IBM z/OS V2R2:
UNIX System Services

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z Systems

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International Technical Support Organization

IBM z/OS V2R2: UNIX System Services

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Note: Before using this information and the product it supports, read the information in "Notices" on page v.

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Contents

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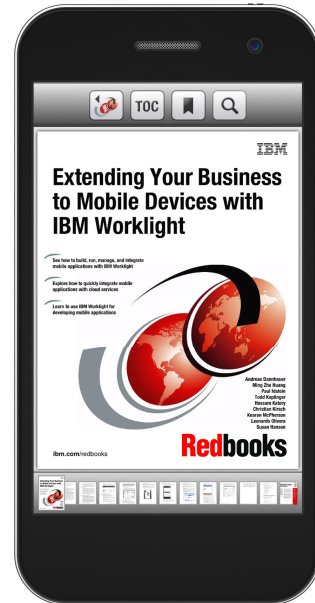
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Preface

This IBM® Redbooks® publication familiarizes you with the technical changes that were introduced into the UNIX System Services areas with IBM z/OS® V2R2.

This book is one of a series of IBM Redbooks publications that take a modular approach to providing information about the updates that are included within z/OS V2R2. This approach has the following goals:

► Provide modular content
► Group the technical changes into a topic
► Provide a more streamlined way of finding relevant information that is based on the topic

We hope you find this approach useful. We value your feedback.

Authors

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64-bit z/OS UNIX stacks above the bar

z/OS UNIX System Services (z/OS UNIX) is the IBM UNIX implementation in the z/OS operating system.

This chapter describes the new 64-bit support for z/OS UNIX stacks above the bar in z/OS Version 2 Release 2 and includes the following topics:

1.1 64-bit z/OS UNIX stacks above the bar

The increasing demand for threads resulted in the capacity approaching maximum limits of the kernel that are below the bar storage. Changes with IBM z/OS V2R2 introduced new 64-bit support; the following possibilities are available:

► Internal dynamic stacks can be moved above the bar.
► The thread capacity is increased.

1.1.1 New z/OS UNIX parmlib statement

There is a new BPXPRMxx parmlib statement that specifies whether to allocate kernel stacks from above or below bar storage, as shown in Example 1-1.

Example 1-1   New BPXPRMxx parmlib statement

```
KERNELSTACKS(ABOVE|BELOW)
```

The two values have the following meaning:

► **ABOVE**

All kernel stacks are allocated above the bar, which increases the thread limit to a maximum of 500,000.

► **BELOW**

All kernel stacks are allocated below the bar, which is the default setting.

> **Note:** As you plan your systems, consider the following points:
>
> ► The value of **KERNELSTACKS** cannot be changed dynamically.
>
> ► Any changes in **KERNELSTACKS** in the BPXPRMxx member do not take effect until the next initial program load (IPL).

1.1.2 OMVS MODIFY and DISPLAY enhancements

There are two new interface controls or output changes that are introduced with z/OS V2R2.

MODIFY OMVS command enhancement

There is a new interface to send Physical File System (PFS) specific commands to a PFS independent of whether the PFS is within the OMVS address space or outside in a colony address space, as shown in Example 1-2.

Example 1-2   Passing a MODIFY command string to a PFS through a z/OS UNIX LFS interface

```
F OMVS,PFS=pfsname,command_string
```

The parameters feature the following meanings:

► `pfsname`

The name of the PFS that receives the command.

► `command-string`

The command string to be passed from the Logical File System (LFS) to the PFS.

> **Important:** This new interface is needed by a 64-bit zFS when it runs in the OMVS address space because the `MODIFY ZFS` commands no longer work.

OMVS storage display output enhancement

If `KERNELSTACKS(ABOVE)` is specified in the BPXPRMxx parmlib member, the output of command `D OMVS,STORAGE` shows thread information instead of stack cell information.

> **Note:** This difference in displays below and above the line are shown in Figure 1-7 on page 5 and Figure 1-8 on page 5.

1.2 z/OS UNIX System Services scenarios

The command enhancements can be used in different environment set ups.

1.2.1 Addressing PFS commands to zFS and TFS

As shown in Example 1-3, zFS and TFS feature their own address space outside OMVS.

Example 1-3   Displays showing zFS and TFS are in a colony address space

```
$> cn "d omvs,p" | grep TFS
   TFS         BPXTFS      TFS         LOCAL     A     2015/07/15 15.15.21
   TFS       GLOBAL SETTINGS: fsfull(99,5) ea 0 em 0
$> cn "d omvs,p" | grep ZFS
   ZFS         IOEFSCM     ZFS         LOCAL     A     2015/07/15 15.15.20
   ZFS           PRM=(74,00)
```

> **Note:** The UNIX command **cn** is a tool to allow IBM MVS™ system commands to be issued and to receive the output to STDOUT in your shell.
>
> For more information, see *IBM z/OS Version 2 Release 1 Technical Updates*, SG24-8140-00, which is available at this website:
>
> ftp://www.redbooks.ibm.com/redbooks/SG248140/

zFS MODIFY commands when zFS is in a colony address space

Example 1-4 shows how to use the two methods that are available to address `MODIFY` commands to zFS when zFS is running in its own address space outside OMVS because it was introduced.

Example 1-4   Running zFS modify commands directly and via the new F OMVS,PFS interface

```
$> cn "f zfs,query,level"
 IOEZ00639I zFS kernel: z/OS     zFS
 Version 02.02.00 Service Level OA47906 - HZFS420.
 Created on Fri May 29 11:49:19 EDT 2015.
 sysplex(filesys,rwshare) interface(4)
 IOEZ00025I zFS kernel: MODIFY command - QUERY,LEVEL completed successfully.
$> cn "f omvs,pfs=zfs,query,level"
 IOEZ00639I zFS kernel: z/OS     zFS
 Version 02.02.00 Service Level OA47906 - HZFS420.
```

```
Created on Fri May 29 11:49:19 EDT 2015.
sysplex(filesys,rwshare) interface(4)
IOEZ00025I zFS kernel: MODIFY command - QUERY,LEVEL completed successfully.
```

TFS MODIFY commands when TFS is in a colony address space

Example 1-5 shows how to use the two ways of addressing `MODIFY` commands to Temporary File System (TFS) when TFS is running in its own address space outside OMVS.

Example 1-5   Running TFS modify commands directly and via the new F OMVS,PFS interface

```
$> cn "f tfs,q" | grep "GLOBAL SETTINGS"
 BPXTF012I GLOBAL SETTINGS: fsfull(99,5) ea 0 em 0
$> cn "f omvs,pfs=tfs,fsfull(80,5)"
 BPXTF012I GLOBAL SETTINGS: fsfull(80,5) ea 0 em 0
$> cn "f tfs,ea 10"
 BPXTF012I GLOBAL SETTINGS: fsfull(80,5) ea 10 em 0
$> cn "f omvs,pfs=tfs,em 5"
 BPXTF012I GLOBAL SETTINGS: fsfull(80,5) ea 10 em 5
```

TFS MODIFY commands when the TFS PFS is within OMVS

Example 1-6 shows the difference when the PFS is not running in its own address space as the `MODIFY` interface is not available.

> **Attention:** Changing a TFS to be within OMVS is not meant as a suggestion. It is done for demonstration purposes only. We still suggest running a TFS in a colony address space. However, you can move a TFS into OMVS in addition to HFS and zFS.

Example 1-6   For a TFS within OMVS MODIFY commands only work via F OMVS,PFS=

```
$> cat "//'SYS1.PARMLIB(BPXPRMTF)'"
 FILESYSTYPE TYPE(TFSO)
             ENTRYPOINT(BPXTFS)
             PARM('-fsfull(80,5) -ea 1 -em 1')
$> cn "set omvs=(tf)"
 BPX0032I THE SET OMVS COMMAND WAS SUCCESSFUL.
$> cn "d omvs,p" | grep TFSO
   TFSO       BPXTFS
   TFSO         -fsfull(80,5) -ea 1 -em 1
   TFSO      GLOBAL SETTINGS: fsfull(80,5) ea 1 em 1
$> cn "f tfso,ea 0"
 IEE341I TFSO                NOT ACTIVE
$> cn "f omvs,pfs=tfso,ea 0"
 BPXTF012I GLOBAL SETTINGS: fsfull(80,5) ea 0 em 1
```

Because the MODIFY OMVS interface always works for addressing commands to zFS and TFS, the following tip is suggested.

> **Tip:** If you switch to always use F OMVS,PFS=, this change is independent of the location of the PFS and helps reduce potential errors.

1.2.2 Displaying OMVS storage information

Example 1-7 and Example 1-8 shows how the output of the **D OMVS,STORAGE** command differs depending on the BPXPRMxx setting of **KERNELSTACKS**.

In Example 1-7, **KERNELSTACKS** is set to **BELOW**, which is the default and works as it did before.

Example 1-7   Displaying OMVS storage information if KERNELSTACKS is set to BELOW

```
$> cn "d omvs,o" | grep KERNELSTACKS
 KERNELSTACKS   = BELOW
$> cn "d omvs,storage"
 BPX0075I 20.44.51 DISPLAY OMVS 395
 OMVS     0011 ACTIVE              OMVS=(2A)
                     KERNEL STORAGE USAGE
 PRIVATE STORAGE:
 CURRENT USAGE     MAXIMUM AVAILABLE     HIGH WATER      REGION SIZE
     59740158          363046502          59748350       1830789120
 STACK CELLS:
 CURRENT USAGE     MAXIMUM CELLS        HIGH WATER
         36             35453                   46
                     PROCESS STACK CELL USAGE
 USER    JOBNAME ASID       PID       PPID STATE    THREADS STACKS
 NO PROCESSES FOUND USING 50 OR MORE SPACE SWITCHED STACK CELLS.
```

In Example 1-8, **KERNELSTACKS** is set to value **ABOVE**.

Example 1-8   Displaying OMVS storage information if KERNELSTACKS is set to ABOVE

```
$> cn "d omvs,o" | grep KERNELSTACKS
 KERNELSTACKS   = ABOVE
$> cn "d omvs,storage"
 BPX0075I 13.01.46 DISPLAY OMVS 919
 OMVS     0011 ACTIVE              OMVS=(74,2A)
                     KERNEL STORAGE USAGE
 PRIVATE STORAGE:
 CURRENT USAGE     MAXIMUM AVAILABLE     HIGH WATER      REGION SIZE
    147451904         1815228416         163024896       1830789120
 THREADS:
 CURRENT USAGE     MAXIMUM THREADS      HIGH WATER
         87            500000                  108
                     PROCESS THREAD USAGE
 USER    JOBNAME ASID       PID       PPID STATE    THREADS
 NO PROCESSES FOUND USING 50 OR MORE THREADS
```

2

z/OS UNIX Shell and Utilities man pages

The z/OS UNIX Shell and Utilities is the complementary part in z/OS to communicate with the IBM UNIX implementation.

This chapter introduces the features and benefits of the new z/OS UNIX man pages.

7

2.1 New z/OS UNIX man pages

The z/OS UNIX man command used IBM BookManager® format for manual pages. ID does not support the BookManager format; instead, it supports the Darwin Information Typing Architecture (DITA) format for document data.

> **Note:** Consider the following points:
> - ▶ An ID attribute assigns a unique identifier to an element so the element can be referenced.
> - ▶ ID values can be generated on request or automatically for DITA elements.
> - ▶ The DITA is an XML data model for authoring and, with the DITA Open Toolkit, publishing.

To use ID, z/OS UNIX man command was updated in z/OS V2R2 to support a new format, Single Tagged pre-Formatted Plain Text (`.stfpt`) for manual pages. The DITA format file can be converted to the new format `.stfpt` manual page.

2.1.1 Advantages of and search processing the new implementation

The new z/OS UNIX man pages enhancements provide the following key advantages:

- ▶ The manual of UNIX System Services Command is converted from DITA to `.stfpt` format and displayed by the man command transparently.
- ▶ The new z/OS UNIX man command does no longer support cached versions of manual pages because of security considerations.

  The older man command used cached versions of manual pages in the UNIX System Services file system, even if it was a zero-byte file, which was invalid.

> **Note:** Consider the following points:
> - ▶ The BookManager format manual is still supported, but now has low priority in comparison to the new format `.stfpt` manual file.
> - ▶ The BookManager manual page of UNIX System Services Command `bpxa5mst.book` will not be delivered.

The man command searches MANPATH for the following files in the order listed:

- ▶ `catn/entry.n` in each directory in MANPATH
- ▶ `mann/*.stfpt` in each directory in MANPATH
- ▶ `mann/*.book` in each directory in MANPATH
- ▶ `mann/entry.n` in each directory in MANPATH

2.1.2 Examples of the use of new man command options

Example 2-1 shows that option -x can be used to see all the files that are searched. The first and last five lines are shown for reference.

Example 2-1   Use of option -x to list where the man command looks for the wanted information

```
$> man -x ls 2>&1 | head -15
Trying /usr/lpp/Printsrv/man/En_US/cat1/ls.1
Trying /usr/lpp/Printsrv/man/En_US/man1/*.stfpt
Trying /usr/lpp/Printsrv/man/En_US/man1/*.book
Trying /usr/lpp/Printsrv/man/En_US/man1/ls.1
Trying /usr/lpp/Printsrv/man/En_US/cat2/ls.2
$> man -x ls 2>&1 >/dev/null | tail -5
Trying /usr/man/C/man1/*.stfpt
Trying /usr/man/C/man1/*.book
        Trying /usr/man/C/man1/bpxa5mst.book
        Looking for topic "ls" in /usr/man/C/man1/bpxa5mst.book
        And converting to codepage 1047
```

Example 2-2 shows how to search for information about keywords.

Example 2-2   Use of option -k to search for information about keywords

```
$> man -k owner
chgrp       - Change the group owner of a file or directory
chown       - Change the owner or group of a file or directory
getfacl     - Display owner, group and ACL
$> man -k group
chgrp       - Change the group owner of a file or directory
chown       - Change the owner or group of a file or directory
getfacl     - Display owner, group and ACL
newgrp      - Change to a new group
```

3

z/OS UNIX file system support in ISPF

The Interactive System Productivity Facility (ISPF) product helps with program development and uses the characteristics of IBM display terminals to increase users productivity in an interactive environment.

This chapter describes the new z/OS UNIX file system support in ISPF that is introduced with IBM z/OS V2R2 and includes the following topics:

3.1 New functions for the ISPF option 3.17

In z/OS V2R2, the following file system-related functions were added to ISPF option 3.17:

- ► The z/OS UNIX ISPF Shell (ISHELL) file system functions were added.
- ► Enhanced displays for mounted file systems:
  - – Lists can be shown ordered by file system name or mount point name.
  - – Lists can be expanded and collapsed to improve usability.

The enhancements have the following advantages:

- ► File system functions are consolidated in a single location. In older versions, the following functions were available with UNIX file systems:
  - – Mount Table functions in the z/OS UNIX ISPF Shell (ISHELL)
  - – z/OS UNIX Directory List Utility (udlist) of ISPF option 3.17
- ► The usability for displaying mounted file systems was improved.
- ► There are practical usability issues when many file systems must be displayed and managed in the ISHELL mount table.

3.2 Showing the new functions

In this section, we describe some of the new functions.

Figure 3-1 shows the new File Systems menu that was added to ISPF option 3.17.

Figure 3-1   New File Systems menu in ISPF option 3.17

Figure 3-2 shows expanding and collapsing list entries for access to files systems.

```
   Menu   Utilities   Options   Help
 _____
                         z/OS UNIX Mounted File Systems          Row 1 from 82

    File System Name               Mount Point                        Type
 ------------------------------------------------------------------------------
 ___     *AMD/u                     /u                                ZFS
 ___     /DEV                       /SC74/dev                         ZFS
 ___     /SC74/TMP                  /SC74/tmp                         ZFS
 ___     /SC75/TMP                  /SC75/tmp                         ZFS
 ___   +BBN.**
 ___   +CEA.**
 ___   +CFZSRV.**
 ___   +CICST42A.**
 ___   -HERING.**
 ___    -HERING.TEST.**
 ___      HERING.TEST.ZFS          /u/hering/test                    ZFS
 ___      HERING.ZFS               /u/hering                         ZFS
 ___   +JES2.**
 ___   +OMVS.**
 ___   +PFA.**
 ___   +PLEX75.**
 ___   +RDZ760.**
 ___   +RDZ801.**
 ___   +TWS.**
 ****************************** Bottom of data **********************************



 Command ===> _____ Scroll ===> CSR
  F1=Help      F3=Exit      F4=Expand    F10=Actions   F12=Cancel
```

Figure 3-2   Expand/contract list entries for access to files systems

Note: Consider the following points:

► The ISHELL is still available for use. The mount table function is still used often.

► If udlist was used in parallel with the ISHELL mount table, see "Utility RXISHMT" on page 42 for more information about an ISHELL mount table only function that is used with filter functions.

4

Enhancements for the System z file system

The z/OS Distributed File Service System z® File System (zFS) is a z/OS UNIX file system that is used in parallel with the hierarchical file system (HFS).

This chapter describes new support and enhancements for zFS in z/OS V2R2 and includes the following chapters:

4.1 zFS 64-bit Support

z/OS V2R2 zFS provides the following enhancements for storage limitations, cache structures, and CPU usage:

- ► 64-bit addressability
- ► A new log method
- ► Elimination of the metadata backing cache and keeping only the use of one metadata cache
- ► Running zFS in the OMVS address space

These enhancements result in the following benefits:

- ► Elimination of issues with running out of storage below the bar
- ► Use of bigger caches and a larger trace history
- ► Improved metadata performance, especially for parallel updates to the same v5 directory
- ► Improved vnode operations

4.1.1 zFS cache enhancements

In z/OS V2R2, a new log caching facility is used and statistics are available in a new format.

The statistics log cache information is available via the zFS API service command ZFSCALL_STATS (0x40000007), option code 247. Consider the following points:

- ► Specifying Version 1 returns the old structure API_LOG_STAT data.
- ► Specifying Version 2 returns the new structure API_NL_STATS data.
- ► z/OS UNIX command `zfsadm query -logcache` and MVS system command `MODIFY ZFS,QUERY,LOG` support the new statistical data.

The following types of caches are no longer available or used:

- ► The Transaction cache was removed.

  With improved logging method, it is no longer needed.

- ► The Client cache was removed.

  z/OS V1R12 cannot coexist with z/OS V2R2; therefore, it is no longer needed.

Elimination of the metadata backing cache

As 64-bit support allows zFS to obtain caches above the bar, there is no longer a need to define a metaback cache in data spaces.

Consider the following points:

- ► The zFS parmlib member option `metaback_cache_size` is used for compatibility.
- ► zFS internally combines meta cache and metaback cache and allocates one cache in zFS address space storage.
- ► It is suggested that where appropriate, remove the `metaback_cache_size` option from your zFS parmlib members and add its value to the `meta_cache_size` option.

4.1.2 Health check for zFS cache removals

There is a health check that is named ZFS_CACHE_REMOVALS to monitor zFS cache removals. Consider the following points:

► The health check determines whether zFS is running with parmlib configuration options `metaback_cache_size`, `client_cache_size`, and `tran_cache_size`.

► Specifying any of the options causes an exception. Therefore, we suggest that not to these options are not specified.

The following override check parameters keywords are available:
► METABACK
► CLIENT
► TRANS

The possible values are `ABSENCE` or `EXISTENCE`. Example 4-1 shows a sample of the parameter setting for this health checker.

Example 4-1   Sample parameter setting for the ZFS_CACHE_REMOVALS health checker

```
PARM('METABACK(EXISTENCE), CLIENT(EXISTENCE), TRANS(EXISTENCE)')
```

If active, the severity is set to low.

4.1.3 Statistics Storage Information API

In z/OS V2R2, a new Statistics Above 2G Storage Information API was introduced. It is available via zFS API service command **ZFSCALL_STATS** (0x40000007), opcode 255 and named STATOP_STORAGE_ABOVE.

> **Note:** The Statistics Storage Information API STATOP_STORAGE option code 241 uses API_STOR_STATS2 for Version 2.

The `MODIFY ZFS,QUERY,STORAGE,DETAILS` command provides many free lists for serviceability. An example is shown in Figure 4-1.

```
                    zFS Primary Address Space >2G Stge Usage
                    ----------------------------------------

Total Storage Above 2G Bar Available:          209715200K
Total Storage Above 2G Bar Allocated:          1457520640

Total Bytes Allocated by IOEFSCM (Stack+Heap):    3145728
IOEFSCM Heap Bytes Allocated:                     3145728
IOEFSCM Heap Pieces Allocated:               66
IOEFSCM Heap Allocation Requests:            66
IOEFSCM Heap Free Requests:                   0

Total Bytes Allocated by IOEFSKN (Stack+Heap):  317718528
Total Bytes Discarded (unbacked) by IOEFSKN:      6242304
IOEFSKN Heap Bytes Allocated:                   283492216
IOEFSKN Heap Pieces Allocated:           633099
IOEFSKN Heap Allocation Requests:        648930
IOEFSKN Heap Free Requests:               15831
```

Figure 4-1   zFS storage information above 2 GB

4.1.4 Running zFS within the OMVS address space

In z/OS V2R2, zFS can run in the OMVS address space. Depending on the workload circumstances, this configuration might reduce CPU usage based on the shorter path lengths.

Consider the following points if you want to move zFS into the OMVS address space:

► You must remove the ASNAME keyword in the FILESYSTYPE statement for zFS in the BPXPRMxx parmlib member.

► If you still use the IOEZPRM DD statement in the zFS STC to point to the zFS configuration parameters, this DD statement should be added to the OMVS STC.

► If OMVS does not use the value that is defined in IBM-supplied Program Properties Table (PPT), ensure that the OMVS ID has the proper privileges as the zFS STC user ID did.

This issue might not be a problem because the OMVS user ID also is set up with high authority as is zFS.

► You must use the new `MODIFY OMVS,PFS=ZFS` command to address `zFS MODIFY` commands to zFS because there is no extra zFS STC active.

> **Note:** For more information about this new command interface, see "MODIFY OMVS command enhancement" on page 2 and "Addressing PFS commands to zFS and TFS" on page 3.

4.1.5 Specifying larger values with the 64-bit zFS support

The new 64-bit support provides support for larger caches; the value ranges are listed in Table 4-1.

Table 4-1   Old and new cache range values

zFS configuration options	Old range	New range
vnode_cache_size	32 - 500,000	1000 - 10,000,000
meta_cache_size	1 M – 1024 M	1 M – 64 G
token_cache_size	20480 – 2,621,440	20480 – 20,000,000
trace_table_size	1 M – 2048 M	1 M – 65535 M
xcf_trace_table_size	1 M – 2048 M	1 M – 65535 M

The larger numbers use the following suffixes for counters and storage sizes:

► For counters:

  – t: Units of 1,000
  – m: Units of 1,000,000
  – b: Units of 1,000,000,000
  – tr: Units of 1,000,000,000,000

► For storage sizes:

  – K: Units of 1,024.
  – M: Units of 1,048,576.
  – G: Units of 1,073,741,824
  – T: Units of 1,099,511,627,776

4.1.6 Migration and coexistence considerations

Several required actions and possibilities are described in this section that are based on the conditions and software levels that were available at the time of this writing. We suggest you research the APAR numbers for any other related information.

Toleration APAR OA46026

Toleration APAR OA46026 must be installed and active on all z/OS V1R13 and z/OS V2R1 systems before z/OS V2R2 is introduced.

Consider the following points regarding the new format of the log cache statistics:

► Down level systems can recognize the new logging method and run the new log recovery and return Version 1 output, although most of the API_LOG_STAT values are 0.

► Applications that use STATOP_LOG_CACHE (opcode 247) to request Version 1 output must be updated to use Version 2 output.

► z/OS UNIX command `zfsadm query -logcache` and MVS system command `MODIFY ZFS,QUERY,LOG` return the new statistics.

Removing transaction cache and client cache

If the zFS parmlib configuration option tran_cache_size or client_cache_size are used, the specifications are ignored.

Use of Statistics APIs

Consider the following points regarding the use usage of Statistics APIs:

- The use of STATOP_USER_CACHE (opcode 242) remote VM_STATS are shown as all zero for Version 1 requests. No remote VM_STATs are provided for Version 2 requests.

  Version 1 requests should be updated to Version 2 to receive the new output.

- When STATOP_TRAN_CACHE (opcode 250) is used, all zeros are returned for Version 1 requests and nothing is returned for Version 2 requests.

  You should use STATOP_LOG_CACHE (opcode 247) with a Version 2 request to get the new output.

- The use one of Query Config Option tran_cache_size setting (opcode 208), client_cache_size setting (231) or Set Config Option tran_cache_size (opcode 160), client_cache_size (opcode 230) APIs has no effect.

Using commands

Consider the following points regarding the use of commands:

- Commands `zfsadm config` or `zfsadm configquery` with options `-tran_cache_size` or `-client_cache_size` have no effect, as shown in Example 4-2.

Example 4-2   Output of command zfsadm configquery -client_cache_size

```
$> zfsadm configquery -client_cache_size
IOEZ00317I The value for configuration option -client_cache_size is 32M.
IOEZ00668I zFS Configuration option -client_cache_size is obsolete and is not
used.
```

- Command `zfsadm query -trancache` now displays all zeros. We suggest removing the use of the command.

- In the `MODIFY ZFS,QUERY,LFS` command report transaction, cache data was removed.

4.2 zFS enhanced and new functions

The following main enhancements were added in z/OS V2R2:

- The 4-byte counters (version 1) are replaced by 8-byte counters (version 2).
- Three new sysplex-related APIs are provided.
- A new powerful FSINFO function to obtain detailed file system information was introduced.

These enhanced new functions provide the following benefits:

- Monitoring statistics over a much longer period is possible.
- Improved performance in the use of API services.
- FSINFO provides more detailed information for single and multiple file systems in a faster and more flexible manner, including sysplex-wide information.
- More detailed statistics per file system.

4.2.1 New 8-byte counter support

The following APIs that manage statistic numbers now support 8-byte counters:

► STATOP_LOCKING (opcode 240)
► STATOP_STORAGE (opcode 241)
► STATOP_USER_CACHE (opcode 242)
► STATOP_IOCOUNTS (opcode 243)
► STATOP_IOBYAGGR (opcode 244)
► STATOP_IOBYDASD (opcode 245)
► STATOP_KNPFS (opcode 246)
► STATOP_META_CACHE (opcode 248)
► STATOP_VNODE_CACHE (opcode 251)

The `zfsadm query` and `MODIFY QUERY` commands are affected by the new 8-byte counters; therefore, we suggest that you review any automation or scripts that parse or reference the output from the commands.

4.2.2 New sysplex-related APIs

The following new sysplex-related APIs are available:

► Statistics Sysplex Client Operation Info, named STATOP_CTKC (opcode 253)

  This API returns information about the number of local operations that required sending a message to another system.

► Server Token management Info, named STATOP_STKM (opcode 252)

  This API returns the server token manager statistics.

► Statistics Sysplex Owner Operation, named STATOP_SVI (opcode 254)

  This API returns information about the number of calls that were processed on the local system as a result of a message that was sent from another system.

zfsadm query commands

The API is used by the following new zfsadm query options:

► `zfsadm query -ctkc`
► `zfsadm query -stkm`
► `zfsadm query -svi`

zFS MODIFY commands

The following `MODIFY ZFS,QUERY` commands now support 8-byte counters:

► `MODIFY ZFS,QUERY,CTKC`
► `MODIFY ZFS,QUERY,STKM`
► `MODIFY ZFS,QUERY,SVI`

New FSINFO interface

The new and powerful FSINFO interface provides the following enhancements:

► A `zfsadm` command.
► A detailed file system API command that is named `ZFSCALL_FSINFO` (0x40000013).
► A `zFS MODIFY` command.
► Support for 8-byte counters.

> **Tip:** We recommend the use of FSINFO instead of List Aggregate Status (opcode 135 or 140) or List File system status (opcode 142).

4.2.3 z/OS UNIX command zfsadm fsinfo

Figure 4-2 shows syntax information for the `zfsadm fsinfo` command.

```
zfsadm fsinfo [-aggregate name | -path path_name | -all]
              [-basic |-owner | -full |-reset]
              [-select criteria | -exceptions]
              [-sort sort_name][-level][-help]
```

Figure 4-2   zfsadm fsinfo syntax

Available fsinfo options

The `fsinfo` command features the following options:

- ► `-aggregate name`

  This option is used to specify the name of the aggregate. Use an asterisk (*) at the beginning, end, or both of the name as a wildcard. When wildcards are used, the default display mode is `-basic`. Otherwise, the default display is `-owner`.

- ► `-path path_name`

  This option specifies the path name of a file or directory that is contained in the file system. The default information display is `-owner`.

- ► `-all`

  This option displays information for all aggregates in the sysplex. The default information display is `-owner`.

- ► `-basic`

  This option displays a line of basic file system information for each specified file system.

- ► `-owner`

  This option displays only information that is maintained by the system that owns each specified file system.

- ► `-full`

  This option displays information that is maintained by the system that owns each specified file system. It also displays information that is locally maintained by each system in the sysplex that has each specified file system locally mounted.

- ► `-reset`

  This option resets zFS statistics that relate to each specified file system. This option requires system administrator authority.

Displaying information about aggregates with exceptional conditions

Use the `-exceptions` option to display information about aggregates with exception conditions. Table 4-2 on page 23 lists the available exceptions.

Table 4-2   Available exceptions

Exceptions	Description
CE	XCF communication failures between clients systems and owning systems
DA	Marked damaged by the zFS salvager
DI	Disabled for reading and writing
GD	Disabled for dynamic grow
GF	Failures on dynamic grow attempts
IE	Disk IO errors
L	Less than 1 MB of free space; forces increased XCF traffic for writing files
Q	Currently quiesced
SE	Returned ENOSPC errors to applications
V5D	Shown for aggregates that are disabled for conversion to version 1.5

Specifying select criteria

Use the **-select** option to indicate that each specified file system that matches the criteria is displayed. Multiple criteria are separated by commas, such as **-select Q,DI,L**.

Note: This option cannot be specified with **-exceptions**, **-reset**, and **-path**.

To use this select option, specify one or more select criteria that are listed in Table 4-3.

Table 4-3   Selection criteria

Criteria	Description
CE	XCF communication failures between clients systems and owning systems
DA	Marked damaged by the zFS salvager
DI	Disabled for reading and writing
GD	Disabled for dynamic grow
GF	Failures on dynamic grow attempts
GR	Currently being grown
IE	Returned ENOSPC errors to applications
L	Less than 1 MB of free space; forces increased XCF traffic for writing files
NS	Mounted NORWSHARE
OV	Extended (v5) directories that are using overflow pages
Q	Currently quiesced
RQ	Had application activity
RO	Mounted read-only
RW	Mounted read/write
RS	Mounted RWSHARE (sysplex-aware)

Criteria	Description
SE	Returned ENOSPC errors to applications
TH	Having sysplex thrashing objects in them
V4	Aggregates that are version 1.4
V5	Aggregates that are version 1.5
V5D	Aggregates that are disabled for conversion to version 1.5
WR	Had application write activity

Requesting sorted display data

Use the **-sort** *sort_name* option to specify that the information that is displayed is sorted as specified by the value of sort name, as listed in Table 4-4.

Table 4-4   Sort names for sorting information that is displayed

sort_name	Function
Name	Sort by file system name, in ascending order. This option is the default.
Requests	Sort by the number of external requests that are made to the file system by user applications, in descending order. The most actively requested file systems are listed first.
Response	Sort by response time of requests to the file system, in descending order. The slower responding file systems are listed first.

Note: This option cannot be specified with **-reset**.

General zfsadm options

For other **zfsadm** commands, **fsinfo** supports the following options:

► -level

This option prints the level of the **zfsadm** command. Except for **-help**, all valid options that are specified with **-level** are ignored.

► -help

This option prints the online help for this command. All other valid options that are specified with this option are ignored.

4.2.4 Displaying zfsadm fsinfo examples

An example of how to use an asterisk (*) as a wildcard is shown in Figure 4-3.

```
$> zfsadm fsinfo hering*
HERING.TEST.DUMMY.ZFS                          SC74      RW,RS,Q,L
HERING.TEST.ZFS                                SC74      RW,NS,L
HERING.ZFS                                     SC74      RW,RS

Legend: RW=Read-write,Q=Quiesced,L=Low on space,RS=Mounted RWSHARE
        NS=Mounted NORWSHARE
$>
```

Figure 4-3   Use of an asterisk to list all file systems starting with string "hering"

An example that provides a path name is shown in Figure 4-4.

```
$> zfsadm fsinfo -path test -basic
HERING.TEST.ZFS                                SC74      RW,NS,L

Legend: RW=Read-write, L=Low on space, NS=Mounted NORWSHARE

$>
```

Figure 4-4   Listing base information for the zFS to which the specific path belongs

More information about the same path and zFS file system is shown in Figure 4-5.

```
$> zfsadm fsinfo -path test
File System Name: HERING.TEST.ZFS

   *** owner information ***
   Owner:              SC74          Converttov5:            OFF,n/a
   Size:               36000K        Free 8K Blocks:         88
   Free 1K Fragments:  46            Log File Size:          112K
   Bitmap Size:        8K            Anode Table Size:       80K
   File System Objects: 257          Version:                1.5
   Overflow Pages:     0             Overflow HighWater:     0
   Thrashing Objects:  0             Thrashing Resolution:   0
   Token Revocations:  0             Revocation Wait Time:   0.000
   Devno:              54            Space Monitoring:       0,0
   Quiescing System:   n/a           Quiescing Job Name:     n/a
   Quiescor ASID:      n/a           File System Grow:       ON,0
   Status:             RW,NS,L
   Audit Fid:          C2C8F5E2 E3F20184 0000

   File System Creation Time: Sep  8 09:38:25 2006
   Time of Ownership:         Jul 31 11:57:53 2015
   Statistics Reset Time:     Jul 31 11:57:53 2015
   Quiesce Time:              n/a
   Last Grow Time:            n/a

   Connected Clients:   n/a


Legend: RW=Read-write, L=Low on space, NS=Mounted NORWSHARE

$>
```

Figure 4-5   Listing more information about the zFS to which the specific path belongs

All zFS aggregates that are quiesced or not mounted sysplex-aware are shown in Figure 4-6.

```
$> zfsadm fsinfo -select q,ns
HERING.TEST.DUMMY.ZFS                           SC74     RW,RS,Q,L
HERING.TEST.ZFS                                 SC74     RW,NS,L

Legend: RW=Read-write,Q=Quiesced,L=Low on space,RS=Mounted RWSHARE
        NS=Mounted NORWSHARE
$>
```

Figure 4-6   Listing all quiesced or not sysplex-aware mounted zFS aggregates

You can also retrieve information about zFS aggregates that are not attached, as shown in Figure 4-7 on page 27.

```
$> rxdowner -a hering.largedir.v4
RXDWN004E Aggregate HERING.LARGEDIR.V4 cannot be found.
$> zfsadm fsinfo hering.largedir.v4
File System Name: HERING.LARGEDIR.V4

   *** owner information ***
   Owner:             n/a          Converttov5:          OFF,n/a
   Size:              360000K      Free 8K Blocks:       9152
   Free 1K Fragments: 7            Log File Size:        3600K
   Bitmap Size:       56K          Anode Table Size:     250264K
   File System Objects: 1000003    Version:              1.5
   Overflow Pages:    0            Overflow HighWater:   0
   Thrashing Objects: 0            Thrashing Resolution: 0
   Token Revocations: 0            Revocation Wait Time: 0.000
   Devno:             0            Space Monitoring:     0,0
   Quiescing System:  n/a          Quiescing Job Name:   n/a
   Quiescor ASID:     n/a          File System Grow:     OFF,0
   Status:            NM
   Audit Fid:         C2C8F5D6 C5F1000A 0000

   File System Creation Time: Jun 16 00:48:25 2013
   Time of Ownership:       Aug 12 22:38:19 2015
   Statistics Reset Time:   Aug 12 22:38:19 2015
   Quiesce Time:            n/a
   Last Grow Time:          n/a

   Connected Clients:  n/a


Legend: NM=Not mounted

$>
```

Figure 4-7   Listing information about a zFS aggregate that is not mounted and not attached

4.2.5 New zFS API ZFSCALL_FSINFO (0x40000013)

As for most zFS API calls, the pfsctl (BPX1PCT) application programming interface is used to send requests to the zFS physical file system. The simplified format for FSINFO is shown in Figure 4-8.

```
BPX1PCT("ZFS      ", /* File system type followed by 5 blanks */
        0x40000013, /* ZFSCALL_FSINFO – fsinfo operation */
        parmlen,    /* Length of parameter buffer */
        parmbuf,    /* Address of parameter buffer */
        &rv,        /* return value */
        &rc,        /* return code */
        &rsn)       /* reason code */
```

Figure 4-8   Format of the fsinfo pfsctl() interface call

FSINFO features the following subcommands:

► Query file system info (opcode 153)

This subcommand requires a minimum buffer size of 10 K for a single-aggregate query and 64 K for a multi-aggregate query.

► Reset file system statistics (opcode 154)

This command requires a minimum buffer size of 10 K.

4.2.6 REXX example that uses the new ZFSCALL_FSINFO API

A sample REXX named rxlstqsd that uses the new fsinfo API was created for demonstration and reference for this book. Consider the following points:

► Sample rxlstqsd uses the new pfsctl() command **ZFSCALL_FSINFO** to list all quiesced zFS aggregates in a sysplex sharing environment.

► It was created run in z/OS UNIX, TSO, and as a SYSREXX routine.

► The utility is provided in ASCII text mode as other material for this IBM Redbooks publication. When the utility is transferred from your workstation to z/OS via FTP, it is suggested that you perform the following tasks:

   – Transfer the rxlstqsd.txt file in text mode (not binary) to z/OS UNIX first.

   – Use the FTP **quote site sbd=(1047,819)** subcommand before you run the transfer and rename it to rxlstqsd.

   – From UNIX, you can copy it to a TSO REXX and a SYSREXX library.

How to use the utility from different environments is shown in Figure 4-9.

```
$> rxlstqsd
HERING.TEST.PRELE.ZFS
HERING.TEST.RW.ZFS
HERING.TEST.ZFS
$> cn "f axr,rxlstqsd"
 ZFSQS004I RXLSTQSD on SC74                                              -
 HERING.TEST.PRELE.ZFS
 HERING.TEST.RW.ZFS
 HERING.TEST.ZFS
$> sudo zfsadm unquiesce HERING.TEST.PRELE.ZFS
IOEZ00166I Aggregate HERING.TEST.PRELE.ZFS successfully unquiesced
$> sudo zfsadm unquiesce HERING.TEST.RW.ZFS
IOEZ00166I Aggregate HERING.TEST.RW.ZFS successfully unquiesced
$> sudo zfsadm unquiesce HERING.TEST.ZFS
IOEZ00166I Aggregate HERING.TEST.ZFS successfully unquiesced
$> rxlstqsd
ZFSQS006I There are no quiesced aggregates.
$> tsocmd "rxlstqsd"
rxlstqsd
ZFSQS006I There are no quiesced aggregates.
$>
```

Figure 4-9   Use of rxlstqsd from z/OS UNIX, TSO, and as SYSREXX routine

> **Note:** On a down-level system, you receive a message that you must be at least on z/OS V2R2 to use the utility.

4.2.7 FSINFO zFS Modify interface command

The syntax of the `FSINFO zFS Modify interface` command is similar to the corresponding `zfsadm` command. The syntax is shown in Figure 4-10.

```
modify zFS_procname,fsinfo[,{aggrname | all}
                    [,{full | basic | owner | reset}
                    [,{select=criteria | exceptions}]
                    [,sort=sort_name]]]
```

Figure 4-10   FSINFO zFS Modify interface command

Consider the following points regarding the command:

► Multiple selection criteria are separated by blanks.
► Parameters are positional.

4.2.8 Removing two zFS health checks

In z/OS V2R2, the following zFS health checks were removed because they are no longer needed:

► ZOSMIGV1R13_ZFS_FILESYS
► ZOSMIGREC_ZFS_RM_MULTIFS

4.3 Moving zFS into the OMVS address space

In this section, we described how to move zFS within OMVS.

4.3.1 Move preparation

First, we ensure that we are running with KERNELSTACKS above the bar or at least after the next IPL. The option is shown in Figure 4-11.

```
$> cn "d omvs,o" | grep KERNELSTACKS
 KERNELSTACKS    = ABOVE
$>
```

Figure 4-11   Displaying the OMVS KERNELSTACKS setting

It must be made clear that you have (at least) a BPXPRMxx member that is processed locally on next IPL and assures the new set up, as shown in Figure 4-12.

```
$> echo "The local sysclone value is:" $(sysvar SYSCLONE)
The local sysclone value is: 74
$> cat "//'SYS1.PARMLIB(IEASYS00)'" | grep OMVS
 OMVS=(&SYSCLONE.,&OMVSPARM.),
$> cat "//'SYS1.PARMLIB(BPXPRM74)'"
  KERNELSTACKS(ABOVE)

  FILESYSTYPE TYPE(ZFS)
              ENTRYPOINT(IOEFSCM)
              PARM('PRM=(&SYSCLONE.,00)')
$>
```

Figure 4-12   Showing the BPXPRMxx parmlib settings for KERNELSTACKS and zFS

4.3.2 Moving and running zFS commands

If an IPL was needed to move, check to see whether this move was successful.

Displaying zFS related information and running zFS commands

The **MODIFY ZFS** command is no longer available. You must use the new **MODIFY OMVS,PFS=ZFS** interface, as shown in Figure 4-13.

```
$> cn "d omvs,p" | grep ZFS
   ZFS         IOEFSCM
   ZFS          PRM=(74,00)
$> cn "f zfs,query,level"
 IEE341I ZFS               NOT ACTIVE
$> cn "f omvs,pfs=zfs,query,level"
 IOEZ00639I zFS kernel: z/OS    zFS
 Version 02.02.00 Service Level OA47915 - HZFS420.
 Created on Fri May 29 13:31:44 EDT 2015.
 sysplex(filesys,rwshare) interface(4)
 IOEZ00025I zFS kernel: MODIFY command - QUERY,LEVEL completed successfully.
$>
```

Figure 4-13   Displaying information about zFS by using the new MODIFY interface

5

z/OS OpenSSH new functions

z/OS OpenSSH is the z/OS implementation of open source product OpenSSH.

This chapter describes the OpenSSH upgrade to 6.4p1 for IBM Ported Tools for OpenSSH V1R3 and z/OS OpenSSH V2R2 and includes the following topics:

► 5.1, "OpenSSH upgrade to 6.4p1" on page 32
► 5.2, "Examples for use of OpenSSH" on page 38

5.1 OpenSSH upgrade to 6.4p1

IBM Ported Tools for z/OS is a non-priced program product; it is not part of the z/OS operating system.

z/OS Ported Tools OpenSSH V1R3 is delivered available now. A follow-on release z/OS OpenSSH V2R2 is scheduled for inclusion in z/OS V2R2.

Note: OpenSSH V1R3 and V2R2 have the same functions.

5.1.1 Overview

z/OS OpenSSH was upgraded to OpenSSH 6.4p1 and includes the following benefits:

► Provides a much more current OpenSSH version
► Same versions of OpenSSL 1.0.1c and zlib 1.2.3 are used
► The ssh-rand-helper tool is no longer supported in 6.4p1
► Support for many new crypto algorithms are included, which provides compatibility with other OpenSSH or SSH implementations that prefer to use these new algorithms
► Many functional enhancements

Important: As ssh-rand-helper is no longer supported in 6.4p1, ICSF is now required.

5.1.2 Enhanced ICSF support

AES-CTR mode support was added to ICSF via APAR OA45548. It was added to work similar to g AES-CBC mode ICSF support.

The following OpenSSH algorithm names are affected:

► aes128-ctr
► aes192-ctr
► aes256-ctr

Note: Consider the following points:
► AES-CTR is Advanced Encryption Standard (AES) Counter mode
► AES-CBC is Cipher Block Chaining
► AES-CTR is preferred over AES-CBC

The change was made because z/OS OpenSSH must support ICSF acceleration of CTR mode AES ciphers. This support is important because the defaults in open source OpenSSH recently changed so that AES-CTR is preferred over AES-CBC. For these connections, ICSF acceleration previously was not available.

Note: This enhancement may provide the benefit of reducing CPU usage over software implementation when AES-CTR Ciphers are used.

5.1.3 Improved SMF support

Support was added for better SSH connection accounting and auditing.

A new triplet was added to the SFTP client transfer SMF record for the target path name. The SFTP client did not record the target path name in the past.

A new SMF 119 record was created that is written at the beginning of a successful SSH connection, just after user authentication. The SSH client and SSHD server feature their own new subtypes.

Existing Common TCPIP and SSH Common Security triplets are included.

Note: Access to `BPX.SMF` is required to record the SSH client connection started record because the SSH client is not APF authorized.

5.1.4 Support for the TSO OMVS shell

The SSH client can be started under a TSO OMVS shell. However, entering password credentials is still not allowed so that exposures and displaying passwords is prevented.

This configuration makes diagnosing connection and handshake problems easier for many customers.

It allows verifying a working network connection, acceptance of server host keys, and a completed connection if a password is not required.

Note: Passwords are not required if SSH user keys are used.

5.1.5 Relaxing the syntax of IdentityKeyRingLabels

The IBM-added option IdentityKeyRingLabel was complex to use in a shell script because literal double-quotes are required. This problem was solved with the implementation of the following changes:

► The syntax of IdentityKeyRingLabel was relaxed so that double quotes are optional when it is entered from an SSH, SFTP, or SCP command line. However, the quotes are still required when the keyword appears in the `zos_ssh_config` or `authorized_keys` files.

► The HostKeyRingLabel is similarly relaxed so that double quotes are not required when this keyword is used on an SSHD command line.

► The old syntax still works.

Note: Difficult multiple shell script escape sequences are no longer required.

5.1.6 Use of OpenSSH

The use of OpenSSH is described in this section,.

Key Exchange algorithms

Key exchange (also known as *key establishment*) is any method in cryptography by which cryptographic keys are exchanged between two parties that allows the use of a cryptographic algorithm.

The following Key Exchange algorithms can now be specified via the **-oKexAlgorithms** option:

► Old algorithms:

  – `diffie-hellman-group1-sha1`
  – `diffie-hellman-group14-sha1`
  – `diffie-hellman-group-exchange-sha1`
  – `diffie-hellman-group-exchange-sha256`

► New National Institute of Standards and Technology (NIST) Elliptic-curve algorithms:

  – `ecdh-sha2-nistp256`
  – `ecdh-sha2-nistp384`
  – `ecdh-sha2-nistp521`

Key algorithms

The following Key algorithms are supported:

► Old algorithms: ssh-rsa and ssh-dss

► New NIST Elliptic-curve DSA with SHA-2 algorithms added:

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

► OpenSSH certificates also were added.

> **Note:** Non-standard non-RFC names are marked with "0@openssh.com".

Cipher algorithms

In cryptography, a cipher (or cypher) is an algorithm for performing encryption or decryption.

The following cipher algorithms are supported. The default preference order is as shown. New ciphers are highlighted in bold and ICSF support is noted by * (already supported) or ** (newly supported):

► `aes128-ctr**, aes192-ctr**, aes256-ctr**, and arcfour256,arcfour128,`

► **`aes128-gcm@openssh.com`** and **`aes256-gcm@openssh.com,`**

► `aes128-cbc*, 3des-cbc*, blowfish-cbc, and cast128-cbc, aes192-cbc*,`

► `aes256-cbc*, arcfour, and rijndael-cbc@lysator.liu.se*`

> **Note:** The new ciphers are called AES Gallois Counter Mode (GCM) ciphers. These ciphers function as cipher and HMAC in one.

MAC algorithms

In cryptography, a message authentication code (MAC) is a short piece of information that is used to authenticate a message and provide integrity and authenticity assurances on the message.

A keyed-hash message authentication code (HMAC) is a specific construction for calculating a MAC that includes a cryptographic hash function with a secret cryptographic key.

The following MAC algorithms are supported. The default preference order is as shown. New MAC algorithms are highlighted in bold and ICSF support is denoted by * (already supported) or ** (newly supported).

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

> **Note:** Consider the following points:
>
> - ▶ SHA-2 algorithms added are supported with ICSF.
>
> - ▶ Support for the umac algorithm support was added. A message authentication code that is based on universal hashing, or UMAC, is a type of MAC that is calculated choosing a hash function from a class of hash functions according to some secret (random) process and applying it to the message.
>
> - ▶ The -etm@openssh.com algorithms are not new algorithms. These algorithms are variants that indicate that the MAC is calculated after encryption (Encrypt-then-MAC) rather than the inverse.

Dynamic port assignment for remote port forwarding

You can use the `ssh -R 0:`*`host`*`:`*`port`* command for dynamic port assignment. A remote port of 0 can be specified in which case a dynamic port is assigned on the server. The client reports 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 certificates are not X.509 certificates. Rather, these certificates are a simpler implementation that is unique to OpenSSH. A single key (CA key) can sign (vouch for) the public keys of many users or servers. If a host or user trusts the CA public key, it implicitly accepts the keys that were signed by it.

Multiple user authentication methods

The server (see **AuthenticationMethods** in the `sshd_config` file) can specify that more than one authentication method is required for a user or for all users. For example, it can be requested to need a key and to enter a password.

SFTP enhancements

The following SFTP enhancements are available:

- ▶ Support for recursively transferring files in a directory tree via **get -r** and **put -r**
- ▶ SFTP server read-only mode
- ▶ SFTP **df** command for displaying file system attributes
- ▶ Improved performance of directory listings
- ▶ Support of the **ls -h** option - **human** readable file attribute units

5.1.7 Eliminating ssh-rand-helper function

z/OS OpenSSH now requires a working `/dev/random` UNIX device. Consider the following points:

- ▶ The **ssh-rand-helper** function was slow, not as secure, and often timed out.
- ▶ ICSF `/dev/random` support is now required to start SSH or SSHD.
- ▶ If `/dev/random` is not available, SSH and SSHD start fails and results in the following error message:

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

> **Note:** Consider the following points:
>
> - ▶ A crypto card is not required With HCR77A0.
> - ▶ CSFRNG check can be skipped by defining a resource in class XFACILIT that is named `CSF.CSFSERV.AUTH.CSFRNG.DISABLE`.

5.1.8 SMF records

For more information about the new functions that were implemented, see "Improved SMF support" on page 33.

New algorithms are added to the related SMF records. The SFTP client records target path name was added in subtype 97. Another triplet was added to this record that contains the target (remote) path name for a SFTP client file transfer.

The following new SMF 119 records were added. The SSH client and SSHD server feature their own new subtypes:

- ▶ Type 94 (x"5E"): Client connection started record
- ▶ Type 95 (x"5F"): Server connection started record

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; this identifies which algorithms were used

5.1.9 Migration and coexistence considerations

Consider the following points regarding migration actions and coexistence:

- ► As in previous releases, protocol 1 is disabled by default.
- ► Different from the open source Version 6.4 of OpenSSH, SFTP is changed so that non-error messages are not printed to `stdout` if a batch file (**-b**) is run.

  In effect, the **-q** (quiet mode) option is turned on with **-b** and cannot be turned off. Because this configuration affects many installations, it was changed in the z/OS port so that **-b** does not force **-q**. The **-q** option can be specified in addition to **-b**.

  Therefore, this action is not a migration action; however, the behavior is not consistent with other implementations.

- ► Preferences for GlobalKnownHostsFile in ssh_config:

  `/etc/ssh/ssh_known_hosts, /etc/ssh/ssh_known_hosts2`

- ► Preferences for IdentityFile in ssh_config:

  For protocol version 2, the default is:

  `~/.ssh/id_rsa, ~/.ssh/id_dsa, and ~/.ssh/id_ecdsa`

- ► Preferences for UserKnownHostsFile in ssh_config:

  `~/.ssh/known_hosts, ~/.ssh/known_hosts2`

- ► Preferences for AuthorizedKeysFile in sshd_config:

  `.ssh/authorized_keys, .ssh/authorized_keys2`

- ► Preferences for HostKey in sshd_config:

  `/etc/ssh/ssh_host_rsa_key, /etc/ssh/ssh_host_dsa_key and /etc/ssh/ssh_host_ecdsa_key`

> **Note:** We do not show all the configuration file and command changes here. For more information, see *OpenSSH User's Guide* SC27-6806.

5.1.10 OpenSSH Installation

Consider the following points regarding installation:

- ► z/OS Ported Tools OpenSSH V1R3 is supported in z/OS 1.13 and later.
- ► OpenSSH V2R2 is packaged as a base element of z/OS V2R2.
- ► ICSF FMID HCR7780 or later is required with PTF for APAR OA45548. OpenSSH V1R3 and V2R2 do not run without ICSF started because `/dev/random` is now required.

> **Note:** HCR77A0 or later supports `/dev/random` without a crypto card.
>
> HCR77A1 allows for SAF checking of CSFRNG to be disabled.

Figure 5-1 shows the updated parts of OpenSSH for z/OS V1R3 and that routine ssh-rand-helper was removed.

```
/bin/ssh
/bin/scp
/bin/sftp
/bin/ssh-add
/bin/ssh-agent
/bin/ssh-keygen
/bin/ssh-keyscan
/usr/lib/ssh/ssh-keysign
usr/lib/ssh/sftp-server
/usr/sbin/sshd
/usr/lib/nls/msg/C/openssh.cat
/usr/man/C/man1/fotz200.book
/samples/ssh_smf.h
SYS1.MACLIB(FOTSMF77)
```

Figure 5-1   Updated OpenSSH parts

5.2 Examples for use of OpenSSH

Basic examples for the use of OpenSSH are described in this section.

5.2.1 Verifying version and showing basic debug information

Example 5-1 shows how to verifying the version of the SSH command.

Example 5-1   Verifying the actual version of the SSH command

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

In Example 5-2 on page 38, we show a simple way for getting basic debug information on running SSHD in test mode by using option **-t**. This options checks only the validity of the sshd_config configuration file and the sanity of the keys.

Example 5-2   Testing the sshd command

```
$> sudo /usr/sbin/sshd -dt
debug1: zsshSmfTestRecord: SMF is collecting type 119, subtype 96 records
debug1: sshd version OpenSSH_6.4, OpenSSL 1.0.1c 10 May 2012
debug1: read PEM private key done: type RSA
debug1: private host key: #0 type 1 RSA
debug1: read PEM private key done: type DSA
debug1: private host key: #1 type 2 DSA
debug1: could not open key file '/etc/ssh/ssh_host_ecdsa_key': EDC5129I No such
file or directory. (errno2=0x05620062)
FOTS1438 Could not load host key: /etc/ssh/ssh_host_ecdsa_key
$>
```

The error message is shown because no such key file was provided. This error does not mean that the server cannot start normally.

5.2.2 Use of SFTP from TSO OMVS and a PuTTY session

Two examples are described in this section. When a session is open to node WTSC70OE, the authorization is achieved by a keypair. As with WTSC74OE, no keys are available and you must enter a password, which is still not permitted from OMVS.

Example 5-3 shows how starting a session can be achieved by using OMVS.

Example 5-3   Use OMVS for starting SFTP sessions

```
$> echo We are logon in system $(sysvar SYSNAME).
We are logon in system SC65.
$> id
uid=888(HERING) gid=2(SYS1) groups=1047(USSTEST)
$> sftp hering@wtsc70oe
Connected to wtsc70oe.
sftp> pwd
Remote working directory: /u/hering
sftp> cd /tmp
sftp> pwd
Remote working directory: /SC70/tmp
sftp> quit
$> sftp hering@wtsc74oe
FOTS3322 Passwords may not be entered from 3270 terminals
FOTS0841 Connection closed
```

In Example 5-4, we see the option of starting from within a PuTTY session.

Example 5-4   Using a PuTTY session for starting sftp sessions

```
$> sftp hering@wtsc74oe
hering@wtsc74oe's password: xxxxxxxx
Connected to wtsc74oe.
sftp> cd /tmp
sftp> pwd
Remote working directory: /SC74/tmp
sftp> quit
```

5.2.3 Use of ISPFSFTP utility

There is a utility available for the use of SFTP from TSO. It also provides a useful batch interface. For more information, see 6.3, "ISPFSFTP utility" on page 45.

6

z/OS UNIX Tools and Solutions

This chapter describes several z/OS UNIX utilities and provides examples for achieving a specific goal. The tools that are described in this chapter are available at the following ITSO website:

ftp://www.redbooks.ibm.com/redbooks/SG247035/

This chapter includes the following topics:

- ► 6.1, "Utility RXISHMT" on page 42
- ► 6.2, "zFS zfsfsutl utility" on page 43
- ► 6.3, "ISPFSFTP utility" on page 45
- ► 6.4, "rxdowner utility" on page 47

6.1 Utility RXISHMT

The utility RXISHMT filters the mount table display, which is not supported in ISHELL. The tool is based on the V2R1 version of ISHELL with some extra functions to support the mount table only.

6.1.1 Starting RXISHMT in TSO/ISPF

You can run the utility by using the following command from any ISPF panel command line:

```
tso rxishmt
```

All of your file systems are listed as in the original ISHELL when the mount table display is started.

6.1.2 Use of FILTER command

The use of a new **FILTER** command you can reduce the list according to filter specifications regarding the owning system, mount point, and file system name. The syntax of the command is shown in Figure 6-1.

```
filter [ reset | [o=[*]string[*]] [m=[*]string[*] [f=[*]string[*] ]
```

Figure 6-1   Syntax of the FILTER command

Consider the following points regarding this command:

▸ The **reset** option clears all filter settings and shows the complete list of file systems.

▸ The **o=** option filters entries that are shown according to the owning system.

▸ The **m=** option filters entries that are shown according to the file systems mount point directory.

▸ The option **f=** filters entries that are shown according to the file system name. Filter testing is done against the file system name that is changed to uppercase letters.

▸ In the syntax of the **FILTER** command, *string* remains for a continuous string that is part of an option value.

▸ Specifying an asterisk * at the beginning of a filter value means that the corresponding option value can start with an arbitrary number of characters before the *string* as specified.

▸ Specifying a trailing asterisk * means that the corresponding option value can have an arbitrary number of characters following the *string* as specified.

▸ If "filter" without options is used, you see a panel that shows the current filter options. You can modify the current settings as wanted.

> **Note:** The panel that is displayed and used for this function is the original ISHELL that was used for filtering file entries in a directory list display. Therefore, do not use HELP on that panel.

▸ In all cases, only the specified filter is changed. The other filter settings are not changed.

▸ Only the first three filter specifications are used. If one of the specifications is invalid, you see that at least one filter parameter was invalid and ignored.

6.1.3 Use of the FILTER command

For more information about the sample tools see the corresponding files on the ITSO disk:

`ftp://www.redbooks.ibm.com/redbooks/SG247035/`

The following files are available on the disc:

- ► `rxishmt.pdf`: This file describes the tool `rxishmt`.
- ► `rxishmt.zip`: This file contains the REXX procedure that must be included in a REXX library within the SYSPROC or SYSEXEC library chain.

If the ISHELL is supported, you also can use this tool. It also shares all the ISPF variables and panels with the ISHELL.

If you want to change the mount table display, call the ISHELL and then, call RXISHMT again.

6.2 zFS zfsfsutl utility

In z/OS V2R1, the zFS utilities IOEAGFMT and IOEAGSLV were rewritten in Metal C and for the new super tool that is named IOEFSUTL. Consider the following points:

- ► The utilities no longer can be used in UNIX via external links.
- ► The utilities run as batch utilities only.

  Use SYSPRINT as the output ddname.

  IOEAGFMT and IOEAGSLV switch to another ASID.

- ► IOEFSUTL is the strategic tool and must be used.

A sample of step JCL is shown in Example 6-1.

Example 6-1   Running utility IOEFSUTL in a batch program

```
//VERIFY   EXEC PGM=IOEFSUTL,REGION=0M,
// PARM=('salvage -aggregate HERING.TEST.ZFS -verifyonly')
//SYSPRINT DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//STDERR   DD SYSOUT=*
//SYSOUT   DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//CEEDUMP  DD SYSOUT=*
```

6.2.1 The zfsfsutl tool

The utility can work by incorporating the following modifications:

- ► The zfsfsutl tool allows the use of IOEFSUTL from UNIX:
  - IOEFSUTL stays in its initial ASID when working.
  - IOEFSUTL must be set as an authorized program by adding it to "AUTHPGM NAMES" in the IKJTSOxx parmlib member for TSO.
- ► The zfsfsutl tool performs the following tasks:
  - Uses a temporarily named pipe in the `/tmp` directory that is allocated with ddname SYSPRINT to be used via Address TSO.

- A simple **cp** command is started via **spawnp** to read the data from the pipe and write it to STDOUT (/dev/fd1).
- IOEFSUTL command is addressed to TSO via the following TSO **call** command:

  `call *(ioefsutl)`

6.2.2 Use of the zfsfsutl utility

Example 6-2 shows to two samples of how to use the zfsfsut1 utility to display help information.

Example 6-2   Displaying help information by using zfsfsutl

```
$> zfsfsutl -help
IOEZ00559I zFS IOEFSUTL: Initializing z/OS    zFS
Version 02.01.00 Service Level OA45948 - HZFS410.
Created on Fri Jan 30 15:41:22 EST 2015.
Address space asid x6C
IOEZ00760I No IOEZPRM DD specified. Parmlib search being used.
IOEZ00229I IOEFSUTL:  Commands are:
apropos         search by help text
converttov4     Convert aggregate to version 4
converttov5     Convert aggregate to version 5
format          format an aggregate
help            get help on commands
level           display service level
salvage         Salvage an aggregate
$> zfsfsutl salvage -help
IOEZ00559I zFS IOEFSUTL: Initializing z/OS    zFS
Version 02.01.00 Service Level OA45948 - HZFS410.
Created on Fri Jan 30 15:41:22 EST 2015.
Address space asid x6C
IOEZ00760I No IOEZPRM DD specified. Parmlib search being used.
Usage: IOEFSUTL salvage -aggregate <name> [-verifyonly] [-level] [-help]
$>
```

Example 6-3 shows a sample of verifying a zFS aggregate.

Example 6-3   Verifying a zFS aggregate

```
$> zfsfsutl salvage HERING.TEST.ZFS -verifyonly
IOEZ00559I zFS IOEFSUTL: Initializing z/OS zFS
…
IOEZ00707I Log file size 13 8K blocks, verified correct
IOEZ00729I Verification of aggregate HERING.TEST.ZFS started
IOEZ00705I Formatted v4 aggregate size 2250 8K blocks, dataset size 2250 8K blocks
IOEZ00707I Log file size 13 8K blocks, verified correct
IOEZ00709I Bitmap size 1 8K blocks, verified correct
IOEZ00782I Salvage has verified 1 of 13 pages in the anode table.
IOEZ00782I Salvage has verified 2 of 13 pages in the anode table.
…
IOEZ00782I Salvage has verified 13 of 13 pages in the anode table.
IOEZ00782I Salvage has verified 8 of 8 directories in the directory tree.
IOEZ00782I Salvage has verified 2 of 2 pages in the partially-free page list.
IOEZ00782I Salvage has verified 1 of 1 pages in the totally free page stack.
IOEZ00722I Primary file system size 21 8K blocks, verified correct
IOEZ00739I Salvage processed 10 directory pages, 333 anodes, 18 indirect blocks
```

```
and 13 anode table pages.
IOEZ00730I Verification of aggregate HERING.TEST.ZFS completed, no errors found.
$>
```

Example 6-4 shows how to create and format a non-sms zFS aggregate and perform an initial format of 6000 cylinders.

Example 6-4   Formatting a non-SMS managed zFS initially to 6000 cylinders

```
$> zfsadm define hering.nonsms.zfs -volumes BH5ST3 BH5ST4 BH5ST5 BH5ST6 \
> -cylinders 500 500
IOEZ00248I VSAM linear dataset hering.nonsms.zfs successfully created.
$> tsocmd "alter 'hering.nonsms.zfs' extaddr"
alter 'hering.nonsms.zfs' extaddr
ENTRY HERING.NONSMS.ZFS ALTERED
$> zfsfsutl format hering.nonsms.zfs -size 540000 -grow 4500 \
> -version5
IOEZ00559I zFS IOEFSUTL: Initializing z/OS    zFS
Version 02.02.00 Service Level OA47915 - HZFS420.
Created on Fri May 29 13:31:44 EDT 2015.
Address space asid x54
IOEZ00760I No IOEZPRM DD specified. Parmlib search being used.
IOEZ00004I Formatting to 8K block number 45000 for primary extent of HERING.NONSMS.ZFS.
IOEZ00005I Primary extent loaded successfully for HERING.NONSMS.ZFS.
IOEZ00323I Attempting to extend HERING.NONSMS.ZFS to 49500 8K blocks.
IOEZ00324I Formatting to 8K block number 49500 for secondary extents of HERING.NONSM ...
IOEZ00323I Attempting to extend HERING.NONSMS.ZFS to 54000 8K blocks.
IOEZ00324I Formatting to 8K block number 54000 for secondary extents of HERING.NONSM ...
…
IOEZ00323I Attempting to extend HERING.NONSMS.ZFS to 535500 8K blocks.
IOEZ00324I Formatting to 8K block number 535500 for secondary extents of HERING.NONS ...
IOEZ00323I Attempting to extend HERING.NONSMS.ZFS to 540000 8K blocks.
IOEZ00324I Formatting to 8K block number 540000 for secondary extents of HERING.NONS ...
IOEZ00077I HFS-compatibility aggregate HERING.NONSMS.ZFS has been successfully created
$>
```

Consider the following points regarding the formatting:

► The `IOEFSUTL format` command always creates zFS aggregates with unique FIDs.
► One cylinder of a zFS aggregate contains 90 8 K blocks.
► 4500 8 K blocks are 500 cylinders; 540000 8 K blocks are 6000 cylinders.
► 6000 cylinders of a zFS aggregate contain more than 4 GB of data.

6.3 ISPFSFTP utility

ISPFSFTP is a TSO utility that is used to run SFTP sessions in an interactive mode from the ISPF foreground.

It picks up the terminal emulation code page from ISPF and the user can enter the commands as though the session is set up with code page 01047.

It also supports reaching a target node via private and public key (preferred) or a password. Password support is available via OpenSSH SSH_ASKPASS environment variable if no keys are available.

It also contains UNIX shell scripts for copying files between MVS and UNIX with or without conversion to or from ASCII.

For more information, see the corresponding files on the ITSO disk.

The following files are available on the disc:

- `ispfsftp.pdf`: This file describes the `ispfsftp`tool.
- `ispfsftp.zip`: This file contains all the files of the tool.

6.3.1 Use of the ISPFSFTP utility

This section describes some examples of the use of the ISPFSFTP utility.

Example 6-5 shows a sample of using ispfsftp when keys are used for authentication.

Example 6-5   Use of ispfsftp from ISPF by using keys

```
ispfsftp hering@wtsc70oe
Connected to wtsc70oe.
 sftp>
cd /tmp
 sftp> cd /tmp
 sftp>
pwd
 sftp> pwd
 Remote working directory: /SC70/tmp
 sftp>
quit
 sftp> quit
 ISFTP005I The sftp session ended normally.
 ***
```

Password support can be used, as shown in Example 6-6.

Example 6-6   Use of ispfsftp from ISPF by using its password support

```
ispfsftp hering@wtsc74oe
Connected to wtsc74oe.
 sftp>
cd /tmp
 sftp> cd /tmp
 sftp>
pwd
 sftp> pwd
 Remote working directory: /SC74/tmp
 sftp>
quit
 sftp> quit
 ISFTP005I The sftp session ended normally.
 ***
```

Example 6-7 shows a sample jobstep to start IBATSFTP in batch.

Example 6-7   Sample IBATSFTP JCL step for use of SFTP in batch mode

```
//IBATSFTP EXEC PGM=IKJEFT01,PARM=IBATSFTP
//SYSEXEC  DD DSNAME=HERING.UNIX.REXX.EXEC,DISP=SHR
//SFTPDATA DD DATA,DLM=##
ispfsftp hering@wtsc70oe
cd /tmp
! pwd
!mvs2uss "'hering.test.file'" hering.test.file y y
put hering.test.file hering.test.file
! rm hering.test.file
quit
##
//SFTPENV  DD DATA,DLM=##
PATH=/u/hering/bin:/usr/local/bin:/bin
_EDC_ADD_ERRNO2=1
##
//CODEPAGE DD DATA,DLM=##
ISPFSFTP_CP=01141      < Terminal Emulation CP for the job and job log
##
//SYSTSIN  DD DUMMY
//SYSTSPRT DD SYSOUT=*,LRECL=136,RECFM=VB
```

6.4 rxdowner utility

The rxdowner tool is provided with the zfstools package. It can be used to display owner-related information about z/OS UNIX file systems and zFS aggregates.

The syntax to run the tool is shown in Figure 6-2.

```
rxdowner -l|-d uss_direntry | -f file_system | -a zfs_aggrname
```

Figure 6-2   Syntax of command rxdowner

The following parameters are available:

▶ uss_direntry

   This parameter is a UNIX System Services file system directory entry.

▶ file_system

   This parameter is the name of a mounted z/OS UNIX file system.

▶ zfs_aggrname

   This parameter is the name of an active zFS aggregate.

As a result, the owner and owner-related information is displayed. Example 6-8 shows sample commands.

Example 6-8   Sample rxdowner commands

```
$> sudo /usr/sbin/mount -t zFS -o rwshare -f HERING.TEST.ZFS test
$> rxdowner -d test

MP Directory : /u/hering/test
File System  : HERING.TEST.ZFS
PFS Type     : ZFS
Local Sysname: SC70     - File System local-client=N
USS Owner    : SC70     - File System read-only=N
zFS Owner    : SC70     - Aggregate read-only=N, sysplex-aware=Y

$> sudo /usr/sbin/chmount -d SC65 test
$> zfsowner HERING.TEST.ZFS
zFS Owner    : SC70     - Aggregate read-only=N, sysplex-aware=Y
$> rxdowner -d test

MP Directory : /u/hering/test
File System  : HERING.TEST.ZFS
PFS Type     : ZFS
Local Sysname: SC70     - File System local-client=N
USS Owner    : SC65     - File System read-only=N
zFS Owner    : SC70     - Aggregate read-only=N, sysplex-aware=Y

$>
```
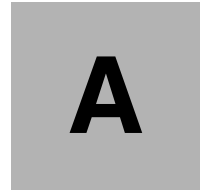
For more information, see the corresponding files starting with string "zfstools" that are on the ITSO disk.

Additional material

This book refers to additional material that can be downloaded from the Internet as described in the following sections.

Locating the web material

The web material that is associated with this book is available in softcopy from the following website:

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rxlstqsd.zip   Zipped Code Sample

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Related publications

The publications that are listed in this section are considered particularly suitable for a more detailed discussion of the topics that are covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide more information about the z/OS V2R2 updates. Some of the publications that are referenced in this list might be available in softcopy only:

► *z/OS V2R2: JES2, JES3, and SDSF,* SG24-8287
► *z/OS V2R2: Security,* SG24-8287
► *z/OS V2R2: Storage Management and Utilities,* SG24-8289
► *z/OS V2R2: Availability Management,* SG24-8290
► *z/OS V2R2: Performance,* SG24-8292
► *z/OS V2R2: Operations,* SG24-8305
► *z/OS V2R2: Diagnostics,* SG24-8306
► *z/OS V2R2: Sysplex,* SG24-8307
► *z/OS V2R2: UNIX System Services* SG24-8310
► *z/OS V2R2: User Interfaces,* SG24-8311
► *z/OS V2R2: ServerPac*, SG24-8500

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Other publications

The following publications also are relevant as further information sources:

► *z/OS V2R2 UNIX System Services Command Reference* SA23-2280
► *z/OS V2R2 Using REXX and z/OS UNIX System Services,* SA23-2283
► *z/OS UNIX System Services Planning,* GA32-0884-
► *z/OS UNIX System Services File System Interface Reference,* SA23-2285
► *z/OS MVS System Commands*, SA38-0666
► *z/OS MVS Initialization and Tuning Reference,* SA23-1380
► *z/OS Distributed File Service zFS Administration*, SC23-6887
► *z/OS Distributed File Service Messages and Codes,* SC23-6885
► *IBM Health Checker for z/OS User's Guide,* SC23-6843
► *z/OS V2R2 OpenSSH User's Guide,* SC27-6806
► *z/OS Cryptographic Services ICSF Overview,* SC14-7505
► *z/OS Cryptographic Services ICSF Administrator's Guide,* SC14-7506
► *z/OS Cryptographic Services ICSF System Programmer's Guide,* SC14-7507
► *z/OS Cryptographic Services ICSF Application Programmer's Guide,* SC14-7508
► *z/OS Cryptographic Services ICSF Writing PKCS #11 Applications,* SC14-7510

Online resources

The following websites also are relevant as further information sources:

► IBM Ported Tools for z/OS:

http://www.ibm.com/servers/eserver/zseries/zos/unix/ported/

► IBM Ported Tools for z/OS: OpenSSH:

http://www.ibm.com/servers/eserver/zseries/zos/unix/ported/openssh/index.html

► OpenSSH:

http://www.openssh.org/

► OpenSSL:

http://www.openssl.org

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