNIX, Windows, z/OS
See:	“NETENCRYPT System Option” on page 19, “ENCRYPTFIPS System Option” on page 17
Examples:	“SSL for a SAS/CONNECT Windows Spawner: Example ” on page 51 “SSL on a z/OS Spawner on a SAS/CONNECT Server: Example” on page 59 “SSL for a SAS/CONNECT UNIX Spawner: Example ” on page 49

Syntax

NETENCRYPTALGORITHM *algorithm | (“algorithm-1”... “algorithm-n”)*

Syntax Description

algorithm | (“algorithm–1”... “algorithm-n”)

specifies the algorithm or algorithms that can be used for encrypting data that is transferred between a client and a server across a network. When you specify two or more encryption algorithms, use a space or a comma to separate them, and enclose the algorithms in parentheses.

The following algorithms can be used:

- RC2
- RC4
- DES
- TripleDES
- SASProprietary
- SSL
- AES

Restrictions:

The SSL option is not applicable to the Integrated Object Model (IOM) metadata, OLAP, and table servers.

When ENCRYPTFIPS is specified, only the SSL or the AES algorithm can be specified. Otherwise, an error message is output.

Details

The NETENCRYPTALGORITHM option must be specified in the server session.

Use this option to specify one or more encryption algorithms that you want to use to protect the data that is transferred across the network. If more than one algorithm is specified, the client session negotiates the first specified algorithm with the server session. If the client session does not support that algorithm, the second algorithm is negotiated, and so on.

If either the client or the server session specifies the NETENCRYPT option (which makes encryption mandatory) but a common encryption algorithm cannot be negotiated, the client cannot connect to the server.

If the NETENCRYPTALGORITHM option is specified in the server session only, then the server's values are used to negotiate the algorithm selection. If the client session supports only one of multiple algorithms that are specified in the server session, the client can connect to the server.

There is an interaction between either NETENCRYPT or NONETENCRYPT and the NETENCRYPTALGORITHM option.

Table 2.1 Client/Server Connection Outcomes

Server Settings	Client Settings	Connection Outcome
NONETENCRYPT NETENCRALG*alg*	No settings	If the client is capable of encryption, the client/server connection will be encrypted. Otherwise, the connection will not be encrypted.
NETENCRYPT NETENCRALG*alg*	No settings	If the client is capable of encryption, the client/server connection will be encrypted. Otherwise, the client/server connection will fail.
No settings	NONETENCRYPT NETENCRALG*alg*	A client/server connection will not be encrypted.
No settings	NETENCRYPT NETENCRALG*alg*	A client/server connection will fail.
NETENCRYPT or NONETENCRYPT NETENCRALG*alg–1*	NETENCRALG*alg-2*	Regardless of whether NETENCRYPT or NONETENCRYPT is specified, a client/server connection will fail.

Example

In the following example, the client and the server specify different values for the NETENCRYPTALGORITHM option.

The client specifies two algorithms in the following OPTIONS statement:

```
options netencryptalgorithm=(rc2 tripledes);
```

The server specifies three algorithms and requires encryption in the following OPTIONS statement:

```
options netencrypt netencryptalgorithm=(ssl des tripledes);
```

The client and the server negotiate an algorithm that they share in common, TripleDES, for encrypting data transfers.

NETENCRYPTKEYLEN= System Option

Specifies the key length that is used by the encryption algorithm for encrypted client/server data transfers.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Alias: NETENCRKEY=

Default: 0

Operating environment: UNIX, Windows, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*, “Starting the Windows Spawner” in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*, and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Syntax

NETENCRYPTKEYLEN= 0 | 40 | 128

Syntax Description

0
specifies that the maximum key length that is supported at both the client and the server is used.

40
specifies a key length of 40 bits for the RC2 and RC4 algorithms.

128
specifies a key length of 128 bits for the RC2 and RC4 algorithms. If either the client or the server does not support 128-bit encryption, the client cannot connect to the server.

Details

The NETENCRYPTKEYLEN= option supports only the RC2 and RC4 algorithms. The SASProprietary, DES, TripleDES, SSL, and AES algorithms are not supported.

By default, if you try to connect a computer that is capable of only a 40-bit key length to a computer that is capable of both a 40-bit and a 128-bit key length, the connection is made using the lesser key length. If both computers are capable of 128-bit key lengths, a 128-bit key length is used.

Using longer keys consumes more CPU cycles. If you do not need a high level of encryption, set NETENCRYPTKEYLEN=40 to decrease CPU usage.

SSLCALISTLOC= System Option

Specifies the location of digital certificates for trusted certification authorities (CA).

Client: required

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the UNIX Spawner" in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and "Options to Start the z/OS Spawner" in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: "SSL for a SAS/CONNECT UNIX Spawner: Example " on page 49

"SSL on a z/OS Spawner on a SAS/CONNECT Server: Example" on page 59

Syntax

SSLCALISTLOC="*file–path*"

Syntax Description

"file-path"

specifies the location of a file that contains the digital certificates for the trusted certification authority (CA).

Details

The SSLCALISTLOC= option identifies the certification authority that SSL should trust. This option is required at the client because at least one CA must be trusted in order to validate a server's digital certificate. This option is required at the server only if the SSLCLIENTAUTH option is also specified at the server.

The CA list must be PEM-encoded (base64). Under z/OS, the file must be formatted as ASCII and must reside in a UNIX file system.

SSLCERTISS= System Option

Specifies the name of the issuer of the digital certificate that SSL should use.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: Windows

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the Windows Spawner" in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Example: "SSL for SAS/SHARE under Windows: Examples " on page 54

Syntax

SSLCERTISS="*issuer-of-digital-certificate*"

Syntax Description

"*issuer-of-digital-certificate*"
specifies the name of the issuer of the digital certificate that should be used by SSL.

Details

The SSLCERTISS= option is used with the SSLCERTSERIAL= option to uniquely identify a digital certificate from the Microsoft Certificate Store.

Note: You can also use the SSLCERTSUBJ= option to identify a digital certificate instead of using the SSLCERTSERIAL= and the SSLCERTISS= options.

SSLCERTLOC= System Option

Specifies the location of the digital certificate that is used for authentication.

Client: optional

Server: required

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the UNIX Spawner" in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and "Options to Start the z/OS Spawner" in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: "SSL for a SAS/CONNECT UNIX Spawner: Example " on page 49

"SSL on a z/OS Spawner on a SAS/CONNECT Server: Example" on page 59

"SSL for SAS/SHARE under UNIX: Example " on page 53

Syntax

SSLCERTLOC="*file-path*"

Syntax Description

"*file-path*"
specifies the location of a file that contains a digital certificate.

Details

The SSLCERTLOC= option is required for a server. It is required at the client only if the SSLCLIENTAUTH option is specified at the server.

If you want the spawner to locate the appropriate digital certificate, you must specify both the -SSLCERTLOC and -SSLPVTKEYLOC options in the -SASCMD script.

The certificate must be PEM-encoded (base64). Under z/OS, the file must be formatted as ASCII and must reside in a UNIX file system.

SSLCERTSERIAL= System Option

Specifies the serial number of the digital certificate that SSL should use.

Client:	optional
Server:	optional
Valid in:	Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line
Category:	Communications: Networking and Encryption
PROC OPTIONS GROUP=	Communications
Operating environment:	Windows
Tip:	When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the Windows Spawner" in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.
Example:	"SSL for SAS/SHARE under Windows: Examples " on page 54

Syntax

SSLCERTSERIAL="*serial-number*"

Syntax Description

"*serial-number*"
specifies the serial number of the digital certificate that should be used by SSL.

Details

The SSLCERTSERIAL= option is used with the SSLCERTISS= option to uniquely identify a digital certificate from the Microsoft Certificate Store.

Note: You can also use the SSLCERTSUBJ= option to identify a digital certificate instead of using the SSLCERTISS= and the SSLCERTSERIAL= options.

SSLCERTSUBJ= System Option

Specifies the subject name of the digital certificate that SSL should use.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: Windows

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the Windows Spawner” in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Example: “SSL for a SAS/CONNECT Windows Spawner: Example ” on page 51

Syntax

SSLCERTSUBJ=“*subject-name*”

Syntax Description

“subject-name”
specifies the subject name of the digital certificate that SSL should use.

Details

The SSLCERTSUBJ= option is used to search for a digital certificate from the Microsoft Certificate Store.

Note: You can also use the SSLCERTISS= and the SSLCERTSERIAL= options instead of the SSLCERTSUBJ= option to identify a digital certificate.

SSLCLIENTAUTH System Option

Specifies whether a server should perform client authentication.

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, Windows, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*, “Starting the Windows Spawner” in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*, and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Syntax

SSLCLIENTAUTH | NOSSLCLIENTAUTH

Syntax Description

SSLCLIENTAUTH
specifies that the server should perform client authentication.

NOSSLCLIENTAUTH
specifies that the server should not perform client authentication.

Details

Server authentication is always performed, but the SSLCLIENTAUTH option enables a user to control client authentication. This option is valid only when used on a server.

SSLCRLCHECK System Option

Specifies whether a Certificate Revocation List (CRL) is checked when a digital certificate is validated.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, Windows, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods*

for SAS/CONNECT and SAS/SHARE, “Starting the Windows Spawner” in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*, and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Syntax

SSLCRLCHECK | **NOSSLCRLCHECK**

Syntax Description

SSLCRLCHECK
specifies that CRLs are checked when digital certificates are validated.

NOSSLCRLCHECK
specifies that CRLs are not checked when digital certificates are validated.

Details

A Certificate Revocation List (CRL) is published by a Certification Authority (CA) and contains a list of revoked digital certificates. The list contains only the revoked digital certificates that were issued by a specific CA.

The SSLCRLCHECK option is required at the server only if the SSLCLIENTAUTH option is also specified at the server. Because clients check server digital certificates, this option is relevant for the client.

SSLCRLLOC= System Option

Specifies the location of a Certificate Revocation List (CRL).

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS configuration, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Syntax

SSLCRLLOC=“*file-path*”

Syntax Description

"file-path"
specifies the location of a file that contains a Certificate Revocation List (CRL).

Details

The SSLCRLLOC= option is required only when the SSLCRLCHECK option is specified.

SSLPKCS12LOC= System Option

Specifies the location of the PKCS #12 encoding package file.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the UNIX Spawner" in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and "Options to Start the z/OS Spawner" in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: "SSL on a z/OS Spawner on a SAS/CONNECT Server: Example" on page 59
"SSL for SAS/SHARE under z/OS: Example " on page 61

Syntax

SSLPKCS12LOC="*file-path*"

Syntax Description

"file-path"
specifies the location of the PKCS #12 DER encoding package file that contains the certificate and the private key.

z/OS specifics: If you run in a z/OS operating environment, this file must be in the UNIX file system. The OpenSSL library cannot read MVS data sets.

Details

If the SSLPKCS12LOC= option is specified, the PKCS #12 DER encoding package must contain both the certificate and private key. The SSLCERTLOC= and SSLPVTKEYLOC= options will be ignored.

You must specify both the -SSLPKCS12LOC and the -SSLPKCS12PASS options in the -SASCMD script if you want the spawner to locate the appropriate digital certificate.

SSLPKCS12PASS= System Option

Specifies the password that SSL requires for decrypting the private key.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: “SSL on a z/OS Spawner on a SAS/CONNECT Server: Example” on page 59

“SSL for SAS/SHARE under z/OS: Example ” on page 61

Syntax

SSLPKCS12PASS=*password*

Syntax Description

password

specifies the password that SSL requires in order to decrypt the PKCS #12 DER encoding package file. The PKCS #12 DER encoding package is stored in the file that is specified by using the SSLPKCS12LOC= option.

Details

The SSLPKCS12PASS= option is required only when the PKCS #12 DER encoding package is encrypted. The z/OS RACDCERT EXPORT command always encrypts package files when exporting the certificate and the private key.

You must specify both the -SSLPKCS12LOC and the -SSLPKCS12PASS options in the -SASCMD script if you want the spawner to locate the appropriate digital certificate.

SSLPVTKEYLOC= System Option

Specifies the location of the private key that corresponds to the digital certificate.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see "Starting the UNIX Spawner" in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and "Options to Start the z/OS Spawner" in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: "SSL for a SAS/CONNECT UNIX Spawner: Example " on page 49

"SSL for SAS/SHARE under UNIX: Example " on page 53

Syntax

SSLPVTKEYLOC="*file-path*"

Syntax Description

"file-path"
specifies the location of the file that contains the private key that corresponds to the digital certificate that was specified by using the SSLCERTLOC= option.

Details

The SSLPVTKEYLOC= option is required at the server only if the SSLCERTLOC= option is also specified at the server.

The key must be PEM-encoded (base64). Under z/OS, the file must be formatted as ASCII and must reside in a UNIX file system.

You must specify both the -SSLCERTLOC and the -SSLPVTKEYLOC options in the -SASCMD script if you want the spawner to locate the appropriate digital certificate.

SSLPVTKEYPASS= System Option

Specifies the password that SSL requires for decrypting the private key.

Client: optional

Server: optional

Valid in: Configuration file, OPTIONS statement, SAS System Options window, SAS invocation, SAS/CONNECT spawner command line

Category: Communications: Networking and Encryption

PROC OPTIONS GROUP= Communications

Operating environment: UNIX, z/OS

Tip: When additional encryption options are specified on the spawner command line, the options must be included in the -SASCMD value. The spawner does not automatically pass the encryption values. For detailed information about -SASCMD, see “Starting the UNIX Spawner” in Chapter 8 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE* and “Options to Start the z/OS Spawner” in Chapter 7 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Examples: “SSL for a SAS/CONNECT UNIX Spawner: Example ” on page 49

“SSL for SAS/SHARE under UNIX: Example ” on page 53

Syntax

SSLPVTKEYPASS=“*password*”

Syntax Description

“password”

specifies the password that SSL requires in order to decrypt the private key. The private key is stored in the file that is specified by using the SSLPVTKEYLOC= option.

Details

The SSLPVTKEYPASS= option is required only when the private key is encrypted. OpenSSL performs key encryption.

Note: No SAS system option is available to encrypt private keys.

Chapter 3

SAS Environment Variables for Encryption

Overview of Environment Variables

UNIX environment variables are variables that apply to both the current shell and to any subshells that it creates. The way in which you define an environment variable depends on the shell that you are running. For more information, see "Defining Environment Variables in UNIX Environments" in Chapter 1 of *SAS Companion for UNIX Environments*.

z/OS environment variables are specified in a SAS data set that is referred to as the TKMVSENV data set file. For more information about setting environment variables in the TKMVSENV file, see "TKMVSENV File" in Chapter 1 of *SAS Companion for z/OS*.

For Windows, you can choose to define a SAS environment variable using the SET system option or to define a Windows environment variable using the Windows SET command. For more information, see "Using Environment Variables" in Chapter 5 of *SAS Companion for Windows*.

Dictionary

SAS_SSL_MIN_PROTOCOL Environment Variable

Specifies the minimum TLS or SSL protocol that can be negotiated when using OpenSSL. This environment variable is available when security hot fixes are applied.

Client: optional

Server: optional

Valid in: Configuration file, command line

Categories: Communications: Networking and Encryption

System Administration: Security

Default: TLS 1.0. When the security hot fixes are applied to the second maintenance release for SAS 9.3, the minimum OpenSSL protocol default is TLS 1.0.

Operating environment: UNIX, z/OS, and Windows

Note: This environment variable must be set before TLS or SSL are loaded. It cannot be changed after TLS or SSL are loaded. You must set the environment variable before the SAS/CONNECT spawner is started and before SAS is started on the client.

Tip: You can also define SET commands for Windows by using the System Properties dialog box that you access from the Control Panel.

See: "Defining Environment Variables in UNIX Environments" in Chapter 1 of *SAS Companion for UNIX Environments*, "TKMVSENV File" in Chapter 1 of *SAS Companion for z/OS*, "Using Environment Variables" in Chapter 5 of *SAS Companion for Windows*

Examples: Export the environment variable on UNIX hosts for the Bourne Shell:

```
export SAS_SSL_MIN_PROTOCOL=TLS
```

Set the environment variable on UNIX hosts for the C Shell environment:

```
SETENV SAS_SSL_MIN_PROTOCOL SSLv3
```

Set the environment variable at SAS invocation for UNIX hosts:

```
-set "SAS_SSL_MIN_PROTOCOL=SSLv3"
```

Set the environment variable on Windows hosts:

```
SET SAS_SSL_MIN_PROTOCOL=TLS1.0
```

Syntax

SAS_SSL_MIN_PROTOCOL= *protocol*

"**SAS_SSL_MIN_PROTOCOL=** *protocol*"

SAS_SSL_MIN_PROTOCOL *protocol*

Syntax Description

protocol

specifies the minimum TLS or SSL protocol version that is negotiated between UNIX, z/OS, and Windows servers when using OpenSSL. This environment variable is available only when security hot fixes are applied to the second maintenance release for SAS 9.3.

Valid OpenSSL protocol values available for this environment variable are as follows.

- SSL3
- SSLv3
- TLS
- TLS1.0
- TLSv1
- TLSv1.0

CAUTION:
SSL 3.0 is insecure. It is highly recommended that you use TLS 1.0.

Note: When the security hot fixes are applied, the default minimum protocol for OpenSSL is set to TLS 1.0.

Note: A message is written to the SAS log when an invalid value is specified.

Details

When the security hot fixes are applied in the second maintenance release for SAS 9.3, the SAS_SSL_MIN_PROTOCOL environment variable enables you to set a minimum SSL or TLS protocol that can be negotiated. During the first SSL or TLS handshake attempt, the highest supported protocol version is offered. If this handshake fails, earlier protocol versions are offered instead.

TLS 1.0 is the default minimum OpenSSL protocol version set when the hot fixes are applied. The SSL 3.0 value can be specified as a fallback value. However, the use of SSL 3.0 is not recommended.

Refer to **http://support.sas.com/security/alerts.html** and **Technical Support Hot Fixes**.

SAS_SSL_CIPHER_LIST Environment Variable

Specifies the ciphers that can be used on UNIX and z/OS for OpenSSL.

Client: optional

Server: optional

Valid in: Configuration file, command line

Categories: Communications: Networking and Encryption
System Administration: Security

Operating environment: UNIX and z/OS

Note: This environment variable must be set before TLS or SSL are loaded. It cannot be changed after TLS or SSL are loaded. You must set the environment variable before the SAS/CONNECT spawner is started and before SAS is started on the client.

Tip: You can also define SET commands for Windows by using the System Properties dialog box that you access from the Control Panel.

See: “Defining Environment Variables in UNIX Environments” in Chapter 1 of *SAS Companion for UNIX Environments*, “TKMVSENV File” in Chapter 1 of *SAS Companion for z/OS*

Examples: Export the environment variable on UNIX hosts for the Bourne Shell:

```
export SAS_SSL_CIPHER_LISTSS=TLS
```

Set the environment variable on UNIX hosts for the C Shell environment:

```
SETENV SAS_SSL_CIPHER_LISTS HIGH
```

Set the environment variable at SAS invocation for UNIX hosts:

```
-set "SAS_SSL_CIPHER_LISTS "3DES:RC2"
```

Set the environment variable on Windows hosts:

```
SET SAS_SSL_CIPHER_LISTS SHA256
```

Syntax

SAS_SSL_CIPHER_LIST=*openssl_cipher_list*

"**SAS_SSL_CIPHER_LIST=** *openssl_cipher_list*"

SAS_SSL_CIPHER_LIST*openssl_cipher_list*

Syntax Description

openssl-cipher-list

The SAS_SSL_CIPER_LIST environment variable specifies the ciphers that can be used on UNIX and z/OS for OpenSSL. Refer to the OpenSSL ciphers document to see how to format the *openssl-cipher-list* and for a complete list of the ciphers that work with your TLS or SSL version. The OpenSSL cipher documentation can be found at the following URL: **https://www.openssl.org/docs/apps/ciphers.html#**

Note: SAS does not support CAMELLIA, IDEA, MD2, and RC5 ciphers.

This environment variable is available in the second maintenance release for SAS 9.3 when security hot fixes are applied.

Note: If you set a minimum protocol that does not allow some ciphers, you might get an error.

For Windows, you can configure the SSL Cipher Suite Order in the group policy settings. Search the **http://msdn.microsoft.com** website for information about how to set the SSL or TLS Cipher Suite Order.

Details

This environment variable is available on UNIX and z/OS platforms when security hot fixes are applied second maintenance release for SAS 9.3. Refer to **http://support.sas.com/security/alerts.html** and **Technical Support Hot Fixes**for the latest information about Hot Fixes.

This environment variable can be specified anytime before SSL is used. After SSL is loaded, it cannot be changed. Search the **http://msdn.microsoft.com** website for information about how to set the SSL or TLS Cipher Suite Order.

Refer to the OpenSSL documentation about ciphers for information about the ciphers that can be specified for this environment variable. This information can be found at the following URL: **https://www.openssl.org/docs/apps/ciphers.html#**

Chapter 4

PWENCODE Procedure

Overview: PWENCODE Procedure

The PWENCODE procedure enables you to encode passwords. Encoded passwords can be used in place of plaintext passwords in SAS programs that access relational database management systems (RDBMSs) and various servers, such as SAS/CONNECT servers, SAS/SHARE servers, and SAS Integrated Object Model (IOM) servers (such as the SAS Metadata Server).

Concepts: PWENCODE Procedure

Using Encoded Passwords in SAS Programs

When a password is encoded with PROC PWENCODE, the output string includes a tag that identifies the string as having been encoded. An example of a tag is `{sas001}`. The tag indicates the encoding method. SAS servers and SAS/ACCESS engines recognize the tag and decode the string before using it. Encoding a password enables you to write SAS programs without having to specify a password in plaintext.

Note: PROC PWENCODE passwords can contain up to a maximum of 512 characters, which include alphanumeric characters, spaces, and special characters. Data set passwords, however, must follow SAS naming rules. For information about SAS

naming rules, see “Rules for Most SAS Names” in Chapter 3 of *SAS Language Reference: Concepts*.

The encoded password is never written to the SAS log in plain text. Instead, each character of the password is replaced by an X in the SAS log.

Encoding versus Encryption

PROC PWENCODE uses encoding to disguise passwords. With encoding, one character set is translated to another character set through some form of table lookup. Encryption, by contrast, involves the transformation of data from one form to another through the use of mathematical operations and, usually, a “key” value. Encryption is generally more difficult to break than encoding. PROC PWENCODE is intended to prevent casual, non-malicious viewing of passwords. You should not depend on PROC PWENCODE for all your data security needs; a determined and knowledgeable attacker can decode the encoded passwords.

Syntax: PWENCODE Procedure

PROC PWENCODE IN='*password*' <OUT=*fileref*> <METHOD=*encoding-method*>;

Statement	Task	Example
“PROC PWENCODE Statement”	Encode a password	Ex. 1, Ex. 2, Ex. 3, Ex. 4

PROC PWENCODE Statement

Encodes a password.

Examples:
“Example 1: Encoding a Password” on page 42
“Example 2: Using an Encoded Password in a SAS Program” on page 42
“Example 3: Saving an Encoded Password to the Paste Buffer” on page 44
“Example 4: Specifying an Encoding Method for a Password” on page 45

Syntax

PROC PWENCODE IN='*password*' <OUT=*fileref*> <METHOD=*encoding-method*>;

Required Argument

IN='*password*'
specifies the password to encode. The password can contain up to a maximum of 512 characters, which include alphanumeric characters, spaces, and special characters.

Note: Data set passwords must follow SAS naming rules. If the IN=*password* follows SAS naming rules, it can also be used for SAS data sets. For information

about SAS naming rules, see “Rules for Most SAS Names” in Chapter 3 of *SAS Language Reference: Concepts*.

If the password contains embedded single or double quotation marks, use the standard SAS rules for quoting character constants. These rules can be found in the SAS Constants in Expressions chapter of *SAS Language Reference: Concepts*.

Note: Each character of the encoded password is replaced by an X when written to the SAS log.

See:

“Example 1: Encoding a Password” on page 42

“Example 2: Using an Encoded Password in a SAS Program” on page 42

“Example 3: Saving an Encoded Password to the Paste Buffer” on page 44

Optional Arguments

OUT=*fileref*

specifies a fileref to which the output string is to be written. If the OUT= option is not specified, the output string is written to the SAS log.

Note: The global macro variable

`_PWENCODE`

is set to the value that is written to the OUT= fileref or to the value that is displayed in the SAS log.

See: “Example 2: Using an Encoded Password in a SAS Program” on page 42

METHOD=*encoding-method*

specifies the encoding method. Here are the supported values for *encoding-method*:

Table 4.1 *Supported Encoding Methods*

Encoding Method	Description	Supported Data Encryption Algorithm
`sas001`	Uses base64 to encode passwords.	None
`sas002`, which can also be specified as **`sasenc`**	Uses a 32-bit key to encode passwords. This is the default.	SASProprietary, which is included in SAS software.
`sas003`	Uses a 256-bit key to encode passwords.	AES (Advanced Encryption Standard), which is supported in SAS/SECURE.

Note: SAS/SECURE is an add-on product that requires a separate license. For details about SAS/SECURE, the SASProprietary algorithm, and the AES algorithm, see *Encryption in SAS*.

If the METHOD= option is omitted, the default encoding method is used. When the FIPS 140-2 compliance option, -encryptfips, is specified, the encoding default method is **`sas003`**. For all other cases, encoding method **`sas002`** is the default method used.

Examples: PWENCODE Procedure

Example 1: Encoding a Password

Features: IN= argument

Details

This example shows a simple case of encoding a password and writing the encoded password to the SAS log.

Program

```
proc pwencode in='my password';
run;
```

Program Description

Encode the password.

```
proc pwencode in='my password';
run;
```

Log

Note that each character of the password is replaced by an X in the SAS log.

```
19   proc pwencode in=XXXXXXXXXXXXX;
20   run;


{SAS002}DBCC571245AD0B31433834F80BD2B99E16B3C969

NOTE: PROCEDURE PWENCODE used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds
```

Example 2: Using an Encoded Password in a SAS Program

Features: IN= argument
OUT= option

Details

This example illustrates the following:

- encoding a password and saving it to an external file
- reading the encoded password with a DATA step, storing it in a macro variable, and using it in a SAS/ACCESS LIBNAME statement

Program 1: Encoding the Password

```
filename pwfile
'external-filename'

proc pwencode in='mypass1' out=pwfile;
run;
```

Program Description

Declare a fileref.

```
filename pwfile
'external-filename'
```

Encode the password and write it to the external file. The OUT= option specifies which external fileref the encoded password will be written to.

```
proc pwencode in='mypass1' out=pwfile;
run;
```

Program 2: Using the Encoded Password

```
filename pwfile
'external-filename';

options symbolgen;

data _null_;
infile pwfile truncover;
input line :$50.;
call symputx('dbpass',line);
run;

libname x odbc dsn=SQLServer user=testuser password="&dbpass";
```

Program Description

Declare a fileref for the encoded-password file.

```
filename pwfile
'external-filename';
```

Set the SYMBOLGEN SAS system option. The purpose of this step is to show that the actual password cannot be revealed, even when the macro variable that contains the encoded password is resolved in the SAS log. This step is not required in order for the program to work properly.

```
options symbolgen;
```

Read the file and store the encoded password in a macro variable. The DATA step stores the encoded password in the macro variable DBPASS.

```
data _null_;
infile pwfile truncover;
input line :$50.;
call symputx('dbpass',line);
run;
```

Use the encoded password to access a DBMS. You must use double quotation marks (“ ”) so that the macro variable resolves properly.

```
libname x odbc dsn=SQLServer user=testuser password="&dbpass";
```

Log

```
1    filename pwfile 'external-filename';
2    options symbolgen;
3    data _null_;
4    infile pwfile truncover;
5    input line :$50.;
6    call symputx('dbpass',line);
7    run;

NOTE: The infile PWFILE is:
      Filename=external-filename
      RECFM=V,LRECL=256,File Size (bytes)=4,
      Last Modified=12Apr2012:13:23:49,
      Create Time=12Apr2012:13:23:39

NOTE: 1 record was read from the infile PWFILE.
      The minimum record length was 4.
      The maximum record length was 4.
NOTE: DATA statement used (Total process time):
      real time           0.57 seconds
      cpu time            0.04 seconds
8
9   libname x odbc
SYMBOLGEN:  Macro variable DBPASS resolves to {sas002}bXlwYXNzMQ==
9 !               dsn=SQLServer user=testuser password="&dbpass";
NOTE: Libref X was successfully assigned as follows:
      Engine:        ODBC
      Physical Name: SQLServer
```

Example 3: Saving an Encoded Password to the Paste Buffer

Features: IN= argument
OUT= option

Other features: FILENAME statement with CLIPBRD access method

DETAILS

This example saves an encoded password to the paste buffer. You can then paste the encoded password into another SAS program or into the password field of an authentication dialog box.

Program

```
filename clip clipbrd;

proc pwencode in='my password' out=clip;
run;
```

Program Description

Declare a fileref with the CLIPBRD access method.

```
filename clip clipbrd;
```

Encode the password and save it to the paste buffer. The OUT= option saves the encoded password to the fileref that was declared in the previous statement.

```
proc pwencode in='my password' out=clip;
run;
```

Log

Note that each character of the password is replaced by an X in the SAS log.

```
24
25   filename clip clipbrd;
26     proc pwencode in=XXXXXXXXXXXXX out=clip;
27   run;

NOTE: PROCEDURE PWENCODE used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds
```

Example 4: Specifying an Encoding Method for a Password

Features: METHOD= argument

Details

This example shows a simple case of encoding a password using the **sas003** encoding method and writing the encoded password to the SAS log.

Program

```
proc pwencode in='my password' method=sas003;
run;
```

Program Description

Encode the password.

```
proc pwencode in='my password' method=sas003;
run;
```

Log

Note that each character of the password is replaced by an X in the SAS log.

```
8   proc pwencode in=XXXXXXXXXXXXX method=sas003;
29   run;

{SAS003}08D7B93810D390916F615117D71B2639B4BE

NOTE: PROCEDURE PWENCODE used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds
```

Chapter 5

Encryption Technologies: Examples

SAS/SECURE for SAS/CONNECT: Example

SAS/CONNECT Client under UNIX

The following statements configure the client. The NETENCRYPTALGORITHM= option specifies the use of the RC4 algorithm.

```
options netencryptalgorithm=rc4;
options remote=unxnode comamid=tcp;
signon;
```

SAS/CONNECT Server under UNIX

The following command starts a spawner on the computer that runs the server. The -NETENCRYPT option specifies that encryption is required for all clients that connect to the spawner. The -NETENCRYPTALGORITHM option specifies the use of the RC4 algorithm for encrypting all network data. The -SASCMD option specifies the SAS start-up command.

```
sastcpd -service spawner -netencrypt -netencryptalgorithm rc4 -sascmd mystartup
```

The spawner executes a UNIX shell script that executes the commands to start SAS.

```
#!/bin/ksh
#_________________
# mystartup
#_________________
. ~/.profile
sas dmr -noterminal -comamid tcp $*
```

SASProprietary for SAS/SHARE: Example

SAS/SHARE Client

In this example, the NETENCRYPTALGORITHM= option is set to SASProprietary to specify the use of the proprietary algorithm to encrypt the data between the client and the server. The NETENCRYPTALGORITHM= option must be set before the LIBNAME statement establishes the connection to the server.

```
options netencryptalgorithm=saspropriety;
options comamid=tcp;
libname sasdata 'edc.prog2.sasdata' server=rmthost.share1;
```

SAS/SHARE Server

This example shows how to set the options for encryption services on a SAS/SHARE server. The NETENCRYPT option specifies that encryption is required by any client that accesses this server. The NETENCRYPTALGORITHM= option specifies that the

SASProprietary algorithm be used for encryption of all data that is exchanged with connecting clients.

```
options netencrypt netencryptalgorithm=saspropriety;
options comamid=tcp;
proc server id=share1;
run;
```

SSL for a SAS/CONNECT UNIX Spawner: Example

Start-up of a UNIX Spawner on a SAS/CONNECT Server

After digital certificates are generated for the CA, the server, and the client, and a CA trust list for the client is created, you can start a UNIX spawner program that runs on a server that SAS/CONNECT clients connect to.

The following example code starts the spawner using SSL encryption and specifies a private password that must be provided either through prompting or within a file:

```
% sastcpd -service unxspawn -netencryptalgorithm ssl
-sslcertloc /users/server/certificates/server.pem
-sslpvtkeyloc /users/server/certificates/serverkey.pem
-sslpvtkeypass starbuck1
-sslcalistloc /users/server/certificates/sas.pem
-sascmd /users/server/command.ksh
```

The following table explains the SAS commands that are used to start a spawner on a SAS/CONNECT single-user server.

Table 5.1 *SAS Commands and Arguments for Spawner Start-Up Tasks*

SAS Commands and Arguments	Function
SASTCPD	Starts the spawner
-SERVICE *unxspawn*	Specifies the spawner service (configured in the services file)
-NETENCRYPTALGORITM *SSL*	Specifies the SSL encryption algorithm
-SSLCERTLOC */users/server/certificates/server.pem*	Specifies the file path for the location of the server's certificate
-SSLPVTKEYLOC */users/server/certificates/serverkey.pem*	Specifies the file path for the location of the server's private key
-SSLPVTKEYPASS *password*	Specifies the password to access the server's private key
-SSLCALISTLOC */users/server/certificates/sas.pem*	Specifies the CA trust list

SAS Commands and Arguments	Function
-SASCMD */users/server/command.ksh*	Specifies the name of an executable file that starts a SAS session when you sign on without a script file

In order for the UNIX spawner to locate the appropriate server digital certificate, you must specify the -SSLCERTLOC and -SSLPVTKEYLOC or the SSLPKCS12LOC and SSLPKCS12PASS system options in the script that is specified by the -SASCMD option.

For complete information about starting a Windows spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Here is an example of an executable file:

```
#!/bin/ksh
#----------------------------------
# mystartup
#----------------------------------

. ~/.profile
sas -noterminal -sslcertloc /users/server/certificates/server.pem
-sslpvtkeyloc /users/server/certificates/serverkey.pem $*
#-----------------------------
```

For complete information about starting a UNIX spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Connection of a SAS/CONNECT Client to a UNIX Spawner

After a UNIX spawner is started on a SAS/CONNECT server, a SAS/CONNECT client can connect to it.

The following example shows how to connect a client to a spawner that is running on a SAS/CONNECT server:

```
options netencryptalgorithm=ssl;
options sslcalistloc="/users/johndoe/certificates/cacerts.pem";
%let machine=apex.server.com;
signon machine.spawner user=_prompt_;
```

The following table explains the SAS options that are used to connect to a SAS/CONNECT server.

Table 5.2 *SAS Options, Statements, and Arguments for Client Access to a SAS/CONNECT Server*

SAS Options, Statements, and Arguments	Client Access Tasks
NETENCRYPTALGORITHM=*SSL*	Specifies the encryption algorithm
SSLCALISTLOC=*cacerts.pem*	Specifies the CA trust list
SIGNON=*server-ID.service*	Specifies the server and service to connect to

SAS Options, Statements, and Arguments	Client Access Tasks
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server-ID and the server's Common Name, which was specified in the server's digital certificate, must be identical.

For complete information about connecting to a UNIX spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

SSL for a SAS/CONNECT Windows Spawner: Example

Start-up of a Windows Spawner on a Single-User SAS/CONNECT Server

After digital certificates for the CA, the server, and the client have been generated and imported into the appropriate Certificate Store, you can start a spawner program that runs on a server that SAS/CONNECT clients connect to.

Here is an example of how to start a Windows spawner on a SAS/CONNECT server:

```
spawner -install -netencryptalgorithm ssl -sslcertsubj "apex.pc.com"
-sascmd mysas.bat -servuser userid -servpass password
```

The following table shows the SAS commands that are used to start a spawner on a SAS/CONNECT single-user server.

Table 5.3 *SAS Commands and Arguments for Spawner Start-Up Tasks*

SAS Command and Arguments	Function
SPAWNER	Starts the spawner
-INSTALL	Causes an instance of a spawner to be installed as a Windows service. For information about the -INSTALL option, see “Options for the Windows Spawner” in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.
-NETENCRYPTALGORITHM *SSL*	Specifies the SSL encryption algorithm
-SSLCERTSUBJ "*apex.pc.com*"	Specifies the subject name that is used to search for a certificate from the Microsoft Certificate Store
-SASCMD *mysas.bat*	Specifies the name of an executable file that starts a SAS session when you sign on without a script file.

SAS Command and Arguments	Function
-SERVUSER *user-ID*	Specifies the *user-ID* to be used to start the spawner and to obtain a digital certificate. The -SERVUSER and the -SERVPASS options are used together and must be specified when the spawner is installed as a service (the -INSTALL option is specified). For information about the -SERVUSER option, see "Options for the Windows Spawner" in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.
-SERVPASS *password*	Specifies the *password* to be used to start the spawner and to obtain a digital certificate. The -SERVUSER and the -SERVPASS options are used together and must be specified when the spawner is installed as a service (the -INSTALL option is specified). For information about the -SERVPASS option, see "Options for the Windows Spawner" in Chapter 9 of *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

In order for the Windows spawner to locate the appropriate server digital certificate in the Microsoft Certificate Store, you must specify the -SSLCERTSUBJ system option in the script that is specified by the -SASCMD option. -SSLCERTSUBJ specifies the subject name of the digital certificate that SSL should use. The subject that is assigned to the -SSLCERTSUBJ option and the computer that is specified in the client signon must be identical.

Note: You can also use the SSLCERTISS= and the SSLCERTSERIAL= options instead of the SSLCERTSUBJ= option to identify a digital certificate.

If the Windows spawner is started as a service, the -SERVPASS and -SERVUSER options must also be specified in the Windows spawner start-up command in order for SSL to locate the appropriate CA digital certificate.

For complete information about starting a Windows spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Connection of a SAS/CONNECT Client to a Windows Spawner on a SAS/CONNECT Server

After a spawner has been started on a SAS/CONNECT server, a SAS/CONNECT client can connect to it.

Here is an example of how to make a client connection to a Windows spawner that is running on a SAS/CONNECT server:

```
options comamid=tcp netencryptalgorithm=ssl;
%let machine=apex.pc.com;
signon machine user=_prompt_;
```

The computer that is specified in the client signon and the subject (the -SSLCERTSUBJ option) that is specified at the server must be identical.

The following table shows the SAS options that are used to connect to a Windows spawner that runs on a SAS/CONNECT server.

Table 5.4 *SAS Options, Statements, and Arguments for Client Access to a SAS/CONNECT Server*

SAS Options, Statements, and Arguments	Function
COMAMID=*TCP*	Specifies the TCP/IP access method
NETENCRYPTALGORITHM=*SSL*	Specifies the encryption algorithm
SIGNON=server-ID	Specifies which server to connect to
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server-ID and the server's Common Name, which was specified in the server's digital certificate, must be identical.

SSL for SAS/SHARE under UNIX: Example

Start-up of a Multi-UserSAS/SHARE Server

After certificates for the CA, the server, and the client have been generated, and a CA trust list for the client has been created, you can start a SAS/SHARE server.

Here is an example of starting a secured SAS/SHARE server:

```
%let tcpsec=_secure_;
options netencryptalgorithm=ssl;
options sslcertloc="/users/johndoe/certificates/server.pem";
options sslpvtkeyloc="/users/johndoe/certificates/serverkey.pem";
options sslpvtkeypass="password";
proc server id=shrserv authenticate=opt;
run;
```

The following table lists the SAS option or statement that is used for each task to start a server.

Table 5.5 *SAS Options and Statements for Server Start-Up Tasks*

SAS Options and Statements	Server Start-Up Tasks
TCPSEC= _SECURE_	Secures the server
NETENCRALG=*SSL*	Specifies SSL as the encryption algorithm
SSLCERTLOC=*server.pem*	Specifies the filepath for the location of the server's certificate
SSLPVTKEYLOC=*serverkey.pem*	Specifies the filepath for the location of the server's private key

SAS Options and Statements	Server Start-Up Tasks
SSLPVTKEYPASS="*password*"	Specifies the password to access server's private key
PROC SERVERID=*shrserv*	Starts the server
AUTHENTICATE=*OPT*	Allow trusted users to access the server without authentication.

Note: As an alternative to using the SSLPVTKEYPASS= option to protect the private key, you might prefer that the private key remain unencrypted, and use the file system permissions to prevent Read and Write access to the file that contains the private key. To store the private key without encrypting it, use the-NODES option when requesting the certificate.

SAS/SHARE Client Access of a SAS/SHARE Server

After a SAS/SHARE server has been started, the client can access it.

Here is an example of how to make a client connection to a secured SAS/SHARE server:

```
options sslcalistloc="/users/johndoe/certificates/cacerts.pem";
%let machine=apex.server.com;
libname a '.' server=machine.shrserv user=_prompt_;
```

The following table lists the SAS options that are used to access a SAS/SHARE server from a client.

Table 5.6 *SAS Options and Arguments Tasks for Accessing a SAS/SHARE Server from a Client*

SAS Options and Arguments	Client Access Tasks
SSLCALISTLOC=*cacerts.pem*	Specifies the CA trust list
SERVER=*machine.shrserv*	Specifies the machine and server to connect to
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server-ID and the server's Common Name, which was specified in the server's certificate, must be identical.

SSL for SAS/SHARE under Windows: Examples

Start-up of a Multi-UserSAS/SHARE Server

After certificates for the CA, the server, and the client have been generated, and imported into the appropriate certificate store, you can start a SAS/SHARE server. Here is an example of how to start a secured SAS/SHARE server:

```
%let tcpsec=_secure_;
options comamid=tcp netencryptalgorithm=ssl;
options sslcertiss="Glenn's CA";
options sslcertserial="0a1dcfa3000000000015";
proc server id=shrserv;
run;
```

The following table lists the SAS option or statement that is used for each task to start a server.

Table 5.7 *SAS Options, Statements, and Arguments for Server Start-Up Tasks*

SAS Options, Statements, and Arguments	Server Start-Up Tasks
TCPSEC= _SECURE_	Secures the server
COMAMID=*TCP*	Specifies the TCP/IP access method
NETENCRALG=*SSL*	Specifies SSL as the encryption algorithm
SSLCERTISS="*Glenn's CA*"	Specifies the name of the issuer of the digital certificate that SSL should use
SSLCERTSERIAL="*0a1dcfa3000000000015*"	Specifies the serial number of the digital certificate that SSL should use
PROC SERVERID=*shrserv*;	Starts the server

SAS/SHARE Client Access of a SAS/SHARE Server

After a SAS/SHARE server has been started, the client can access it.

Here is an example of how to make a client connection to a secured SAS/SHARE server:

```
options comamid=tcp;
%let machine=apex.server.com;
libname a '.' server=machine.shrserv user=_prompt_;
```

The following table lists the SAS options that are used for accessing a server from a client.

Table 5.8 *SAS Options and Arguments for Accessing a SAS/SHARE Server from a Client*

SAS Options and Arguments	Client Access Tasks
COMAMID=*TCP*	Specifies the TCP/IP access method
SERVER=*machine.shrserv*	Specifies the machine and server to connect to
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server-ID and the server's Common Name, which was specified in the server's certificate, must be identical.

SAS/SECURE for the IOM Bridge: Examples

IOM Bridge Encryption Configuration

The IOM Bridge for SAS clients can use SAS/SECURE to encrypt network data between SAS and its clients.

SAS/SECURE must be installed at the SAS server and at the SAS client. SAS clients include COM clients and Java clients.

You can configure encryption properties in either metadata or in code.

- "IOM Bridge for SAS Clients: Metadata Configuration" on page 56
- "IOM Bridge for COM: Configuration in Code" on page 56
- "IOM Bridge for Java: Configuration in Code" on page 57

IOM Bridge for SAS Clients: Metadata Configuration

In order to connect a SAS client to a SAS server, the CreateObjectByLogicalName function must obtain encryption information from metadata that is stored in the metadata repository. SAS Management Console can be used to configure encryption properties into the metadata repository, as follows:

Required encryption level
: In SAS Management Console, follow this path:

  <Connection> ⇨ Options ⇨ Advanced Options ⇨ Encryption ⇨ Required Encryption Level

  Valid values for required encryption levels are as follows:

  None
  : No encryption

  Credentials
  : Only user credentials (ID and password) are encrypted. This is the default.

  Everything
  : All client/server transfers, including credentials, are encrypted.

Server encryption algorithm
: In SAS Management Console, follow this path:**<Connection> ⇨ Options ⇨ Advanced Options ⇨ Encryption ⇨ Server Encryption Algorithms**

  Valid values for server encryption algorithms are RC2, RC4, DES, TRIPLEDES, AES, and SASPROPRIETARY (the default). For more information, refer to the chapters on encryption in *SAS Intelligence Platform: Security Administration Guide*.

IOM Bridge for COM: Configuration in Code

When using the CreateObjectByServer function to connect a Windows client to a SAS server, specify the following properties in your client code in the ServerDef object:

- BridgeEncryptionLevel
- BridgeEncryptionAlgorithm

Here is an example:

```
obServerDef.BridgeEncryptionLevel=EncryptAll;
obServerDef.BridgeEncryptionAlgorithm="TripleDes";
```

EncryptAll
causes all data, including credentials (user IDs and passwords), to be encrypted in client/server transfers.

TripleDes
is the specific encryption algorithm to be applied to data transfers.

For a complete list of encryption values, see the SAS Object Manager class reference (sasoman.chm).

IOM Bridge for Java: Configuration in Code

When using the BridgeServer object to connect a Java client to a SAS server, use the following functions to specify your encryption settings:

- setEncryptionContent
- setEncryptionAlgorithms
- setEncryptionPolicy

Here is an example:

```
obBridgeServer.setEncryptionContent(BridgeServer.ENCRYPTION_CONTENT_ALL);
obBridgeServer.setEncryptionAlgorithms(BridgeServer.ENCRYPTION_ALGORITHM_TRIPLEDES);
obBridgeServer.setEncryptionPolicy(BridgeServer.ENCRYPTION_POLICY_REQUIRED);
```

ENCRYPTION_CONTENT_ALL
causes all data, including credentials (user ID and password), to be encrypted in client/server transfers.

ENCRYPTION_ALGORITHM_TRIPLEDES
is the specific encryption algorithm to be applied to data transfers.

ENCRYPTION_POLICY_REQUIRED
specifies that encryption is required. If the server does not support encryption, the connection fails.

See *SAS Integration Technologies: Java Client Developer's Guide* for information about the IOM Bridge for Java.

SSH Tunnel for SAS/CONNECT: Example

Start-up of a UNIX Spawner on a Single-User SAS/CONNECT Server

Here is an example of code for starting a UNIX spawner program that runs on a server that SAS/CONNECT clients connect to:

```
sastcpd -service 4321
```

The UNIX spawner is started and is listening on destination port 4321. For complete details about starting a UNIX spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Connection of a SAS/CONNECT Client to a UNIX Spawner on a SAS/CONNECT Server

After the UNIX spawner has been started on a SAS/CONNECT server, a SAS/CONNECT client can connect to it.

Here is an example of code for setting up an SSH tunnel using OpenSSH and making a client connection to the UNIX spawner that is running on a SAS/CONNECT server:

```
ssh -N -L
5555:SSH-client-computer:4321
SSH-server-computer
```

The SSH command is entered in the command line. The SSH software is started on the computer on which the SSH client will run. The SSH client's listen port is defined as 5555. The SAS/CONNECT client will access the SSH client's listen port that is tunneled to the UNIX spawner, which runs on destination port 4321.

```
%let sshhost=SSH-client-computer
5555;
signon sshhost;
```

In SAS, the macro variable SSHHOST is assigned to the SSH client computer and its listen port 5555. A sign-on is specified to a SAS/CONNECT client at listen port 5555. The SSH client forwards the request from port 5555 through an encrypted tunnel to the SSH server, which forwards the request to the UNIX spawner that is listening on destination port 4321.

SSH Tunnel for SAS/SHARE: Example

Start-up of a Multi-UserSAS/SHARE Server

Here is an example of code for starting a SAS/SHARE server:

```
proc server id=_4321; run;
```

A SAS/SHARE server is started and is ready to receive requests on destination port 4321.

SAS/SHARE Client Access of a SAS/SHARE Server

Here is an example of code for setting up an SSH tunnel and making a client connection to a SAS/SHARE server:

```
ssh -N -L
5555:SSH-client-computer:4321
SSH-server-computer
```

The SSH command is entered in the command line. The SSH software is started on the computer on which the SSH client will run. The SSH client's listen port is defined as 5555. The SAS/SHARE client will access the SSH client's listen port that is tunneled to the SAS/SHARE server, which runs on destination port 4321.

```
%let sshhost=SSH-client-computer
5555;
libname orion '.' server=sshhost;
```

In SAS, the macro variable SSHHOST is assigned to the SSH client computer and its listen port 5555. A LIBNAME statement is specified to access the library that is located on the SAS/SHARE server. The SSH client forwards the request from port 5555 through an encrypted tunnel to the SSH server, which forwards the request to destination port 4321 on the SAS/SHARE server.

SSL on a z/OS Spawner on a SAS/CONNECT Server: Example

Start-up of a z/OS Spawner on a SAS/CONNECT Server

After digital certificates are generated for the CA, the server, and the client, and a CA trust list for the client is created, you can start a z/OS spawner program that runs on a server that SAS/CONNECT clients connect to.

For example:

```
//SPAWNER  EXEC PGM=SASTCPD,
//         PARM='-service 4321 =</DDN:SYSIN'
//STEPLIB  DD   DISP=SHR,DSN=<customer.high.level.pfx>.LIBRARY
//STEPLIB  DD   DISP=SHR,DSN=<customer.high.level.pfx>.LIBE
//SYSPRINT DD   SYSOUT=*
//SYSTERM  DD   SYSOUT=*
//TKMVSJNL DD   SYSOUT=*
//SYSOUT   DD   SYSOUT=*
//SYSIN    DD   *
-netencryptalgorithm ssl
-sslpkcs12loc /users/server/certificates/server.p12
-sslpkcs12pass starbuck1
-sslcalistloc /users/server/certificates/sas.pem
-sascmd /users/server/command.sh
```

The following table explains the SAS commands that are used to start a spawner on a SAS/CONNECT server.

Table 5.9 *SAS Commands and Arguments for Spawner Start-Up Tasks*

SAS Commands and Arguments	Function
SASCPD	Starts the spawner
-SERVICE *4321*	Specifies the spawner service that is listening on part 4321
- NETENCRYPTALGORITHM *SSL*	Specifies the SSL encryption algorithm
-SSLPKCS12LOC */users/server/certificates/serverkey.p12*	Specifies the file path for the location of the server's PKCS #12 DER encoding package

SAS Commands and Arguments	Function
-SSLPKCS12PASS *password*	Specifies the password to access the server's private key in the PKCS #12 package
-SSLCALISTLOC */users/server/certificates/sas.pem*	Specifies the CA trust list
-SASCMD */users/server/command.sh*	Specifies the name of an executable file that starts a SAS session when you sign on without a script file

In order for the z/OS spawner to locate the appropriate server digital certificate, you must specify the -SSLCERTLOC and -SSLPVTKEYLOC or the -SSLPKCS12LOC and -SSLPKCS12PASS system options in the script that is specified by the -SASCMD option.

Here is an example of an executable file, **command.sh**:

```
#!/bin/sh
args=$*
if [ -n "$INHERIT" ] ; then
   args="$args -inherit $INHERIT"
fi
if [ -n "$NETENCRALG" ] ; then
   args="$args -netencralg $NETENCRALG"
fi
if [ -n "$SASDAEMONPORT" ] ; then
   args="$args -sasdaemonport $SASDAEMONPORT"
fi
if [ -n "$SASCLIENTPORT" ] ; then
   args="$args -sasclientport $SASCLIENTPORT"
fi
export TSOOUT=
export SYSPROC=SAS.CLIST
/bin/tso -t %sas -dmr -noterminal
-sslpkcs12loc /users/server/certificates/serverkey.p12
-sslpkcs12pass password $args
```

For complete information about starting a z/OS spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

Connection of a SAS/CONNECT Client to a z/OS Spawner

After a z/OS spawner is started on a SAS/CONNECT server, a SAS/CONNECT client can connect to it.

The following example shows how to connect a client to a spawner that is running on a SAS/CONNECT server:

```
options netencryptalgorithm=ssl;
options sslcalistloc="/users/johndoe/certificates/cacerts.pem";
%let machine=apex.server.com;
signon machine.spawner user=_prompt_;
```

The following table explains the SAS options that are used to connect to a SAS/CONNECT server.

Table 5.10 SAS Options and Arguments for Client Access to a SAS/CONNECT Server

SAS Options and Arguments	Client Access Tasks
NETENCRYPTALGORITHM=*SSL*	Specifies the encryption algorithm
SSLCALISTLOC=*cacerts.pem*	Specifies the CA trust list
SIGNON=*server-ID.service*	Specifies the server and service to connect to
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server ID and the server's Common Name, which was specified in the server's digital certificate, must be identical.

For complete information about connecting to a z/OS spawner, see *Communications Access Methods for SAS/CONNECT and SAS/SHARE*.

SSL for SAS/SHARE under z/OS: Example

Start-up of a Multi-UserSAS/SHARE Server

After certificates for the CA, the server, and the client have been generated, and a CA trust list for the client has been created, you can start a SAS/SHARE server.

Here is an example of starting a secured SAS/SHARE server:

```
%let tcpsec=_secure_;
options netencryptalgorithm=ssl;
options sslpkcs12loc="/users/johndoe/certificates/server.p12;
options sslpkcs12pass="password";
proc server id=shrserv authenticate=opt;
run;
```

The following table lists the SAS option or statement that is used for each task to start a server.

Table 5.11 SAS Options, Statements, and Arguments for Server Start-Up Tasks

SAS Options, Statements, and Arguments	Server Start-Up Tasks
TCPSEC= _SECURE_	Secures the server
NETENCRALG=*SSL*	Specifies SSL as the encryption algorithm
SSLPKCS12LOC=*server.p12*	Specifies the filepath for the location of the server's private key
SSLPKCS12PASS="*password*"	Specifies the password to access server's private key

SAS Options, Statements, and Arguments	Server Start-Up Tasks
PROC SERVERID=*shrserv*	Starts the server
AUTHENTICATE=*OPT*	Allows trusted users to access the server without authentication

SAS/SHARE Client Access of a SAS/SHARE Server

After a SAS/SHARE server has been started, the client can access it.

Here is an example of how to make a client connection to a secured SAS/SHARE server:

```
options sslcalistloc="/users/johndoe/certificates/cacerts.pem";
%let machine=apex.server.com;
libname a '.' server=machine.shrserv user=_prompt_;
```

The following table lists the SAS options that are used to access a SAS/SHARE server from a client.

Table 5.12 *SAS Options and Arguments for Accessing a SAS/SHARE Server from a Client*

SAS Options and Arguments	Client Access Tasks
SSLCALISTLOC=*cacerts.pem*	Specifies the CA trust list
SERVER=*machine.shrserv*	Specifies the machine and server to connect to
USER=_PROMPT_	Prompts for the user ID and password to be used for authenticating the client to the server

The server-ID and the server's Common Name, which was specified in the server's certificate, must be identical.

Part 2

Installing and Configuring SSL

Chapter 6

Installing and Configuring SSL under UNIX

SSL under UNIX: System and Software Requirements

The system and software requirements for using SSL under UNIX operating environments are as follows:

- a computer that runs UNIX.
- Internet access and a web browser such Mozilla Firefox.
- the TCP/IP communications access method.
- access to the OpenSSL utility at `OpenSSL source` if you plan to use OpenSSL or if you plan to build FIPS 140-2 capable OpenSSL.
- knowledge of your site's security policy, practices, and technology. The properties of the digital certificates that you request are based on the security policies that have been adopted at your site.

Note: The 9.3 version of OpenSSL provided by SAS is not FIPS compliant. Refer to "Building FIPS 140-2 Capable OpenSSL for UNIX" on page 66 for details.

Building FIPS 140-2 Capable OpenSSL for UNIX

SAS ships OpenSSL libraries on UNIX. However, these are not FIPS 140-2 compliant libraries. You must compile a FIPS 140-2 compliant version of OpenSSL and install it. If you plan to build FIPS 140-2 capable OpenSSL for UNIX, access the OpenSSL utility at **OpenSSL source**. Then follow the instructions in the following documents for downloading and building FIPS 140-2 compliant OpenSSL:

- **OpenSSL FIPS 140-2 Security Policy Version 1.2**
- **OpenSSL FIPS 140-2 User Guide**

Note: Different operating systems require the use of different library file extensions. For example, HPUX, Linux, and Solaris use libcrypto.so.1.0.0 and libssl.so.1.0.0. AIX uses libcrypto.so and libssl.so. Refer to your operating system vendor documentation when using the vendor's OpenSSL libraries. There might be additional procedures that need to be followed to make the libraries work properly in your environment.

If you are using your own FIPS 140-2 compliant OpenSSL libraries, your system administrator needs to set the environment path variables to pick up this software. Go to the **SASHome/SASFoundation/9.4/bin** directory. This directory contains the sasenv script that sets the environment variables that are required by SAS. When you customize environment variable values, modify the sasenv_local file. Set the location of the FIPS 140-2 compliant libraries in the sasenv_local file. Depending on your operating system, set the LD_LIBRARY_PATH and the SHLIB_PATH to be the same, and set LIBPATH on AIX.

For example, you might add the following code to the sasenv_local file.

```
export LD_LIBRARY_PATH=<FIPS library path>:$LD_LIBRARY_PATH
```

For more information, see Appendix 1, "Contents of the !SASROOT Directory," in *SAS Companion for UNIX Environments*.

Note: Prepend the customized library path in the script that is run before invoking SAS.

To configure a FIPS 140-2 compliant system, specify SAS system options ENCRYPTFIPS and NETENCRALG= (set to AES or SSL). When ENCRYPTFIPS is specified, an INFO message is written at server start-up to indicate that FIPS encryption is enabled. Refer to "ENCRYPTFIPS System Option" on page 17 for details.

Setting Up Digital Certificates for SSL under UNIX

Perform the following tasks to set up and use SSL:

Step 1. Download and Build SSL

If you want to use OpenSSL as your trusted Certification Authority (CA), follow the instructions for downloading and building OpenSSL that are given at **https://www.openssl.org/source**. For complete documentation about the OpenSSL utility, visit **https://www.openssl.org/docs/apps/openssl.html**.

The following sites provide information about alternative CA:

- For VeriSign, see **http://www.verisign.com**

- For Thawte, see **`http://www.thawte.com`**

Step 2. Create a Digital Certificate Request

The tasks that you perform to request a digital certificate for the CA, the server, and the client are similar. However, the values that you specify are different.

In this example, Proton, Inc. is the organization that is applying to become a CA by using OpenSSL. After Proton, Inc. becomes a CA, it can serve as a CA for issuing digital certificates to clients (users) and servers on its network.

Perform the following tasks:

1. Select the **`apps`** subdirectory of the directory where OpenSSL was built.
2. Initialize OpenSSL.

   ```
   $ openssl
   ```

3. Issue the appropriate command to request a digital certificate.

Table 6.1 *Open SSL Commands for Requesting a Digital Certificate*

Request Certificate for	OpenSSL Command
CA	req -config ./openssl.cnf -new -out sas.req -keyout saskey.pem -nodes -sha1
Server	req -config ./openssl.cnf -new -out server.req -keyout serverkey.pem -sha1
Client	req -config ./openssl.cnf -new -out client.req -keyout clientkey.pem -sha1

Note: The -sha1 command is specified only when using FIPS 140-2 compliant SSL.

Table 6.2 *Arguments and Values Used in OpenSSL Commands*

OpenSSL Arguments and Values	Functions
req	Requests a certificate
-config ./openssl.cnf	Specifies the storage location for the configuration details for the OpenSSL program
-new	Identifies the request as new
-out sas.req	Specifies the storage location for the certificate request
-keyout saskey.pem	Specifies the storage location for the private key
-nodes	Prevents the private key from being encrypted

OpenSSL Arguments and Values	Functions
-sha1	Specifies that the FIPS 140-2 compliant hash algorithm, SHA-256, will be used

4. Informational messages are displayed and prompts for additional information appear according to the specific request.

   To accept a default value, press the Enter key. To change a default value, type the appropriate information and press the Enter key.

   Note: Unless the -NODES option is used in the OpenSSL command when creating a digital certificate request, OpenSSL prompts you for a password before allowing access to the private key.

   The following is an example of a request for a digital certificate:

```
OpenSSL> req -config ./openssl.cnf -new -out sas.req -keyout saskey.pem -nodes
Using configuration from ./openssl.cnf
Generating a 1024 bit RSA private key
.............................++++++
.........................................++++++
writing new private key to 'saskey.pem'
-----
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [US]:
State or Province Name (full name) [North Carolina]:
Locality Name (city) [Cary]:
Organization Name (company) [Proton Inc.]:
Organizational Unit Name (department) [IDB]:
Common Name (YOUR name) []: proton.com
Email Address []:Joe.Bass@proton.comPlease enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
OpenSSL>
```

The request for a digital certificate is complete.

Note: For the server, the Common Name must be the name of the computer that the server runs on, for example, apex.serv.com.

Step 3. Generate a Digital Certificate from the Request

Perform the following tasks to generate a digital certificate for a CA, a server, and a client.

1. Issue the appropriate command to generate a digital certificate from the digital certificate request.

Table 6.3 *OpenSSL Commands for Generating Digital Certificates under UNIX*

Generate Certificate for	OpenSSL Command
CA	x509 -req -in sas.req -signkey saskey.pem -out sas.pem -sha1
Server	ca -config ./openssl.cnf -in server.req -out server.pem -sha1
Client	ca -config ./openssl.cnf -in client.req -out client.pem -sha1

Note: The -sha1 command is specified only when using FIPS 140-2 compliant SSL.

Table 6.4 *Arguments and Values Used in OpenSSL Commands under UNIX*

OpenSSL Arguments and Values	Functions
x509	Identifies the certificate display and signing utility
-req	Specifies that a certificate be generated from the request
ca	Identifies the Certification Authority utility
-config ./openssl.cnf	Specifies the storage location for the configuration details for the OpenSSL utility
-in filename.req	Specifies the storage location for the input for the certificate request
-out filename.pem	Specifies the storage location for the certificate
-signkey saskey.pem	Specifies the private key that will be used to sign the certificate that is generated by the certificate request
-sha1	Specifies that the FIPS 140-2 compliant hash algorithm, SHA-256, will be used

2. Informational messages are displayed and prompts for additional information appear according to the specific request.

   To accept a default value, press the Enter key. To change a default value, type the appropriate information, and press the Enter key.

   Here is a sample of the messaging for creating a server digital certificate:

   Note: The password is for the CA's private key.

```
Using configuration from ./openssl.cnf
Enter PEM pass phrase: password
Check that the request matches the signature
```

```
Signature ok
The Subjects Distinguished Name is as follows
countryName           :PRINTABLE:'US'
stateOrProvinceName   :PRINTABLE:'NC'
localityName          :PRINTABLE:'Cary'
organizationName      :PRINTABLE:'Proton, Inc.'
organizationalUnitName:PRINTABLE:'IDB'
commonName            :PRINTABLE:'proton.com'
Certificate is to be certified until Oct 16 17:48:27 2003 GMT (365 days)
Sign the certificate? [y/n]:y
1 out of 1 certificate requests certified, commit? [y/n]y
Write out database with 1 new entries Data Base Updated
```

The subject's Distinguished Name is obtained from the digital certificate request.

A root CA digital certificate is self-signed, which means that the digital certificate is signed with the private key that corresponds to the public key that is in the digital certificate. Except for root CAs, digital certificates are usually signed with a private key that corresponds to a public key that belongs to someone else, usually the CA.

The generation of a digital certificate is complete.

Step 4. View Digital Certificates

To view a digital certificate, issue the following command:

```
openssl> x509  -text -in filename.pem
```

A digital certificate contains data that was collected to generate the digital certificate timestamps, a digital signature, and other information. However, because the generated digital certificate is encoded (usually in PEM format), it is unreadable.

Step 5. End OpenSSL

To end OpenSSL, type **`quit`** at the prompt.

Step 6. Create a CA Trust List for the SSL Client Application

After generating a digital certificate for the CA, the server, and the client (optional), you must identify for the OpenSSL client application one or more CAs that are to be trusted. This list is called a *trust list*.

If there is only one CA to trust, in the client application, specify the name of the file that contains the OpenSSL CA digital certificate.

If multiple CAs are to be trusted, create a new file and copy-and-paste into it the contents of all the digital certificates for CAs to be trusted by the client application.

Use the following template to create a CA trust list:

```
Certificate for OpenSSL CA

-----BEGIN CERTIFICATE-----

<PEM encoded certificate>

-----END CERTIFICATE-----
```

```
Certificate for Keon CA

-----BEGIN CERTIFICATE-----

<PEM encoded certificate>

-----END CERTIFICATE-----


Certificate for Microsoft CA

-----BEGIN CERTIFICATE-----


-----END CERTIFICATE-----
```

Because the digital certificate is encoded, it is unreadable. Therefore, the content of the digital certificate in this example is represented as **<PEM encoded certificate>** . The content of each digital certificate is delimited with a **-----BEGIN CERTIFICATE-----** and **-----END CERTIFICATE-----** pair. All text outside the delimiters is ignored. Therefore, you might not want to use delimited lines for descriptive comments. In the preceding template, the file that is used contains the content of digital certificates for the CAs: OpenSSL, Keon, and Microsoft.

Note: If you are including a digital certificate that is stored in DER format, you must first convert it to PEM format. For more information, see "Converting between PEM and DER File Formats for SSL" on page 78.

Converting between PEM and DER File Formats for SSL

By default, OpenSSL files are created in PEM (Privacy Enhanced Mail) format. SSL files that are created in Windows operating environments are created in DER (Distinguished Encoding Rules) format.

Under Windows, you can import a file that is created in either PEM or DER format. However, a digital certificate that is created in DER format must be converted to PEM format before it can be included in a trust list under UNIX.

Here is an example of converting a server digital certificate from PEM input format to DER output format:

```
OpenSSL> x509 -inform PEM -outform DER -in server.pem -out
server.der
```

Here is an example of converting a server digital certificate from DER input format to PEM output format:

```
OpenSSL> x509 -inform DER -outform PEM -in server.der -out server.pem
```

Chapter 7

Installing and Configuring SSL under Windows

SSL under Windows: System and Software Requirements

The system and software requirements for using SSL under the Windows operating environment are as follows:

- a computer that runs Windows 2000 (or later).
- depending on your configuration, access to the Internet and a web browser such as Internet Explorer or Mozilla Firefox.
- the TCP/IP communications access method.
- Microsoft Certificate Services add-on software.
- if you are using your own CA, the Microsoft Certification Authority application (which is accessible from your web browser).
- for SAS/CONNECT, a client session that runs on a computer that has a Trusted CA Certificate. This is necessary in order for a SAS/CONNECT client session to connect to a SAS/CONNECT server session via a Windows spawner using SSL encryption.

  The Windows spawner must run on a computer that has a Trusted CA Certificate and a Personal Certificate.
- knowledge of your site's security policy, practices, and technology. The properties of the digital certificates that you request depend on the security policies that have been adopted at your site.

There is a Microsoft issue that needs attention before configuring ENCRYPTFIPS on Microsoft Windows 2003 servers.

Services that run on a computer that uses Microsoft Windows Server 2003 might not recognize Windows environment variable changes. To resolve this issue, perform these steps:

Go to the Microsoft support Website `http://support.microsoft.com/kb/887693` to find out how to resolve the Windows 2003 Server environment variable issue.

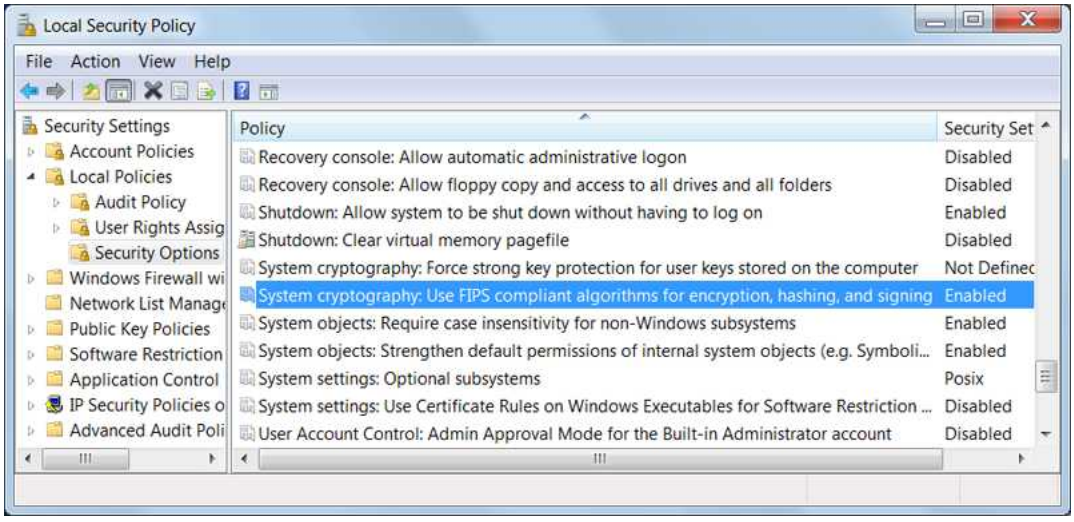
FIPS 140-2 Capable SSL for Windows

For Windows, the SSL version shipped with SAS is FIPS 140-2 compliant. In Windows XP and in later versions of Windows, you need only to enable the **System cryptography: Use FIPS compliant algorithms for encryption, hashing, and signing** setting under your Local Security Policy or as part of Group Policy. This setting informs applications that they should use only cryptographic algorithms that are FIPS 140-2 compliant and in compliance with FIPS approved modes of operation.

To check that your Windows server is configured for FIPS, go to the Windows **Start Menu** ⇨ **Search** and enter "Local Security Policy". The Local Security Policy window appears.

1. In the left pane of the **Security Policies**, expand **Local Policies**.
2. Click **Security Options**.
3. In the right pane, scroll down to **System cryptography: Use FIPS compliant algorithms for encryption, hashing, and signing** and make sure that the item is enabled.

Figure 7.1 *Enable FIPS 140-2 on Windows*



Setting Up Digital Certificates for SSL under Windows

Perform the following tasks to set up digital certificates for SSL:

Step 1. Configure SSL

Complete information about configuring your Windows operating environment for SSL is contained in the Windows installation documentation and at **`www.microsoft.com`**.

The following keywords might be helpful when searching the Microsoft Website:

- digital certificate services
- digital certificate authority
- digital certificate request
- site security planning

Step 2. Request a Digital Certificate

Methods of Requesting a Digital Certificate

The method of requesting a digital certificate depends on the CA that you use:

- "Request a Digital Certificate from the Microsoft Certification Authority" on page 75
- "Request a Digital Certificate from a Certification Authority That Is Not Microsoft" on page 76

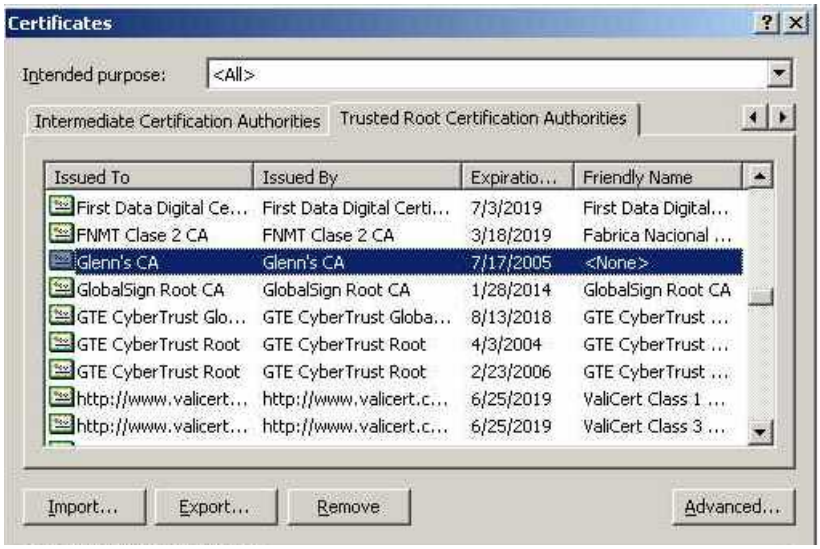
Request a Digital Certificate from the Microsoft Certification Authority

Perform the following tasks to request digital certificates that are issued by the Microsoft Certification Authority:

1. System administrator: If you are running your own CA, use Microsoft Certificate Services to create an active Certification Authority (CA).
2. User:
   a. Use the Certificate Request wizard to request a digital certificate from an active enterprise CA. The Certificate Request wizard lists all digital certificate types that the user can install.
   b. Select a digital certificate type.
   c. Select security options.
   d. Submit the request to an active CA that is configured to issue the digital certificate.

      After the CA issues the requested digital certificate, the digital certificate is automatically installed in the Certificate Store. The installed digital certificate is highlighted, as shown in the following window:

Display 7.1 *Digital Certificate Installation in the Certificate Store*



Request a Digital Certificate from a Certification Authority That Is Not Microsoft

Users should perform the following tasks to request digital certificates that are not issued by the Microsoft CA:

1. Request a digital certificate from a CA.
2. Import the digital certificate to a Certificate Store by using the Certificate Manager Import wizard application from a web browser.

   A digital certificate can be generated by using the Certificate Request wizard or any third-party application that generates digital certificates.

   Note: The Windows operating environment can import digital certificates that were generated in the UNIX operating environment. To convert from UNIX (PEM format) to Windows (DER format) before importing, see "Converting between PEM and DER File Formats for SSL" on page 78.

For details about importing existing digital certificates, see "Import a Digital Certificate to a Certificate Store" on page 76.

Import a Digital Certificate to a Certificate Store

Digital certificates that were issued by a Certification Authority that is not Microsoft can be imported to an appropriate Certificate Store as follows:

Certificate Type	Certificate Storage Location
Client	Personal Certificate Store
Server	Personal Certificate Store
CA (self-signed)	Trusted Root Certification Authorities

Perform the following tasks to import a digital certificate to a Certificate Store:

1. Access the Certificate Manager Import wizard application from your web browser. From the **Tools** drop-down menu, select **Internet Options**.

   Then select the **Content** tab, and click **Certificates**.

   Specify the digital certificate to import to a Certificate Store by selecting the **Personal** tab in the **Certificates** window, as shown in the following window:

Display 7.2 *Digital Certificate Selections for a Personal Certificate Store*

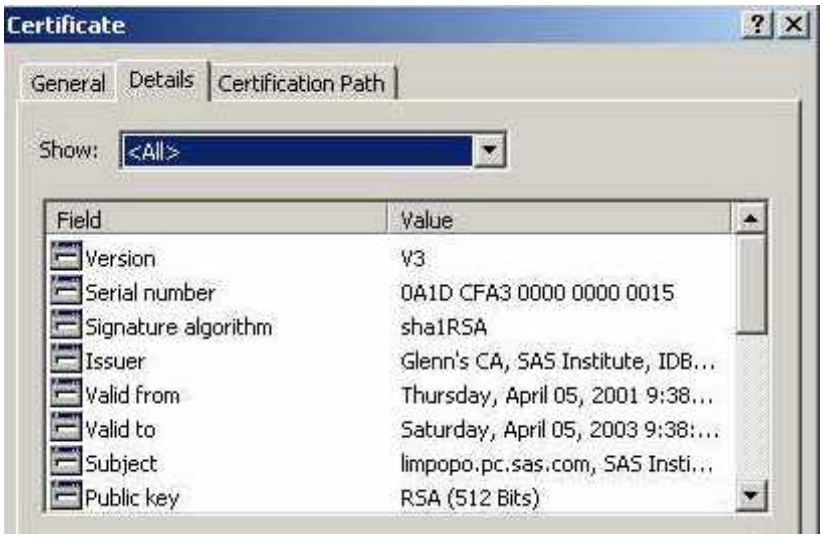
2. Click **Import** and follow the instructions to import digital certificates.

   Repeat this task in order to import the necessary digital certificates for the CA, the server, and the client, as appropriate.

3. After you have completed the selections for your personal Certificate Store, select the appropriate tab to view your selections.

4. To view the details about a digital certificate, select the digital certificate and click **View**. Typical results are shown in the following window:

Display 7.3 *Digital Certificate Details Tab*



Converting between PEM and DER File Formats for SSL

By default, OpenSSL files are created in Privacy Enhanced Mail (PEM) format. SSL files that are created in Windows operating environments are created in Distinguished Encoding Rules (DER) format.

Under Windows, you can import a file that is created in either PEM or DER format. However, a digital certificate that is created in DER format must be converted to PEM format before it can be included in a trust list under UNIX.

Here is an example of converting a server digital certificate from PEM input format to DER output format:

```
OpenSSL> x509 -inform PEM -outform DER -in server.pem -out
server.der
```

Here is an example of converting a server digital certificate from DER input format to PEM output format :

```
OpenSSL> x509 -inform DER -outform PEM -in server.der -out server.pem
```

Chapter 8

Installing and Configuring SSL under z/OS

SSL under z/OS: System and Software Requirements

The system and software requirements for using SSL under z/OS operating environments are as follows:

- a computer that runs z/OS.
- the TCP/IP communications access method.
- if you are planning to use a computer that runs z/OS as the CA, access to the RACDCERT command on z/OS.
- knowledge of your site's security policy, practices, and technology. The properties of the digital certificates that you request are based on the security policies that have been adopted at your site.

Note: The z/OS version of SSL is not FIPS 140-2 compliant.

Setting Up Digital Certificates for SSL under z/OS

Perform these tasks to set up and use SSL:

Step 1. Authorize Access to the RACDCERT Command

To use z/OS as your trusted Certification Authority (CA), you must authorize access to the RACDCERT command in order to set up the CA and to create and sign certificates. Authorize the trusted administrator using CONTROL access to these profiles in the FACILITY class:

- IRR.DIGTCERT.ADD
- IRR.DIGTCERT.DELETE
- IRR.DIGTCERT.EXPORT
- IRR.DIGTCERT.GENCERT
- IRR.DIGTCERT.LIST

The following sites provide information about alternative CAs:

- For VeriSign, see **www.verisign.com**
- For Thawte, see **www.thawte.com**

Step 2. Create the Digital Certificate for the CA

The tasks that you perform to generate a digital certificate for the CA, the server, and the client are similar; however, the values that you specify are different.

In this example, Proton, Inc. is the organization that is applying to become a CA by using RACDCERT. After Proton, Inc. becomes a CA, it can serve as a CA for issuing digital certificates to clients (users) and servers on its network.

Perform these tasks:

1. Request a digital CA certificate. Here is an example of a request:

```
RACDCERT GENCERT CERTAUTH +
SUBJECTSDN( +
  CN('proton.com') +
  C('US') +
  SP('North Carolina') +
  L('Cary') +
  O('Proton Inc.') +
  OU('IDB') +
) +
ALTNAME( +
  EMAIL('Joe.Bass@proton.com') +
) +
WITHLABEL('Proton CA')
```

2. Export the CA certificate in PEM format:

```
RACDCERT CERTAUTH EXPORT(LABEL('Proton CA')) +
DSN(CA.CERT)
```

3. Copy the certificate to the UNIX file system. Use the TSO OPUT and OCOPY commands to copy the files to your UNIX file system.

   Note: SSL certificate and key files must reside in the z/OS UNIX file system. The OpenSSL library cannot read MVS data sets.

```
cp //ca.cert ca.cert
```

4. Convert the certificate file to ASCII format

   Note: SSL PEM format certificate files must be converted to ASCII format. The OpenSSL library code in SAS cannot read EBCDIC text.

```
iconv -f ibm-1047 -t iso8859-1 ca.cert >ca.cert.ascii
```

The creation of the CA digital certificate is complete.

A root CA digital certificate is self-signed, which means that the digital certificate is signed using the private key that corresponds to the public key that is in the digital certificate. Except for root CAs, digital certificates are usually signed using a private key that corresponds to a public key that belongs to someone else, usually the CA.

You will specify the CA digital certificate using the SSLCALISTLOC= system option.

Step 3. Create the Server and Client Digital Certificates

Perform these tasks to create a digital certificate for a server and a client. The steps are identical for the server and the client. This example shows the tasks for the server.

1. Request a signed server certificate.

   Here is an example of a request for a signed server certificate for user SERVER that runs on **`proton.zos.com`**.

```
RACDCERT GENCERT ID(SERVER) +
SUBJECTSDN( +
  CN('proton.zos.com') +
  C('US') +
  SP('North Carolina') +
  L('Cary') +
  O('Proton Inc.') +
  OU('IDB') +
) +
ALTNAME( +
  EMAIL('Joe.Bass@proton.com') +
) +
WITHLABEL('Proton Server') +
SIGNWITH(CERTAUTH LABEL('Proton CA'))
```

2. Export the server certificate and key that are specified in PKCS #12 DER encoding package format.

   Note: The PKCS #12 DER encoding package is the format used by the RACDCERT utility to encode the exported certificate and private key for an entity, such as a server. It is a binary format.

```
RACDCERT ID(SERVER) EXPORT(LABEL('Proton Server')) +
DSN(SERVER.P12) +
PASSWORD('abcd')
```

3. Copy the certificate to the UNIX file system.

   Note: The PKCS #12 DER encoding package file must reside in the z/OS UNIX file system. The OpenSSL library cannot read MVS data sets. Because the file is already in binary format, its conversion to ASCII is unnecessary.

```
cp //server.p12 server.p12
```

The creation of the server digital certificate and key is complete.

A PKCS #12 DER encoding package is the format that RACDCERT uses to export a certificate and a key for an entity. The exported package file contains both the certificate and the key. The content of the package file is secure by using the password that is specified in the RACDCERT EXPORT command.

Specify a server or client PKCS #12 package using the SSLPKCS12LOC= system option. Specify the password for the package using the SSLPKCS12PASS= option.

Note: For the server, the Common Name must be the name of the computer that the server runs on (for example, **proton.zos.com**.)

Step 4. View Digital Certificates

To view a digital certificate, issue these commands:

```
RACDCERT CERTAUTH LIST(LABEL('Proton CA'))
RACDCERT ID(SERVER) LIST(LABEL('Proton Server'))
```

A digital certificate contains data that was collected to generate the digital certificate timestamps, a digital signature, and other information. However, because the generated digital certificate is encoded (usually in PEM format), it is unreadable.

To read the certificate files, issue these commands:

```
RACDCERT CHECKCERT(CA.CERT)
RACDCERT CHECKCERT(SERVER.P12) PASS('abcd')
```

Step 5. Create a CA Trust List for the SSL Client Application

After generating a digital certificate for the CA, the server, and the client (optional), you must identify for the OpenSSL client application one or more CAs that are to be trusted. This list is called a *trust list*.

If there is only one CA to trust (for example, Proton CA), in the client application, use the SSLCALISTLOC= option to specify the name of the file that contains the CA digital certificate, which was created in Step 2.

If multiple CAs are to be trusted by the client application, use the UNIX **cat** command to concatenate the contents of all the digital certificates for CAs. All the certificates must be encoded in PEM format and in ASCII format.

As an alternative method for creating a CA trust list, use this template to copy and paste the digital certificates into one file:

```
Certificate for Proton CA

-----BEGIN CERTIFICATE-----

<PEM encoded certificate>

-----END CERTIFICATE-----


Certificate for Keon CA

-----BEGIN CERTIFICATE-----

<PEM encoded certificate>

-----END CERTIFICATE-----


Certificate for Microsoft CA

-----BEGIN CERTIFICATE-----
```

```
-----END CERTIFICATE-----
```

Because the digital certificate is encoded, it is unreadable. Therefore, the content of the digital certificate in this example is represented as **<PEM encoded certificate>** . The content of each digital certificate is delimited using a **-----BEGIN CERTIFICATE-----** and **-----END CERTIFICATE-----** pair. All text outside the delimiters is ignored. Therefore, you might not want to use delimited lines for descriptive comments. In the preceding template, the file that is used contains the content of digital certificates for the CAs: Proton, Keon, and Microsoft.

Glossary

block cipher
a type of encryption algorithm that divides a message into blocks and encrypts each block.

Certificate Revocation List
a list of revoked digital certificates. CRLs are published by Certification Authorities (CAs), and a CRL contains only the revoked digital certificates that were issued by a specific CA. Short form: CRL.

Certification Authority
a commercial or private organization that provides security services to the e-commerce market. A Certification Authority creates and maintains digital certificates, which help to preserve the confidentiality of an identity. Microsoft, VeriSign, and Thawte are examples of commercial Certification Authorities.

ciphertext
unintelligible data.

CRL
See Certificate Revocation List.

cryptography
the science of encoding and decoding information to protect its confidentiality.

data security technologies
software features that protect data that is exchanged in client/server data transfers across a network.

DER
See Distinguished Encoding Rules.

digital certificate
an electronic document that binds a public key to an individual or an organization. A digital certificate usually contains a public key, a user's name, an expiration date, and the name of a Certification Authority.

digital signature
a digital code that is appended to a message. The digital signature is used to verify to a recipient that the message was sent by a particular business, organization, or individual, and that the message has not been changed en route. The message can be any kind of file that is transmitted electronically.

Distinguished Encoding Rules
a format that is used for creating SSL files in Windows operating environments. Short form: DER.

PEM
See Privacy Enhanced Mail.

PKCS #12
See Public Key Cryptography Standard #12.

plaintext
intelligible data.

port forwarding
See SSH tunnel.

Privacy Enhanced Mail
a format that is used for creating OpenSSL files. Short form: PEM.

public key
a number that is associated with a specific entity such as an individual or an organization. A public key can be known by everyone who needs to have trusted interactions with that entity. A public key is always associated with a single private key, and can be used to verify digital signatures that were generated using that private key.

Public Key Cryptography Standard #12
a personal information exchange syntax standard. It defines a file format that is used to store private keys with accompanying public-key certificates. Short form: PKCS #12.

public-key cryptography
the science that uses public and private key pairs to protect confidential information. The public key can be known by anyone. The private key is known only to the owner of the key pair. The public key is used primarily for encryption, but it can also be used to verify digital signatures. The private key is used primarily for decryption, but it can also be used to generate a digital signature.

SAS/SECURE
an add-on product that uses the RC2, RC4, DES, and TripleDES encryption algorithms. SAS/SECURE requires a license, and it must be installed on each computer that runs a client and a server that will use the encryption algorithms. SAS/SECURE provides a high level of security.

SASProprietary algorithm
a fixed encoding algorithm that is included with Base SAS software. The SASProprietary algorithm requires no additional SAS product licenses. It provides a medium level of security.

Secure Shell
See SSH.

Secure Sockets Layer
an encryption protocol for securely communicating across the Internet. SSL uses encryption algorithms RC2, RC4, DES, TripleDES, and AES.

SSH
a protocol that enables users to access a remote computer via a secure connection. SSH is available through various commercial products and as freeware. OpenSSH is a free version of the SSH protocol suite of network connectivity tools. Short form: SSH.

SSH tunnel
a secure, encrypted connection between the SSH client, which runs on the same computer as a SAS client, and an SSH server, which runs on the same computer as a SAS server. The SSH client and server act as agents between the SAS client and the SAS server, tunneling information via the SAS client's port to the SAS server's port. Port forwarding is another term for tunneling.

SSL
See Secure Sockets Layer.

SSL (Secure Sockets Layer)
a protocol that provides network security and privacy. SSL uses encryption algorithms RC2, RC4, DES, TripleDES, and AES. SSL provides a high level of security. It was developed by Netscape Communications.

stream cipher
a type of encryption algorithm that encrypts data one byte at a time.

TLS
the successor to Secure Sockets Layer (SSL) V3.0. The Internet Engineering Task Force (IETF) adopted SSL V3.0 as the de facto standard, made some modifications, and renamed it TLS. TLS is virtually SSLV3.1. Short form: TLS.

Transport Layer Security
See TLS.

trust list
a file created by a user that contains the digital certificates for Certification Authorities, if more than one Certification Authority is used.

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