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Problem Diagnosis for OpenSSH on z/OS

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Session Agenda

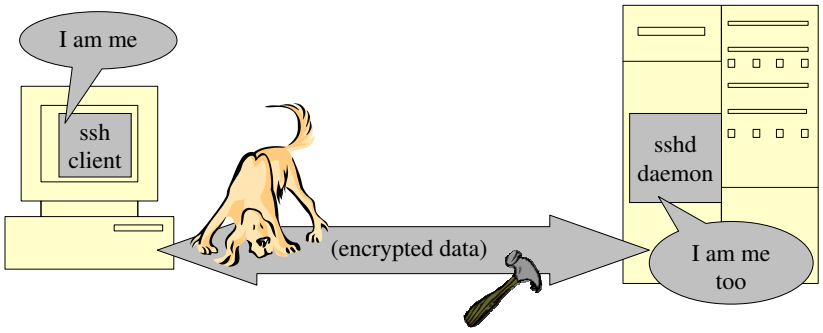
- >> OpenSSH Review <<
- Debug Facilities
- Collecting Debug Documentation
- Reading Debug Output
- Diagnosing Common Problems
- Appendix

This session is based on z/OS OpenSSH 5.0p1, unless otherwise noted [OpenSSH 1.2 HOS1120]

OpenSSH Review

- **The OpenSSH suite gives the following:**
  - Encrypted remote access, including tunneling insecure protocols.
  - Encrypted file transfer.
  - Run remote commands, programs or scripts.
  - Secure replacement for rsh, rlogin, telnet and ftp.
- **OpenSSH prevents:**
  - Eavesdropping of data transmitted over the network.
  - Manipulation of data at intermediate elements in the network (e.g. routers).
  - Address spoofing where an attack hosts pretends to be a trusted host by sending packets with the source address of the trusted host.
  - IP source routing.

OpenSSH Review



OpenSSH Review

- **OpenSSH is a very useful tool, but much of its effectiveness depends on correct use. It cannot protect from any of the following situations:**
  - Misconfiguration, misuse or abuse.
  - Compromised systems, particularly where the root account is compromised.
  - Insecure or inappropriate directory settings, particularly home directory settings.
- The z/OS OpenSSH messages use a FOTS prefix, we endeavor to keep the User's Guide as accurate as possible with explanations and solutions for each.

Functionality Review

- ssh
  - OpenSSH client (remote login program)
  - a secure alternative to rlogin, rsh, rexec
- sshd
  - OpenSSH daemon
  - daemon that listens for connections from ssh clients
  - handles key exchange, encryption, authentication, command execution, and data exchange

Functionality Review

- sftp
  - Secure file transfer program
  - Similar to ftp user interface and performs all operations over encrypted ssh transport
  - Note: sftp does not use standard ftp protocols
  - Assumes files are binary. Files copied between EBCDIC and ASCII platforms are not converted by default. (See 'ascii' subcommand)
- sftp-server
  - Server side of the sftp protocol
  - sftp-server is not intended to be called directly, but from sshd using the Subsystem option.
- scp
  - Secure copy (remote file copy program)
  - Similar to rcp, but will ask for passwords/passphrases if needed and performs all operations over encrypted ssh transport
  - Assumes files are text. Files copied between EBCDIC and ASCII platforms are converted.

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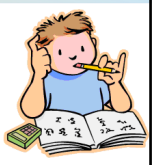
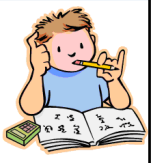
Debug Facilities



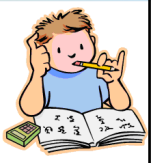
Command:	How to get debug output:
ssh	**-vvv**
scp	**-vvv**
sftp	**-vvv**
sshd	**Use USS syslogd, or in debug mode (-ddd or -De)**
ssh-keygen	**-vvv**
ssh-add	**None**
ssh-agent	**-d**
ssh-keyscan	**-v**
ssh-rand-helper	**-vvv**

Debug Facilities



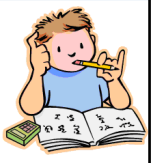
- Important note:
  - The client debug facilities may not be sufficient, for security reasons, they often will not tell the user why they were unable to establish a connection.
    - The server (when configured for debugging) typically provides more detailed information about why a particular connection attempt may have failed.
  - To collect the most amount of information, ideally you'd like to run both the client and server with the most verbose level of debugging and collect both a client and server trace from the same connection attempt.
  - You may also need to watch the MVS console for security messages from RACF (or your favorite security product).

Client Debug Facilities



- ssh
  - -v
    - Verbose mode. Causes ssh to print debugging messages about its progress. This is helpful in debugging connection, authentication, and configuration problems. Multiple -v options increase the verbosity. You can specify up to three -v options.
  - Recommended invocation for debugging:
    - `ssh -vvv [other options] user@remote.host`
    - Debug information will be written to stderr, be prepared to capture if needed.

Client Debug Facilities

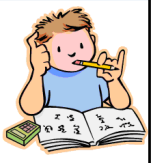


- sftp and scp
  - -v
    - Enables verbose mode. This option is also passed to ssh. Multiple -v options increase the verbosity. You can specify up to three -v options.
    - Since this is passed to ssh as well, you'll continue to receive messages regarding connection, authentication, and configuration problems, in addition to the file transfer messages.
  - Recommended invocation for debugging:
    - `sftp -vvv [other options] user@remote.host`
    - `scp -vvv [other options] user@remote.host`
    - Debug information will be written to stderr, be prepared to capture if needed.

Server Debug Facilities

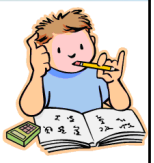
- sftp-server has a debug facility but must be enabled in the sshd_config file, and will only write to syslogd.
  - There is also the ability to cut SMF records for file transfer records
    - Specifically SMF Type 119 and subtype 96, 97, and 98 records
- Two primary methods to debug SSHD
  - Production debugging using USS syslogd
    - Preferred method – best for debugging problems encountered outside of daemon startup.
  - "Debug Mode" – special mode for sshd
    - Doesn't fork a daemon, so if problems lie in system configuration, they may not occur when running in 'debug mode'.

Server Debug Facilities



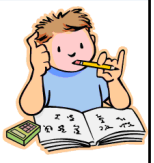
- sshd –t
  - Test mode
    - This instructs sshd to only check the validity of the sshd_config configuration file and sanity of the keys. This does not actually start sshd.
- sshd –ddd
  - Interactively debug sshd in debug mode (up to 3 for increased detail).
  - sshd will terminate after processing a single connection attempt.
- sshd –De
  - Interactively debug sshd, very similar to –ddd but:
    - sshd will remain active until terminated manually (control-c or kill <pid>).
    - Debug level based on value of sshd_config file value for LogLevel.
- sshd and syslogd
  - Best in practice, provides up to DEBUG3 level of detail while continuing to run in a production environment.
  - Can be combined with options to enable debugging in sftp-server.

Server Debug Facilities



- sshd and syslogd
  - sshd has the ability to write to the USS syslogd facility while running in production mode
    - Using these options in /etc/ssh/sshd_config:
      - *SyslogFacility*
        - *Allows you to specify which syslogd facility to write to, we recommend "DAEMON" for debugging.*
      - *LogLevel*
        - *Specify the amount of debug output to write. DEBUG3 is the most verbose and recommended value for debugging.*
    - Changes to the config file require restarting sshd.
  - Best for general debugging and/or failing connection attempts.

Server Debug Facilities



- sftp-server
  - sftp-server also has the ability to write to the USS syslogd facility:
    - In the /etc/ssh/sshd_config file, the default definition for the sftp-server is:
      - `Subsystem sftp /usr/lib/ssh/sftp-server`
    - You can place sftp-server in debug mode by specifying these options on the Subsystem entry in /etc/ssh/sshd_config:
      - *-f SyslogFacility*
        - *Allows you to specify which syslogd facility to write to, we recommend "DAEMON" for debugging.*
      - *-l LogLevel (lower case L)*
        - *Specify the amount of debug output to write. DEBUG3 is the most verbose and recommended value for debugging.*
    - Note: changes to the config file require restarting sshd.

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Collecting output from the shell

- *Typically* client debug information will be written to stderr.
  - You may need to be prepared to capture for later review or to pass along to IBM support teams.
- Shell redirection of output
  - Standard z/OS shell sample:
    - `ssh -vvv user@host 2>&1 | tee ssh-debug.log`
  - This will collect both, stderr and stdout, into a file called 'ssh-debug.log'. The '2>&1' redirects stderr to stdout, while the tee program duplicates stdout into the file (this allows capturing of data while also displaying output on the terminal).

Collecting Client Debug Output

- ssh –vvv
  - Example:
    `ssh -vvv ctware@localhost 2>&1 | tee ssh-debug.log`

```
OpenSSH_5.0p1, OpenSSL 0.9.8k 25 Mar 2009
debug1: Reading configuration data /etc/ssh/ssh_config
debug3: cipher ok: aes128-cbc [aes128-cbc,aes192-cbc,a
debug3: cipher ok: aes192-cbc [aes128-cbc,aes192-cbc,a
debug3: cipher ok: aes256-cbc [aes128-cbc,aes192-cbc,a
debug3: cipher ok: rijndael-cbc@lysator.liu.se [aes128
debug3: cipher ok: 3des-cbc [aes128-cbc,aes192-cbc,aes
debug3: cipher ok: aes128-ctr [aes128-cbc,aes192-cbc,a
debug3: cipher ok: aes192-ctr [aes128-cbc,aes192-cbc,a
debug3: cipher ok: aes256-ctr [aes128-cbc,aes192-cbc,a
debug3: cipher ok: arcfour256 [aes128-cbc,aes192-cbc,a
debug3: cipher ok: arcfour128 [aes128-cbc,aes192-cbc,a
debug3: cipher ok: blowfish-cbc [aes128-cbc,aes192-cbc
debug3: cipher ok: cast128-cbc [aes128-cbc,aes192-cbc,
debug3: cipher ok: arcfour [aes128-cbc,aes192-cbc,aes2
debug3: ciphers ok: [aes128-cbc,aes192-cbc,aes256-cbc,
...
```

Collecting Client Debug Output

- sftp –vvv
  - Example:
    `sftp -vvv ctware@localhost 2>&1 | tee ssh-debug.log`
  - Similar to ssh but also includes things like:

```
sftp> debug3: zsshSmfSetClientOpData: subcommand PUT
debug3: Looking up tmp.out
debug3: Sent message fd 6 T:17 I:2
debug3: Received stat reply T:105 I:2
debug3: Got file attribute "nlink_t_zos@us.ibm.com"
Uploading tmp.out to /u/ctware/tmp.out2
debug3: Sent message SSH2_FXP_OPEN I:3 P:/u/ctware/tmp.out2
debug3: Sent message SSH2_FXP_WRITE I:4 O:0 S:32768
debug3: SSH2_FXP_STATUS 0
debug3: In write loop, ack for 4 32768 bytes at 0
debug3: Sent message SSH2_FXP_WRITE I:5 O:32768 S:32585
debug3: SSH2_FXP_STATUS 0
debug3: In write loop, ack for 5 32585 bytes at 32768
debug3: Sent message SSH2_FXP_CLOSE I:4
debug3: SSH2_FXP_STATUS 0
debug1: zsshSmfWriteRecord: Writing SMF record type 119 subtype
sftp> debug2: channel 0: read<=0 rfd 4 len 0
```


Collecting Client Debug Output

- scp –vvv
  - Example:
    `scp -vvv tmp.out ctware@localhost:tmp.copy 2>&1 | tee ssh-debug.log`
  - Similar to ssh and sftp but also includes things like:

```
debug1: Entering interactive session.
debug2: callback start
debug2: client_session2_setup: id 0
debug1: Sending command: scp -v -t tmp.copy
debug2: channel 0: request exec confirm 0
debug2: fd 3 setting TCP_NODELAY
debug2: callback done
debug2: channel 0: open confirm rwindow 0 rmax 32768
debug2: channel 0: rcvd adjust 2097152
zsshSmfReadPipe: data length read = 198
zsshSmfReadPipe: SMF status = 84
zsshSmfTestRecord: SMF is collecting type 119, subtype 97 records
zsshSmfSetCommonData: SMF type 119 subtype 97
zsshSmfSetClientOpData: subcommand PUT
Sending file modes: C0644 65353 tmp.out
debug2: channel 0: rcvd ext data 26
Sink: C0644 65353 tmp.out
```

Collecting Server Debug Output

- sshd –De -or- sshd –ddd
  - Example:
    ```
    /usr/sbin/sshd -De 2>&1 | tee server.log
    or
    /usr/sbin/sshd -ddd  2>&1 | tee server.log
    ```

```
debug2: load_server_config: filename /etc/ssh/sshd_config
debug2: load_server_config: done config len = 244
debug2: parse_server_config: config /etc/ssh/sshd_config len 244
debug3: /etc/ssh/sshd_config:28 setting Protocol 2
debug3: /etc/ssh/sshd_config:122 setting Subsystem sftp /usr/lib/ssh/sf
debug3: /etc/ssh/sshd_config:129 setting SyslogFacility DAEMON
debug3: /etc/ssh/sshd_config:130 setting LogLevel DEBUG3
debug3: /etc/ssh/sshd_config:131 setting StrictModes no
debug3: /etc/ssh/sshd_config:132 setting Protocol 2,1
debug2: load_server_config: filename /etc/ssh/zos_sshd_config
debug2: load_server_config: done config len = 30
debug2: parse_server_config: config /etc/ssh/zos_sshd_config len 30
debug3: RNG is ready, skipping seeding
   ...
```


Collecting Server Debug Output

- sshd and syslogd
  - Ensure USS syslog daemon is available.
  - Add a configuration statement to /etc/syslog.conf
    - For our purposes we're going to utilize the 'daemon' syslog facility and the 'debug' priority code
    - `daemon.debug  /tmp/syslogd/server.logfile`
      - *ensure the directory /tmp/syslogd/ exists*
  - Update the /etc/ssh/sshd_config file to reflect our desire to run in a debug mode
    - Update/define the option "SyslogFacility" to be "DAEMON"
    - Update/define the option "LogLevel" to be "DEBUG3"
      - ```
        SyslogFacility DAEMON
        LogLevel DEBUG3
        ```
  - After updating configuration settings for the daemons, they require restarting for the changes to be picked up.
        ```

Collecting Server Debug Output

- sshd and syslogd
  - After restarting sshd and syslogd, sshd will be writing debug3 data to /tmp/syslogd/server.logfile while running a production server.
  - syslogd has the added advantage of timestamping all entries, and will show the creation of child address spaces.

```
sshd[54]: Server listening on 0.0.0.0 port 22.
sshd[54]: debug1: fd 4 clearing O_NONBLOCK
sshd[54]: debug1: Forked child 33554485.
sshd[54]: debug3: send_rexec_state: entering fd = 8 config len
sshd[54]: debug3: ssh_msg_send: type 0
sshd[54]: debug3: send_rexec_state: done
sshd[33554485]: debug1: rexec start in 4 out 4 newsock 4 pipe
sshd[33554485]: debug1: inetd sockets after dupping: 3, 3
sshd[33554485]: debug1: cipher_init: none from source OpenSSL
```


Collecting Server Debug Output

- sftp-server and syslogd
  - Ensure USS syslog daemon is available and configured for collecting sshd debug data as described previously.
  - Update the sftp subsystem configuration statement in /etc/ssh/sshd_config to reflect our desire to run in a debug mode
    - Use –f to define the value for “SyslogFacility” to be “DAEMON”
    - Use –l (lower L) to define the option “LogLevel” to be “DEBUG3”

    ```
    Subsystem sftp /usr/lib/ssh/sftp-server -f DAEMON -l DEBUG3
    ```

  - After updating configuration settings for the daemons, they require restarting for the changes to be picked up.
    - After restarting sshd and syslogd, sftp-server will be writing debug3 data to /tmp/syslogd/server.logfile while running a production server.

Collecting Server Debug Output

- Sample of the sftp-server debug output written to the syslog:

```
sftp-server[52]: session opened for local user ctware from  9.x.x.17
sftp-server[52]: received client version 3
sftp-server[52]: debug3: request 1: realpath
sftp-server[52]: realpath "."
sftp-server[52]: debug1: request 1: sent names count 1
sftp-server[52]: debug3: request 2: stat
sftp-server[52]: stat name "/tmp.copy"
sftp-server[52]: debug3: request 2: sent status 2
sftp-server[52]: sent status No such file
sftp-server[52]: debug3: request 3: open flags 26
sftp-server[52]: debug3: Got file attribute "nlink_t_zos@us.ibm.com"
sftp-server[52]: open "/tmp.copy" flags WRITE,CREATE,TRUNCATE mode 0644
sftp-server[52]: debug1: request 3: sent handle handle 0
sftp-server[52]: debug1: request 4: write "/tmp.copy" (handle 0) off 0 l
sftp-server[52]: debug3: request 4: sent status 0
sftp-server[52]: sent status Success
sftp-server[52]: debug1: request 5: write "/tmp.copy" (handle 0) off 327
sftp-server[52]: debug3: request 5: sent status 0
sftp-server[52]: sent status Success
sftp-server[52]: debug3: request 4: close handle 0
sftp-server[52]: close "/tmp.copy" bytes read 0 written 65353
sftp-server[52]: debug3: request 4: sent status 0
sftp-server[52]: sent status Success
```


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Reading Debug Output

- Recall:
  - For best effectiveness you will likely want to collect a debug trace from both the client and server for the same connection attempt.
  - Since the messages may be intimidating or confusing, remember: when in doubt, Google is your friend.
    - Note: OpenSSH runs on many platforms, keep this in mind when using searching the internet - not everything you discover will apply to the z/OS implementation.
- A great place to begin (if possible) is to also collect a set of traces from a working connection and compare with the failing results.
- Rather than reviewing one of many potential failing scenarios, let's take a look through a working one to build familiarity and comfort…

Client Debug Output – A Walkthrough

- A brief overview of the general flow of an sftp connection (note this will include ssh debug output and scp will be similar):
  - We'll review the output of:
    `sftp -vvv ctware@9.x.x.13`
  - Which is going to do:
    `put tmp.out tmp.copy`
    - Note: Some of the messages will be truncated or omitted for the sake of readability.

Client Debug Output – A Walkthrough

IP Name or Address of Remote System

```
Connecting to 9.x.x.13...
debug3: zsshSmfCreatePipe: SMF pipe created fdout=7, fdin=8
debug1: Reading configuration data /etc/ssh/zos_ssh_config
OpenSSH_5.0p1, OpenSSL 0.9.8k 25 Mar 2009
debug1: Reading configuration data /etc/ssh/ssh_config
debug3: cipher ok: aes128-cbc [aes128-cbc,aes192-cbc,aes256
…
debug2: mac_setup: found hmac-sha1
debug3: mac ok: hmac-sha1 [hmac-sha1,
…
debug3: RNG is ready, skipping seeding
…
```

RNG is ready since /dev/random exists

Client Debug Output – A Walkthrough

ICSF is installed and available

```
debug1: zsshVerifyIcsfSetup: ICSF FMID is 'HCR77A0 '
debug1: zsshVerifyIcsfSetup (163): CSFIQA successful: return
debug2: ------------------------------------
debug2: CRYPTO    SIZE      KEY       SOURCE
debug2: ------------------------------------
debug2: AES       256       SECURE    COP
…
debug1: Connecting to 9.x.x.13 [9.x.x.13] port 22.
debug1: Connection established.
…
debug3: Not a RSA1 key file /u/ctware/.ssh/id_rsa.
debug2: key_type_from_name: unknown key type '-----BEGIN'
debug3: key_read: missing keytype
debug3: key_read: missing whitespace
…
```

List of available Crypto methods and source

Reading private key(s)

Client Debug Output – A Walkthrough

Local and remote versions of OpenSSH

```
debug1: Remote protocol version 2.0, remote software version
  OpenSSH_5.0
debug1: match: OpenSSH_5.0 pat OpenSSH*
…
debug1: Local version string SSH-2.0-OpenSSH_5.0
…
debug3: RNG is ready, skipping seeding
debug1: SSH2_MSG_KEXINIT sent
debug1: SSH2_MSG_KEXINIT received
debug2: kex_parse_kexinit: diffie-hellman-
…
debug1: mac_setup_by_id: hmac-sha1 from source ICSF
debug2: mac_setup: found hmac-sha1
debug1: kex: server->client aes128-cbc hmac-sha1 none
debug1: mac_setup_by_id: hmac-sha1 from source ICSF
debug2: mac_setup: found hmac-sha1
debug1: kex: client->server aes128-cbc hmac-sha1 none
…
```

Beginning key exchange

Using ICSF for message authentication code

Client Debug Output – A Walkthrough

```
debug1: SSH2_MSG_KEX_DH_GEX_INIT sent
debug1: expecting SSH2_MSG_KEX_DH_GEX_REPLY
debug3: check_host_in_hostfile: filename /u/ctware/.ssh/known_hosts
debug3: check_host_in_hostfile: filename /etc/ssh/ssh_known_hosts
…
debug2: key: /u/ctware/.ssh/id_rsa (0)
debug2: key: /u/ctware/.ssh/id_dsa (0)
debug1: Authentications that can continue: publickey,password
…
debug3: authmethod_is_enabled publickey
debug1: Next authentication method: publickey
debug1: Trying private key: /u/ctware/.ssh/id_rsa
debug1: read PEM private key done: type RSA
debug3: sign_and_send_pubkey
debug2: we sent a publickey packet, wait for reply
debug1: Authentications that can continue: publickey,password
debug1: Trying private key: /u/ctware/.ssh/id_dsa
debug1: read PEM private key done: type DSA
```

Host key authentication occurring

User authentication

Client Debug Output – A Walkthrough

```
debug3: sign_and_send_pubkey
debug2: we sent a publickey packet, wait for reply
debug1: Authentications that can continue: publickey,password
debug2: we did not send a packet, disable method
debug3: authmethod_lookup password
debug3: remaining preferred: ,password
debug3: authmethod_is_enabled password
debug1: Next authentication method: password
debug2: we sent a password packet, wait for reply
debug1: Authentication succeeded (password).
…
debug1: Entering interactive session.
debug2: callback start
debug2: client_session2_setup: id 0
debug1: Sending subsystem: sftp
…
```

User authentication occurring

Pubkey failed, trying password

Password Authentication Successful

Requesting sftp

Client Debug Output – A Walkthrough

```
debug3: SSH_FXP_REALPATH . -> /
…
sftp> debug3: zsshSmfSetClientOpData: subcommand PUT
debug3: Looking up tmp.out
…
Uploading tmp.out to /tmp.copy
debug3: Sent message SSH2_FXP_OPEN I:3 P:/tmp.copy
debug3: Sent message SSH2_FXP_WRITE I:4 O:0 S:32768
debug3: SSH2_FXP_STATUS 0
debug3: In write loop, ack for 4 32768 bytes at 0
debug3: Sent message SSH2_FXP_WRITE I:5 O:32768 S:32585
debug3: SSH2_FXP_STATUS 0
debug3: In write loop, ack for 5 32585 bytes at 32768
debug3: Sent message SSH2_FXP_CLOSE I:4
debug3: SSH2_FXP_STATUS 0
debug1: zsshSmfWriteRecord: Writing SMF record type 119 subtype 97
  length 332 with record exit IEFU84.
```

Starting remote directory

Performing a 'put'

File to put

Destination file

Open, Write, Close

32k chunks

Client Debug Output – A Walkthrough

```
sftp> debug2: channel 0: read<=0 rfd 5 len 0
…
debug2: channel 0: close_read
…
debug2: channel 0: ibuf empty
debug2: channel 0: send eof
debug2: channel 0: input drain -> closed
debug2: channel 0: rcvd eof
debug2: channel 0: rcvd close
debug3: channel 0: will not send data after close
debug2: channel 0: almost dead
debug2: channel 0: gc: notify user
debug2: channel 0: gc: user detached
debug2: channel 0: send close
debug2: channel 0: is dead
debug2: channel 0: garbage collecting
debug1: channel 0: free: client-session, nchannels 1
…
debug1: Exit status 0
```

Disconnect flow

Exit Success

Server Debug Output – A Walkthrough

- A brief overview of the general flow of an sftp connection from the server side
  - This is the server trace which corresponds to the sftp client trace we just reviewed.
    - `sftp -vvv ctware@9.x.x.13`
    - Which is going to do:
      `put tmp.out tmp.copy`
  - Note: Some of the messages will be truncated or omitted for the sake of readability and the timestamp prefix information has been removed.
  - Note: sftp-server doesn't have additional debug messages.

Server Debug Output – A Walkthrough

```
sshd[33554489]: debug1: Bind to port 22 on 0.0.0.0.
sshd[33554489]: Server listening on 0.0.0.0 port 22.
…
sshd[33554489]: debug1: Forked child 33554486.
…
sshd[33554486]: Connection from 9.x.x.17 port 43820
…
sshd[33554486]: debug1: Client protocol version 2.0; client
   software version OpenSSH_5.0
sshd[33554486]: debug1: match: OpenSSH_5.0 pat OpenSSH*
sshd[33554486]: debug1: Local version string SSH-2.0-OpenSSH_5.0
sshd[33554486]: debug2: Network child is on pid 83886136
sshd[33554486]: debug3: Current IBM Release level: 23
sshd[33554486]: debug3: MLS: seclabel of AS:          uid:0
…
sshd[33554486]: debug3: mm_answer_pwnamallow
sshd[33554486]: debug3: get_pwnamallow: input user name ctware,
sshd[33554486]: debug3: Trying to reverse map address 9.x.x.17.
…
```

Server is up

Incoming connection

Version info.

Privsep child

z/OS release 1.13

Incoming username

Server Debug Output – A Walkthrough

```
sshd[33554486]: debug3: mm_answer_keyallowed entering
sshd[33554486]: debug3: mm_answer_keyallowed: key_from_blob:
   25DE6120
sshd[33554486]: debug1: temporarily_use_uid: 0/512 (e=0/512)
sshd[33554486]: debug1: trying public key file
   /.ssh/authorized_keys
sshd[33554486]: debug3: key_read: type mismatch
sshd[33554486]: debug2: user_key_allowed: check options: 'ssh-dss
   AAAAB3NzaC…'
sshd[33554486]: debug1: restore_uid: 0/512
sshd[33554486]: debug2: key not found
…
sshd[33554486]: debug3: auth_log: authenticated 0, valid 1,
   failures 0, max 6, half 3, method publickey
sshd[33554486]: Failed publickey for ctware from 9.x.x.17 port
   43820 ssh2
sshd[33554486]: debug3: mm_answer_keyallowed: key 25DE6120 is
   disallowed
…
```

Processing user keys

User DSA public key

Not found

Server Debug Output – A Walkthrough

```
sshd[33554486]: debug3: mm_answer_keyallowed: key_from_blob:
  25DE5078
sshd[33554486]: debug1: temporarily_use_uid: 0/512 (e=0/512)
sshd[33554486]: debug1: trying public key file
  /.ssh/authorized_keys
sshd[33554486]: debug3: key_read: type mismatch
sshd[33554486]: debug2: user_key_allowed: check options: 'ssh-rsa
  AAAAB3…'
sshd[33554486]: debug1: restore_uid: 0/512
sshd[33554486]: debug2: key not found
…
sshd[33554486]: debug3: auth_log: authenticated 0, valid 1,
  failures 1, max 6, half 3, method publickey
sshd[33554486]: Failed publickey for ctware from 9.x.x.17 port
  43820 ssh2
sshd[33554486]: debug3: mm_answer_keyallowed: key 25DE5078 is
  disallowed
…
```

Processing user keys

User **RSA** public key

Not found

Server Debug Output – A Walkthrough

Now trying password

```
sshd[33554486]: debug3: monitor_read: checking request 10
sshd[33554486]: debug3: mm_answer_authpassword: sending result 1
sshd[33554486]: debug3: mm_request_send entering: type 11
sshd[33554486]: debug3: auth_log: authenticated 1, valid 1,
  failures 2, max 6, half 3, method password
sshd[33554486]: Accepted password for ctware from 9.x.x.17 port
  43820 ssh2
sshd[33554486]: debug1: monitor_child_preauth: ctware has been
  authenticated by privileged process
…
```

Successful login

Server Debug Output – A Walkthrough

Message Authentication Code from software

```
sshd[33554486]: debug1: mac_setup_by_id: hmac-sha1 from source
  OpenSSL
sshd[33554486]: debug2: mac_setup: found hmac-sha1
sshd[33554486]: debug3: mm_get_keystate: Waiting for second key
sshd[33554486]: debug3: mm_newkeys_from_blob: 25DE5180(123)
sshd[33554486]: debug1: mac_setup_by_id: hmac-sha1 from source
  OpenSSL
sshd[33554486]: debug2: mac_setup: found hmac-sha1
sshd[33554486]: debug3: mm_get_keystate: Getting compression state
sshd[33554486]: debug3: mm_get_keystate: Getting Network I/O
  buffers
sshd[33554486]: debug2: set_newkeys: mode 0
sshd[33554486]: debug1: cipher_init: aes128-cbc from source OpenSSL
sshd[33554486]: debug2: set_newkeys: mode 1
sshd[33554486]: debug1: cipher_init: aes128-cbc from source OpenSSL
sshd[33554486]: debug1: Entering interactive session for SSH2.
…
```

Ciphers from software (ICSF unavailable on this system)

Server Debug Output – A Walkthrough

Starting an sftp session

```
sshd[33554486]: subsystem request for sftp
sshd[33554486]: debug1: subsystem: exec() /usr/lib/ssh/sftp-server
sshd[33554486]: debug3: do_exec: subsystem 1
sshd[33554486]: debug3: do_exec: passwd name=ctware, uid=0,
  gid=512, dir=/, shell=/bin/sh
…
```

sftp environment

Server Debug Output – A Walkthrough

```
sftp-server[52]: session opened for local user ctware from  9.x.x.17
…
sftp-server[52]: stat name "/tmp.copy"
sftp-server[52]: debug3: request 2: sent status 2
sftp-server[52]: sent status No such file
…
sftp-server[52]: open "/tmp.copy" flags WRITE,CREATE,TRUNCATE mode 0644
sftp-server[52]: debug1: request 3: sent handle handle 0
sftp-server[52]: debug1: request 4: write "/tmp.copy" (handle 0) off 0 l
sftp-server[52]: debug3: request 4: sent status 0
sftp-server[52]: sent status Success
sftp-server[52]: debug1: request 5: write "/tmp.copy" (handle 0) off 327
sftp-server[52]: debug3: request 5: sent status 0
sftp-server[52]: sent status Success
sftp-server[52]: debug3: request 4: close handle 0
sftp-server[52]: close "/tmp.copy" bytes read 0 written 65353
sftp-server[52]: debug3: request 4: sent status 0
sftp-server[52]: sent status Success
…
```

stat() destination file

Open destination file

write destination file

close destination file

Successful write

Server Debug Output – A Walkthrough

```
sshd[33554486]: debug2: channel 0: rcvd eof
sshd[33554486]: debug2: channel 0: output open -> drain
sshd[33554486]: debug2: channel 0: obuf empty
sshd[33554486]: debug2: channel 0: close_write
sshd[33554486]: debug2: channel 0: output drain -> closed
…
sshd[33554486]: debug2: channel 0: send close
sshd[33554486]: debug3: channel 0: will not send data after close
sshd[33554486]: debug2: channel 0: rcvd close
sshd[33554486]: debug3: channel 0: will not send data after close
…
sshd[33554486]: debug2: channel 0: gc: user detached
sshd[33554486]: debug2: channel 0: garbage collecting
sshd[33554486]: Connection closed by 9.x.x.17
sshd[33554486]: debug1: do_cleanup
sshd[33554486]: debug3: zsshCloseOldDev: fd=-1
sshd[33554486]: Closing connection to 9.x.x.17
```

Disconnect flow

Closed by client (using "exit" sftp subcmd)

Server cleanup (and termination of this process)

Reading Debug Output

- Where to go from here, Messages, and Guidance
  - After walking through a successful client/server flow as we've done, when a curveball (i.e. failure) is thrown your way, you hopefully will have better understanding of what part of the connection is in question.
  - If the failure is coupled with a FOTS* message, please refer to the z/OS OpenSSH User Guide for explanations.
  - Note: OpenSSH is a complex product requiring the use of many other components (LE, CRTL, USS, TCP/IP, HFS, etc).
    - Watch for other messages in the job output and MVS console.

Session Agenda

- OpenSSH Review
- Debug Facilities
- Collecting Debug Documentation
- Reading Debug Output
- >> Diagnosing Common Problems <<
- Appendix

This session is based on z/OS OpenSSH 5.0p1, unless otherwise noted [OpenSSH 1.2 HOS1120]

Diagnosing Common Problems

- A few common issues often encountered:
  - Confusion between Host Keys and User Keys
  - StrictModes preventing connections
  - Performance issues with ssh-rand-helper

Key Confusion

- Public/Private Keypairs
  - Generated using ssh-keygen.
    - Public Key
      - *A public key is one of two keys used in public-key encryption (the other being a private key). The user releases a copy of this key to the public to allow anyone to use it for encrypting messages to be sent to the user and for decrypting messages received from the user.*
    - Private Key
      - *The user keeps the private key secret and uses it to encrypt outgoing messages and decrypt incoming messages.*
      - *The permissions for the private key should be set so that only the owner has read/write access.*

Key Confusion

- Types of authentication
  - Server authentication
    - Occurs early on during an ssh connection (prior to user authentication).
    - This prevents systems from pretending to be another system (spoofing), and assures the remote system is the desired system.
    - Authenticating the server has to be done before you send any confidential data to it. In particular, if the user authentication involves a password, the password must not be sent to an unauthenticated server.
    - The remote server provides a Public Key referred to as a Host Key (the server keeps the private key secret). This can be retrieved using ssh-keyscan or stored during an client connection.

Key Confusion

- Server authentication
  - Host Key
    - *Public portion of a public/private key pair.*
    - *This is stored in the client user's ~/.ssh/known_hosts or client system's /etc/ssh/ssh_known_hosts file.*
    - *When connecting with the corresponding server, the client offers this key and the server will match it with it's private portion of the key.*
    - *If the server changes its keypair and the stored host key no longer matches, the client will be notified (batch jobs will likely fail if this case occurs).*

Key Confusion

- Types of authentication
  - User authentication
    - Several methods including password and public key
    - Public Key authentication
      - *This is exactly the same method that is used to authenticate the server, but now the user is trying to prove its identity and the server is verifying it.*
      - *The login attempt is accepted if the user proves that he has the private key and the public key is in the remote system user's authorization list (~/.ssh/authorized_keys on the server).*
    - Typically the keypair is generated on the client system and the public portion of the key is copied (either using sftp and a password, or FTP, or possibly even copy/paste, etc) to the remote system.
      - *It is then stored in the user's authorized_keys file on the remote system.*

StrictModes Issues

- When the server has "StrictModes yes" set, user pubkey authentication may fail
  - The client will not receive any indication why the connection failed (even in debug mode).
  - The server debug trace will indicate the public key was rejected:

```
debug1: temporarily_use_uid: 0/512 (e=0/512)
debug1: trying public key file /userhome/.ssh/authorized_keys
debug1: restore_uid: 0/512
debug3: auth_log: authenticated 0, valid 1, failures 1, max 6, half 3, method publickey
Failed publickey for ctware from 9.00.00.17 port 30582 ssh2
debug3: mm_answer_keyallowed: key 25DE4078 is disallowed
```

StrictModes Issues

- If trying to establish an interactive session, this would still fall through and try to authenticate using password.
- If you're certain the pubkey pair was created and configured properly, verify the server is using StrictModes.
  - An easy test to determine if the connection is failing because of StrictModes, would be to change the server setting to 'no'
    - *Might not be feasible on a production system.*

StrictModes Issues

- If you determine the connection is failing because of StrictModes, SSHD may believe access to your files/directories may be too insecure.
  - Here are some of the files/directories SSHD tests and permissions tested and verified to work:

File	Permissions
User's home directory	755
User's authorized_keys file	644
User's known_hosts file	600
User's private key files	600
User's .ssh directory	700

Performance Issues

- The open source method to generate random numbers (ssh-rand-helper utility) uses various shell commands (listed in /etc/ssh/ssh_prng_cmds) and collects pieces of the output to be combined together to create a random number.
  - On z/OS the execution of this utility may not be as responsive as other platforms.
    - You may encounter SEC6/FF02 abends or see SIGINTs during client execution.
  - Solutions:
    - Will use /dev/random automatically if ICSF hardware is in place.
    - Check if CEE.SCEELPA is in the LPA list
    - Note: APAR OA37278 includes support to use ICSF hardware for additional purposes beyond RNG.

Session Agenda

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Appendix

- **See the updated "IBM Ported Tools for z/OS: OpenSSH User's Guide" for more information**
  (Order Number: SA23-2246-01)
- **Website References**
  - IBM Ported Tools for z/OS:
    http://www.ibm.com/systems/z/os/zos/features/unix/ported/
  - IBM Ported Tools for z/OS: OpenSSH:
    http://www.ibm.com/systems/z/os/zos/features/unix/ported/openssh/
  - OpenSSH: http://www.openssh.org/
  - OpenSSL: http://www.openssl.org/

Appendix

- **ICSF Reference Guides:**
  - z/OS Cryptographic Services ICSF Overview
    (Order Number: SA22-7519-13)
  - z/OS Cryptographic Services ICSF Administrator's Guide
    (Order Number: SA22-7521-14)
  - z/OS Cryptographic Services ICSF System Programmer's Guide
    (Order Number: SA22-7520-14)
  - z/OS Cryptographic Services ICSF Application Programmer's Guide
    (Order Number: SA22-7522-13)
  - z/OS Cryptographic Services Writing PKCS #11 Applications
    (Order Number: SA23-2231-02)
- **Other Reference Guides:**
  - Program Directory for IBM Ported Tools for z/OS
    (Order Number: GI10-0769-06)

System z Social Media

- System z official Twitter handle:
  - @ibm_system_z
- Top Facebook pages related to System z:
  - Systemz Mainframe
  - IBM System z on Campus
  - IBM Mainframe Professionals
  - Millennial Mainframer
- Top LinkedIn Groups related to System z:
  - Mainframe Experts Network
  - Mainframe
  - IBM Mainframe
  - System z Advocates
  - Cloud Mainframe Computing
- YouTube
  - IBM System z

- Leading Blogs related to System z:
  - Evangelizing Mainframe (Destination z blog)
  - Mainframe Performance Topics
  - Common Sense
  - Enterprise Class Innovation: System z perspectives
  - Mainframe
  - MainframeZone
  - Smarter Computing Blog
  - Millennial Mainframer