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OpenSSH for z/OS: New Features and Functions

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We provide z/OS customers world wide with innovative solutions that enhance and transform traditional mainframe workloads:

- Co:Z Co-Processing Toolkit for z/OS
  - z/OS Enabled SFTP, z/OS Hybrid Batch, z/OS Unix Batch integration
  - Runs on IBM Ported Tools for z/OS - OpenSSH

- JZOS

  acquired by IBM in and now part of the z/OS Java SDK

Agenda

- What is SSH and how does it work?
- IBM Ported Tools for z/OS V1.3 – OpenSSH
  - Overview, product notes and future direction
- OpenSSH 6.4p1 feature highlights since 5.0p1
- SMF changes
- Migration considerations
- Configuration and tuning
  - ICSF /dev/random support
  - Hardware accelerated (CPACF via ICSF) Ciphers and MACs
  - Language Environment Tuning

What is SSH?

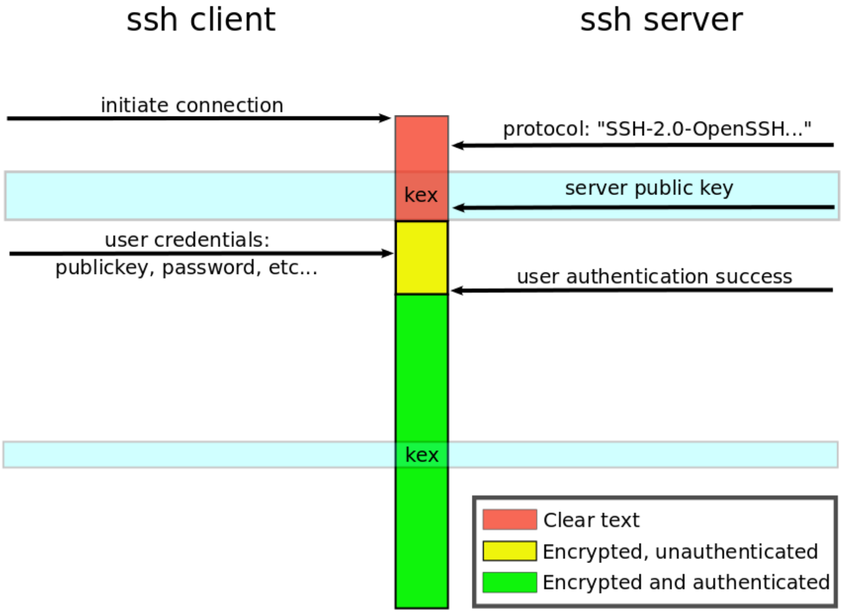
- The IETF SSH-2 standard protocol (RFC 4251 etc)
- Features:
  - A secure (encrypted) connection over **one** TCP/IP socket between a client and a server
  - Authentication of both user and host
  - (optional) LZ compression
  - Support for one or more simultaneous ***application channels*** over the same connection: terminal, sftp, command, port forwarding, ...
- There are many compatible implementations
  - **OpenSSH** is by far the most popular; it is a default package on all Unix/Linux distributions
  - PuTTY is a popular free Windows client

SSH2 Crypto at-a-glance

- **Key Exchange – “kex”**
  - Some variant of Diffie-Hellman
  - Client generated random number and the server key are used to:
    - Allow the client to authenticate the identity of the server
    - Independently generate and exchange a secret session key
      - No private information is exchanged over non-secure channel
    - Enable session rekeying. Typically once/hour or GB.
- **User Authentication**

  At start of session, a password or **user** key pair can be used to authenticate the user to the server.
- **Session Encryption**
  - A symmetric Cipher uses the shared session key to encrypt the packet payload.
  - A MAC algorithm (typically SHA-1) is used to generate a hash of each packet.

SSH Encryption and Authentication


ssh client
ssh server
initiate connection
protocol: "SSH-2.0-OpenSSH..."
kex
server public key
user credentials:
publickey, password, etc...
user authentication success
kex
🟥 Clear text
🟨 Encrypted, unauthenticated
🟩 Encrypted and authenticated

IBM Ported Tools for z/OS V1.3 – OpenSSH Overview

- Base upgraded from OpenSSH 5.0p1 to 6.4p1
- ICSF acceleration of CTR mode AES ciphers
  - CTR mode is now preferred over CBC*
- New SMF logging detail
- Enabled ssh client to be invoked under TSO/OMVS shell
  - entry of password credentials not permitted
- Relaxed syntax of IdentityKeyRingLabel
  - double quotes optional when entered from ssh, sftp, or scp command line
- Remains a no-charge z/OS product; normal IBM support

*http://www.kb.cert.org/vuls/id/958563

IBM Ported Tools for z/OS V1.3 – OpenSSH Product Notes

- New release (HOS1130) installs over the previous release (HOS1120)

- HOS1130 is supported on z/OS 1.13 and later

- HOS1120 supported through z/OS V2R1, but withdrawn from marketing at HOS1130 GA.

- /dev/random is now **required** – HOS1130 will not run without ICSF active!

- Verifying version

```
$ ssh -V
OpenSSH_6.4p1, OpenSSL 1.0.1c 10 May 2012

$ /usr/sbin/sshd -d -t
…
debug1: sshd version OpenSSH_6.4p1, OpenSSL 1.0.1c 10 May 2012
```

Future Direction

- OpenSSH is planned to be provided as a base element in z/OS V2.2
- “IBM plans to add OpenSSH to z/OS and enhance it by providing Kerberos support, which is designed to enable single sign-on from Microsoft™ Windows™ domains, and also to leverage the capabilities of IBM zEnterprise Data Compression (zEDC).”
  - IBM Software Announcement: ZP15-0006, January 14, 2015

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- Key Exchange algorithms can now be specified

  (-oKexAlgorithms)

  diffie-hellman-group1-sha1,
  diffie-hellman-group14-sha1,
  diffie-hellman-group-exchange-sha1,
  diffie-hellman-group-exchange-sha256,
  ecdh-sha2-nistp256,
  ecdh-sha2-nistp384,
  ecdh-sha2-nistp521

- NIST Elliptic-curve algorithms added

Note: new algorithms **highlighted**

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- Key Algorithms – used for ssh host (server) or user keys

  ssh-rsa,ssh-dss,
  ecdsa-sha2-nistp256,ecdsa-sha2-nistp384,ecdsa-sha2-nistp521,
  ssh-rsa-cert-v01@openssh.com,
  ssh-dss-cert-v01@openssh.com,
  ecdsa-sha2-nistp256-cert-v01@openssh.com,
  ecdsa-sha2-nistp384-cert-v01@openssh.com,
  ecdsa-sha2-nistp521-cert-v01@openssh.com,
  ssh-rsa-cert-v00@openssh.com,
  ssh-dss-cert-v00@openssh.com

- NIST Elliptic-curve DSA w/ SHA-2 algorithms added
- OpenSSH “certificates” added (more later)

Notes: new algorithms **highlighted ,**non-standard non-RFC names have “@openssh.com”

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- Cipher algorithms – default preference order shown

aes128-ctr**,aes192-ctr**,aes256-ctr**,arcfour256,arcfour128,
aes128-gcm@openssh.com,aes256-gcm@openssh.com,
aes128-cbc*,3des-cbc*,blowfish-cbc,cast128-cbc,aes192-cbc*,
aes256-cbc*,arcfour,rijndael-cbc@lysator.liu.se*

- AES GCM (Galois/Counter Mode) ciphers added to OpenSSH
  - Function as both Cipher and HMAC in one
- AES CTR mode ICSF support has been added to HOS1130
  - Accelerates the most widely used OpenSSH Ciphers

Note: new algorithms **highlighted,** ICSF support noted with “*” or “**”(new)

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- MAC algorithms – default preference order shown

  hmac-md5-etm@openssh.com*,hmac-sha1-etm@openssh.com*,
  umac-64-etm@openssh.com,umac-128-etm@openssh.com,
  hmac-sha2-256-etm@openssh.com,hmac-sha2-512-etm@openssh.com**,**
  hmac-ripemd160-etm@openssh.com*,
  hmac-sha1-96-etm@openssh.com*,hmac-md5-96-etm@openssh.com*,
  hmac-md5*,hmac-sha1*,
  umac-64@openssh.com,umac-128@openssh.com,hmac-sha2-256,hmac-sha2-512**,**
  hmac-ripemd160*,hmac-ripemd160@openssh.com*,hmac-sha1-96*,hmac-md5-96*

  - SHA-2 algorithm added (with ICSF support)
  - UMAC algorithm support added
  - “-etm@openssh.com” algorithms are **not** new algorithms!

    They are variants that indicate that the MAC is calculated **after** encryption (“Encrypt-then-MAC”) rather than the other way around. The community now considers this more secure (in theory).

Note: new algorithms **highlighted,** ICSF support noted with “*” or “**”(new)

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- Dynamic port assignment for remote port forwarding
  - ssh -R 0:host:port
  - A remote port of "0" can be specified in which case a dynamic port will be assigned on the server.
  - The client will report a message with the specific ephemeral port assigned.
- More flexibility in configuration files
  - Match blocks have more criteria and can include more options within the block.
- Support for public key (user and host) certificates
  - These are not X.509 certificates, but a simpler implementation that is unique to OpenSSH.
    - A single key ("CA key") may sign (vouch for) the public keys of many users or servers. If a host or user trusts the CA public key, then it implicitly accepts the keys that have been signed by it.
  - For more information, see the User's Guide / man page for the ssh-keygen command.
  - These have been available for a few years, but are not widely used.
  - No z/OS Key Ring support for these or their associated keys.

OpenSSH 6.4p1 Feature Highlights
(since 5.0p1)

- Multi factor authentication methods
  - The server may specify that more than one authentication method is required for a/all user(s). For example:
  - AuthenticationMethods publickey,password publickey,publickey

- SFTP enhancements
  - Support for recursive file transfer in a directory tree (get/put -r)
  - sftp server read-only mode
  - sftp “df” command - displays file system attributes
  - improved performance of directory listings
  - “ls -h” option - human readable file attribute units
  - ***No*** sftp support for MVS datasets, spool files, etc.

New SMF type 119 records for OpenSSH

- Two new SMF 119 records were added:
  - type 94(x'5D') Client connection started record
  - type 95(x'5E') Server connection started record
- If SMF recording is configured, these records will be written just after the user has been authenticated by the server.
  - in zos_ssh_config / zos_sshd_config
- The content of these records is identical, and a subset of other 119 SSH records:
  - standard SMF 119 header
  - common 119 TCP/IP identification section
  - SSH common security section (identifies which algorithm(s) were used)
- BPX.SMF permission is now required for ssh client users if SMF recording is enabled, since the **ssh** command is not APF authorized.
- C-level mapping macros in /samples/ssh_smf.h and the assembler mapping macros in SYS1.MACLIB(FOTSMF77) have been updated.

Migration Considerations
Config Files

- Customers with prior releases should review their configuration files to determine applicability of new features. Many new configuration options have been added through OpenSSH 6.4, and defaults for others have been changed.
  - ssh_config
  - sshd_config
  - zos_ssh_config
  - zos_sshd_config

- As in previous releases, protocol 1 is disabled by default.

- RhostsAuthenticaion (protocol 1 only) was removed in OpenSSH 3.7 and is no longer supported. RhostsRSAAuthentication may be used as a more secure alternative.

Migration Considerations
SFTP

- OpenSSH 6.4 changes sftp so that non-error messages are not printed to stdout if running a batch file (-b).
  - In effect, the -q (quiet mode) option is turned on with -b and cannot be turned off.
  - Since this will impact many customers, it has been changed in HOS1130 so that -b does not force -q.
  - The -q option can be specified in addition to -b.   Therefore this is not actually a migration action, but the behavior will not be consistent with other implementations.

Migration Considerations /dev/random

- In OpenSSH 6.4 no longer supports the use of `ssh-rand-helper`
- In HOS1130, neither the ssh client or sshd server will run unless the UNIX /dev/random device is working.
  - ICSF support of /dev/random is now **REQUIRED**.
    - Version HCR7780 or later must be installed and running
    - With HCR77A0, a **crypto card is NOT required**!
    - With HCR77A1, CSFRNG check can be skipped by defining resource `CSF.CSFSERV.AUTH.CSFRNG.DISABLE` in class `XFACILIT`
  - If `/dev/random` is not available, then ssh/sshd will fail with:

```
FOTS1949 PRNG is not seeded.  Please activate the
Integrated Cryptographic Service Facility (ICSF)
```

Configuration and Tuning

- The following guidelines are taken from:

  IBM Ported Tools OpenSSH - Quick Install Guide
  http://dovetail.com/docs/pt-quick-inst/index.html

- For more information, see also:

  IBM Ported Tools for z/OS: OpenSSH
  http://www.ibm.com/servers/eserver/zseries/zos/unix/ported/openssh/index.html

Using ICSF to enable /dev/random

- Required for HOS1130
- Need to allow required users access to ICSF CSFRNG service. For most environments, this can be granted to all:

```
RDEFINE CSFSERV CSFRNG UACC(NONE)
PERMIT CSFRNG CLASS(CSFSERV) ID(*) ACCESS(READ)
SETROPTS RACLIST(CSFSERV) REFRESH
```

- You must authorize all userids that use ssh including both **sshd** userids.
- **Note:** With HCR77A1, this can be skipped by defining resource `CSF.CSFSERV.AUTH.CSFRNG.DISABLE` in class `XFACILIT`

To test (from a normal z/OS user UNIX shell):

```
$ head /dev/random | od -x
```

ICSF Cipher and MAC Acceleration

- ICSF must be active
- CPACF - processor feature 3863
  - free and enabled by default in most countries
- Properly configured, ICSF and CPACF instructions can reduce overall CPU usage by > 50%.
- PTF for APAR OA45548 must be installed to take advantage of AES-CTR mode.

ICSF Cipher and MAC Acceleration

- The following CSFSERV profiles control access:
  - CSFIQA - ICSF Query Algorithm
  - CSF1TRC - PKCS #11 Token record create
  - CSF1TRD - PKCS #11 Token record delete
  - CSF1SKE - PKCS #11 Secret key encrypt
  - CSF1SKD - PKCS #11 Secret key decrypt
  - CSFOWH - One-Way Hash Generate

ICSF Cipher and MAC Acceleration

```
RDEFINE CSFIQA  CLASS(CSFSERV) UACC(NONE)
RDEFINE CSF1TRC CLASS(CSFSERV) UACC(NONE)
RDEFINE CSF1TRD CLASS(CSFSERV) UACC(NONE)
RDEFINE CSF1SKE CLASS(CSFSERV) UACC(NONE)
RDEFINE CSF1SKD CLASS(CSFSERV) UACC(NONE)
RDEFINE CSFOWH  CLASS(CSFSERV) UACC(NONE)
/* permit all, some users, or a group:  */
PERMIT  CSFIQA  CLASS(CSFSERV) ID(*) ACCESS(READ)
...
SETROPTS CLASSACT(CSFSERV)
SETROPTS RACLIST(CSFSERV) REFRESH
```

Note: You must authorize all userids that use ssh including both **sshd** userids.

ICSF Cipher and MAC Acceleration

- Configuration of `sshd_config` and `ssh_config` Ciphers and MACs options
  - The HOS1130 shipped versions of these files are optimized to choose the best fit with conventional OpenSSH installations along with ICSF acceleration
  - See the guide for information/implications reordering these lists

- Update both z/OS specific configuration files:
  - `/etc/ssh/zos_ssh_config` and `/etc/ssh/zos_sshd_config`

```
# Use either software or ICSF for Ciphers and MACs
CiphersSource any
MACsSource any
```

HCR77A1 performance enhancement option

```
RDEFINE CSF.CSFSERV.AUTH.CSFOWH.DISABLE
    CLASS(XFACILIT) UACC(READ)
RDEFINE CSF.CSFSERV.AUTH.CSFRNG.DISABLE
    CLASS(XFACILIT) UACC(READ)
SETROPTS CLASSACT(XFACILIT)
SETROPTS RACLIST(XFACILIT) REFRESH
```

- Defining these profiles in the XFACILIT class will disable SAF/RACF checks for CSFOWH (hash) and CSFRNG (random number) APIs.
- Since ICSF uses CPACF instructions for these anyway (which can’t be protected by SAF/RACF), this is usually an acceptable option.

Verifying ICSF setup

- Run the ssh client under TSO OMVS (new feature!)

```
/SYSTEM/home/user> ssh -vvv myuser@127.0.0.1
```

```
...
debug1: zsshVerifyIcsfSetup: ICSF FMID is ‘HCR77A0’
debug2: -----------------------------------
debug2: CRYPTO    SIZE      KEY       SOURCE
debug2: -----------------------------------
debug2: AES       256       CLEAR     CPU
debug2: DES       56        CLEAR     CPU
```

Verifying ICSF setup

…

```
debug2: MDC-2    128      NA       CPU
debug2: MDC-4    128      NA       CPU
debug2: MD5      128      NA       SW
debug2: SHA-1    160      NA       CPU
debug2: SHA-2    512      NA       CPU
debug2: TDES     168      CLEAR    CPU
```

Note: `SOURCE=CPU` means CPACF, which is what ICSF uses for SSH Cipher and MAC acceleration.

Note: The strength/size is the largest bit length supported by the facility. In the display above, AES-128, AES-192, and AES-256 are supported via ICSF with CPACF.

Verifying ICSF setup

…

```
debug1: mac_setup_by_alg: hmac-sha1 from source ICSF
debug1: zsshIcsfMacInit (429): CSFPTRC successful: return
code = 0, reason code = 0, handle = 'SYSTOK-SESSION-ONLY
00000000S   '
```

Note: These messages indicate that ICSF was used for MAC hmac-sha1

Verifying ICSF setup

…

```
debug1: cipher_init: aes128-ctr from source ICSF
debug1: zsshIcsfCipherInit (977): CSFPTRC successful:
return code = 0, reason code = 0, handle = 'SYSTOK-SESSION-
ONLY             00000003S   '
```

Note: These messages indicate that ICSF was used for Cipher aes128-ctr

LE Tuning Recommendations

- Ported Tools OpenSSH uses LE XPLINK runtime libraries (like Java, WebSphere, etc)

  See: “Placing Language Environment Modules in LPA ..”

  - Add SCEELPA to LPALST
  - Add SCEERUN and SCEERUN2 to LNKLST
  - SCEERUN and SCEERUN2 should be program controlled
  - Implement samples CEE.SCEESAMP(CEEWLPA) and (EDCWLPA) as shipped

References

- IBM Ported Tools for z/OS: OpenSSH User’s Guide

  (Order Number: SA23-2246-***03***)
- Announcement Letter: **ENUS215-009**
- Dovetailed Technologies Resources (dovetail.com)
  - IBM Ported Tools OpenSSH - Quick Install Guide http://dovetail.com/docs/pt-quick-inst/index.html
  - Dovetail webinar recordings:
    - IBM Ported Tools OpenSSH – Key Authentication
    - IBM Ported Tools OpenSSH – Using Key Rings
- Website References:
  - IBM Ported Tools for z/OS - OpenSSH http://www.ibm.com/servers/eserver/zseries/zos/unix/ported/openssh/
  - OpenSSH http://www.openssh.org/

References

- ICSF Reference Guides:
  - z/OS Cryptographic Services ICSF Overview (Order Number: SA22-7519)
  - z/OS Cryptographic Services ICSF Administrator’s Guide (Order Number: SA22-7521)
  - z/OS Cryptographic Services ICSF System Programmer’s Guide (Order Number: SA22-7520)
  - z/OS Cryptographic Services ICSF Application Programmer’s Guide (Order Number: SA22-7522)
  - z/OS Cryptographic Services Writing PKCS #11 Applications (Order Number: SA23-2231)
  - ftp://public.dhe.ibm.com/s390/zos/icsf/pdf/OA45548.pdf
- Other Reference Guides:
  - Program Directory for IBM Ported Tools for z/OS (Order Number: GI10-0769)

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