Linux on zSeries

Device Drivers, Features, and Commands March 23, 2005

Linux Kernel 2.6 - April 2004 stream

SC33-8281-00

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Note

Before using this document, be sure to read the information in “Notices” on page 365.

Fifth Edition – (March 2005)

This edition applies to the Linux for zSeries and S/390 kernel 2.6 (April 2004 stream) and to all subsequent releases and modifications until otherwise indicated in new editions.

This edition replaces LNUX-1403-03. LNUX-1403 is the Linux for zSeries and S/390 kernel 2.6 (April 2004 stream) equivalent to SC33-8282 (earlier LNUX-1313) which applies to Linux for zSeries and S/390 kernel 2.4, June 2003 stream.

Contents

Summary of changes

This revision contains changes related to the March 25th software drop.

Edition 5 changes

New Information

- There is a new character device driver that provides access to the z/VM watchdog timer (see Chapter 17, “Watchdog device driver,” on page 201).
- The SCSI device driver now provides an interface for SAN management clients (see “zfcp HBA API (FC-HBA) support” on page 42).
- There is a new character device driver for reading data from the z/VM monitor DCSS (Chapter 14, “z/VM *MONITOR record reader device driver,” on page 177).
- There is a new character device driver for reading records from the CP recording system services (Chapter 16, “z/VM recording device driver,” on page 193).
- There is a new network device driver (see Chapter 12, “CLAW device driver,” on page 161).
- There is a new command **lsqeth** to gather information on qeth-based network interfaces (see “lsqeth - List qeth based network devices” on page 287).
- There is a kernel builder’s summary of the zSeries and S/390-specific kernel configuration options you can find in the Linux kernel configuration menu (see Chapter 23, “Other features kernel builders should know about,” on page 245).

Changed Information

- There are additional sysfs attributes with SCSI port and device access permission information (see “Displaying port information” on page 51 and “Displaying information on SCSI devices” on page 54).
- The device drivers have been regrouped and a new book part, Part 4, “z/VM virtual server integration,” on page 167, has been introduced (see “How this document is organized” on page xi).
- The generic cryptographic device driver supports additional devices (see Chapter 19, “Generic cryptographic device driver,” on page 219).
- The DCSS device driver now provides a kernel and corresponding module parameter (see “Setting up the DCSS device driver” on page 170).
- The qeth device driver (see Chapter 7, “qeth device driver for OSA-Express (QDIO) and HiperSockets,” on page 81) provides multiple new functions:
  - OSA-Express2, including 10 Gigabit Ethernet
  - Layer2 support (MAC-based addressing for IPv4 packets) (Ethernet only)
  - Large Send (OSA-Express2 only)
  - 640 TCP/IP stacks per CHPID support (OSA-Express2 only)
- There are changes for the following commands:
  - “dasdfmt - Format a DASD” on page 264
  - “dasdview - Display DASD structure” on page 267
  - “fdasd – Partition a DASD” on page 277
  - zipl (see page 313)

- “osasnmpd – Start OSA-Express SNMP subagent” on page 291 has been rewritten and much of the information has been moved to a separate chapter, Chapter 22, “OSA-Express SNMP subagent support,” on page 235.

This revision also includes maintenance and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line to the left of the change.

Deleted Information

- Generic options (-h, --help, --version) that are available for all commands described in Chapter 24, “Useful Linux commands,” on page 261 have been omitted from most of the syntax diagrams.

Edition 4 changes

New Information

- There is a new network device driver that supports CTC based SNA connections (see Chapter 10, “CTCMPC device driver,” on page 149).
- The DASD device driver now supports DASD with device type 3380 and 3390 for control unit types 1750 and 2107.

Changed Information

- None.

This revision also includes maintenance and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line to the left of the change.

Deleted Information

- None.

Edition 3 changes

New Information

- “Booting Linux,” on page 345

Changed Information

- **zipl** now supports FBA type DASD as dump devices (see “zipl – zSeries initial program loader” on page 311).

This revision also includes maintenance and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line to the left of the change.

Deleted Information

- The “Restrictions” subsections have been removed from the device driver chapters. For information on device driver restrictions, visit developerWorks at:

  `ibm.com/developerworks/linux/linux390/april2004_restrictions.shtml`

  If you are routed to the top-level page: On the left navigation bar, under Kernel 2.6, click **April 2004 stream**. On the April 2004 stream page, click **Restrictions**.

About this document

This document describes the device drivers available to Linux™ for the control of zSeries® and S/390® devices and attachments with the kernel 2.6 (April 2004 stream). It also provides information on commands and parameters relevant to configuring Linux for zSeries and S/390.

Unless stated otherwise, the device drivers, features, and commands described in this book are available for the zSeries 64-bit and 31-bit architectures and for the S/390 31-bit architecture with version 2.6 of the Linux kernel.

Unless stated otherwise, all z/VM® related information in this book is based on the assumption that z/VM 4.4 or later is used.

The drivers described herein have been developed with version 2.6 of the Linux kernel. If you are using a later version of the kernel, the kernel parameters may be different from those described in this document.

For more specific information about the device driver structure, see the documents in the kernel source tree at `...linux/Documentation/s390`.

When you have installed Linux including the kernel sources, this path will be on your machine. Typically: `/usr/src/linux/Documentation/s390.`

Note: For tools related to taking and analyzing system dumps, see *Linux for zSeries and S/390 Using the Dump Tools*.

You can find the latest version of this document and of *Linux for zSeries and S/390 Using the Dump Tools* on the developerWorks® Web site at:

`ibm.com/developerworks/linux/linux390/april2004_documentation.shtml`

If you are routed to the top-level page: On the left navigation bar, under Kernel 2.6, click **April 2004 stream**. On the April 2004 stream page, click **Documentation**.

How this document is organized

| The first part of this document contains general and overview information for the
| Linux for zSeries and S/390 device drivers.

| Part two consists of chapters specific to individual storage device drivers.

| Part three consists of chapters specific to individual network device drivers.

| Part four consists of chapters that describe device drivers and features in support
| of z/VM virtual server integration.

| Part five consists of chapters that describe Linux for zSeries and S/390 features
| that are beyond the scope of an individual device driver.

| Part six contains information on the commands and parameters used in
| configuring Linux for zSeries and S/390.

The Appendix provides a description of how you can boot Linux for zSeries and S/390.

Who should read this document

Most of the information in this document is intended for system administrators who want to configure a Linux for zSeries or Linux for S/390 system.

Some sections are of interest primarily to kernel builders who want to build their own Linux kernel. These sections are marked with the same icon on the left margin as this paragraph.

Some sections are of interest primarily to specialists who want to program extensions to the Linux for zSeries and S/390 device drivers and features. These sections are marked with the same icon on the left margin as this paragraph.

Assumptions

The following general assumptions are made about your background knowledge:

- You have an understanding of basic computer architecture, operating systems, and programs.
- You have an understanding of Linux, zSeries, and S/390 terminology.
- You are familiar with Linux device driver software.
- You are familiar with the zSeries and S/390 devices attached to your system.

Distribution specific information

This book does not provide information that is specific to a particular Linux distribution. The device drivers, features, options, and commands it describes are either provided by the April 2004 stream downloads on developerWorks or are commonly available tools.

Your Linux distribution might provide additional utilities for working with zSeries and S/390 devices that are not described in this book. For example, the examples in this book use the **ifconfig** command to activate interfaces. If your distribution provides it, you can also use IP tools instead of **ifconfig**. Refer to the documentation that is provided with your distribution to find out what additional utilities you can use.

Conventions used in this book

This section informs you on the styles, highlighting, and assumptions used throughout the book.

Terminology

In this book, the term *booting* is used for running boot loader code that loads the Linux operating system. *IPL* is used for issuing an IPL command, to load boot loader code, a stand-alone dump utility, or a DCSS. See also “IPL and booting” on page 345.

sysfs

Throughout the book, the mount point for the virtual Linux file system sysfs is assumed to be /sys.

Hexadecimal numbers

Mainframe books and Linux books tend to use different styles for writing hexadecimal numbers. Thirty-one, for example, would typically read X’1F’ in a mainframe book and 0x1f in a Linux book.

Because the Linux style is required in many commands and is also used in some code samples, the Linux style is used throughout this book.

Highlighting

This book uses the following highlighting styles:

- Paths and URLs are highlighted in `monospace`.
- Variables are highlighted in <*italics within angled brackets*>.
- Commands in text are highlighted in **bold**.
- Input and output as normally seen on a computer screen is shown

```
within a screen frame.
Prompts are shown as hash signs:
#
```

Understanding syntax diagrams

This section describes how to read the syntax diagrams in this manual.

To read a syntax diagram follow the path of the line. Read from left to right and top to bottom.

- The ►►─── symbol indicates the beginning of a syntax diagram.
- The ───► symbol, at the end of a line, indicates that the syntax diagram continues on the next line.
- The ►─── symbol, at the beginning of a line, indicates that a syntax diagram continues from the previous line.
- The ───►◄ symbol indicates the end of a syntax diagram.

Syntax items (for example, a keyword or variable) may be:

- Directly on the line (required)
- Above the line (default)
- Below the line (optional)

Case sensitivity

Unless otherwise noted, entries are case sensitive.

Symbols

You **must** code these symbols exactly as they appear in the syntax diagram

*****	Asterisk
:	Colon
,	Comma
=	Equals sign
-	Hyphen
//	Double slash
()	Parentheses
.	Period

+ Add

$ Dollar sign

For example:

```
dasd=0.0.7000-0.0.7fff
```

Variables

An *italicized* lowercase word indicates a variable that you must substitute with specific information. For example:

```
►►── -p <interface>──────────────────────────────────────────────────►◄
```

Here you must code `-p` as shown and supply a value for <*interface*>. An italicized uppercase word indicates a variable that must appear in uppercase:

```
►►──vmhalt=<COMMAND>──────────────────────────────────────────────────►◄
```

Repetition

An arrow returning to the left means that the item can be repeated.

```
      ┌──────────┐
      ▼          │
►►────<repeat>───┴───────────────────────────────────────────────────►◄
```

A character within the arrow means you must separate repeated items with that character.

```
      ┌─,────────┐
      ▼          │
►►────<repeat>───┴───────────────────────────────────────────────────►◄
```

Defaults

Defaults are above the line. The system uses the default unless you override it. You can override the default by coding an option from the stack below the line. For example:

```
      ┌─A─┐
►►────┼───┼──────────────────────────────────────────────────────────►◄
      ├─B─┤
      └─C─┘
```

In this example, A is the default. You can override `A` by choosing `B` or `C`.

Required Choices

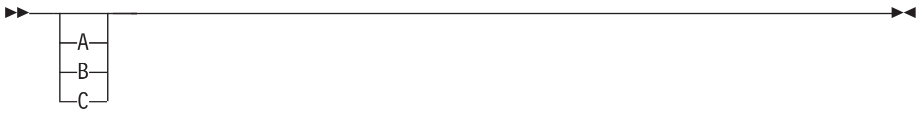
When two or more items are in a stack and one of them is on the line, you **must** specify one item. For example:

```
►►────┬─A─┬──────────────────────────────────────────────────────────►◄
      ├─B─┤
      └─C─┘
```

Here you must enter either `A` or `B` or `C`.

Optional Choice

When an item is below the line, the item is optional. Only one item **may** be chosen. For example:



Here you may enter either `A` or `B` or `C`, or you may omit the field.

Finding referenced IBM literature

The PDF version of this book contains URL links to much of the referenced literature.

For some of the referenced IBM® books, links have been omitted to avoid pointing to a particular edition of a book. You can locate the latest versions of the referenced IBM books through the IBM Publications Center at:

`http://www.elink.ibmlink.ibm.com/public/applications/publications/cgibin/pbi.cgi?`

License conditions

The 3590 tape discipline module (`tape_3590`) is subject to license conditions as reflected in: "International License Agreement for Non-Warranted Programs" on page 367.

Part 1. General concepts

This part provides information at an overview level and describes concepts that apply across different devices drivers and kernel features.

- Chapter 1, “How devices are accessed by Linux”
- Chapter 2, “Devices in sysfs”

Chapter 1. How devices are accessed by Linux

User space programs access devices through:

- Device nodes (character and block devices)
- Interfaces (network devices)

Device nodes and major/minor numbers

The Linux kernel represents the character and block devices it knows as a pair of numbers <*major*>:<*minor*>.

Some major numbers are reserved for particular device drivers, others are dynamically assigned to a device driver when Linux boots. For example, major number 94 is always the major number for DASD devices while the device driver for channel-attached tape devices has no fixed major number. A major number can also be shared by multiple device drivers.

The device driver uses the minor number <*minor*> to distinguish individual physical or logical devices. For example, the DASD device driver assigns four minor numbers to each DASD: one to the DASD as a whole and the other three for up to three partitions.

Device drivers assign device names to their devices, according to a device driver-specific naming scheme (see, for example, "DASD naming scheme" on page 24). Each device name is associated with a minor number.

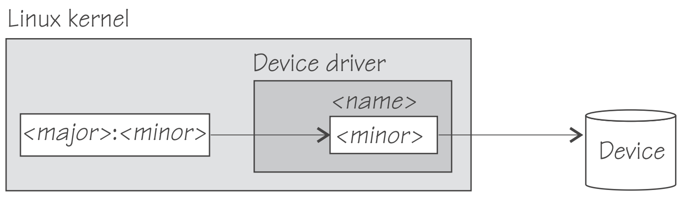


Figure 1. Major and minor numbers

User space programs access character and block devices through *device nodes* also referred to as *device special files*. When a device node is created, it is associated with a major and minor number.

Your distribution might create these device nodes for you or provide udev to create them (see "Device nodes provided by udev" on page 4). If no devices nodes are provided, you need to create them yourself.

Creating device nodes

You can create a device node with an **mknod** command of the form:

```
# mknod <node> <mode> <major> <minor>
```

where:

<node>
: specifies the path to the node. You can use any path. To comply with Linux conventions, the path should begin with `/dev/`.

<mode>
: is “c” for character devices and “b” for block devices. For each minor number you can define a character device and a block device.

<major>
: is the major number that identifies the required device driver to the kernel.

<minor>
: is the minor number that maps to a device name used by the device driver.

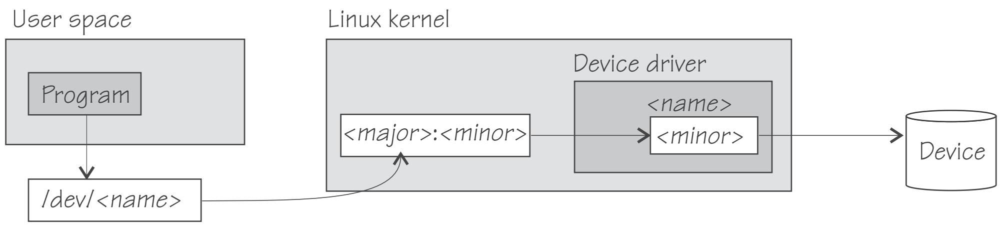


Figure 2. Device nodes

Figure 2 shows a standard device node that matches the device name used by the device driver. You need not use device nodes like this. Which device a device node maps to is determined by the major and minor number associated with it. You can have multiple device nodes that all map to the same device.

For example, the following commands all create device nodes for the same device:

```
# mknod /dev/dasda b 94 0
# mknod /dev/firstdasd b 94 0
# mknod /dev/as/you/please b 94 0
```

For some device drivers, the assignment of minor numbers and names can change between kernel boots, when devices are added or removed in a VM environment, or even if devices are set offline and back online. The same file name, therefore, can lead to a completely different device.

Device nodes provided by udev

If your distribution provides udev, you can use udev to create device nodes for you. udev is a utility program that can use the device information in sysfs (see Chapter 2, “Devices in sysfs,” on page 9) to create device nodes.

Apart from creating device nodes that are based on the device names, udev can create additional device nodes that are based on characteristics of the physical devices, for example, on device bus-IDs or VOLSERs. Unless you change these characteristics of your devices, the device nodes that are based on them remain the same and map to the same device, even if the device name of a device has changed (for example, after rebooting). udev keeps track of the mapping of the device name and the actual devices for you and so helps you ensure that you are addressing the device you intend to.

The format of the nodes that udev creates for you depends on distribution-specific configuration files that reside in `/etc/udev/rules.d/`. If you use udev, be sure that you use the nodes according to your distribution. Refer to your distribution documentation to find out which udev-created device nodes are available.

See "Examples for udev-created DASD device nodes" on page 26 and "Examples for udev-created tape device nodes" on page 64 for examples of what udev created device nodes might look like.

Refer to the udev man page for more details.

Network interfaces

The Linux kernel representation of a network device is an interface.

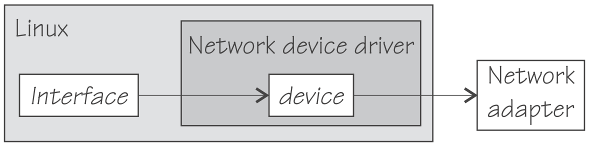


Figure 3. Interfaces

When a network device is defined, it is associated with a real or virtual network adapter. You can configure the adapter properties for a particular network device through the device representation in sysfs (see "Devices and device attributes" on page 10).

You activate or deactivate a connection by addressing the interface with **ifconfig** or an equivalent command. All interfaces that are provided by the network device drivers described in this book are interfaces for the Internet Protocol (IP).

Interface names

The interface names are assigned by the Linux network stack and are of the form <*base_name*><*n*> where <*base_name*> is a base name used for a particular interface type and <*n*> is an index number that identifies an individual interface of a given type.

Table 1 summarizes the base names used for the Linux for zSeries and S/390 network device drivers for interfaces that are associated with real hardware:

Table 1. Interface base names for real devices

Base name	Interface type	Device driver module	Hardware
eth	Ethernet	qeth, lcs	OSA-Express, OSA-2
eth	Ethernet	qeth	OSA-Express2
tr	Token Ring	qeth, lcs	OSA-Express, OSA-2
ctc	Channel-to-Channel	ctc	ESCON® channel card, FICON® channel card
mpc	Channel-to-Channel	mpc	ESCON channel card
claw	CLAW	claw	ESCON channel card

Table 1 summarizes the base names used for the Linux for zSeries and S/390 network device drivers for interfaces that are associated with virtual hardware:

Table 2. Interface base names for virtual devices

Base name	Interface type	Device driver module	Comment
hsi	HiperSockets™, Guest LAN	qeth	Real HiperSockets or HiperSockets guest LAN
eth	Guest LAN	qeth	QDIO guest LAN
ctc	virtual Channel-to-Channel	ctc	virtual CTC/A
mpc	virtual Channel-to-Channel	mpc	virtual CTC/A
iucv	IUCV	netiucv	IUCV must be enabled for the VM guest

Both the qeth device driver and the LCS device driver use the generic base name for Ethernet and Token Ring interfaces.

When the first device for a particular interface name is set online, it is assigned the index number 0, the second is assigned 1, the third 2, and so on. For example, the first HiperSockets interface is named hsi0, the second hsi1, the third hsi2, and so on. As an exception, IUCV devices do not need to be set online and the interface names are assigned when the device is created.

When a network device is set offline, it retains its interface name. When a device is removed, it surrenders its interface name and the name can be reassigned as network devices are defined in the future. When an interface is defined, the Linux kernel always assigns the interface name with the lowest free index number for the particular type. For example, if the network device with an associated interface name hsi1 is removed while the devices for hsi0 and hsi2 are retained, the next HiperSockets interface to be defined becomes hsi1.

Matching devices with the corresponding interfaces

If you define multiple interfaces on a Linux instance, you need to keep track of the interface names assigned to your network devices. Your distribution might provide a way to track the mapping or to assign meaningful names to your interfaces.

How you can keep track of the mapping yourself differs depending on the network device driver.

qeth interfaces

For qeth, you can use the **lsqeth** command (see “lsqeth - List qeth based network devices” on page 287) to obtain a mapping.

IUCV interfaces

For IUCV devices, you can derive the mapping from the naming scheme for interfaces and devices (see “IUCV interfaces and devices” on page 154).

All interfaces

After setting a device online (or creating an IUCV device), read `/var/log/messages` or issue **dmesg** to find the associated interface name in the messages that are issued in response to the device being set online (or created for IUCV).

For each IUCV network device and all other network devices that are online, there is a symbolic link of the form `/sys/class/net/<interface>/device` where <*interface*> is the interface name. This link points to a sysfs directory that represents the corresponding network device. You can read this symbolic link with **readlink** to confirm that an interface name corresponds to a particular network device.

Main steps for setting up a network interface

The following main steps apply to all Linux for zSeries and S/390 network devices drivers. How to perform a particular step can be different for the different device drivers. The main steps for setting up a network interface are:

- Define a network device.

  This means creating directories that represent the device in sysfs.
- Configure the device through its attributes in sysfs (see "Device views in sysfs" on page 12).

  For some devices, there are attributes that can or need to be set later when the device is online or when the connection is active.
- Set the device online (skip this for IUCV devices)

  This makes the device known to the Linux network stack and associates the device with an interface name. For devices that are associated with a physical network adapter it also initializes the adapter for the network interface.
- Activate the interface.

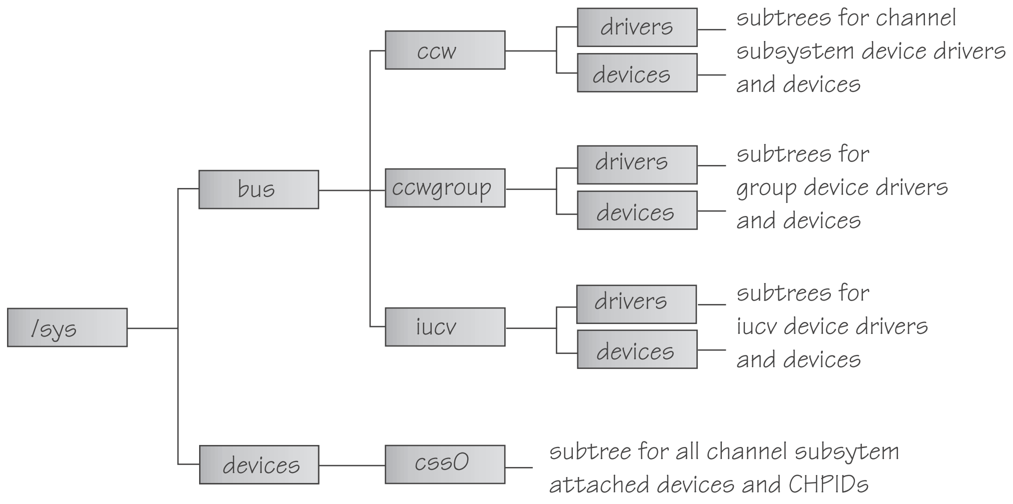
  This adds interface properties like IP addresses, MTU, and netmasks to a network interface and makes the network interface available to user space programs.

Chapter 2. Devices in sysfs

Most of the Linux for zSeries and S/390 device drivers create structures in sysfs. These structures hold information on individual devices and are also used to configure and control the devices. This section provides an overview of these structures and of two of the categories into which the Linux for zSeries and S/390 device drivers and devices are grouped in sysfs.

Device categories

Figure 4 illustrates a part of the Linux for zSeries and S/390 sysfs.



/sys
bus
devices
ccw
ccwgroup
iucv
css0
drivers
devices
subtrees for channel subsystem device drivers and devices
subtrees for group device drivers and devices
subtrees for iucv device drivers and devices
subtree for all channel subsytem attached devices and CHPIDs

Figure 4. sysfs

`/sys/bus` and `/sys/devices` are common Linux directories. The directories following `/sys/bus` sort the device drivers according to the categories of devices they control. Linux for zSeries and S/390 has several categories of devices:

CCW devices
: are devices that can be addressed with channel-command words (CCWs). These devices use a single subchannel on the mainframe's channel subsystem.

CCW group devices
: are devices that use multiple subchannels on the mainframe's channel subsystem.

IUCV devices
: are devices for virtual connections within a zSeries or S/390 mainframe. IUCV devices do not use the channel subsystem.

Table 3 lists the Linux for zSeries and S/390 device drivers:

Table 3. Linux for zSeries and S/390 device drivers

Device driver	Category	sysfs directories
3215 console	CCW	`/sys/bus/ccw/drivers/3215`
3270 console	CCW	`/sys/bus/ccw/drivers/3270`
Hardware console	n/a	n/a
DASD	CCW	`/sys/bus/ccw/drivers/dasd-eckd` `/sys/bus/ccw/drivers/dasd-fba`
SCSI-over-Fibre Channel	CCW	`/sys/bus/ccw/drivers/zfcp`
Tape	CCW	`/sys/bus/ccw/drivers/tape_34xx` `/sys/bus/ccw/drivers/tape_3590`
Cryptographic	n/a	none
DCSS	n/a	`/sys/devices/dcssblk`
z/VM monitor record reader	n/a	none
XPRAM	n/a	`/sys/devices/system/xpram`
z/VM recording device driver	IUCV	`/sys/bus/iucv/drivers/vmlogrdr`
OSA-Express, OSA-Express2 / HiperSockets (qeth)	CCW group	`/sys/bus/ccwgroup/drivers/qeth`
Watchdog device driver	n/a	none
LCS	CCW group	`/sys/bus/ccwgroup/drivers/lcs`
CTC	CCW group	`/sys/bus/ccwgroup/drivers/ctc`
CTCMPC	CCW group	`/sys/bus/ccwgroup/drivers/ctcmpc`
NETIUCV	IUCV	`/sys/bus/iucv/drivers/netiucv`
CLAW	CCW group	`/sys/bus/ccwgroup/drivers/claw`

Some device drivers do not relate to physical devices that are connected through the channel subsystem. Their representation in sysfs differs from the CCW and CCW group devices:

- The following are not categorized and do not have data under `/sys/bus`:
  - Hardware console device driver
  - DCSS device driver
  - z/VM monitor record reader
  - XPRAM device driver
  - Generic cryptographic device driver
  - Watchdog device driver
  - z/VM monitor record reader
- The IUCV device driver and the IUCV-dependent z/VM recording device driver have their own category, IUCV.

The following sections provide more details about devices and their representation in sysfs

Devices and device attributes

Each device that is known to Linux is represented by a directory in sysfs.

For CCW and CCW group devices the name of the directory is a *bus ID* that identifies the device within the scope of a Linux instance. For a CCW device, the bus ID is the device's device number with a leading "0.0.", for example, 0.0.0ab1.

CCW group devices are associated with multiple device numbers. For CCW group devices, the bus ID is the primary device number with a leading "0.0.".

The device directories contain *attributes*. You control a device by writing values to its attributes.

Some attributes are common to all devices in a device category, other attributes are specific to a particular device driver. The following attributes are common to all CCW devices:

online
: You use this attribute to set the device online or offline. To set a device online write the value "1" to its online attribute. To set a device offline write the value "0" to its online attribute.

cutype
: specifies the control unit type and model, if applicable. This attribute is read-only.

cmb_enable
: enables I/O data collection for the device. See "Enabling, resetting, and switching off data collection" on page 230 for details.

devtype
: specifies the device type and model, if applicable. This attribute is read-only.

availability
: indicates if the device can be used. Possible values are:

  good This is the normal state, the device can be used.

  boxed The device has been locked by another operating system instance and cannot be used until the lock is surrendered or forcibly broken (see "Accessing DASD by force" on page 35).

  no device
  Applies to disconnected devices only. The device is gone after a machine check and the device driver has requested to keep the (online) device anyway. Changes back to "good" when the device returns after another machine check and the device driver has accepted the device back.

  no path
  Applies to disconnected devices only. The device has no path left after a machine check or a logical vary off and the device driver has requested to keep the (online) device anyway. Changes back to "good" when the path returns after another machine check or logical vary on and the device driver has accepted the device back.

"Device views in sysfs" on page 12 tells you where you can find the device directories with their attributes in sysfs.

Device views in sysfs

sysfs provides multiple views of device specific data. The most important views are:

- Device driver view
- Device category view
- Device view
- Channel subsystem view

Device driver view

The device driver view is of the form:

```
/sys/bus/<bus>/drivers/<driver>/<device_bus_id>
```

where:

<bus>	is the device category, for example, ccw or ccwgroup.
<driver>	is a name that specifies an individual device driver or the device driver component that controls the device (see Table 3 on page 10).
<device_bus_id>	identifies an individual device (see "Devices and device attributes" on page 10).

Note: Cryptographic devices, DCSSs, and XPRAM are not represented in this view.

Examples:

- This example shows the path for an ECKD™ type DASD device:
  ```
  /sys/bus/ccw/drivers/dasd-eckd/0.0.b100
  ```
- This example shows the path for a qeth device:
  ```
  /sys/bus/ccwgroup/drivers/qeth/0.0.a100
  ```

Device category view

The device category view does not sort the devices according to their device drivers. All devices of the same category are contained in a single directory. The device category view is of the form:

```
/sys/bus/<bus>/devices/<device_bus_id>
```

where:

<bus>	is the device category, for example, ccw or ccwgroup.
<device_bus_id>	identifies an individual device (see "Devices and device attributes" on page 10).

Note: Cryptographic devices, DCSSs, and XPRAM are not represented in this view.

Examples:

- This example shows the path for a CCW device.
  ```
  /sys/bus/ccw/devices/0.0.b100
  ```
- This example shows the path for a CCW group device.
  ```
  /sys/bus/ccwgroup/devices/0.0.a100
  ```

Device view

The device view sorts devices according to their device drivers, but independent from the device category. It also includes logical devices that are not categorized. The device view is of the form:

```
/sys/devices/<driver>/<device>
```

where:

<driver>
: identifies device driver.

<device>
: identifies an individual device. The name of this directory can be a device bus-ID or the name of a DCSS or IUCV device.

Examples:

- This example shows the path for a qeth device.
  ```
  /sys/devices/qeth/0.0.a100
  ```
- This example shows the path for a DCSS block device.
  ```
  /sys/devices/dcssblk/mydcss
  ```

Channel subsystem view

The channel subsystem view shows the devices in relation to their respective subchannels. It is of the form:

```
/sys/devices/css0/<subchannel>/<device_bus_id>
```

where:

<subchannel>
: is a subchannel number with a leading "0.0.".

<device_bus_id>
: identifies the device that is associated with the subchannel (see "Devices and device attributes" on page 10).

Examples:

- This example shows a CCW device with device number 0xb100 that is associated with a subchannel 0x0001.
  ```
  /sys/devices/css0/0.0.0001/0.0.b100
  ```
- This example shows three separate entries for a CCW group device that uses three subchannel 0x0002, 0x0003, and 0x0004.
  ```
  /sys/devices/css0/0.0.0002/0.0.a100
  /sys/devices/css0/0.0.0003/0.0.a101
  /sys/devices/css0/0.0.0004/0.0.a102
  ```

  Each subchannel is associated with a device number. Only the primary device number is used for the bus ID of the device in the device driver view and the device view.

The channel subsystem view also shows the channel-path identifiers (CHPIDs) see "CHPID information" on page 14.

Subchannel attributes

Apart from the bus ID of the attached device, the subchannel directories contain three attributes:

chpids
: is a list of the CHPIDs through with the device is connected.

detach_state
: is reserved for future use.

pimpampom
: provides the path installed, path available and path operational masks. Refer to *z/Architecture™ Principles of Operation*, SA22-7832 for details on the masks.

CHPID information

All CHPIDs that are known to Linux are shown alongside the subchannels in the `/sys/devices/css0` directory. The directories that represent the CHPIDs have the form:

```
/sys/devices/css0/chp0.<chpid>
```

where <*chpid*> is a two digit hexadecimal CHPID.

Example: `/sys/devices/css0/chp0.4a`

Setting a CHPID logically online or offline

Directories that represent CHPIDs contain a "status" attribute that you can use to set the CHPID logically online or offline.

When a CHPID has been set logically offline from a particular Linux instance, the CHPID is, in effect, offline for this Linux instance. A CHPID that is shared by multiple operating system instances can be logically online to some instances and offline to others. A CHPID can also be logically online to Linux while it has been varied off at the SE.

To set a CHPID logically online, set its status attribute to "online" by writing the value "on" to it. To set a CHPID logically offline, set its status attribute to "offline" by writing "off" to it. Issue a command of this form:

Note: Depending on your distribution, it might be necessary to reboot to set the device online.

```
# echo <value> > /sys/devices/css0/chp0.<CHPID>/status
```

where:

<CHPID>
: is a two digit hexadecimal CHPID.

<value>
: is either "on" or "off".

Examples

- To set a CHPID 0x4a logically offline issue:

```
# echo off > /sys/devices/css0/chp0.4a/status
```

- To read the status attribute to confirm that the CHPID has been set logically offline issue:

```
# cat /sys/devices/css0/chp0.4a/status
offline
```

- To set the same CHPID logically online issue:

```
# echo on > /sys/devices/css0/chp0.4a/status
```

- To read the status attribute to confirm that the CHPID has been set logically online issue:

```
# cat /sys/devices/css0/chp0.4a/status
online
```

CCW hotplug events

A hotplug event is generated when a CCW device appears or disappears with a machine check. The hotplug events provide the following variables:

CU_TYPE
for the control unit type of the device that appeared or disappeared.

CU_MODEL
for the control unit model of the device that appeared or disappeared.

DEV_TYPE
for the type of the device that appeared or disappeared.

DEV_MODEL
for the model of the device that appeared or disappeared.

Hotplug events can be used, for example, for:
- Automatically setting devices online as they appear
- Automatically loading driver modules for which devices have appeared

For information on the device driver modules see `/lib/modules/<kernel_version>/modules.ccwmap`. This file is generated when you install the Linux kernel (version *<kernel_version>*).

Part 2. Storage device drivers

This part describes the following device drivers:

- Chapter 3, “DASD device driver”
- Chapter 4, “SCSI-over-Fibre Channel device driver”
- Chapter 5, “Channel-attached tape device driver”
- Chapter 6, “XPRAM device driver”

Note

For prerequisites and restrictions for these device drivers refer to the kernel 2.6 April 2004 stream pages on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Chapter 3. DASD device driver

The DASD device driver provides access to all real or emulated Direct Access Storage Devices (DASD) that can be attached to the channel subsystem of a zSeries or S/390 mainframe. DASD devices include a variety of physical media on which data is organized in blocks or records or both. The blocks or records in a DASD can be accessed for read or write in random order.

Traditional DASD devices are attached to a control unit that is connected to a zSeries or S/390 I/O channel. Today, these real DASD have been largely replaced by emulated DASD, such as the internal disks of the Multiprise® family, the volumes of the RAMAC® virtual array, or the volumes of the IBM TotalStorage® Enterprise Storage Server® (ESS). These emulated DASD are completely virtual and the identity of the physical device is hidden.

SCSI disks attached through a zSeries FCP adapter are not classified as DASD. They are handled by the zfcp driver (see Chapter 4, "SCSI-over-Fibre Channel device driver," on page 39).

Features

The DASD device driver supports the following devices and functions:

- The DASD device driver supports ESS virtual ECKD-type disks
- The DASD device driver supports the control unit attached physical devices as summarized in Table 4:

Table 4. Supported control unit attached DASD

Device format	Control unit type	Device type
ECKD (Extended Count Key Data)	1750	3380 and 3390
	2107	3380 and 3390
	2105	3380 and 3390
	3990	3380 and 3390
	9343	9345
FBA (Fixed Block Access)	6310	9336
	3880	3370

  All models of the specified control units and device types are supported.
- The DASD device driver is also known to work with these devices:
  - Multiprise internal disks
  - RAMAC
  - RAMAC RVA
- Linux for zSeries and S/390 provides a disk format with up to three partitions per disk. See "zSeries and S/390 compatible disk layout" on page 21 for details.

What you should know about DASD

This section describes the available DASD layouts and the naming scheme Linux for zSeries and S/390 uses for DASD devices.

The IBM label partitioning scheme

The DASD device driver is embedded into the Linux generic support for partitioned disks. This implies that you can have any kind of partition table known to Linux on your DASD.

Traditional mainframe operating systems (such as, z/OS®, OS/390®, z/VM, and VSE/ESA™) expect a standard DASD format. In particular, the format of the first two tracks of a DASD is defined by this standard and includes zSeries and S/390 IPL, label, and for some layouts VTOC records. Partitioning schemes for platforms other than zSeries and S/390 generally do not preserve these mainframe specific records.

Linux for zSeries and S/390 includes the IBM label partitioning scheme that preserves the zSeries and S/390 IPL, label, and VTOC records. This partitioning scheme allows Linux to share a disk with other mainframe operating systems. For example, a traditional mainframe operating system could handle backup and restore for a partition that is used by Linux.

The following sections describe the layouts that are supported by the IBM label partitioning scheme:

- "zSeries and S/390 compatible disk layout" on page 21
- "Linux disk layout" on page 23
- "CMS disk layout" on page 24

DASD partitions

A DASD partition is a contiguous set of DASD blocks that is treated by Linux as an independent disk and by the traditional mainframe operating systems as a data set. The compatible disk layout allows for up to three partitions on a DASD. The Linux disk layout and the CMS disk layout both permit a single partition only.

There are several reasons why you might want to have multiple partitions on a DASD, for example:

- **Increase disk space efficiency.** You can use different block sizes for different partitions. A large block size can improve performance, but can also be wasteful of space. As a general rule, wastage amounts to half a block for each file, which can become significant for small files. It can be advantageous to store small files in a partition with a small block size and large files in a different partition with a larger block size.
- **Limit data growth.** Runaway processes or undisciplined users can consume disk space to an extend that the operating system runs short of space for essential operations. Partitions can help to isolate the space that is available to particular processes.
- **Encapsulate your data.** If a file system gets damaged, this damage is likely to be restricted to a single partition. Partitioning can reduce the scope of data damage.

Recommendations:

- Use **fdasd** to create or alter partitions. If you use another partition editor, it is your responsibility to ensure that partitions do not overlap. If they do, data damage will occur.
- Leave no gaps between adjacent partitions to avoid wasting space. Gaps are not reported as errors, and can only be reclaimed by deleting and recreating one or more of the surrounding partitions and rebuilding the file system on them.

A disk need not be partitioned completely. You may begin by creating only one or two partitions at the start of your disk and convert the remaining space to a partition later (perhaps when performance measurements have given you a better value for the block size).

There is no facility for moving, enlarging or reducing partitions, because **fdasd** has no control over the file system on the partition. You only can delete and recreate them. Changing the partition table results in loss of data in all altered partitions. It is up to you to preserve the data by copying it to another medium.

zSeries and S/390 compatible disk layout

Restriction: You can only format ECKD-type DASD with the compatible disk layout.

Figure 5 illustrates a DASD with the compatible disk layout.

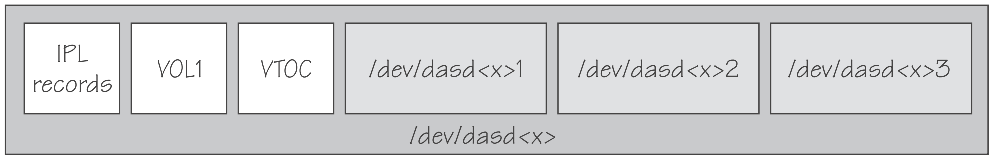


Figure 5. Compatible disk layout

The IPL records, volume label (VOL1), and VTOC of disks with the compatible disk layout are on the first two tracks of the disks. These tracks are not intended for use by Linux applications. Apart from a slight loss in disk capacity this is transparent to the user.

Linux can address the device as a whole as `/dev/dasd<x>`, where `<x>` can be one to four letters that identify the individual DASD (see “DASD naming scheme” on page 24).

Disks with the compatible disk layout can have one to three partitions. Linux can address the partitions as /dev/dasd<*x*>1, /dev/dasd<*x*>2, and /dev/dasd<*x*>3, respectively.

You use the **dasdfmt** command (see “dasdfmt - Format a DASD” on page 264) to format a disk with the compatible disk layout. You use the **fdasd** command (see “fdasd – Partition a DASD” on page 277) to create and modify partitions.

Volume label

The DASD volume label is located in the third block of the first track of the device (cylinder 0, track 0, block 2). This block has a 4-byte key, and an 80-byte data area. The contents are:

key
for disks with the compatible disk layout, contains the four EBCDIC characters “VOL1” to identify the block as a volume label.

label identifier
is identical to the key field.

VOLSER
is a name that you can use to identify the DASD device. A volume serial number (VOLSER) can be one to six EBCDIC characters. If you want to use VOLSERs as identifiers for your DASD, be sure to assign unique VOLSERs.

You can assign VOLSERs from Linux by using the **dasdfmt** or **fdasd** command. These commands enforce that VOLSERs:

- Are alphanumeric
- Are uppercase (by uppercase conversion)
- Contain no embedded blanks
- Contain no special characters other than $, #, @, and %

  Recommendation: Avoid special characters altogether.

Restriction: The VOLSER values `SCRTCH`, `PRIVAT`, `MIGRAT` or `L`*nnnnn* (An "L" followed by five digits) are reserved for special purposes by other mainframe operating systems and should not be used by Linux.

These rules are more restrictive than the VOLSERs that are allowed by the traditional mainframe operating systems. For compatibility, Linux tolerates existing VOLSERs with lowercase letters and special characters other than $, #, @, and %. You might have to enclose a VOLSER with special characters in apostrophes when specifying it, for example, as a command parameter.

VTOC address
contains the address of a standard IBM format 4 data set control block (DSCB). The format is: *cylinder* (2 bytes) *track* (2 bytes) *block* (1 byte).

All other fields of the volume label contain EBCDIC space characters (code 0x40).

VTOC

Linux for zSeries and S/390 does not use the normal Linux partition table to keep an index of all partitions on a DASD. Like other zSeries and S/390 operating systems, Linux for zSeries and S/390 uses a Volume Table Of Contents (VTOC). The VTOC contains pointers to the location of every data set on the volume. In Linux for zSeries and S/390, these data sets form the Linux partitions.

The VTOC is located in the second track (cylinder 0, track 1). It contains a number of labels, each written in a separate block:

- One format 4 DSCB that describes the VTOC itself
- One format 5 DSCB

  The format 5 DSCB is required by other operating systems but is not used by Linux. **fdasd** sets it to zeroes.
- For volumes with more than 65636 tracks, one format 7 DSCB following the format 5 DSCB
- A format 1 DSCB for each partition

  The key of the format 1 DSCB contains the data set name, which identifies the partition to z/OS, OS/390, z/VM or VSE/ESA.

The VTOC can be displayed with standard zSeries and S/390 tools such as VM/DITTO. A Linux DASD with physical device number 0x0193, volume label "LNX001", and three partitions might be displayed like this:

```
                             VM/DITTO DISPLAY VTOC                  LINE 1 OF 5
===>                                                          SCROLL ===> PAGE

CUU,193 ,VOLSER,LNX001   3390, WITH   100 CYLS, 15 TRKS/CYL, 58786 BYTES/TRK

--- FILE NAME --- (SORTED BY =,NAME  ,) ---- EXT    BEGIN-END     RELTRK,
1...5...10...15...20...25...30...35...40.... SQ   CYL-HD   CYL-HD      NUMTRKS
 *** VTOC EXTENT ***                           0     0  1     0  1      1,1
LINUX.VLNX001.PART0001.NATIVE                  0     0  2    46 11      2,700
LINUX.VLNX001.PART0002.NATIVE                  0    46 12    66 11    702,300
LINUX.VLNX001.PART0003.NATIVE                  0    66 12    99 14   1002,498
 *** THIS VOLUME IS CURRENTLY 100 PER CENT FULL WITH      0 TRACKS AVAILABLE

PF  1=HELP      2=TOP       3=END       4=BROWSE    5=BOTTOM    6=LOCATE
PF  7=UP        8=DOWN      9=PRINT    10=RGT/LEFT 11=UPDATE   12=RETRIEVE
```

In Linux, this DASD might appear so:

```
ls -l /dev/dasd/0.0.0193/
total 0
brw-------   1 root     root      94,  12 Jun  1  2001 disc -> ../../dasda
brw-------   1 root     root      94,  13 Jun  1  2001 part1 -> ../../dasda1
brw-------   1 root     root      94,  14 Jun  1  2001 part2 -> ../../dasda2
brw-------   1 root     root      94,  15 Jun  1  2001 part3 -> ../../dasda3
```

where the `disc` file and the `device` file represent the whole DASD and the `part#` files represent the individual partitions.

Linux disk layout

You can only format ECKD-type DASD with the Linux disk layout. Figure 6 illustrates a disk with the Linux disk layout.

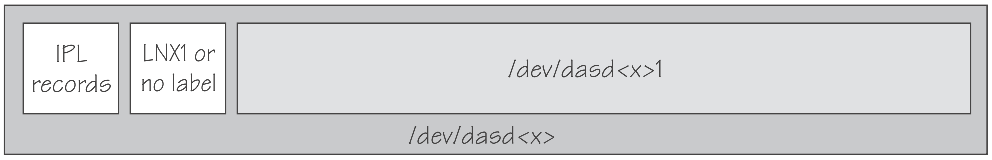


Figure 6. Linux disk layout

DASDs with the Linux disk layout either have an LNX1 label or are not labeled. The IPL records and volume label are not intended for use by Linux applications. Apart from a slight loss in disk capacity this is transparent to the user.

All remaining records are grouped into a single partition. You cannot have more than a single partition on a DASD that is formatted in the Linux disk layout.

Linux can address the device as a whole as `/dev/dasd<x>`, where `<x>` can be one to four letters that identify the individual DASD (see "DASD naming scheme" on page 24). Linux can access the partition as `/dev/dasd<x>1`.

You use the **dasdfmt** command (see "dasdfmt - Format a DASD" on page 264) to format a disk with the Linux disk layout.

CMS disk layout

The CMS disk layout only applies to Linux as a VM guest operating system. The disks are formatted using z/VM tools. Both ECKD- or FBA-type DASD can have the CMS disk layout. Apart from accessing the disks as ECKD or FBA devices, you can also access them using DIAG calls.

Figure 7 illustrates two variants of the CMS disk layout.

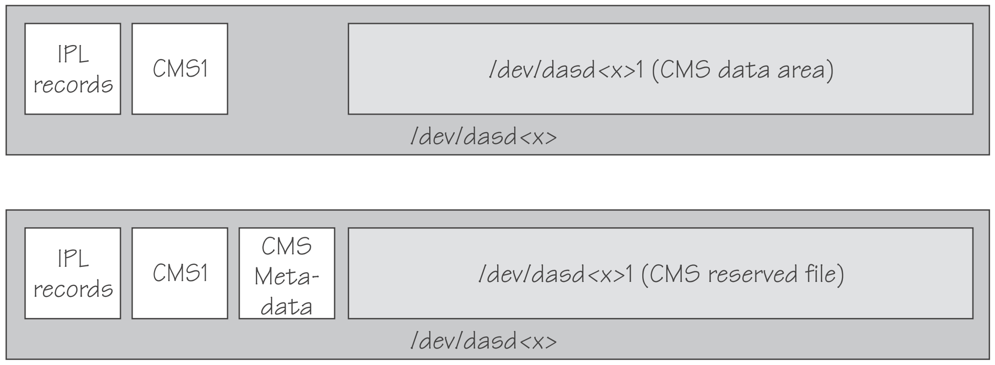


Figure 7. CMS disk layout

The variant in the upper part of Figure 7 contains IPL records, a volume label (CMS1), and a CMS data area. Linux treats DASD like this equivalent to a DASD with the Linux disk layout, where the CMS data area serves as the Linux partition.

The lower part of Figure 7 illustrates a CMS reserved volume. DASD like this have been reserved by a `CMS RESERVE fn ft fm` command. In addition to the IPL records and the volume label, DASD with the CMS disk layout also have CMS metadata. The CMS reserved file serves as the Linux partition.

Both variants of the CMS disk layout only allow a single Linux partition. The IPL record, volume label and (where applicable) the CMS metadata, are not intended for use by Linux applications. Apart from a slight loss in disk capacity this is transparent to the user.

Addressing the device and partition is the same for both variants. Linux can address the device as a whole as `/dev/dasd<x>`, where `<x>` can be one to four letters that identify the individual DASD (see "DASD naming scheme"). Linux can access the partition as `/dev/dasd<x>1`.

"Enabling DIAG calls to access DASDs" on page 36 describes how you can enable DIAG.

DASD naming scheme

The DASD device driver uses the major number 94. For each configured device it uses 4 minor numbers:

- The first minor number always represents the device as a whole, including IPL, VTOC and label records.
- The remaining three minor numbers represent the up to three partitions.

With 1,048,576 (20-bit) available minor numbers, the DASD device driver can address 262,144 devices.

The DASD device driver uses a device name of the form dasd<*x*> for each DASD. In the name, <*x*> is one to four lowercase letters. Table 5 shows how the device names map to the available minor numbers.

Table 5. Mapping of DASD names to minor numbers

Name for device as a whole		**Minor number for device as a whole**		**Number of devices**
From	**To**	**From**	**To**	
dasda	dasdz	0	100	26
dasdaa	dasdzz	104	2804	676
dasdaaa	dasdzzz	2808	73108	17,576
dasdaaaa	dasdnwtl	73112	1048572	243,866
Total number of devices:				262,144

The DASD device driver also uses a device name for each partition. The name of the partition is the name of the device as a whole with a 1, 2, or 3 appended to identify the first, second, or third partition. The three minor numbers following the minor number of the device as a whole are the minor number for the first, second, and third partition.

Examples:

- "dasda" refers to the whole of the first disk in the system and "dasda1", "dasda2", and "dasda3" to the three partitions. The minor number for the whole device is 0. The minor numbers of the partitions are 1, 2, and 3.
- "dasdz" refers to the whole of the 101st disk in the system and "dasdz1", "dasdz2", and "dasdz3" to the three partitions. The minor number for the whole device is 100. The minor numbers of the partitions are 101, 102, and 103.
- "dasdaa" refers to the whole of the 102nd disk in the system and "dasdaa1", "dasdaa2", and "dasdaa3" to the three partitions. The minor number for the whole device is 104. The minor numbers of the partitions are 105, 106, and 107.

Creating device nodes

User space programs access DASD by device nodes. Your distribution might create the device nodes for you or provide udev to create them (see "Device nodes provided by udev" on page 4).

If no device nodes are created for you, you need to create them yourself, for example, with the **mknod** command. Refer to the **mknod** man page for further details.

Tip: Use the device names to construct your nodes (see "DASD naming scheme" on page 24).

Example:

The following nodes use the form `/dev/<device_name>` for the device nodes. The assignment of minor numbers is according to Table 5.

```
# mknod -m 660 /dev/dasda  b 94 0
# mknod -m 660 /dev/dasda1 b 94 1
# mknod -m 660 /dev/dasda2 b 94 2
# mknod -m 660 /dev/dasda3 b 94 3
# mknod -m 660 /dev/dasdb  b 94 4
# mknod -m 660 /dev/dasdb1 b 94 5
...
```

Examples for udev-created DASD device nodes

Note

The format of the nodes that udev creates for you depends on distribution-specific configuration files that reside in `/etc/udev/rules.d`. If you use udev, be sure that you use the nodes according to your distribution. The following examples use hypothetical nodes that are provided for illustration purposes only.

If your distribution provides udev, you can use udev to create DASD device nodes for you. udev is a utility program that can use the device information in sysfs (see Chapter 2, “Devices in sysfs,” on page 9) to create device nodes.

Apart from creating device nodes that are based on the device names, udev can create additional device nodes that are based on, for example, on device bus-IDs or VOLSERs. Unless you change the VOLSERs or device numbers of your devices, device nodes that are based on a device bus-ID or VOLSER remain the same and map to the same device, even if the device name of a device has changed (for example, after rebooting). udev keeps track of the mapping of the device name and the actual devices for you and so helps you ensure that you are addressing the device you intend to.

For example, the configuration file might instruct udev to create three nodes for each device name. For a DASD with two partitions, a device bus-ID 0.0.b100 (device number 0xb100), and a VOLSER LNX001 it might create:

For the whole DASD:
- `/dev/dasdzzz` (standard device node according to the DASD naming scheme)
- `/dev/dasd/0.0.b100/disc`
- `/dev/dasd/LNX001/disc`

For the first partition:
- `/dev/dasdzzz1` (standard device node according to the DASD naming scheme)
- `/dev/dasd/0.0.b100/part1`
- `/dev/dasd/LNX001/part1`

For the second partition:
- `/dev/dasdzzz2` (standard device node according to the DASD naming scheme)
- `/dev/dasd/0.0.b100/part2`
- `/dev/dasd/LNX001/part2`

There is a program that you can use to read DASD VOLSERs from sysfs. You can use it to write your own udev rules for creating VOLSER based DASD device nodes. The following udev rule specification returns a VOLSER:

```
PROGRAM="/sbin/udev_volume_id -d -l
```

The sections that follow show how such nodes can be used to access a device by VOLSER or device bus-ID, regardless of its device name.

Accessing DASD by bus-ID

You can use device nodes that are based on your DASDs' device bus-IDs to be sure that you access a DASD with a particular bus-ID, regardless of the device name that is assigned to it.

Example

The examples in this section assume that udev provides device nodes as described in "Examples for udev-created DASD device nodes" on page 26. To assure that you are addressing a device with bus-ID 0.0.b100 you could make substitutions like the following.

Instead of issuing:

```
# fdasd /dev/dasdzzz
```

issue:

```
# fdasd /dev/dasd/0.0.b100/disc
```

In the file system information in `/etc/fstab` you could replace the following specifications:

```
/dev/dasdzzz1 /temp1 ext2 defaults 0 0
/dev/dasdzzz2 /temp2 ext2 defaults 0 0
```

with these specifications:

```
/dev/dasd/0.0.b100/part1 /temp1 ext2 defaults 0 0
/dev/dasd/0.0.b100/part2 /temp2 ext2 defaults 0 0
```

Accessing DASD by VOLSER

If you want to use device nodes based on VOLSER, be sure that the VOLSERs in your environment are unique (see "Volume label" on page 21).

You can assign VOLSERs to ECKD-type devices with **dasdfmt** when formatting or later with **fdasd** when creating partitions. If you assign the same VOLSER to multiple devices, Linux can access all of them through the device nodes that are based on the respective device names. However, only one of them can be accessed through the VOLSER-based device node. This makes the node ambiguous and should be avoided. Furthermore, if the VOLSER on the device that is addressed by the node is changed, the previously hidden device is not automatically addressed instead. This requires a reboot or needs to be forced, for example, by issuing:

```
# blockdev --rereadpt /dev/dasdzzz
```

Examples

The examples in this section assume that udev provides device nodes as described in "Examples for udev-created DASD device nodes" on page 26. To assure that you are addressing a device with VOLSER LNX001 you could make substitutions like the following.

Instead of issuing:

```
# fdasd /dev/dasdzzz
```

issue:

```
# fdasd /dev/dasd/LNX001/disc
```

In the file system information in `/etc/fstab` you could replace the following specifications:

```
/dev/dasdzzz1 /temp1 ext2 defaults 0 0
/dev/dasdzzz2 /temp2 ext2 defaults 0 0
```

with these specifications:

```
/dev/dasd/LNX001/part1 /temp1 ext2 defaults 0 0
/dev/dasd/LNX001/part2 /temp2 ext2 defaults 0 0
```

Further information

For information on the IBM TotalStorage Enterprise Storage Server (ESS) and ECKD:

- Visit: `ibm.com/servers/storage/disk/ess/`
- Refer to *IBM TotalStorage Enterprise Storage Server User's Guide 2105 Models E10, E20, F10, and F20*, SC26-7295
- Refer to *IBM TotalStorage Enterprise Storage Server System/390® Command Reference 2105 Models E10, E20, F10, and F20*, SC26-7295

For information on DIAG refer to:

- *z/VM CP Programming Services*, SC24-5956

Building a kernel with the DASD device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the DASD device driver.

The DASD device driver is provided as a base component with supplementary components for different device formats and optional functions. The driver can be compiled into the kernel or as a suite of separate modules that can be added and removed at run-time.

Figure 8 on page 29 gives an overview of the available DASD kernel configuration options and the corresponding modules.

```
Block device drivers

   Support for DASD devices                          (CONFIG_DASD)
   ├─Profiling support for dasd devices              (CONFIG_DASD_PROFILE)
   ├─Support for ECKD Disks                          (CONFIG_DASD_ECKD)
   ├─Support for FBA Disks                           (CONFIG_DASD_FBA)
   ├─Support for DIAG access to Disks                (CONFIG_DASD_DIAG)
   └─Compatibility interface for DASD channel        (CONFIG_DASD_CMB)
     measurement blocks
```

Figure 8. DASD kernel configuration menu options

CONFIG_DASD
This option is required if you want to work with DASD devices and is a prerequisite for all other DASD options. It can be compiled into the kernel or as a separate module, dasd_mod.

This option depends on CONFIG_CCW.

CONFIG_DASD_PROFILE
This option makes the DASD device driver write profiling information to `/proc/dasd/statistics`.

CONFIG_DASD_ECKD
This option can be compiled into the kernel or as a separate module, dasd_eckd_mod.

CONFIG_DASD_FBA
This option can be compiled into the kernel or as a separate module, dasd_fba_mod.

CONFIG_DASD_DIAG
This option provides support for accessing disks under VM with the Diagnose250 command. It can be compiled into the kernel or as a separate
| module, dasd_diag_mod. It is available for 31-bit only. You must also enable
| the support for ECKD or FBA disks in order to get the device online.

CONFIG_DASD_CMB
This option provides an additional interface to the channel measurement facility, which is normally accessed though sysfs. It is only needed to run applications written for the kernel 2.4 DASD channel measurement facility interface. It can be compiled into the kernel or as a pair of separate modules, cmf and dasd_cmf.

Setting up the DASD device driver

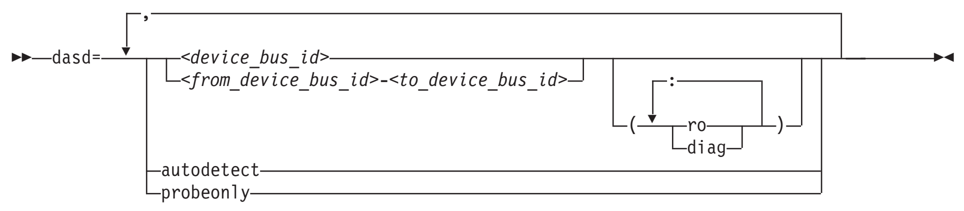
This section describes the parameters that you can use to configure the DASD device driver.

For information on device nodes see "DASD naming scheme" on page 24.

Kernel parameters

This section describes how to configure the DASD device driver if at least the base module has been compiled into the kernel. You configure the device driver by adding parameters to the kernel parameter line.

DASD kernel parameter syntax



where:

autodetect
: causes the DASD device driver to allocate device names and the corresponding minor numbers to all DASD devices and set them online during the boot process. See "DASD naming scheme" on page 24 for the naming scheme.

  The device names are assigned in order of ascending subchannel numbers. Auto-detection can yield confusing results if you change your I/O configuration and reboot, or if you are running as a guest operating system in VM because the devices might appear with different names and minor numbers after rebooting.

probeonly
: causes the DASD device driver to reject any "open" syscall with `EPERM`.

autodetect,probeonly
: causes the DASD device driver to assign device names and minor numbers as for auto-detect. All devices regardless of whether or not they are accessible as DASD return `EPERM` to any "open" requests.

<device_bus_id>
: specifies a single DASD.

<from_device_bus_id>-<to_device_bus_id>
: specifies the first and last DASD in a range. All DASD devices with bus IDs in the range are selected. The device bus-IDs *<from_device_bus_id>* and *<to_device_bus_id>* need not correspond to actual DASD.

(ro) specifies that the given device or range is to be accessed in read-only mode.

(diag) forces the device driver to access the device (range) using the DIAG access method.

If you supply a DASD kernel parameter with device specifications `dasd=`*`<device-list1>`*`,`*`<device-list2>`* `...` the device names and minor numbers are assigned in the order in which the devices are specified. The names and corresponding minor numbers are always assigned, even if the device is not present, or not accessible.

Example

The following kernel parameter specifies a range of DASD devices and two individual DASD devices.

```
dasd=0.0.7000-0.0.7002,0.0.7005(ro),0.0.7006
```

Table 6 shows the resulting allocation of device names and minor numbers:

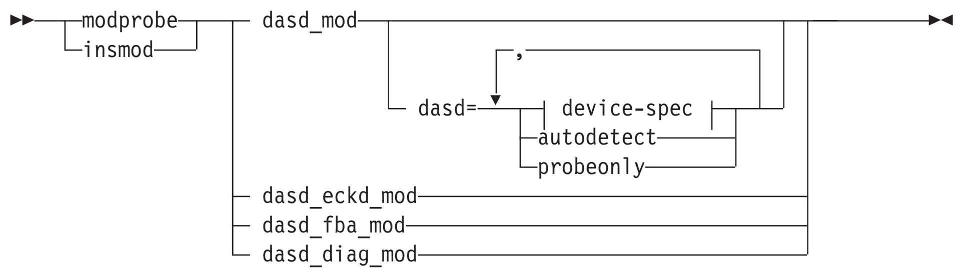
Table 6. Example mapping of device names and minor numbers to devices

Minor	Name	To access
0	dasda	device 0.0.7000 as a whole
1	dasda1	the first partition on 0.0.7000
2	dasda2	the second partition on 0.0.7000
3	dasda3	the third partition on 0.0.7000
4	dasdb	device 0.0.7001 as a whole
5	dasdb1	the first partition on 0.0.7001
6	dasdb2	the second partition on 0.0.7001
7	dasdb3	the third partition on 0.0.7001
8	dasdc	device 0.0.7002 as a whole
9	dasdc1	the first partition on 0.0.7002
10	dasdc2	the second partition on 0.0.7002
11	dasdc3	the third partition on 0.0.7002
12	dasdd	device 0.0.7005 as a whole
13	dasdd1	the first partition on 0.0.7005 (read-only)
14	dasdd2	the second partition on 0.0.7005 (read-only)
15	dasdd3	the third partition on 0.0.7005 (read-only)
16	dasde	device 0.0.7006 as a whole
17	dasde1	the first partition on 0.0.7006
18	dasde2	the second partition on 0.0.7006
19	dasde3	the third partition on 0.0.7006

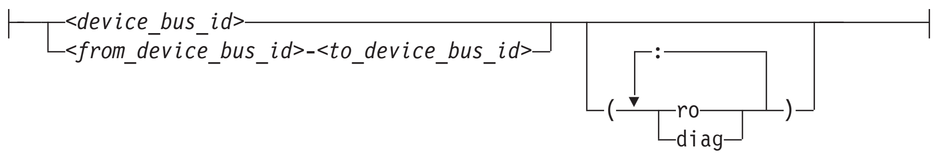
Module parameters

This section describes how to load and configure those components of the DASD device driver that have been compiled as separate modules.

DASD module parameter syntax



device-spec:



Where:

dasd_mod
: loads the device driver base module.

  When loading the base module you can specify the `dasd=` parameter. The variables and key words have the same meaning as in "Kernel parameters" on page 29.

dasd_eckd_mod
: loads the ECKD module.

dasd_fba_mod
: loads the FBA module.

dasd_diag_mod
: loads the DIAG module.

The DASD base component is required by the other modules. Be sure that it has been compiled into the kernel or that it is loaded first if it has been compiled as a separate module. **modprobe** takes care of this dependency for you and ensures that the base module is loaded automatically, if necessary.

For details on **insmod** and **modprobe** refer to the respective man pages.

Example

```
insmod dasd_mod dasd=0.0.7000-0.0.7002,0.0.7005(ro),0.0.7006
```

For the same mainframe setup, the resulting allocation of device nodes and minor numbers would be the same as in Table 6 on page 31.

Working with the DASD device driver

This section describes typical tasks that you need to perform when working with DASD devices.

Preparing an ECKD-type DASD for use

This section describes the main steps for enabling an ECKD-type DASD for use by Linux for zSeries and S/390.

Before you can use an ECKD-type DASD as a Linux for zSeries and S/390 disk, you must format it with a suitable disk layout. If you format the DASD with the compatible disk layout, you need to create one, two, or three partitions. You can then use your partitions as swap areas or to create a Linux file system.

Before you start:

- The DASD must have been subjected to hardware formatting by ICKDSF in stand-alone mode or through a traditional mainframe operating system.
- The base component and the ECKD component of the DASD device driver must have been compiled into the kernel or have been loaded as modules.
- The DASD device driver must have recognized the device as an ECKD-type device.
- You need to know the device node through which the DASD can be addressed. The DASD device nodes have the form `/dev/dasd<x>`, where *<x>* can be one to four lowercase alphabetic characters.

Perform these steps to prepare the DASD:

1. Assure that device nodes exist to address the DASD as a whole and for the partitions you intend to create.

   Example: To check if the device nodes for a DASD dasdzzz exist, change to `/dev` and issue:

   ```
   # ls dasdzzz*
   ```

   If necessary, create the device nodes. For example, issue:

   ```
   # mknod -m 660 /dev/dasdzzz b 94 73108
   # mknod -m 660 /dev/dasdzzz1 b 94 73109
   # mknod -m 660 /dev/dasdzzz2 b 94 73110
   # mknod -m 660 /dev/dasdzzz3 b 94 73111
   ```

   See Table 5 on page 25 for the mapping of device names and minor numbers.

2. Format the device with the **dasdfmt** command (see "dasdfmt - Format a DASD" on page 264 for details). The formatting process can take hours for large DASD.

   Recommendations:

   - Use the default `-d cdl` option. This option formats the DASD with the IBM compatible disk layout that permits you to create partitions on the disk.
   - Use the `-p` option to display a progress bar.

   Example:

   ```
   dasdfmt -b 4096 -d cdl -p  /dev/dasdzzz
   ```

3. Proceed according to your chosen disk layout:

   - If you have formatted your DASD with the Linux disk layout, skip this step and continue with step 4. You already have one partition and cannot add further partitions on your DASD.
   - If you have formatted your DASD with the compatible disk layout use the **fdasd** command to create up to three partitions (see "fdasd – Partition a DASD" on page 277 for details).

     Example: To start the partitioning tool in interactive mode for partitioning a device `/dev/dasdzzz` issue:

     ```
     fdasd /dev/dasdzzz
     ```

     If you create three partitions for a DASD `/dev/dasdzzz`, the device nodes for the partitions are: `/dev/dasdzzz1`, `/dev/dasdzzz2`, and `/dev/dasdzzz3`.

     Result: fdasd creates the partitions and updates the partition table (see "VTOC" on page 22).

4. Depending on the intended use of each partition, create a file system on the partition or define it as a swap space.

   Either: Create a file system of your choice. For example, use the Linux **mke2fs** command to create an ext2 file system (refer to the man page for details).

   Restriction: You must not make the block size of the file system lower than that used for formatting the disk with the **dasdfmt** command.

   Recommendation: Use the same block size for the file system that has been used for formatting.

Example:

```
# mke2fs -b 4096 /dev/dasdzzz1
```

Or: Define the partition as a swap space with the **mkswap** command (refer to the man page for details).

5. Mount each file system to the mount point of your choice in Linux and enable your swap partitions.

   Example: To mount a file system in a partition /dev/dasdzzz1 to a mount point /mnt and to enable a swap partition /dev/dasdzzz2 issue:

   ```
   # mount /dev/dasdzzz1 /mnt
   # swapon /dev/dasdzzz2
   ```

Preparing an FBA-type DASD for use

This section describes the main steps for enabling an FBA-type DASD for use by Linux for zSeries and S/390.

Before you start:

- The base component and the FBA component of the DASD device driver must have been compiled into the kernel or have been loaded as modules.
- The DASD device driver must have recognized the device as an FBA device.
- You need to know the device bus-ID or the device node through which the DASD can be addressed. The DASD device nodes have the form /dev/dasd<*x*>, where <*x*> can be one to four lowercase alphabetic characters.

Perform these steps to prepare the DASD:

1. Assure that device nodes exist to address the DASD as a whole and the partition.

   Example: To check if the device nodes for a DASD dasdzzy exist, change to /dev and issue:

   ```
   # ls dasdzzy*
   ```

   If necessary, create the device nodes. For example, issue:

   ```
   # mknod -m 660 /dev/dasdzzy b 94 73104
   # mknod -m 660 /dev/dasdzzy1 b 94 73105
   ```

   See Table 5 on page 25 for the mapping of device names and minor numbers.

2. Depending on the intended use of the partition, create a file system on it or define it as a swap space.

   Either: Create a file system of your choice. For example, use the Linux **mke2fs** command to create an ext2 file system (refer to the man page for details).

   Example: `mke2fs -b 4096 /dev/dasdzzy1`

   Or: Define the partition as a swap space with the **mkswap** command (refer to the man page for details).

3. Mount the file system to the mount point of your choice in Linux or enable your swap partition.

   Example: To mount a file system in a partition /dev/dasdzzy1 issue:

```
# mount /dev/dasdzzy1 /mnt
```

Setting a DASD online or offline

When Linux boots, it senses your DASD. Depending on your specification for the "dasd=" parameter, it automatically sets devices online.

Use the **chccwdev** command ("chccwdev - Set a CCW device online" on page 263) to set a DASD online or offline. Alternatively, you can write "1" to the device's online attribute to set it online or "0" to set it offline.

Examples

- To set a DASD with device bus-ID 0.0.b100 online, issue:

  ```
  # chccwdev -e 0.0.b100
  ```

  or

  ```
  # echo 1 > /sys/bus/ccw/devices/0.0.b100/online
  ```

- To set a DASD with device bus-ID 0.0.b100 offline, issue:

  ```
  # chccwdev -d 0.0.b100
  ```

  or

  ```
  # echo 0 > /sys/bus/ccw/devices/0.0.b100/online
  ```

Dynamic attach and detach

You can dynamically attach devices to a running Linux for zSeries and S/390 instance, for example, from VM.

When a DASD is attached, Linux attempts to initialize it according to the DASD device driver configuration (see "Kernel parameters" on page 29). You can then set the device online. You can automate setting dynamically attached devices online by using CCW hotplug events (see "CCW hotplug events" on page 15).

Note

Detachment in VM of a device still open or mounted in Linux may trigger a limitation in the Linux kernel 2.6 common code and cause the system to hang or crash. Be sure that you unmount a device and set it offline before you detach it.

Accessing DASD by force

When a Linux instance boots in a mainframe environment, it can encounter DASD that are locked by another system. Such a DASD is referred to as "externally locked" or "boxed". The Linux instance cannot analyze a DASD while it is externally locked.

To check if a DASD has been externally locked, read its availability attribute. This attribute should be "good". If it is "boxed", the DASD has been externally locked.

Because boxed DASD might not be recognized as DASD, it might not show up in the device driver view in sysfs. If necessary, use the device category view instead (see "Device views in sysfs" on page 12).

Issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/availabilty
```

Example: This example shows that a DASD with device bus-ID 0.0.b110 (device number 0xb110) has been externally locked.

```
# cat /sys/bus/ccw/devices/0.0.b110/availabilty
boxed
```

If the DASD is an ECKD-type DASD and if you know the device bus-ID, you can break the external lock and set the device online. This means that the lock of the external system is broken with the "unconditional reserve" channel command.

CAUTION:
Breaking an external lock can have unpredictable effects on the system that holds the lock.

To force a boxed DASD online write "force" to the online device attribute. Issue a command of this form:

```
# echo force > /sys/bus/ccw/devices/<device_bus_id>/online
```

If the external lock is successfully broken or if it the lock has been surrendered by the time the command is processed, the device is analyzed and set online. If it is not possible to break the external lock (for example, because of a timeout, or because it is an FBA-type DASD), the device remains in the boxed state. This command might take some time to complete.

Example: To force a DASD with device number 0xb110 online issue:

```
# echo force > /sys/bus/ccw/devices/0.0.b110/online
```

For information on how to break the look of a DASD that has already been analyzed see "tunedasd - Adjust DASD performance" on page 308.

Enabling DIAG calls to access DASDs

| **Before you start:** This section only applies to Linux instances and DASD for which
| all of the following are true:
| • The Linux instance runs as a VM guest
| • The Linux instance has a 31-bit kernel that has been compiled with the
| CONFIG_DASD_DIAG option (see "Building a kernel with the DASD device
| driver" on page 28).
| • The DASD must be CMS-formatted.
| • The DIAG component (dasd_diag_mod) must be loaded or compiled into kernel.
| • The component that corresponds to the DASD type (dasd_eckd_mod or
| dasd_fba_mod) must be loaded or compiled into kernel.
| • The DASD is offline.

You can use DIAG calls to access both ECKD- and FBA-type DASD. You use the device's use_diag attribute to enable or switch off DIAG calls. Set the use_diag attribute to "1" to enable DIAG calls. Set the use_diag attribute to "0" to switch off DIAG calls (this is the default).

Alternatively, you can specify "diag" on the commandline to force the device driver to access the device (range) using the DIAG access method.

Issue a command of this form:

```
# echo <flag> > /sys/bus/ccw/devices/<device_bus_id>/use_diag
```

Where:

<device_bus_id>
    identifies the DASD.

If DIAG calls are not available and you set the use_diag attribute to "1", you will not be able to set the device online (see "Setting a DASD online or offline" on page 35).

Example

In this example, DIAG calls are enabled for a DASD with device number 0xb100.

Note: You can only use the use_diag attribute when the device is offline.

```
# echo 1 > /sys/bus/ccw/devices/0.0.b100/use_diag
```

After this you must use the online attribute to enable the device:

```
# echo 1 > /sys/bus/ccw/devices/0.0.b100/online
```

External programming interfaces

This section provides information for those who want to program additional functions for the DASD device driver.

ioctl

The **ioctl** interface of the DASD device driver follows the common format:

`int ioctl (int fd, int command, xxx)`

The argument 'fd' is a descriptor of an open file. 'command' is the action requested and the third argument '*xxx*' is a pointer to a data structure specific to the request.

You can find the definitions of the available DASD ioctl in the Linux source tree at:

- `drivers/s390/block/dasd_ioctl.c`
- `drivers/s390/block/dasd_eckd.c`
- `drivers/s390/block/dasd_proc.c`
- `drivers/s390/block/dasd_cmb.c`
- `include/asm-s390/dasd.h`
- `include/asm-s390/cmb.h`

If you need more **ioctl** functionality for your applications, you can register your own **ioctl** commands to the DASD device driver. You do this with the function:

```
dasd_ioctl_no_register   (struct module     *owner,
                          int               no,
                          dasd_ioctl_fn_t   handler)
```

A previously added **ioctl** command can be deleted using:

```
dasd_ioctl_no_unregister (struct module     *owner,
                          int               no,
                          dasd_ioctl_fn_t   handler)
```

These dynamically added **ioctl**s are scanned if none of the statically defined commands fulfils the requested command. If no related command is found in the static or in the dynamic list the driver returns "ENOTTY".

For more information about **ioctl** refer to the **ioctl** man page or the public Linux documentation.

Examples of the implementation of the DASD **ioctl** interface can be found in the sections about DASD tools, in particular **dasdfmt** ("dasdfmt - Format a DASD" on page 264) and **fdasd** ("fdasd – Partition a DASD" on page 277).

Chapter 4. SCSI-over-Fibre Channel device driver

This chapter describes the SCSI-over-Fibre Channel device driver (zfcp device driver) for the QDIO-based zSeries SCSI-over-Fibre Channel (zSeries FCP channel). The zfcp device driver provides support for Fibre Channel-attached SCSI devices on Linux for zSeries and S/390.

Throughout this chapter, the term *FCP channel* refers to a single virtual instance of a QDIO-based zSeries SCSI-over-Fibre Channel.

Both the zSeries 64-bit and 31-bit architectures are supported.

Features

The zfcp device driver supports the following devices and functions:

- Linux for zSeries and S/390 can make use of all SAN-attached SCSI device types currently supported by Linux on other platforms. These include, for example, SCSI disks, tapes, CD-ROMs, and DVDs.
- SAN access through the following FCP adapters:
  - FICON
  - FICON Express
  - FICON Express2
- The zfcp device driver supports switched fabric and point-to-point topologies.
- The zfcp device driver provides an interface for SAN management clients (see "zfcp HBA API (FC-HBA) support" on page 42).

What you should know about zfcp

The zfcp device driver is a low-level or host-bus adapter driver that supplements the Linux SCSI stack. Figure 9 on page 40 illustrates how the device drivers work together.

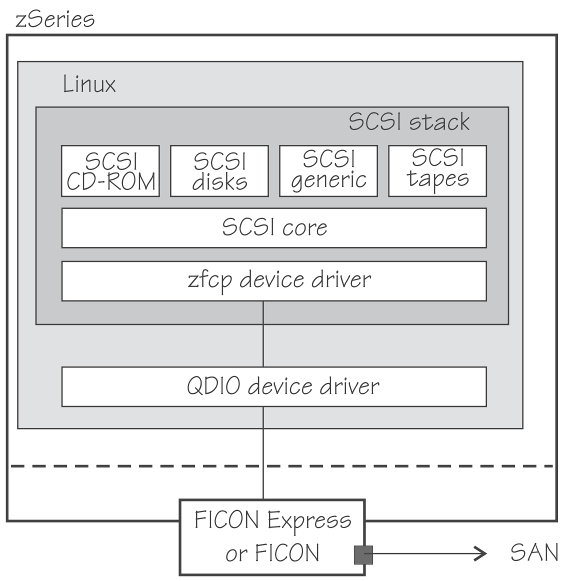


Figure 9. Device drivers supporting the Linux for zSeries FCP environment

sysfs structures for FCP channels and SCSI devices

FCP channels are CCW devices.

When Linux is booted, it senses the available FCP channels and creates directories of the form:

```
/sys/bus/ccw/drivers/zfcp/<device_bus_id>
```

where *<device_bus_id>* is the device bus-ID that corresponds to the FCP channel. You use the attributes in this directory to work with the FCP channel.

Example: `/sys/bus/ccw/drivers/zfcp/0.0.5901`

You can extend this structure by adding target ports to the FCP channel (see "Configuring and removing ports" on page 50). For each port you add you get a directory of the form:

```
/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>
```

where *<wwpn>* is the world wide port number of the target port. You use the attributes of this directory to work with the port.

Example: `/sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000`

You can further extend this structure by adding SCSI devices to the ports (see "Configuring SCSI devices" on page 53). For each SCSI device you add you get a directory of the form:

```
/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<fcp_lun>
```

where *<fcp_lun>* is the logical unit number (LUN) of the SCSI device. You use the attributes in this directory to work with an individual SCSI device.

Example:
`/sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000`

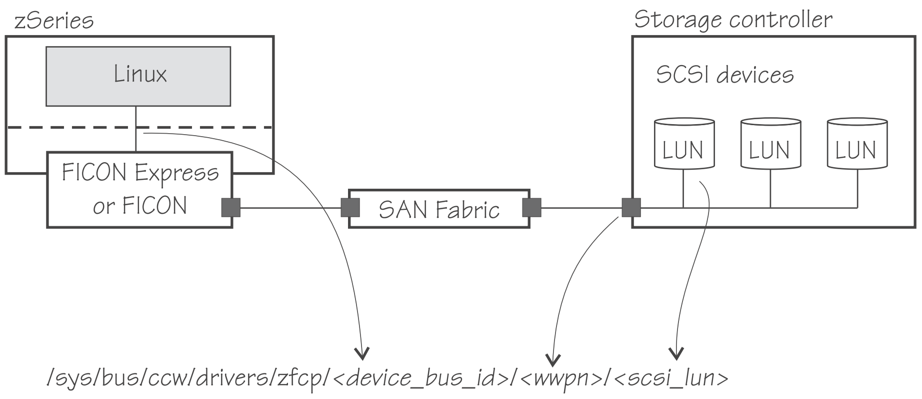


Figure 10. SCSI device in sysfs

Figure 10 illustrates how the path to the sysfs representation of a SCSI device is derived from properties of various components in a zSeries FCP environment.

See also “Mapping the representations of a SCSI device in sysfs” on page 55.

SCSI device nodes

User space programs access SCSI devices through device nodes.

SCSI device names are assigned in the order in which the devices are detected. In a typical SAN environment, this can mean a seemingly arbitrary mapping of names to actual devices that can change between boots. Therefore, using standard device nodes of the form `/dev/`*<device_name>* where *<device_name>* is the device name that the zfcp device driver assigns to a device, can be a challenge.

If you are using a distribution that provides udev, udev might create device nodes for you that allow you to identify the corresponding actual device. Refer to your distribution documentation to find out if udev is present and which device nodes it provides. See “Device nodes and major/minor numbers” on page 3 for more general information on udev.

You can create your own device nodes with **mknod** commands of the form:

```
# mknod /dev/<your_name> b <major> <minor>
```

See “Finding the major and minor numbers for a device” on page 56 if you need to create your own nodes.

The examples in this chapter use standard device nodes as assigned by the SCSI stack. These nodes have the form `/dev/sd`*<x>* for entire disks and `/dev/sd`*<x><n>* for partitions. In these node names *<x>* represents one or more letters and *<n>* is an integer. Refer to `Documentation/devices.txt` in the Linux source tree for more information on the SCSI device naming scheme.

Partitioning a SCSI device

You can partition SCSI devices that are attached through an FCP channel in the same way that you can partition SCSI attached devices on other platforms. Use the **fdisk** command to partition a SCSI disk not **fdasd**.

If your distribution provides udev, udev might create device nodes for your partition. Refer to your distribution documentation for details. If you need to create your own nodes for your partitions, see “Finding the major and minor numbers for a device” on page 56.

Example

To partition a SCSI disk with a device node `/dev/sda` issue:

```
# fdisk /dev/sda
```

zfcp HBA API (FC-HBA) support

The zfcp host bus adapter API (HBA API) provides an interface for SAN management clients that run on Linux on zSeries.

As shown in Figure 11, the zfcp HBA API support includes a kernel module and a user space library.

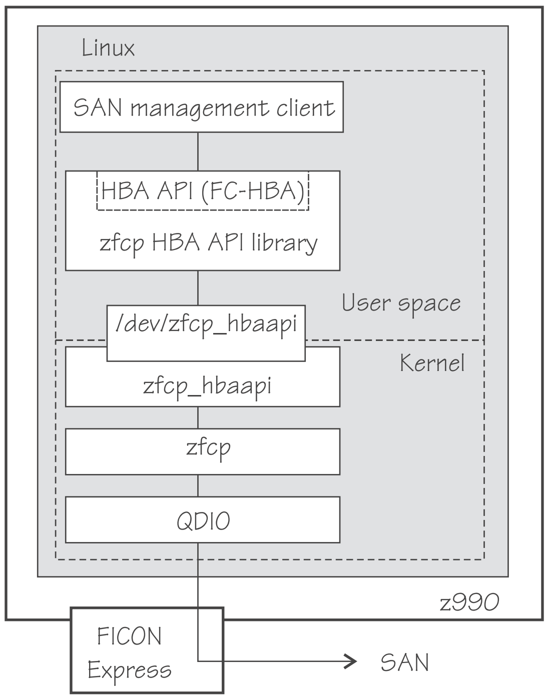


Figure 11. zfcp HBA API support modules

The library provides the zfcp HBA API to SAN management applications and uses a misc device file to communicate with the kernel module. The kernel module uses the SCSI-over-Fibre Channel device driver (zfcp) to communicate with the FCP adapter and the SAN.

Setting up the zfcp HBA API support

Setting up the zfcp HBA API support includes:

1. Ensuring that the module is loaded if the support has been compiled as a module and, optionally, providing kernel or module parameters (see "zfcp HBA API kernel parameters" on page 45 and "zfcp HBA API module parameters" on page 46)
2. "Installing the zfcp HBA API library" on page 46
3. "Ensuring that the required device node exists for the HBA API support" on page 47

FCP LUN access control

Access to devices can be restricted by access control software on the FCP channel. For more information on FCP LUN Access Control, visit The IBM Resource Link Web site at:

`https://www.ibm.com/servers/resourcelink/hom03010.nsf/pages/fcpaccumain?opendocument`

The Resource Link page requires registration. If you are not a registered user of Resource Link, you will need to register and then log in. On the left navigation bar, click **Tools**, then in the Servers column on the ACT page, click the link **Configuration Utility for FCP LUN Access Control**.

Further information

FCP/SCSI-3 specifications
Describes SCSI-3, the Fibre Channel Protocol, and related information.

`http://www.t10.org` and `http://www.t11.org`

Getting Started with zSeries Fibre Channel Protocol
Introduces the concepts of zSeries Fibre Channel Protocol support, and shows how various SCSI devices can be configured to build a zSeries FCP environment. The information is written for Linux 2.4, but much of it is of a general nature and also applies to Linux 2.6:

`ibm.com/redbooks/redpapers/pdfs/redp0205.pdf`

Linux for zSeries: Fibre Channel Protocol Implementation Guide
Includes an explanation of how FCP is configured using SUSE SLES9 under kernel 2.6.

`ibm.com/redbooks/abstracts/sg246344.html?Open`

Supported FCP connectivity options
Lists supported SCSI devices and provides links to further documentation on FCP and SCSI.

`ibm.com/servers/eserver/zseries/connectivity/`

zfcp HBA API
See "API provided by the zfcp HBA API support" on page 59.

Note: The detailed specification of functions and structures of modules zfcp and zfcp_hbaapi that are relevant for ZFCP HBA API can be found in the kernel sources. A template Documentation/DocBook/zfcp-hba-api.tmpl exists. With this template documentation is generated which contains information about all interfaces and some internals of kernel modules. To create a PDF version of this documentation, in the top level kernel source directory issue the command **make pdfdocs**. This generates the file Documentation/DocBook/zfcp-hba-api.pdf.

Building a kernel with the zfcp device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the zfcp device driver.

Figure 12 summarizes the kernel configuration menu options that are relevant to the zfcp device driver:

```
SCSI Device Support --->
   SCSI low-level drivers --->
      FCP host bus adapter driver for IBM eServer zSeries  (CONFIG_ZFCP)
      └─ FC HBA Support                                    (CONFIG_ZFCP_HBAAPI)
```

Figure 12. zfcp kernel configuration menu options

CONFIG_ZFCP
: This option is required for zfcp support. Can be compiled into the kernel or as a separate module, zfcp.

CONFIG_ZFCP_HBAAPI
: This option includes zfcp HBA API support. It can be compiled into the kernel or as a separate module, zfcp_hbaapi.

In addition, the following common code options are required:
- CONFIG_QDIO
- CONFIG_SCSI
- CONFIG_SCSI_MULTI_LUN

You need to deselect the following common code option if you want to work with zfcp devices:
- CONFIG_SCSI_REPORT_LUNS

As for Linux on any platform, you need the common code options for specific devices and file systems you want to support. For example:
- SCSI disks support and PC-BIOS disk layout support

  Partitioning is only possible if PC-BIOS disk layout support is compiled into the kernel
- SCSI tapes support
- SCSI CD-ROM and ISO 9660 file system
- SCSI generic support

Setting up the zfcp device driver

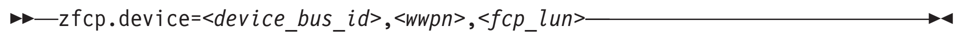
This section provides information on how you can specify a SCSI boot device and how you can set up the zfcp HBA API support.

Device driver kernel parameters

This section describes how to configure the zfcp device driver if it has been compiled into the kernel. You configure the device driver by adding parameters to the kernel parameter line.

Use the zfcp.device kernel parameter to enable a SCSI device to be used as initial device.

zfcp kernel parameter syntax



```
►►──zfcp.device=<device_bus_id>,<wwpn>,<fcp_lun>──────────────────────►◄
```

where:

<device_bus_id>
: specifies the device bus-ID of the FCP channel through which the SCSI device is attached.

<wwpn>
: specifies the target port through which the SCSI device is accessed.

<fcp_lun>
: specifies the LUN of the SCSI device.

Example

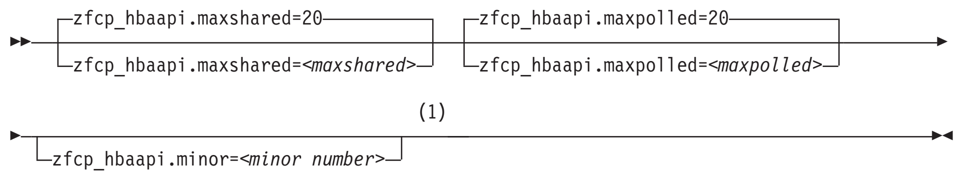
The following parameter in the kernel parameter line allows you to boot from a SCSI device with LUN 0x600e000000000000, accessed through a target port with WWPN 0x4005000000000000 and connected through an FCP channel with device bus-ID 0.0.5901. Assuming that a device node `/dev/sda1` has been created for that SCSI device:

```
zfcp.device=0.0.5901,0x4005000000000000,0x600e000000000000 root=/dev/sda1
```

zfcp HBA API kernel parameters

If the HBA API support (see “zfcp HBA API (FC-HBA) support” on page 42) has been compiled into the kernel, you can optionally configure it by adding parameters to the kernel parameter line:

zfcp HBA API kernel parameter syntax



```
   ┌─zfcp_hbaapi.maxshared=20──────────┐ ┌─zfcp_hbaapi.maxpolled=20──────────┐
►►─┼───────────────────────────────────┼─┼───────────────────────────────────┼──►
   └─zfcp_hbaapi.maxshared=<maxshared>─┘ └─zfcp_hbaapi.maxpolled=<maxpolled>─┘

                                       (1)
►─┬──────────────────────────────────┬───────────────────────────────────────►◄
  └─zfcp_hbaapi.minor=<minor number>─┘
```

Notes:

1 If you specify multiple parameters, separate them with blanks.

where:

<maxshared>
: is the maximum number of events in the shared event queue. The default is 20.

<maxpolled>
: is the maximum number of events in the polled event queue. The default is 20.

<minor number>
: is the minor number for the misc device that is registered. If no minor number is specified, it is allocated dynamically.

Example

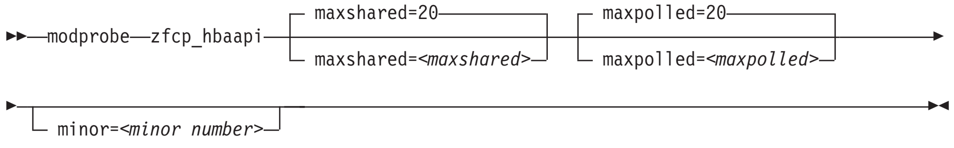
The following parameters in the kernel parameter line limit the number of events in the zfcp HBA API shared event queue to 10 and forces the minor number for the character device to be 50.

```
zfcp_hbaapi.maxshared=10 zfcp_hbaapi.minor=50
```

zfcp HBA API module parameters

If your zfcp HBA API support has been compiled as a module, load the module with **modprobe** to assure that any other required modules are loaded. When you load the module, you can, optionally, provide parameters to configure the zfcp HBA API support.

zfcp HBA API module parameter syntax



where:

<maxshared>
: is the maximum number of events in the shared event queue. The default is 20.

<maxpolled>
: is the maximum number of events in the polled event queue. The default is 20.

<minor number>
: is the minor number for the misc device that is registered. If no minor number is specified, it is allocated dynamically.

Installing the zfcp HBA API library

If you want to provide zfcp HBA API support, you need to install the zfcp HBA API library. You can find the library as a source package lib-zfcp-hbaapi-1.x.tar.gz at developerWorks:

```
ibm.com/developerworks/linux/linux390/index.shtml
```

Perform the following steps to install the library:

1. Download the source package lib-zfcp-hbaapi-1.<*x*>.tar.gz from developerWorks. In the library name, <*x*> represents the newest available version.
2. Compile and install the package:

```
# tar xzf lib-zfcp-hbaapi-1.<x>.tar.gz
# cd lib-zfcp-hbaapi-1.<x>
# ./configure
# make
# make install
```

3. Optionally, build and install documentation. For this step you require the package doxygen.

```
# make dox
# make install
```

Result: You have installed:
- Shared and static versions of libzfcphbaapi at `/usr/local/lib`.
- The header file hbaapi.h at `/usr/local/include`.
- Optionally, the documentation package at `/usr/local/share/doc/zfcp-hbaapi-1.<x>`.

Ensuring that the required device node exists for the HBA API support

The zfcp HBA API support provides a misc device. This misc device is used for kernel-user-space communication. The major number for the device is 10. You can specify a minor number as a kernel or module parameter (see "zfcp HBA API kernel parameters" on page 45 and "zfcp HBA API module parameters" on page 46) or use a dynamic minor number.

Check for the device node, for example at /dev/zfcp_hbaapi. If your distribution does not create a device node for the zfcp HBA API support (for example, with udev), you need to create one.

To find out the major and minor number for your monitor device read the dev attribute of the device's representation in sysfs:

```
# cat /sys/class/misc/zfcp_hbaapi/dev
```

The value of the dev attribute is of the form 10:*<minor>*.

To create issue a command of the form:

```
# mknod <node> c 10:<minor>
```

where *<node>* is your device node.

Example:

To create a device node `/dev/zfcp_hbaapi`:

```
# cat /sys/class/misc/zfcp_hbaapi/dev
10:64
# mknod /dev/zfcp_hbaapi c 10 64
```

In the example, the major number was 10 and the minor 64.

After the minor number has been assigned, you can create the device node, `/dev/zfcp_hbaapi`, using the following commands:

```
# minor='cat /proc/misc | awk "\$2==\"zfcp_hbaapi\" {print \$1}"'
# mknod /dev/zfcp_hbaapi c 10 $minor
```

Working with the zfcp device driver

This section describes typical tasks that you need to perform when working with FCP channels, target ports, and SCSI devices. Set an FCP channel online before you attempt to perform any other tasks.

- Working with FCP channels
  - Setting an FCP channel online or offline
  - Displaying adapter information
  - Recovering a failed FCP channel
  - Configuring and removing ports
- Working with target ports
  - Displaying port information
  - Recovering a failed port
  - Configuring SCSI devices
- Working with SCSI devices
  - Displaying information on SCSI devices
  - Mapping the representations of a SCSI device in sysfs
  - Finding the major and minor numbers for a device
  - Recovering a failed SCSI device
  - Removing SCSI devices

Displaying the device driver version

The read-only attribute “version” in sysfs provides the version of the zfcp device driver:

`/sys/bus/ccw/drivers/zfcp/version`

Setting an FCP channel online or offline

By default, FCP channels are offline. Set an FCP channel online before you perform any other tasks.

Use the **chccwdev** command (“chccwdev - Set a CCW device online” on page 263) to set an FCP channel online or offline. Alternatively, you can write “1” to an FCP channel’s online attribute to set it online, or “0” to set it offline.

Setting an FCP channel online registers it with the Linux SCSI stack.

When you set an FCP channel offline, the port and LUN subdirectories are preserved but it is unregistered from the SCSI stack and its attribute values are no longer valid.

When the FCP channel is set back online, the SCSI device names and minor numbers are freshly assigned. The mapping of devices to names and numbers might be different from what they were before the FCP channel was set offline.

Examples

- To set an FCP channel with device bus-ID 0.0.5901 online issue:

```
# chccwdev -e 0.0.5901
```

or

```
# echo 1 > /sys/bus/ccw/drivers/zfcp/0.0.5901/online
```

- To set an FCP channel with device bus-ID 0.0.5901 offline issue:

```
# chccwdev -d 0.0.5901
```

or

```
# echo 0 > /sys/bus/ccw/drivers/zfcp/0.0.5901/online
```

Displaying adapter information

Before you start: The FCP channel must be online for the adapter information to be valid.

For each online FCP channel, there is a number of read-only attributes in sysfs that provide information on the corresponding adapter card. Table 7 summarizes the relevant attributes.

Table 7. Attributes with adapter information

lic_version	Hardware microcode level
wwnn	Node world wide name (WWNN) of adapter
wwpn	Port world wide name (WWPN)
scsi_host_no	Host number of the SCSI stack
fc_link_speed	Fibre Channel link speed
in_recovery	Shows if adapter is in recovery (0 or 1)
failed	Shows if adapter is in failed state (0 or 1)
online	Shows if adapter is online (0 or 1)
s_id	Source ID of adapter port
serial_number	Serial number of adapter
fc_topology	Fibre channel topology (for example, “fabric” or “point-to-point”)
peer_wwnn	WWNN of peer for a point-to-point connection
peer_wwpn	WWPN of peer for a point-to-point connection
peer_d_id	Destination ID of the peer for a point-to-point connection

Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<attribute>
```

where:

<device_bus_id>
is the device bus-ID that corresponds to the FCP channel.

<attribute>
is one of the attributes of Table 7.

Example

In this example, information is displayed on an adapter card for an FCP channel that corresponds to a device bus-ID 0.0.5901:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/hardware_version
0x00000000
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/lic_version
0x00009111
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/scsi_host_no
1
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/wwnn
0x3abc000000000000
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/wwpn
0x4004000000000000
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/fc_link_speed
2 Gb/s
```

Recovering a failed FCP channel

Before you start: The FCP channel must be online.

Failed FCP channels are automatically recovered by the zfcp device driver. You can read the in_recovery attribute to check if recovery is under way. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/in_recovery
```

The value is “1” if recovery is under way and “0” otherwise. If the value is “0” for a non-operational FCP channel, recovery might have failed or the device driver might have failed to detect that the FCP channel is malfunctioning.

To find out if recovery has failed read the failed attribute. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/failed
```

The value is “1” if recovery has failed and “0” otherwise.

You can start or restart the recovery process for the FCP channel by writing “0” to the failed attribute. Issue a command of this form:

```
# echo 0 > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/failed
```

Example

In the following example, an FCP channel with a device bus ID 0.0.5901 is malfunctioning. The first command reveals that recovery is not already under way. The second command manually starts recovery for the FCP channel:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/in_recovery
0
# echo 0 > /sys/bus/ccw/drivers/zfcp/0.0.5901/failed
```

Configuring and removing ports

Before you start: The FCP channel must be online.

To configure a port for an FCP channel write the port's WWPN to the FCP channel's port_add attribute. Issue a command of this form:

```
# echo <wwpn> > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/port_add
```

where:

<device_bus_id>
is the device bus-ID that corresponds to the FCP channel.

<wwpn>
is the world wide port number of the port to be added.

Adding a port creates a directory in `/sys/bus/ccw/drivers/zfcp/<device_bus_id>` with the WWPN as the directory name.

You cannot read from the port_add attribute. List the contents of `/sys/bus/ccw/drivers/zfcp/<device_bus_id>` to find out which ports are currently configured for the FCP channel.

To remove a port from an FCP channel write the port's WWPN to the FCP channel's port_remove attribute. Issue a command of this form:

```
# echo <wwpn> > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/port_remove
```

where:

<device_bus_id>
is the device bus-ID that corresponds to the FCP channel.

<wwpn>
is the world wide port number of the port to be removed.

You cannot remove a port while SCSI devices are configured for it (see "Configuring SCSI devices" on page 53) or if the port is in use, for example, by error recovery.

Example

In this example, a port with WWPN 0x4004000000000000 has already been configured for an FCP Channel with device bus-ID 0.0.5901. An additional target port with WWPN 0x4005000000000000 is configured and then the port with WWPN 0x4004000000000000 is removed.

```
# ls /sys/bus/ccw/drivers/zfcp/0.0.5901/0x*
0x4004000000000000
# echo 0x4005000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/port_add
# ls /sys/bus/ccw/drivers/zfcp/0.0.5901/0x*
0x4004000000000000
0x4005000000000000
# echo 0x4004000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/port_remove
# ls /sys/bus/ccw/drivers/zfcp/0.0.5901/0x*
0x4005000000000000
```

Displaying port information

For each target port, there is a number of read-only attributes in sysfs that provide port information. Table 8 on page 52 summarizes the relevant attributes.

Table 8. Attributes with port information

scsi_id	SCSI ID for the target port
wwnn	WWNN of the storage controller to which the port belongs
access_denied	Flag that indicates if the port access is restricted by access control software on the FCP channel (see “FCP LUN access control” on page 43). The value is “1” if access is denied and “0” if access is permitted.
d_id	Destination ID of remote port
in_recovery	Shows if port is in recovery (0 or 1)
failed	Shows if port is in failed state (0 or 1)

Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<attribute>
```

where:

<device_bus_id>
is the device bus-ID that corresponds to the FCP channel.

<wwpn>
is the WWPN of the target port.

<attribute>
is one of the attributes in Table 8.

Example

In this example, information is displayed for a target port 0x4005000000000000 that is attached through an FCP channel that corresponds to a device bus-ID 0.0.5901:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/scsi_id
1
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/wwnn
0x30f7000000000000
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/access_denied
0
```

Recovering a failed port

Before you start: The FCP channel must be online.

Failed target ports are automatically recovered by the zfcp device driver. You can read the in_recovery attribute to check if recovery is under way. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/in_recovery
```

where the variables are the same as in “Configuring and removing ports” on page 50.

The value is “1” if recovery is under way and “0” otherwise. If the value is “0” for a non-operational port, recovery might have failed or the device driver might have failed to detect that the port is malfunctioning.

To find out if recovery has failed read the failed attribute. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/failed
```

The value is “1” if recovery has failed and “0” otherwise.

You can start or restart the recovery process for the port by writing “0” to the failed attribute. Issue a command of this form:

```
# echo 0 > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/failed
```

Example

In the following example, a port with WWPN 0x4005000000000000 that is connected through an FCP channel with a device bus ID 0.0.5901 is malfunctioning. The first command reveals that recovery is not already under way. The second command manually starts recovery for the port:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/in_recovery
0
# echo 0 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/failed
```

Configuring SCSI devices

To configure a SCSI device for a target port write the device’s LUN to the port’s unit_add attribute. Issue a command of this form:

```
# echo <fcp_lun> > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/unit_add
```

where:

<fcp_lun>
: is the LUN of the SCSI device to be configured.

<device_bus_id>
: is the device bus-ID that corresponds to the FCP channel.

<wwpn>
: is the WWPN of the target port.

Adding a SCSI device creates a directory in `/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>` with the LUN as the directory name.

You cannot read from the unit_add attribute. List the contents of `/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>` to find out which SCSI devices are currently configured for the port.

Adding a SCSI device also registers the device with the SCSI stack and creates a sysfs entry in the SCSI branch (see “Mapping the representations of a SCSI device in sysfs” on page 55).

Example

In this example, a target port with WWPN 0x4005000000000000 is connected through an FCP channel with device bus-ID 0.0.5901. A SCSI device with LUN

0x600e000000000000 is already configured for the port. An additional SCSI device with LUN 0x600f000000000000 is added to the port.

```
# ls /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x*
0x600e000000000000
# echo 0x600f000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/unit_add
# ls /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x*
0x600e000000000000
0x600f000000000000
```

Displaying information on SCSI devices

For each SCSI device, there is a number of read-only attributes in sysfs that provide access information for the device. These attributes indicate if the device access is restricted by access control software on the FCP channel. Table 9 summarizes the relevant attributes.

Table 9. Attributes with device access information

access_denied	Flag that indicates if access to the device is restricted by access control software on the FCP channel. The value is “1” if access is denied and “0” if access is permitted. (See “FCP LUN access control” on page 43).
access_shared	Flag that indicates if access to the device is shared or exclusive. The value is “1” if access is shared and “0” if access is exclusive. (See “FCP LUN access control” on page 43).
access_readonly	Flag that indicates if write access to the device is permitted or if access is restricted to read-only. The value is “1” if access is restricted read-only and “0” if write access is permitted. (See “FCP LUN access control” on page 43).
in_recovery	Shows if unit is in recovery (0 or 1)
failed	Shows if unit is in failed state (0 or 1)

Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<scsi_lun>/<attribute>
```

where:

<device_bus_id>
: is the device bus-ID that corresponds to the FCP channel.

<wwpn>
: is the WWPN of the target port.

<scsi_lun>
: is the FCP LUN of the SCSI device.

<attribute>
: is one of the attributes in Table 9.

Example

In this example, information is displayed for a SCSI device with LUN 0x600e000000000000 that is accessed through a target port with WWPN 0x4005000000000000 and is connected through an FCP channel with device bus-ID 0.0.5901. For the device, shared read-only access is permitted.

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/access_denied
0
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/access_shared
1
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/access_readonly
1
```

For the device to be accessible, the access_denied attribute of the target port, 0x4005000000000000, must also be “0” (see “Displaying port information” on page 51).

Mapping the representations of a SCSI device in sysfs

Each SCSI device that is configured is represented by multiple directories in sysfs. In particular:

- A directory in the zfcp branch (see “Configuring SCSI devices” on page 53)
- A directory in the SCSI branch

The directory in the sysfs SCSI branch has the following form:

`/sys/bus/scsi/devices/<`*`scsi_host_no`*`>:0:<`*`scsi_id`*`>:<`*`scsi_lun`*`>`

where:

<scsi_host_no>
: This is the value of the scsi_host_no attribute of the corresponding FCP channel.

<scsi_id>
: This is the value of the scsi_id attribute of the corresponding target port.

<scsi_lun>
: This is the value of the scsi_lun attribute of the SCSI device.

Figure 13 shows how the directory name is composed of attributes of consecutive directories in the sysfs zfcp branch. You can find the name of the directory in the sysfs SCSI branch by reading the corresponding attributes in the zfcp branch.

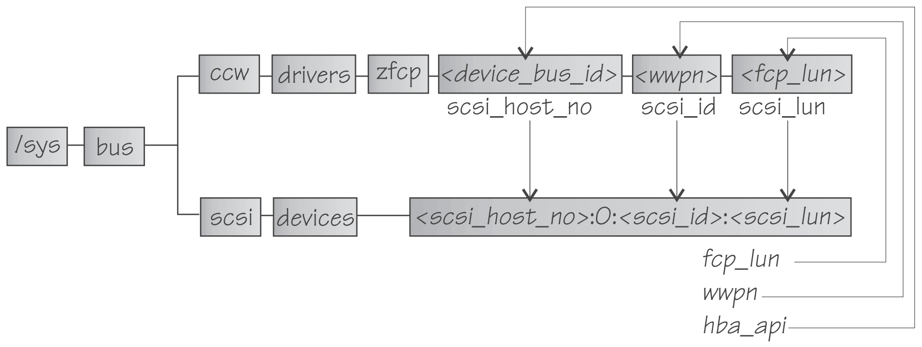


Figure 13. SCSI devices in sysfs

Conversely, the directory in the SCSI branch has three attributes, hba_id, wwpn, and fcp_lun, that hold the names of the directories in the zfcp branch.

Example

The following example finds the directory that corresponds to a SCSI device with LUN 0x600e000000000000, accessed through a target port with WWPN 0x4005000000000000 and an FCP channel with a device bus-ID 0.0.5901:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/scsi_host_no
0
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/scsi_id
1
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/scsi_lun
1
```

This makes the corresponding directory in the sysfs SCSI branch:
`/sys/bus/scsi/devices/0:0:1:1`

To confirm that this is the correct directory:

```
# cat /sys/bus/scsi/devices/0:0:1:1/hba_id
0.0.5901
# cat /sys/bus/scsi/devices/0:0:1:1/wwpn
0x4005000000000000
# cat /sys/bus/scsi/devices/0:0:1:1/fcp_lun
0x600e000000000000
```

Finding the major and minor numbers for a device

You can find the major and minor numbers of a SCSI device and of SCSI partitions from the device representation in the sysfs SCSI branch (see "Mapping the representations of a SCSI device in sysfs" on page 55).

`/sys/bus/scsi/devices/<scsi_device>/block/dev`

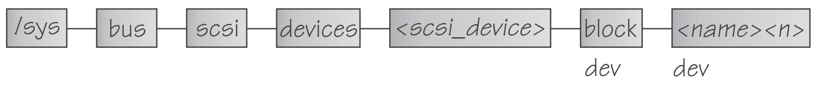


Figure 14. Major/minor numbers for SCSI devices in sysfs

In Figure 14, <*scsi_device*> is the directory that represents a SCSI device (compare Figure 13 on page 55). If the disk is partitioned, the block directory that follows contains directories of the form <*name*><*n*> that represent the partitions. <*name*> is a standard name that the SCSI stack has assigned to the SCSI device and <*n*> is a positive integer that identifies the partition.

Both the block directory and the directories that represent the partitions contain an attribute dev. Read the dev attribute to find out the major and minor numbers for the entire device or for an individual partition. The value of the dev attributes is of the form <*major*>:<*minor*>.

Example

The following command shows a major of 8 and a minor of 0 for the SCSI device 0:0:1:1:

```
# cat /sys/bus/scsi/devices/0:0:1:1/block/dev
8:0
```

Assuming that the device has three partitions sda1, sda2, and sda3, the following commands show the respective major and minor numbers:

```
# cat /sys/bus/scsi/devices/0:0:1:1/block/sda1/dev
8:1
# cat /sys/bus/scsi/devices/0:0:1:1/block/sda2/dev
8:2
# cat /sys/bus/scsi/devices/0:0:1:1/block/sda3/dev
8:3
```

Recovering a failed SCSI device

Before you start: The FCP channel must be online.

Failed SCSI devices are automatically recovered by the zfcp device driver. You can read the in_recovery attribute to check if recovery is under way. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<scsi_lun>/in_recovery
```

where the variables have the same meaning as in "Configuring SCSI devices" on page 53.

The value is "1" if recovery is under way and "0" otherwise. If the value is "0" for a non-operational SCSI device, recovery might have failed or the device driver might have failed to detect that the SCSI device is malfunctioning.

To find out if recovery has failed read the failed attribute. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<scsi_lun>/failed
```

The value is "1" if recovery has failed and "0" otherwise.

You can start or restart the recovery process for the SCSI device by writing "0" to the failed attribute. Issue a command of this form:

```
# echo 0 > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/<scsi_lun>/failed
```

Example

In the following example, SCSI device with LUN 0x600e000000000000 is malfunctioning, The SCSI device is accessed through a target port with WWPN 0x4005000000000000 that is connected through an FCP channel with a device bus ID 0.0.5901. The first command reveals that recovery is not already under way. The second command manually starts recovery for the SCSI device:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/in_recovery
0
# echo 0 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/failed
```

Removing SCSI devices

To remove a SCSI device from a target port you need to first unregister the device from the SCSI stack and then remove it from the target port.

You unregister the device by writing "1" to the delete attribute of the directory that represents the device in the sysfs SCSI branch. See "Mapping the representations of a SCSI device in sysfs" on page 55 for information on how to find this directory. Issue a command of this form:

```
# echo 1 > /sys/bus/scsi/devices/<device>/delete
```

You can then remove the device from the port by writing the device's LUN to the port's unit_remove attribute. Issue a command of this form:

```
# echo <fcp_lun> > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>/unit_remove
```

where the variables have the same meaning as in "Configuring SCSI devices" on page 53.

Example

The following example removes a SCSI device with LUN 0x600e000000000000, accessed through a target port with WWPN 0x4005000000000000 and an FCP channel with a device bus-ID 0.0.5901. The corresponding directory in the sysfs SCSI branch is assumed to be `/sys/bus/scsi/devices/0:0:1:1`.

```
# echo 1 > /sys/bus/scsi/devices/0:0:1:1/delete
# echo 0x600e000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/unit_remove
```

Scenario

The following scenario describes the life-cycle of a SCSI device with LUN 0x600e000000000000. The device is attached through an FCP channel with device bus-ID 0.0.5901 and accessed through a target port 0x4005000000000000.

The FCP channel is set online, then port and device are configured.

```
# echo 1 > /sys/bus/ccw/drivers/zfcp/0.0.5901/online
# echo 0x4005000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/port_add
# echo 0x600e000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/unit_add
```

SCSI device and port are now to be removed. First the SCSI device must be unregistered from the SCSI stack. The following commands read attributes that help to identify the device representation in the sysfs SCSI branch.

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/scsi_host_no
0
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/scsi_id
1
# cat /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/0x600e000000000000/scsi_lun
1
```

This makes the corresponding directory in the sysfs SCSI branch: `/sys/bus/scsi/devices/0:0:1:1`. The following commands read attributes to confirm that this is the correct directory:

```
# cat /sys/bus/scsi/devices/0:0:1:1/hba_id
0.0.5901
# cat /sys/bus/scsi/devices/0:0:1:1/wwpn
0x4005000000000000
# cat /sys/bus/scsi/devices/0:0:1:1/fcp_lun
0x600e000000000000
```

The SCSI device can now be unregistered, then first the device and then the port is removed from the FCP channel configuration:

```
# echo 1 > /sys/bus/scsi/devices/0:0:1:1/delete
# echo 0x600e000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/0x4005000000000000/unit_remove
# echo 0x4005000000000000 > /sys/bus/ccw/drivers/zfcp/0.0.5901/port_remove
```

API provided by the zfcp HBA API support

This section provides information for those who want to program SAN management clients that run on z/Series Linux.

Functions provided

The zfcp HBA API (see “zfcp HBA API (FC-HBA) support” on page 42) is defined in the Fibre Channel - HBA API (FC-HBA) specification (see http://www.t11.org).

The zfcp HBA API implements the following FC-HBA functions:
- HBA_GetVersion()
- HBA_LoadLibrary()
- HBA_FreeLibrary()
- HBA_GetWrapperLibraryAttributes()
- HBA_GetVendorLibraryAttributes()
- HBA_GetNumberOfAdapters()
- HBA_GetAdapterName()
- HBA_OpenAdapter()
- HBA_CloseAdapter()
- HBA_RefreshInformation()
- HBA_RefreshAdapterConfiguration()
- HBA_GetAdapterAttributes()
- HBA_GetAdapterPortAttributes()
- HBA_GetDiscoveredPortAttributes()
- HBA_SendScsiInquiry()
- HBA_SendReadCapacity()
- HBA_SendReportLUNs()
- HBA_GetFcpTargetMapping()
- HBA_SendCTPassThru()
- HBA_GetRNIDMgmtInfo()
- HBA_GetEventBuffer()
- HBA_SendRNID()
- HBA_SendRLS()
- HBA_SendRPS()
- HBA_GetPortStatistics()
- HBA_ResetStatistics()

All other FC-HBA functions return status code HBA_STATUS_ERROR_NOT_SUPPORTED where possible. The exception are the following commands that are not implemented: HBA_GetSBTargetMapping(), HBA_GetSBStatistics(), and HBA_SBDskCapacity().

Restriction: ZFCP HBA API for Linux 2.6 can access only adapters, ports and units that are configured in the operating system. As an exception, ELS commands can also be sent to ports that are not configured within zfcp.

Environment variables

The zfcp HBA API support uses the following environment variables for logging errors in the zfcp HBA API library:

LIB_ZFCP_HBAAPI_LOG_LEVEL
to specify the log level. If not set or set to zero there is no logging. If set to an integer value greater than 1, logging is enabled.

LIB_ZFCP_HBAAPI_LOG_FILE
specifies a file for the logging output. If not specified stderr is used.

LIB_ZFCP_HBAAPI_DEVICE_FILE
specifies the name of the misc device file to be used. The default is `/dev/hba_api`.

Chapter 5. Channel-attached tape device driver

The 3590 tape discipline module ('tape_3590.o') is subject to license conditions as reflected in: "International License Agreement for Non-Warranted Programs" on page 367.

The Linux for zSeries and S/390 tape device driver supports channel-attached tape devices.

SCSI tape devices attached through a zSeries FCP adapter are handled by the zfcp device driver (see Chapter 4, "SCSI-over-Fibre Channel device driver," on page 39).

Features

The tape device driver supports the following devices and functions:

- The tape device driver supports channel-attached tape drives that are compatible with IBM 3480, 3490, and 3590 magnetic tape subsystems. Various models of these device types are handled (for example, the 3490/10).
- Character and block devices (see "Tape device modes and logical devices")
- Control operations through **mt** (see "Using the mt command" on page 65)
- Message display support ("tape390_display - display messages on tape devices and load tapes" on page 306)
- Up to 128 physical tape devices.

What you should know about channel-attached tape devices

This section provides information about the available operation modes, about devices names, and about device nodes for your channel-attached tape devices.

Tape device modes and logical devices

The tape device driver supports up to 128 physical tape devices. Each physical tape device can be used in three different modes. The tape device driver treats each mode as a separate logical device:

Non-rewinding character device
Provides sequential (traditional) tape access without any caching done in the kernel.

You can use the character device in the same way as any other Linux tape device. You can write to it and read from it using normal Linux facilities such as GNU **tar**. You can perform control operations (such as rewinding the tape or skipping a file) with the standard tool **mt**. Most Linux tape software should work with the character device.

When the device is closed, the tape is left at the current position.

Rewinding character device
Provides tape access like the non-rewinding device, except that the tape is rewound when the device is closed.

Block device
Provides a read-only tape block device.

This device could be used for the installation of software in the same way as tapes are used under other operating systems on the zSeries and S/390 platforms. (This is similar to the way most Linux software distributions are shipped on CD using the ISO9660 file system.)

It is advisable to use only the ISO9660 file system on Linux for zSeries and S/390 tapes, because this file system is optimized for CD-ROM devices, which – just like 3480, 3490, or 3590 tape devices – cannot perform fast seeks.

The ISO9660 file system image file need not be the first file on the tape but can start at any position. The tape must be positioned at the start of the image file before the mount command is issued to the tape block device.

The file system image must reside on a single tape. Tape block devices cannot span multiple tape volumes.

Tape naming scheme

The tape device driver assigns minor numbers along with an index number when a physical tape device comes online. The naming scheme for tape devices is summarized in Table 10:

Table 10. Tape device names and minor numbers

	Names	**Minor numbers**
Non-rewinding character devices	ntibm<*n*>	2×<*n*>
Rewinding character devices	rtibm<*n*>	2×<*n*>+1
Block devices	btibm<*n*>	2×<*n*>

where <*n*> is the index number assigned by the device driver. The index starts from 0 for the first physical tape device, 1 for the second, and so on. The name space is restricted to 128 physical tape devices, so the maximum index number is 127 for the 128th physical tape device.

The index number and corresponding minor numbers and device names are not permanently associated with a specific physical tape device. When a tape device goes offline it surrenders its index number. The device driver assigns the lowest free index number when a physical tape device comes online. An index number with its corresponding device names and minor numbers can be reassigned to different physical tape devices as devices go offline and come online.

Tip: Use the **lstape** command (see "lstape - List tape devices" on page 289) to determine the current mapping of index numbers to physical tape devices.

When the tape device driver is loaded, it dynamically allocates a major number to channel-attached character tape devices and a major number to channel-attached block tape devices. The major numbers can but need not be the same. Different major number might be used when the device driver is reloaded, for example when Linux is rebooted.

For online tape devices, there are directories that provide information on the major/minor assignment. The directories have the form:
- `/sys/class/tape390/ntibm<n>`
- `/sys/class/tape390/rtibm<n>`
- `/sys/block/btibm<n>`

Each of these directories has a dev attribute. The value of the dev attribute has the form <*major*>:<*minor*>, where <*major*> is the major number for the character or block tape devices and <*minor*> is the minor number specific to the logical device.

Example

In this example, four physical tape devices are present, with three of them online. The TapeNo column shows the index number and the BusID indicates the associated physical tape device. In the example, no index number has been allocated to the tape device in the first row. This means that the device is offline and, currently, no names and minor numbers are assigned to it.

```
# lstape
TapeNo  BusID      CuType/Model DevType/DevMod  BlkSize State   Op      MedState
0       0.0.01a1   3490/10      3490/40         auto    UNUSED  ---     UNLOADED
1       0.0.01a0   3480/01      3480/04         auto    UNUSED  ---     UNLOADED
2       0.0.0172   3590/50      3590/11         auto    IN_USE  ---     LOADED
N/A     0.0.01ac   3490/10      3490/40         N/A     OFFLINE ---     N/A
```

The resulting names and minor numbers for the online devices are:

Bus ID	Index (TapeNo)	Device	Device name	Minor number
0.0.01ac	not assigned	not assigned		not assigned
0.0.01a1	0	non-rewind	ntibm0	0
		rewind	rtibm0	1
		block	btibm0	0
0.0.01a0	1	non-rewind	ntibm1	2
		rewind	rtibm1	3
		block	btibm1	2
0.0.0172	2	non-rewind	ntibm2	4
		rewind	rtibm2	5
		block	btibm2	4

For the online character devices, the major/minor assignments can be read from their respective representations in `/sys/class`:

```
# cat /sys/class/tape390/ntibm0/dev
254:0
# cat /sys/class/tape390/ntibm0/dev
254:1
# cat /sys/class/tape390/ntibm1/dev
254:2
# cat /sys/class/tape390/ntibm1/dev
254:3
# cat /sys/class/tape390/ntibm2/dev
254:4
# cat /sys/class/tape390/ntibm2/dev
254:5
```

In the example, the major number used for character devices is 254 the minor numbers are as expected for the respective device names.

Similarly, the major/minor assignments for the online block devices can be read from their respective representations in `/sys/block`:

```
# cat /sys/block/btibm0/dev
254:0
# cat /sys/block/btibm1/dev
254:1
# cat /sys/block/btibm2/dev
254:2
```

The minor numbers are as expected for the respective device names. In the example, the major number used for block devices is also 254.

Creating device nodes

User space programs access tape devices by *device nodes*. Your distribution might create these device nodes for you or provide udev to create them (see “Device nodes provided by udev” on page 4).

If no device nodes are created for you, you need to create them yourself, for example, with the **mknod** command. Refer to the **mknod** man page for further details.

Tip: Use the device names to construct your nodes (see “Tape naming scheme” on page 62).

Example: Defining standard tape nodes

In this example, the tape major number is assumed to be 254 for both the character and block devices. The nodes use the standard form `/dev/<device_name>` for the device nodes and the assignment of minor numbers is according to Table 10 on page 62.

```
# mknod /dev/ntibm0 c 254 0
# mknod /dev/rtibm0 c 254 1
# mknod /dev/btibm0 b 254 0
# mknod /dev/ntibm1 c 254 2
# mknod /dev/rtibm1 c 254 3
# mknod /dev/btibm1 b 254 2
# mknod /dev/ntibm2 c 254 4
# mknod /dev/rtibm2 c 254 5
# mknod /dev/btibm2 b 254 4
...
```

Examples for udev-created tape device nodes

Note

The format of the nodes that udev creates for you depends on distribution-specific configuration files that reside in `/etc/udev/rules.d`. If you use udev, be sure that you use the nodes according to your distribution. The following examples use hypothetical nodes that are provided for illustration purposes only.

If your distribution provides udev, you can use udev to create tape device nodes for you. udev is a utility program that can use the device information in sysfs (see Chapter 2, “Devices in sysfs,” on page 9) to create device nodes.

Apart from creating device nodes that are based on the device names, udev can create additional device nodes that are based on, for example, on device bus-IDs. Unless you change the device bus-IDs of your devices, device nodes that are based on a device bus-ID remain the same and map to the same device, even if the device name of a tape device has changed (for example, after rebooting). udev keeps track of the mapping of the device name and the actual devices for you and so helps you ensure that you are addressing the device you intend to.

For example, the configuration file might instruct udev to create two nodes for each logical device, the standard node and a node that is based on the device bus-ID. For a tape device with a device bus-ID 0.0.01ac it might create:

For the non-rewinding character device:
- `/dev/ntibm0` (standard device node according to the tape naming scheme)
- `/dev/tape/0.0.01ac/non-rewinding`

For the rewinding character device:
- `/dev/rtibm0` (standard device node according to the tape naming scheme)
- `/dev/tape/0.0.01ac/rewinding`

For the block device:
- `/dev/btibm0` (standard device node according to the tape naming scheme)
- `/dev/tape/0.0.01ac/block`

The next section shows how such nodes can be used to access a tape device by device bus-ID, regardless of its device name.

Accessing tapes by bus-ID

You can use device nodes that are based on your tape devices' device bus-IDs to be sure that you access a tape device with a particular bus-ID, regardless of the device name that is assigned to it.

Example

The examples in this section assume that udev provides device nodes as described in "Examples for udev-created tape device nodes" on page 64. To assure that you are addressing a device with bus-ID 0.0.01ac you could make substitutions like the following:

Instead of issuing:

```
# mt -f /dev/ntibm0 unload
```

issue:

```
# mt -f /dev/tape/0.0.01ac/non-rewinding unload
```

Using the mt command

Basic Linux tape control is handled by the **mt** utility. Refer to the man page for general information on **mt**.

Be aware that for channel-attached tape hardware there are some differences in the MTIO interface with corresponding differences for some operations of the **mt** command:

setdensity
: has no effect because the recording density is automatically detected on channel-attached tape hardware.

drvbuffer
: has no effect because channel-attached tape hardware automatically switches to unbuffered mode if buffering is unavailable.

lock / unlock
: have no effect because channel-attached tape hardware does not support media locking.

setpartition / mkpartition
: have no effect because channel-attached tape hardware does not support partitioning.

status returns a structure that, aside from the block number, contains mostly SCSI-related data that does not apply to the tape device driver.

load does not automatically load a tape but waits for a tape to be loaded manually.

offline or **rewoffl** or **eject**
: all include expelling the currently loaded tape. Depending on the stacker mode, it might attempt to load the next tape (see "Loading and unloading tapes" on page 71 for details).

Building a kernel with the tape device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the tape device driver.

The tape device driver is available as a base component with supplementary components for particular hardware and for the block device mode.

Figure 15 summarizes the kernel configuration menu options that are relevant to the tape device driver:

```
Character device drivers
   S/390 tape device support               (CONFIG_S390_TAPE)
   ├─Support for tape block devices         (CONFIG_S390_TAPE_BLOCK)
   └─Support for 3480/3490 tape hardware    (CONFIG_S390_TAPE_34XX)
```

Figure 15. Tape kernel configuration menu options

CONFIG_S390_TAPE
: This option is required if you want to work with channel-attached tape devices. It can be compiled into the kernel or as a separate module, tape.

CONFIG_S390_TAPE_BLOCK
: This base component option allows you to use channel-attached tapes as block devices.

CONFIG_S390_TAPE_34XX
: This option can be compiled into the kernel or as a separate module, tape_34xx.

The 3590 tape support is not available in source code format. You can obtain it as an OCO module from developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Setting up the tape device driver

There are no kernel or module parameters for the tape device driver. This section describes how to load the tape modules, where applicable.

For information on device nodes see "Tape naming scheme" on page 62.

Loading the tape device driver

If the tape_34xx component has not been built into the kernel, you have to load it before you can work with 3480 and 3490 tape devices. The tape_3590 component is always provided as a separate module that you must load before you can work with 3590 tape devices.

Use the **modprobe** command to ensure that any other required modules are loaded in the correct order.

Tape module syntax

```
►►──modprobe──┬─tape_34xx─┬──────────────────────────────────────────►◄
              └─tape_3590─┘
```

Refer to the **modprobe** man page for details on **modprobe**.

Working with the tape device driver

This section describes typical tasks that you need to perform when working with tape devices:

- Setting a tape device online or offline
- Displaying tape information
- Enabling compression
- Loading and unloading tapes

For information on working with the channel measurement facility, see Chapter 20, "Channel measurement facility," on page 229.

For information on how to display messages on a tape device's display unit, see "tape390_display - display messages on tape devices and load tapes" on page 306.

Setting a tape device online or offline

Setting a physical tape device online makes all corresponding logical devices accessible:
- The non-rewind character device
- The rewind character device
- The block device (if supported)

At any time, the device can be online to a single Linux instance only. You must set the tape device offline to make it accessible to other Linux instances in a shared environment.

Use the **chccwdev** command (see "chccwdev - Set a CCW device online" on page 263) to set a tape online or offline. Alternatively, you can write "1" to the device's online attribute to set it online or "0" to set it offline.

When a physical tape device is set online, the device driver assigns an index number to it. This index number is used in the standard device nodes (see "Creating device nodes" on page 64) to identify the corresponding logical devices. The index number is in the range 0 to 127. A maximum of 128 physical tape devices can be online concurrently.

If you are using the standard device nodes, you need to find out which index number the tape device driver has assigned to your tape device. This index number, and consequently the associated standard device node, can change after a tape device has been set offline and back online.

Your distribution might use udev to create alternative device nodes that distinguish devices by the physical device's bus ID instead of the index number. If you are using such device nodes you do not need to know the index number (see "Examples for udev-created tape device nodes" on page 64).

If you need to know the index number, issue a command of this form:

```
# lstape <device_bus_id>
```

where *<device_bus_id>* is the device bus-ID that corresponds to the physical tape device. The index number is the value in the TapeNo column of the command output.

Examples

- To set a physical tape device with device bus-ID 0.0.015f online, issue:

  ```
  # chccwdev -e 0.0.015f
  ```

  or

  ```
  # echo 1 > /sys/bus/ccw/devices/0.0.015f/online
  ```

  To find the index number the tape device driver has assigned, issue:

  ```
  # lstape 0.0.015f
  TapeNo  BusID      CuType/Model DevType/Model   BlkSize State   Op      MedState
  2       0.0.015f   3480/01      3480/04         auto    UNUSED  ---     LOADED
  ```

  In the example, the assigned index number is "2". The standard device nodes for working with the device until it is set offline are then:
  - `/dev/ntibm2` for the non-rewinding device
  - `/dev/rtibm2` for the rewinding device
  - `/dev/btibm2` for the block device
- To set a physical tape device with device bus-ID 0.0.015f offline, issue:

  ```
  # chccwdev -d 0.0.015f
  ```

  or

```
# echo 0 > /sys/bus/ccw/devices/0.0.015f/online
```

Displaying tape information

Each physical tape device is represented in a sysfs directory of the form

`/bus/ccw/devices/<device_bus_id>`

where *<device_bus_id>* is the device bus-ID that corresponds to the physical tape device. This directory contains a number of attributes with information on the physical device. The attributes: blocksize, state, operation, and medium_state, might not show the current values if the device is offline.

Table 11. Tape device attributes

online	"1" if the device is online or "0" if it is offline (see "Setting a tape device online or offline" on page 67)
cmb_enable	"1" if channel measurement block is enabled for the physical device or "0" if it is not enabled (see Chapter 20, "Channel measurement facility," on page 229)
cutype	Type and model of the control unit
devtype	Type and model of the physical tape device
blocksize	Currently used block size in bytes or "0" for auto
state	State of the physical tape device, either of: **UNUSED** Device is not in use and is currently available to any operating system image in a shared environment **IN_USE** Device is being used as a character device by a process on this Linux image **BLKUSE** Device is being used as a block device by a process on this Linux image **OFFLINE** The device is offline. **NOT_OP** Device is not operational
operation	The current tape operation, for example: **---** No operation **WRI** Write operation **RFO** Read operation There are several other operation codes, for example, for rewind and seek.
medium_state	Current state of the tape cartridge: **1** Cartridge is loaded into the tape device **2** No cartridge is loaded **0** The tape device driver does not have information about the current cartridge state

Issue a command of this form to read an attribute:

```
# cat /bus/ccw/devices/<device_bus_id>/<attribute>
```

where <*attribute*> is one of the attributes of Table 11 on page 69.

Tip: You can display a summary of this information by using the **lstape** command (see "lstape - List tape devices" on page 289).

Example

The following sequence of commands reads the attributes for a physical tape device with a device bus-ID 0.0.015f:

```
# cat /bus/ccw/devices/0.0.015f/online
1
# cat /bus/ccw/devices/0.0.015f/cmb_enable
0
# cat /bus/ccw/devices/0.0.015f/cutype
3480/01
# cat /bus/ccw/devices/0.0.015f/devtype
3480/04
# cat /bus/ccw/devices/0.0.015f/blocksize
0
# cat /bus/ccw/devices/0.0.015f/state
UNUSED
# cat /bus/ccw/devices/0.0.015f/operation
---
# cat /bus/ccw/devices/0.0.015f/medium_state
1
```

Issuing an **lstape** command for the same device yields:

```
# lstape 0.0.015f
TapeNo  BusID      CuType/Model DevType/Model   BlkSize State   Op      MedState
2       0.0.015f   3480/01      3480/04         auto    UNUSED  ---     LOADED
```

Enabling compression

You can use the **mt** command to control Improved Data Recording Capability (IDRC) compression.

Compression is off after the tape device driver has loaded. To switch compression on, issue:

```
# mt -f <node> compression
```

or

```
# mt -f <node> compression 1
```

where <*node*> is the device node for a character device, for example, `/dev/ntibm0`.

To switch compression off, issue:

```
# mt -f <tape> compression 0
```

Any other numeric value has no effect, and any other argument switches compression off.

Example

To switch on compression for a tape device with a device node `/dev/ntibm0` issue:

```
# mt -f /dev/ntibm0 compression 1
```

Loading and unloading tapes

You can unload tapes by issuing a command of this form:

```
# mt -f <node> unload
```

where <*node*> is one of the character device nodes.

Whether or not you can load tapes from your Linux instance depends on the stacker mode of your tape hardware. There are three possible modes:

manual
: Tapes must always be loaded manually by an operator. You can use the **tape390_display** command (see "tape390_display - display messages on tape devices and load tapes" on page 306) to display a short message on the tape device's display unit when a new tape is required.

automatic
: If there is another tape present in the stacker, the tape device automatically loads a new tape when the current tape is expelled. You can load a new tape from Linux by expelling the current tape with the **mt** command.

system
: The tape device loads a tape when instructed from the operating system. From Linux, you can load a tape with the **tape390_display** command (see "tape390_display - display messages on tape devices and load tapes" on page 306). You cannot use the **mt** command to load a tape.

Example

To expel a tape from a tape device that can be accessed through a device node `/dev/ntibm0`, issue:

```
# mt -f /dev/ntibm0 unload
```

Assuming that the stacker mode of the tape device is "system" and that a tape is present in the stacker, you can load a new tape by issuing:

```
# tape390_display -l "NEW TAPE" /dev/ntibm0
```

"NEW TAPE" is a message that is displayed on the tape devices display unit until the tape device receives the next tape movement command.

Scenario: Using a tape block device

In this scenario, an ISO9660 file system is to be created as the second file on a tape. The scenario uses the **mt** and **mkisofs** commands. Refer to the respective man pages for details.

Assumptions: The following assumptions are made:

- The required tape device driver modules have either been compiled into the kernel or have already been loaded.
- Device nodes are available as defined in “Example: Defining standard tape nodes” on page 64.
- The ISO9660 file system support has been compiled into the kernel.
- A tape device is attached through a device bus-ID 0.0.015f.

1. Create a Linux directory, `somedir`, and fill it with the contents of the file system:
```
# mkdir somedir
# cp <contents> somedir
```
2. Set the tape online:
```
# chccwdev -e 0.0.015f
```
3. If you are using standard device nodes, find out which index number the tape device driver has assigned to it. You can skip this step if you are using udev-created device nodes that distinguish devices by device bus-ID rather than the index number.
```
# lstape 0.0.015f
TapeNo  BusID      CuType/Model DevType/Model   BlkSize State   Op      MedState
1       0.0.015f   3480/01      3480/04         auto    UNUSED  ---     LOADED
```
   The index number is shown in the TapeNo column of the command output, “1” in the example. The standard device nodes are therefore `/dev/ntibm1`, `/dev/rtibm1`, and `/dev/btibm1`.
4. Insert a tape.
5. Ensure the tape is positioned at the correct position on the tape. For example, to set it to the beginning of the second file, issue:
```
# mt -f /dev/ntibm1 rewind
# mt -f /dev/ntibm1 fsf 1
```
   `fsf` skips a specified number of files, one in the example.
6. Set the block size of the character driver. (The block size 2048 bytes is commonly used on ISO9660 CD-ROMs.)
```
# mt -f /dev/ntibm1 setblk 2048
```
7. Write the file system to the character device driver:
```
# mkisofs -l -f -o file.iso somedir
# dd if=file.iso of=/dev/ntibm1 bs=2048
```
8. Set the tape to the beginning of the file:
```
# mt -f /dev/ntibm0 rewind
# mt -f /dev/ntibm0 fsf 1
```
9. Now you can mount your new file system as a block device:
```
# mount -t iso9660 -o ro,block=2048 /dev/btibm0 /mnt
```

Chapter 6. XPRAM device driver

The zSeries architecture in 31-bit mode and the S/390 architecture support only 2 GB (gigabytes) of main storage (main memory). To overcome this limitation additional storage can be declared and accessed as expanded storage. For compatibility reasons, expanded storage can also be declared in the 64-bit mode of zSeries.

The XPRAM device driver is a block device driver that enables Linux for zSeries and S/390 to access expanded storage. Thus XPRAM can be used as a basis for fast swap devices and/or fast file systems. Expanded storage range can be swapped in or out of the main storage in 4 KB blocks. All XPRAM devices do always provide a block size of 4096 bytes.

XPRAM features

The XPRAM device driver provides the following features:

- Automatic detection of expanded storage.

  If expanded storage is not available, XPRAM fails gracefully with a log message reporting the absence of expanded storage.
- The expanded storage can be divided into up to 32 partitions.

What you should know about XPRAM

This section provides information on XPRAM partitions and the device nodes that make them accessible.

XPRAM partitions and device nodes

The XPRAM device driver uses major number 35. The standard device names are of the form xpram<*n*>, where <*n*> is the corresponding minor number.

You can use the entire available expanded storage as a single XPRAM device or divide it into up to 32 partitions. Each partition is treated as a separate XPRAM device.

If the entire expanded storage is used a single device, the device name is xpram0. For partitioned expanded storage, the <*n*> in the device name denotes the (n+1)th partition. For example, the first partition is called xpram0, the second xpram1, and the 32nd partition is called xpram31.

Table 12. XPRAM device names, minor numbers, and partitions

Minor	Name	To access
0	xpram0	the first partition or the entire expanded storage if there are no partitions
1	xpram1	the second partition
2	xpram2	the third partition
...	...	...
<n>	xpram<n>	the (<n>+1)th partition
...	...	...
31	xpram31	the 32nd partition

Creating device nodes

User space programs access XPRAM devices by *device nodes*. Your distribution might create these device nodes for you or provide udev to create them (see "Device nodes provided by udev" on page 4).

If no device nodes are created for you, you need to create them yourself, for example, with the **mknod** command. Refer to the **mknod** man page for further details.

Tip: Use the device names to construct your nodes (see "XPRAM partitions and device nodes" on page 73).

Example: Defining standard XPRAM nodes

The nodes use the standard form /dev/<*device_name*> for the device nodes and the assignment of minor numbers is according to Table 12 on page 73.

```
# mknod /dev/xpram0 b 35 0
# mknod /dev/xpram1 b 35 1
# mknod /dev/xpram2 b 35 2
...
# mknod /dev/xpram30 b 35 30
# mknod /dev/xpram31 b 35 31
```

XPRAM use for diagnosis

Issuing an IPL command to reboot Linux for zSeries and S/390 does not reset expanded storage, so it is persistent across IPLs and could be used, for example, to store diagnostic information. The expanded storage is reset by an IML (power off/on).

Reusing XPRAM partitions

You might be able to reuse existing file systems or swap devices on an XPRAM device or partition after reloading the XPRAM device driver (for example, after rebooting Linux). For file systems or swap devices to be reusable, the XPRAM kernel or module parameters for the new device or partition must match the parameters of the previous use of XPRAM.

If you change the XPRAM parameters, you must create a new file system (for example with **mke2fs**) or a new swap device for each partition that has changed. A device or partition is considered changed if its size has changed. All partitions following a changed partition are also considered changed even if their sizes are unchanged.

Building a kernel with the XPRAM device driver

This section is intended for those who want to build their own kernel.

To build a kernel with XPRAM support you need to select option CONFIG_BLK_DEV_XPRAM in the configuration menu:

```
Block devices
   XPRAM disk support                              (CONFIG_BLK_DEV_XPRAM)
```

Figure 16. XPRAM kernel configuration menu option

The XPRAM support is available as a module, xpram, or built-in.

Setting up the XPRAM device driver

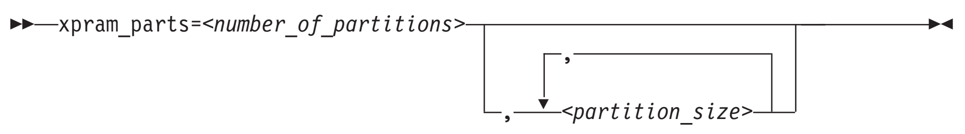
This section describes the parameters that you can optionally use to split the available expanded storage into partitions. The syntax is different for the kernel parameters and the corresponding module parameters. By default the entire expanded storage is treated as a single partition.

See "Creating device nodes" on page 74 for information on the device nodes that you need to access the partitions.

Kernel parameters

This section describes how to configure the XPRAM device driver if it has been compiled into the kernel. You can optionally partition the available expanded storage by adding the xpram_parts kernel parameter to the kernel parameter line.

XPRAM kernel parameter syntax



where:

<number_of_partitions>
: is an integer in the range 1 to 16 that defines how many partitions the expanded storage is split into.

<partition_size>
: specifies the size of a partition. The i-th value defines the size of the i-th partition.

  Each size may be blank, specified as a decimal value, or a hexadecimal value preceded by `0x`, and may be qualified by a magnitude:
  - `k` or `K` for Kilo (1024) is the default
  - `m` or `M` for Mega (1024×1024)
  - `g` or `G` for Giga (1024×1024×1024)

  You can specify up to *<number_of_partitions>* values. If you specify less values than *<number_of_partitions>*, the missing values are interpreted as blanks. Blanks are treated like zeros.

Any partition defined with a non-zero size is allocated the amount of memory specified by its size parameter.

Any remaining memory is divided as equally as possible among any partitions with a zero or blank size parameter, subject to the two constraints that blocks must be allocated in multiples of 4K and addressing constraints may leave un-allocated areas of memory between partitions.

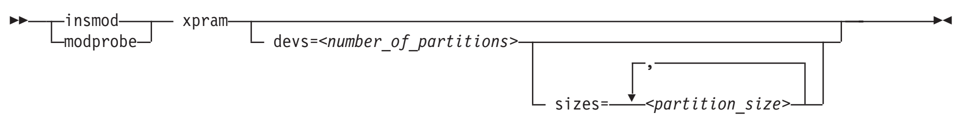
Examples

- The following specification allocates the extended storage into four partitions. Partition 1 has 2 GB (hex 800M), partition 4 has 4 GB, and partitions 2 and 3 use equal parts of the remaining storage. If the total amount of extended storage was 16 GB, then partitions 3 and 4 would each have approximately 5 GB.
  ```
  xpram_parts=4,0x800M,0,0,4g
  ```
- The following specification allocates the extended storage into three partitions. The partition 2 has 512 KB and the partitions 1 and 3 use equal parts of the remaining storage.
  ```
  xpram_parts=3,,512
  ```
- The following specification allocates the extended storage into two partitions of equal size.
  ```
  xpram_parts=2
  ```

Module parameters

This section describes how to load and configure the XPRAM device driver if it has been compiled as a separate module. You can optionally partition the available expanded storage by using the devs and sizes module parameters when you load the xpram module.

XPRAM module parameter syntax



where:

<number_of_partitions>
: is an integer in the range 1 to 16 that defines how many partitions the expanded storage is split into.

<partition_size>
: specifies the size of a partition. The i-th value defines the size of the i-th partition.

  Each size is a non-negative integer that defines the size of the partition in KB or a blank. Only decimal values are allowed and no magnitudes are accepted.

  You can specify up to *<number_of_partitions>* values. If you specify less values than *<number_of_partitions>*, the missing values are interpreted as blanks. Blanks are treated like zeros.

Any partition defined with a non-zero size is allocated the amount of memory specified by its size parameter.

Any remaining memory is divided as equally as possible among any partitions with a zero or blank size parameter, subject to the two constraints that blocks must be allocated in multiples of 4K and addressing constraints may leave un-allocated areas of memory between partitions.

Examples

- The following specification allocates the extended storage into four partitions. Partition 1 has 2 GB (2097152 KB), partition 4 has 4 GB (4194304 KB), and partitions 2 and 3 use equal parts of the remaining storage. If the total amount of extended storage was 16 GB, then partitions 3 and 4 would each have approximately 5 GB.

```
# modprobe xpram devs=4 sizes=2097152,0,0,4194304
```

- The following specification allocates the extended storage into three partitions. The partition 2 has 512 KB and the partitions 1 and 3 use equal parts of the remaining extended storage.

```
# modprobe xpram devs=3 sizes=,512
```

- The following specification allocates the extended storage into two partitions of equal size.

```
# modprobe xpram devs=2
```

Part 3. Network device drivers

This part describes the following device drivers:

- Chapter 7, “qeth device driver for OSA-Express (QDIO) and HiperSockets”
- Chapter 8, “LAN channel station device driver”
- Chapter 9, “CTC device driver”
- Chapter 10, “CTCMPC device driver”
- Chapter 11, “NETIUCV device driver”
- Chapter 12, “CLAW device driver”

Note

For prerequisites and restrictions for these device drivers refer to the kernel 2.6 April 2004 stream pages on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Chapter 7. qeth device driver for OSA-Express (QDIO) and HiperSockets

The qeth network device driver supports zSeries OSA-Express and OSA-Express2 features in QDIO mode and HiperSockets as follows:

- OSA-Express:
  - Fast Ethernet
  - 1000Base-T Ethernet
  - Gigabit Ethernet
  - Token Ring
  - ATM
- OSA-Express2:
  - Gigabit Ethernet
  - 10 Gigabit Ethernet
- HiperSockets:
  - Virtual network devices that provide virtual networks within a zSeries mainframe.

Most of the qeth device driver parameters are common to HiperSockets and to OSA-Express devices in QDIO mode.

OSA-Express is a LAN adapter that is used to connect an S/390 or zSeries mainframe to a LAN.

Note: Unless otherwise indicated, OSA-Express refers to OSA-Express and OSA-Express2.

Features

The qeth device driver supports the following functions:

- (OSA-Express2 only) Up to 640 TCP/IP stacks or connections per dedicated CHPID or 640 total stacks across multiple LPARs using a shared or spanned CHPID.
- Virtual QDIO guest LAN environments
- HiperSockets
- Guest LANs using virtual HiperSockets
- Auto-detection of qeth subchannels (see "Overview of the steps for setting up a qeth group device" on page 83)
- Internet Protocol Version 4 (IPv4)
- Internet Protocol Version 6 (IPv6) for Ethernet interfaces (see "Support for IP Version 6 (IPv6)" on page 89)
- Routing (see "Setting up a Linux router" on page 95)
- Checksumming (see "Setting the checksumming method" on page 98)
- Priority queueing for OSA-Express CHPID in QDIO mode (see "Using priority queueing" on page 99)
- Broadcast (see "Setting the scope of Token Ring broadcasts" on page 100 and "Faking broadcast capability" on page 101)

- Query and purge of ARP data (see "qetharp - Query and purge OSA and HiperSockets ARP data" on page 292)
- SNMP via the OSA-Express feature (see "osasnmpd – Start OSA-Express SNMP subagent" on page 291)
- IP address takeover (see "Taking over IP addresses" on page 107)
- VLAN (see "Scenario: Virtual LAN (VLAN) support" on page 118)
- Virtual IP addresses for OSA-Express CHPID in QDIO mode (see "Scenario: VIPA – minimize outage due to adapter failure" on page 111)
- DHCP for OSA-Express CHPID in QDIO mode (see "Setting up for DHCP with IPv4" on page 127)
- | MAC-based addressing for qeth devices (see "MAC address handling for IPv4 with the layer2 option" on page 88)

What you should know about the qeth device driver

This section describes qeth group devices in relation to subchannels and their corresponding device numbers and device bus-IDs. It also describes the interface names that are assigned to qeth group devices, and how an OSA-Express adapter handles IPv4 packets.

qeth group devices

The qeth device driver requires three I/O subchannels for each HiperSockets CHPID or OSA-Express CHPID in QDIO mode. One subchannel is for control reads, one for control writes, and the third is for data. The qeth device driver uses the QDIO protocol to communicate with the HiperSockets and OSA-Express adapter.

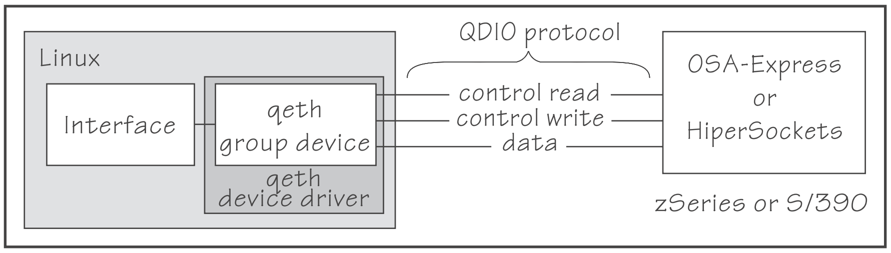


Figure 17. I/O subchannel interface

The three device bus-IDs that correspond to the subchannel triplet are grouped as one qeth group device. The following rules apply for the device bus-IDs:

read	must be even.
write	must be the device bus-ID of the read subchannel plus one.
data	can be any free device bus-ID on the same CHPID.

You can configure different triplets of device bus-IDs on the same CHPID differently. For example, if you have CHPID 0xfc, then you can configure 0.0.fc00,0.0.fc01,0.0.fc02 and 0.0.fc04,0.0.fc05,0.0.fc06 with different attribute values, for example for priority queueing.

Overview of the steps for setting up a qeth group device

Before you start: Find out how the hardware is configured and which qeth device bus-IDs are on which CHPID, for example by looking at the IOCDS. Identify the device bus-IDs that you want to group into a qeth group device. The three device bus-IDs must be on the same CHPID.

Hint: After booting Linux, each qeth device bus-ID is represented by a subdirectory in `/sys/bus/ccw/drivers/qeth/`. These subdirectories are the named with the bus IDs of the devices. For example, a qeth device with bus-ID 0.0.fc00 is represented as `/sys/bus/ccw/drivers/qeth/0.0.fc00`

There are several steps you need to perform until user space applications on your Linux instance can use a qeth group device:

- Create the qeth group device.
- Configure the device.
- Set the device online.
- Activate the device.

These tasks and the configuration options are described in detail in "Working with the qeth device driver" on page 91.

qeth interface names and device directories

The qeth device driver automatically assigns interface names to the qeth group devices and creates the corresponding sysfs structures. According to the type of CHPID and feature used, the naming scheme uses three base names:

eth<*n*>
: for Ethernet features (including the OSA-Express ATM device when emulating Ethernet in QDIO mode).

hsi<*n*>
: for HiperSockets devices.

tr<*n*>
: for Token Ring features.

where <*n*> is an integer that uniquely identifies the device. When the first device for a base name is set online it is assigned 0, the second is assigned 1, the third 2, and so on. Each base name is counted separately.

For example, the interface name of the first Ethernet feature that is set online is "eth0", the second "eth1", and so on. When the first HiperSockets device is set online, it is assigned the interface name "hsi0".

While an interface is online, it is represented in sysfs as:

```
/sys/class/net/<interface>
```

The qeth device driver shares the name space for Ethernet and Token Ring interfaces with the LCS device driver. Each driver uses the name with the lowest free identifier <*n*>, regardless of which device driver occupies the other names. For example, if the first qeth Token Ring feature is set online and there is already one LCS Token Ring feature online, the LCS feature is named "tr0" and the qeth feature is named "tr1". See also "LCS interface names" on page 131.

The mapping between interface names and the device bus-ID that represents the qeth group device in sysfs is preserved when a device is set offline and back online. However, it can change when rebooting, when devices are ungrouped, or when devices appear or disappear with a machine check.

"Finding out the interface name of a qeth group device" on page 104 and "Finding out the bus ID of a qeth interface" on page 104 provide information on how to map device bus-IDs and interface names.

MAC address handling for IPv4

In LAN environments, data packets find their destination through Media Access Control (MAC) addresses in their Logical Link Control (LLC) header (see Figure 18).

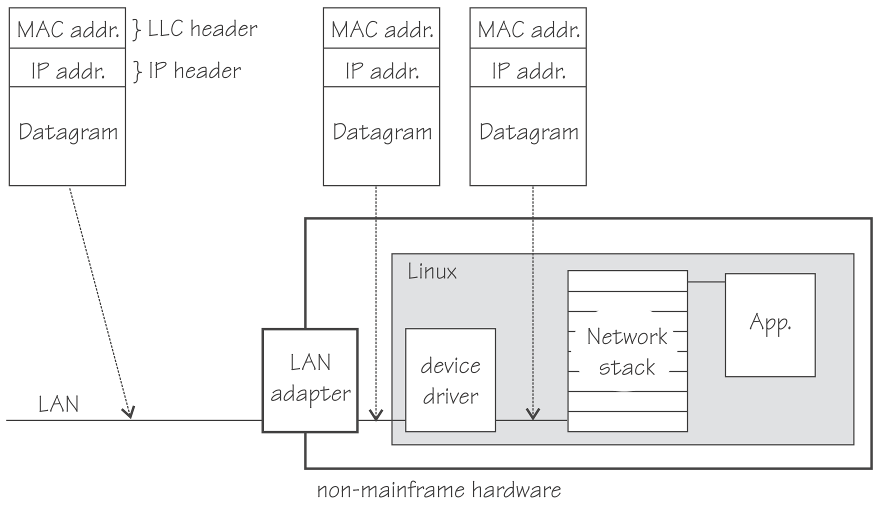


Figure 18. IPv4 processing in non-mainframe environments

MAC address handling as shown in Figure 18) also applies to an environment with an OSA-Express adapter where the layer2 option is enabled (see "MAC address handling for IPv4 with the layer2 option" on page 88).

For IPv6, both inbound and outbound packets are complete packets with LLC headers. The OSA-Express adapter in QDIO mode passes complete packets to the Linux image and the device driver lets the network stack compose packets with an LLC header.

For IPv4 without the layer2 option, the adapter removes the LLC header before passing the packet to the network stack of the recipient Linux image (see Figure 19 on page 85).

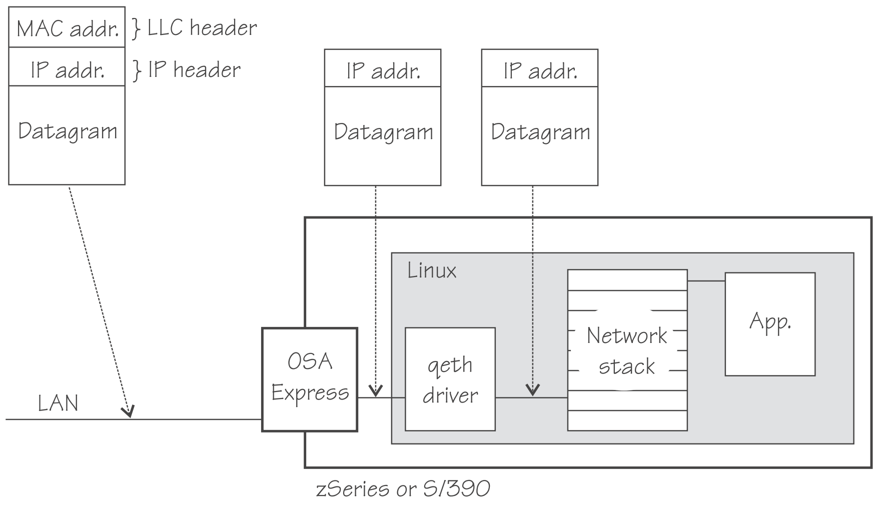


Figure 19. IPv4 processing by OSA-Express

For outbound packets, without the layer2 option, the adapter adds the LLC header to IPv4 packets with the destination MAC address.

Letting the OSA-Express hardware handle the LLC header allows multiple operating systems to share an OSA-Express adapter. Usually, LLC processing by the OSA-Express adapter also yields better performance than letting the Linux images that share the OSA-Express handle the LLC header themselves.

IP addresses

The network stack of each operating system that shares an OSA-Express adapter in QDIO mode registers all its IP addresses with the adapter. Whenever IP addresses are deleted from or added to a network stack, the device drivers download the resulting IP address list changes to the OSA-Express adapter.

For the registered IP addresses, the OSA-Express adapter off-loads various functions, in particular also:

- Handling MAC addresses and LLC headers
- ARP processing

LLC headers

Without the layer2 option, the OSA-Express adapter in QDIO mode removes the LLC header with the MAC address from incoming IPv4 packets and uses the registered IP addresses to forward a packet to the recipient TCP/IP stack. Thus the OSA-Express adapter is able to deliver IPv4 packets to the correct Linux images. Apart from broadcast packets, a Linux image can only get packets for IP addresses it has configured in the stack and registered with the OSA-Express adapter.

Because the OSA-Express QDIO microcode builds LLC headers for outgoing IPv4 packets and removes them from incoming IPv4 packets, the operating systems' network stacks only send and receive IPv4 packets without LLC headers.

This can be a problem for applications that expect LLC headers. For examples of how such problems can be resolved see:

- DHCP (see "Setting up for DHCP with IPv4" on page 127)
- tcpdump (see "Setting up for tcpdump with IPv4" on page 129)

ARP

The OSA-Express adapter in QDIO mode responds to Address Resolution Protocol (ARP) requests for all registered IP addresses.

ARP is a TCP/IP protocol that translates 32-bit IP addresses into the corresponding hardware addresses. For example, for an Ethernet, the hardware addresses are 48-bit Ethernet Media Access Control (MAC) addresses. The mapping of IP addresses to the corresponding hardware addresses is defined in the ARP cache. When it needs to send a packet, a host consults the ARP cache of its network adapter to find the MAC address of the target host.

If there is an entry for the destination IP address, the corresponding MAC address is copied into the LLC header and the packet is added to the appropriate interface's output queue. If the entry is not found, the ARP functions retain the IP packet, and broadcast an ARP request asking the destination host for its MAC address. When a reply is received, the packet is sent to its destination.

This short overview is intended as background information for the sections that follow and is by no means an exhaustive description of the ARP protocol. Consult the TCP/IP literature for more details on ARP.

Faking LLC headers

Note: The information in this section is not applicable if you are using the layer2 option (see "MAC address handling for IPv4 with the layer2 option" on page 88). If you are using the layer2 option, the qeth device driver ignores your setting for faking LLC headers.

Before you start:

- This section applies to IPv4 only.
- The device must be offline while you enable faking LLC headers.
- If you are setting up an IPv4 interface for an OSA-Express CHPID in QDIO mode you must not enable the layer2 option (see "MAC address handling for IPv4 with the layer2 option" on page 88).

IPv4 packets within mainframe environments do not have LLC headers. HiperSockets do not use LLC headers and the OSA-Express QDIO microcode removes LLC headers from incoming packets (see "MAC address handling for IPv4" on page 84). This is a problem for network programs that require incoming packets with LLC headers.

The fake_ll attribute instructs qeth to insert a fake LLC header in all incoming packets. The packets are then passed to the Linux network stack and finally to the recipient programs or applications (Figure 20 on page 87).

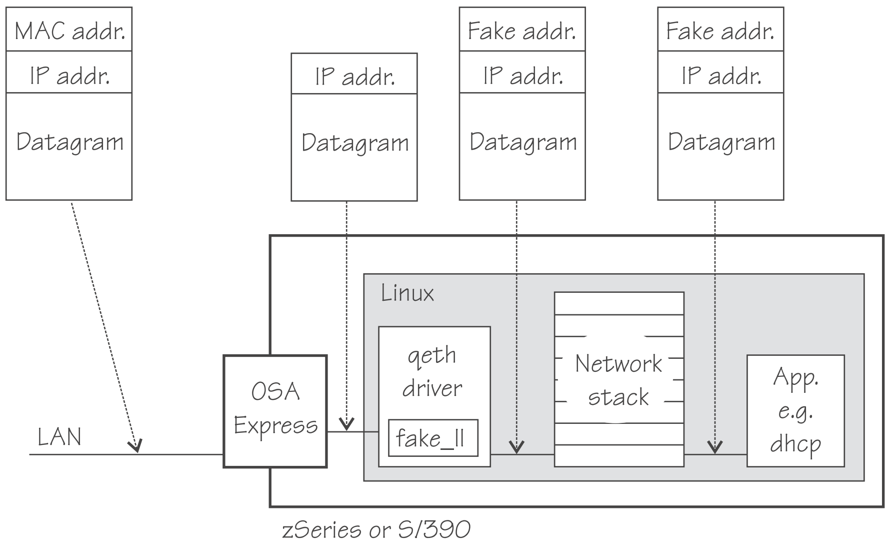


Figure 20. qeth with fake_ll option for incoming packets

Network programs that expect incoming packets to have a LLC header can then be used as usual, without any patches. Examples for programs that expect an LLC header are the DHCP server program *dhcp* and client program *dhcpcd* (see "Setting up for DHCP with IPv4" on page 127).

Shortcomings of fake_ll: An obvious disadvantage of fake_ll is, that it introduces additional processing and, thus, has an adverse effect on performance.

Because fake_ll is a qeth option, it also cannot supply fake LLC headers for programs that intercept outgoing packets before they have reached the qeth driver.

| The OSA-Express adapter in QDIO mode suppresses the construction of LLC headers in the associated network stacks. Outgoing packets that originate from programs that build their own LLC headers and bypass the Linux network stack have LLC headers. Outgoing packets from all programs that work through the
| network stack do not have an LLC header until they reach the OSA-Express
| adapter.

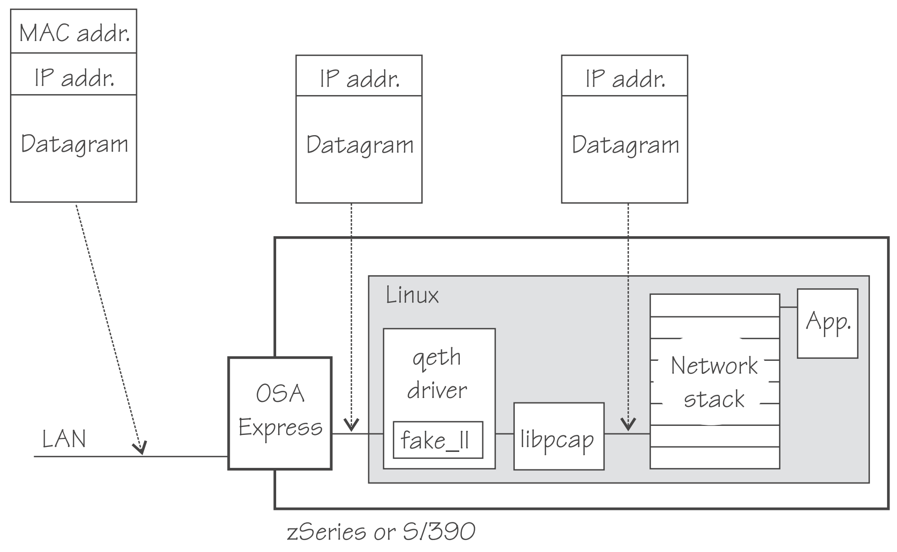


Figure 21. qeth with fake_ll option for outgoing packets

An example of a program that expects LLC headers in outgoing packets is *libpcap* a program that captures outgoing packets for *tcpdump*.

See "Setting up for tcpdump with IPv4" on page 129 for information on how to make tcpdump work correctly for IPv4.

Setting the fake_ll attribute: Set the value of the device's fake_ll attribute to "1" to insert fake LLC headers in incoming IPv4 packets and to "0" to suppress inserting fake LLC headers. By default, the qeth device driver does not insert fake LLC headers.

Example: To make a device 0xa110 insert fake LLC headers in incoming IPv4 packets issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a110/fake_ll
```

MAC address handling for IPv4 with the layer2 option

The layer2 option stops the OSA-Express adapter from stripping the MAC addresses from incoming packets. Incoming and outgoing packets are complete with an LLC header at all stages between the Linux network stack and the LAN as shown in Figure 18 on page 84. This layer 2 based forwarding requires unique MAC addresses for all concerned Linux instances.

Be aware that in conjunction with the *layer2* option, the following cannot be configured as described in the respective sections:

- Router definitions (see "Setting up a Linux router" on page 95)
- HiperSockets network concentrator (see "HiperSockets Network Concentrator" on page 121)
- IP address takeover (see "Taking over IP addresses" on page 107)
- Proxy ARP (see "Configuring a device for proxy ARP" on page 109)
- VIPA (see "Configuring a device for virtual IP address (VIPA)" on page 110)

- Stateless autoconfiguration in IPv6 (see "Support for IP Version 6 (IPv6)")

Accordingly, you cannot use the following commands if you are using the *layer2* option:

- qetharp (see "qetharp - Query and purge OSA and HiperSockets ARP data" on page 292)
- qethconf (see "qethconf - Configure qeth devices" on page 294)

If your environment does not fulfill the requirements, or you want to use a feature that you cannot use in conjunction with the *layer2* option, consider using the *fake_ll* option instead (see "Faking LLC headers" on page 86).

For connections within a QDIO based z/VM guest LAN environment, z/VM assigns the necessary MAC addresses to its guests.

For Linux instances that are directly attached to an OSA-Express adapter in QDIO mode, you need to assign the MAC addresses yourself. Consult your distribution documentation on how to assign a MAC address. Be sure not to assign the MAC address of the OSA-Express adapter to your Linux instance. See Chapter 4 "Planning for Guest LANs and Virtual Switches"" in *z/VM: Connectivity*, SC24-6080, for further information on configuring MAC addresses.

Support for IP Version 6 (IPv6)

IPv6 applies only to the Ethernet interfaces of the OSA-Express adapter running in QDIO mode. IPv6 is not supported on HiperSockets nor on the OSA-Express Token Ring and ATM features.

There are noticeable differences between the IP stacks for versions 4 and 6. Some concepts in IPv6 are different from IPv4, such as neighbor discovery, broadcast, and IPSec. IPv6 uses a 16-byte address field, while the addresses under IPv4 are 4 bytes in length.

Without the layer2 option, (see "MAC address handling for IPv4 with the layer2 option" on page 88), stateless autoconfiguration generates unique IP addresses for all Linux instances, even if they share an OSA-Express adapter with other operating systems. With the layer2 option, each Linux instances is associated with a unique MAC addresses.

Using IPv6 is largely transparent to users. You must be aware of the IP version when specifying IP addresses and when using commands that return IP version specific output (for example, qetharp).

Further information

For details on OSA-Express in QDIO, mode refer to *OSA-Express Customer's Guide and Reference*, SA22-7935.

For information on guest LANs and virtual HiperSockets refer to:

- `http://www.linuxvm.org/Info/HOWTOs/guestlan.html`
- The Redbook *zSeries HiperSockets*, SG24-6816
- *z/VM CP Command and Utility Reference*, SC24-6008

For information on proxy ARP visit: `http://www.sjdjweis.com/linux/proxyarp/`.

Building a kernel with the qeth device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the qeth device driver.

Figure 22 summarizes the kernel configuration menu options that are relevant to the qeth device driver:

```
Base setup
   QDIO support                                        (CONFIG_QDIO)
   └─Performance statistics in /proc                   (CONFIG_QDIO_PERF_STATS)
Networking support
└─S/390 network device drivers
  └─Gigabit Ethernet device support                    (CONFIG_QETH)
    ├─IPv6 support for qeth                            (CONFIG_QETH_IPV6)
    ├─VLAN support for qeth                            (CONFIG_VLAN)
    └─Performance statistics in /proc                  (CONFIG_QETH_PERF_STATS)
```

Figure 22. qeth kernel configuration menu options

CONFIG_QDIO
This option provides the interface between the zSeries or S/390 mainframe and an OSA-Express CHPID in QDIO mode or a HiperSockets CHPID.

It is required if you want to work with qeth devices. It depends on the common code option “TCP/IP networking” (CONFIG_INET).

It can be compiled into the kernel or as a separate module, qdio.

CONFIG_QDIO_PERF_STATS
This option gathers QDIO performance statistics in procfs.

CONFIG_QETH
This option is required if you want to work with qeth devices. It can be compiled into the kernel or as a separate module, qeth. This option depends on the common code options, “Token Ring driver support” (CONFIG_TR), “Ethernet (10 or 100 Mbit)” (CONFIG_NET_ETHERNET), and “IP: multicasting”(CONFIG_IP_MULTICAST).

CONFIG_QETH_IPV6
Provides IPv6 support for the qeth device driver.

CONFIG_VLAN
Provides IEEE 802.1q VLAN support for the qeth device driver (see “Scenario: Virtual LAN (VLAN) support” on page 118).

CONFIG_QETH_PERF_STATS
Gathers QDIO performance statistics in procfs.

If you want to configure qeth devices for VIPA (see “Configuring a device for virtual IP address (VIPA)” on page 110), you also need the common code option CONFIG_DUMMY. It can be compiled into the kernel or as a separate module, dummy.

Setting up the qeth device driver

There are no kernel or module parameters for the qeth device driver. qeth devices are set up using sysfs.

Loading the qeth device driver modules

If the qeth device driver has not been built into the kernel, you have to load it before you can work with qeth devices. Use the **modprobe** command to load the qeth device driver to automatically load all required additional modules in the correct order:

```
# modprobe qeth
```

Working with the qeth device driver

This section provides an overview of the typical tasks that you need to perform when working with qeth group devices.

Most of these tasks involve writing to and reading from attributes of qeth group devices in sysfs. Table 13 serves as both a task overview and a summary of the attributes and the possible values you can write to them. Underlined values are defaults.

Not all attributes are applicable to each device. Some attributes apply only to HiperSockets or only to OSA-Express CHPIDs in QDIO mode, other attributes are applicable to IPv4 interfaces only. Refer to the respective task descriptions to see the applicability of each attribute.

The layer2 option changes the way OSA-Express CHPIDs in QDIO mode handle MAC addresses (see "MAC address handling for IPv4" on page 84) and is applicable to IPv4 interfaces only. Layer2 is not compatible with some of the other attributes. Attributes that cannot be specified in conjunction with layer2 are highlighted in grey.

Table 13. qeth tasks and attributes – compatible with the layer2 attribute

Task	**Corresponding attributes**	**Possible attribute values**
"Creating a qeth group device" on page 93	none	n/a
"Assigning a port name" on page 94	portname	any valid port name
"Setting up a Linux router" on page 95	route4 route6	primary_router secondary_router primary_connector secondary_connector multicast_router no_router
"Setting the checksumming method" on page 98	checksumming	hw_checksumming sw_checksumming no_checksumming
"Providing Large Send" on page 98	large_send	no EDDP TSO

Table 13. qeth tasks and attributes – compatible with the layer2 attribute (continued)

Task	Corresponding attributes	Possible attribute values
"Using priority queueing" on page 99	priority_queueing	prio_queueing_prec prio_queueing_tos no_prio_queueing no_prio_queueing:0 no_prio_queueing:1 no_prio_queueing:2 no_prio_queueing:3
"Setting the Token Ring MAC address format" on page 100	canonical_macaddr	0 or 1
"Setting the scope of Token Ring broadcasts" on page 100	broadcast_mode	broadcast_local broadcast_allrings
"Faking broadcast capability" on page 101	fake_broadcast	0 or 1
"Faking LLC headers" on page 86	fake_ll	0 or 1
| "Setting the layer2 attribute" on page 102 | **Note:** If you specify the layer2 attributes your settings for | any of the attributes highlighted in grey are ignored and the | defaults apply.	layer2	0 or 1
"Adding additional hardware-header space" on page 102	add_hhlen	integer in the range 0 to 1024, the default is 0
"Specifying the number of inbound buffers" on page 102	buffer_count	integer in the range 8 to 128, the default is 16
"Specifying the relative port number" on page 103	portno	integer in the range 0 to 15, the default is 0
"Finding out the type of your network adapter" on page 103	card_type	n/a, read-only
"Setting a device online or offline" on page 103	online	0 or 1
"Finding out the interface name of a qeth group device" on page 104	if_name	n/a, read-only
"Finding out the bus ID of a qeth interface" on page 104	none	n/a
"Activating an interface" on page 104	none	n/a
"Deactivating an interface" on page 106	none	n/a
"Taking over IP addresses" on page 107	ipa_takeover/enable	0 or 1 or toggle
	ipa_takeover/add4 ipa_takeover/add6 ipa_takeover/del4 ipa_takeover/del6	IPv4 or IPv6 IP address and mask bits
	ipa_takeover/invert4 ipa_takeover/invert6	0 or 1 or toggle
"Configuring a device for proxy ARP" on page 109	rxip/add4 rxip/add6 rxip/del4 rxip/del6	IPv4 or IPv6 IP address
"Configuring a device for virtual IP address (VIPA)" on page 110	vipa/add4 vipa/add6 vipa/del4 vipa/del6	IPv4 or IPv6 IP address
"Recovering a device" on page 110	recover	1

Table 13. qeth tasks and attributes – compatible with the layer2 attribute (continued)

Task	Corresponding attributes	Possible attribute values
Tips: • Instead of using the attributes for IPA, proxy ARP and VIPA directly, use the **qethconf** command. • Your distribution might also provide a distribution-specific configuration tool. Refer to your distribution documentation for distribution-specific alternatives.		

sysfs provides multiple paths through which you can access the qeth group device attributes. For example, if a device with bus-ID 0.0.a100 corresponds to interface eth0:

```
/sys/bus/ccwgroup/drivers/qeth/0.0.a100
/sys/bus/ccwgroup/devices/0.0.a100
/sys/devices/qeth/0.0.a100
/sys/class/net/eth0/device
```

all lead to the attributes for the same device. For example, the following commands are all equivalent and return the same value:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/if_name
eth0
# cat /sys/bus/ccwgroup/devices/0.0.a100/if_name
eth0
# cat /sys/devices/qeth/0.0.a100/if_name
eth0
# cat /sys/class/net/eth0/device/if_name
eth0
```

However, the path through the /sys/class/net branch is available only while the device is online. Furthermore, it might lead to a different device if the assignment of interface names changes after rebooting or when devices are ungrouped and new group devices created.

Tips:

- Work through one of the paths that are based on the device bus-ID.
- Your distribution might provide a distribution-specific configuration file through which you can set the attributes. Refer to your distribution documentation for distribution-specific information.

The following sections describe the tasks in detail.

Creating a qeth group device

Before you start: You need to know the device bus-IDs that correspond to the read, write, and data subchannel of your OSA-Express CHPID in QDIO mode or HiperSockets CHPID as defined in the IOCDS of your mainframe.

To define a qeth group device, write the device numbers of the subchannel triplet to /sys/bus/ccwgroup/drivers/qeth/group. Issue a command of the form:

```
# echo <read_device_bus_id>,<write_device_bus_id>,<data_device_bus_id> > /sys/bus/ccwgroup/drivers/qeth/group
```

Result: The qeth device driver uses the device bus-ID of the read subchannel to create a directory for a group device:

/sys/bus/ccwgroup/drivers/qeth/*<read_device_bus_id>*

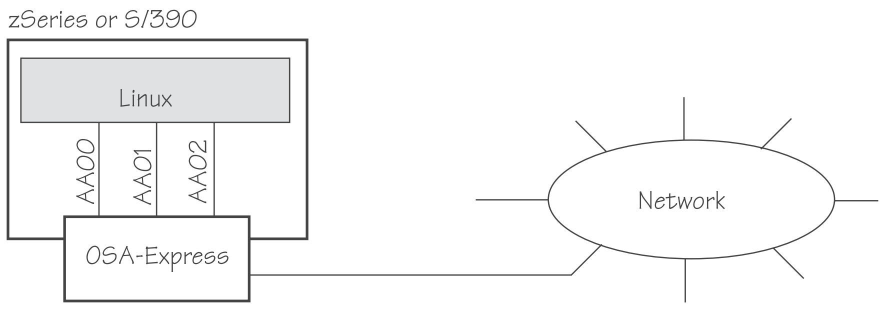
This directory contains a number of attributes that determine the settings of the qeth group device. The following sections describe how to use these attributes to configure a qeth group device.

Note: If you have defined an OSA-Express CHPID in QDIO mode for a mainframe earlier than z990 you might need to set the portname attribute (see "Assigning a port name").

Example

In this example, a single OSA-Express CHPID in QDIO mode is used to connect a Linux instance to a network.

Mainframe configuration:



Linux configuration:

Assuming that 0xaa00 is the device number that corresponds to the read subchannel:

```
# echo 0.0.aa00,0.0.aa01,0.0.aa02 > /sys/bus/ccwgroup/drivers/qeth/group
```

This command results in the creation of the following directories in sysfs:
- `/sys/bus/ccwgroup/drivers/qeth/0.0.aa00`
- `/sys/bus/ccwgroup/devices/0.0.aa00`
- `/sys/devices/qeth/0.0.aa00`

Both the command and the resulting directories would be the same for a HiperSockets CHPID.

Assigning a port name

Before you start:
- This section does not apply to:
  - HiperSockets CHPIDs
  - z990 mainframes
  - z900 and z800 mainframes with a microcode level of at least Driver 3G - EC stream J11204, MCL032 (OSA level 3.33).
  - z/VM guest LAN environments with APAR VM63308 applied.
- The device must be offline while you assign the port name.

For S/390 mainframes and z900 or z800 mainframes that are not exempted by the conditions listed under "Before you start," you must associate each OSA-Express CHPID in QDIO mode with a port name. The port name identifies the port for sharing by other operating system instances. The port name can be 1 to 8 characters long and must be uppercase. All operating system instances that share the port must use the same port name.

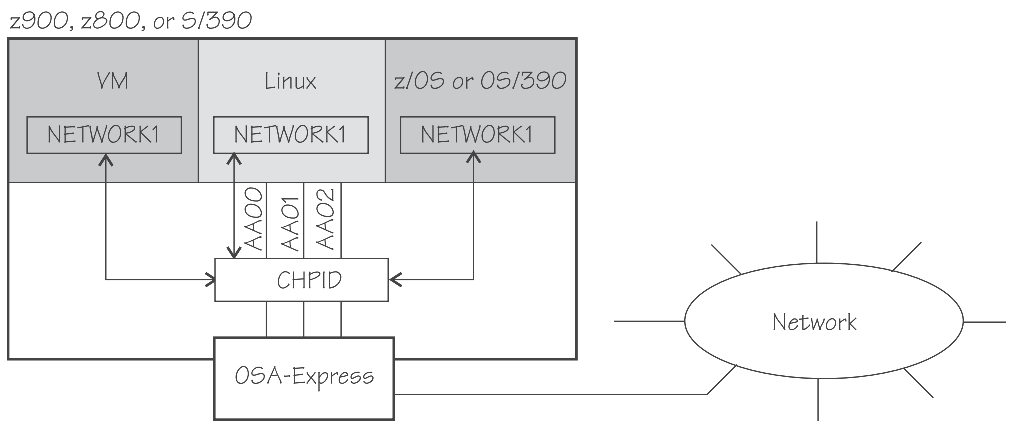
To assign a port name set the portname device group attribute to the name of the port. Issue a command of the form:

```
# echo <PORTNAME> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/portname
```

Example

In this example, two other mainframe operating systems share the OSA-Express CHPID in QDIO mode and use the port name "NETWORK1".

Mainframe configuration:



Linux configuration:

```
# echo NETWORK1 > /sys/bus/ccwgroup/drivers/qeth/0.0.aa00/portname
```

Setting up a Linux router

| **Note:** If you enable the layer2 option (see "MAC address handling for IPv4 with
| the layer2 option" on page 88) the qeth device driver ignores the router
| settings described in this section. With the layer2 option enabled, set up a
| router as you would in a discrete server environment.

Before you start:

- A suitable hardware setup is in place that permits your Linux instance to act as a router.
- The Linux instance is set up as a router.
- You must not enable the layer2 option if you are setting up an IPv4 interface for an OSA-Express CHPID in QDIO mode.

By default, your Linux instance is not a router. Depending on your IP version, IPv4 or IPv6 you can use the route4 or route6 attribute of your qeth device to define it as a router. You can set the route4 or route6 attribute dynamically, while the qeth device is online.

The same values are possible for route4 and route6 but depend on the type of CHPID:

An OSA-Express CHPID in QDIO mode honors the following values:

primary_router
to make your Linux instance the principal connection between two networks.

secondary_router
to make your Linux instance a backup connection between two networks.

primary_connector
to make your Linux instance the principal connection between a HiperSockets network and an external network (see "HiperSockets Network Concentrator" on page 121).

secondary_connector
to make your Linux instance a backup connection between a HiperSockets network and an external network (see "HiperSockets Network Concentrator" on page 121).

A HiperSockets CHPID honors the following value, provided the microcode level supports this feature:

multicast_router
causes the qeth driver to receive all multicast packets of the CHPID. For a unicast function for HiperSockets see "HiperSockets Network Concentrator" on page 121.

Both types of CHPIDs honor:

no_router
is the default. You can use this value to reset a router setting to the default.

Note: To configure Linux running as a VM guest or in an LPAR as a router, IP forwarding must be enabled in addition to setting the route4 or route6 attribute.

For IPv4, this can be done by issuing:

```
# sysctl -w net.ipv4.conf.all.forwarding=1
```

For IPv6, this can be done by issuing:

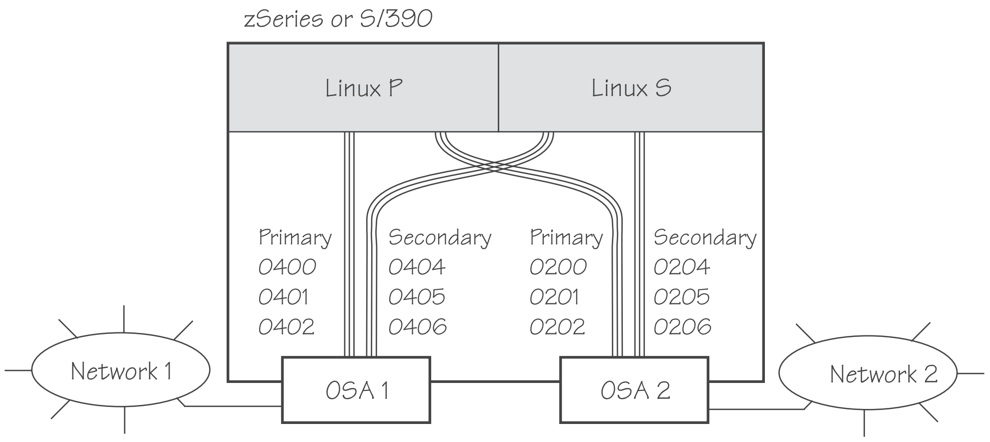
```
# sysctl -w net.ipv6.conf.all.forwarding=1
```

Depending on your distribution, you might be able to use distribution-specific configuration files. Refer to your distribution documentation for distribution-specific procedures.

Example

In this example, two Linux instances, "Linux P" and "Linux S", running on a zSeries or S/390 use OSA-Express to act as primary and secondary routers between two networks. IP forwarding needs to be enabled for Linux in an LPAR or as a VM guest to act as a router. This is usually done in procfs or in a configuration file; refer to your distribution manual for details.

Mainframe configuration:



It is assumed that both Linux instances are configured as routers in their respective LPARs or in VM.

Linux P configuration:

To create the qeth group devices:

```
# echo 0.0.0400,0.0.0401,0.0.0402 > /sys/bus/ccwgroup/drivers/qeth/group
# echo 0.0.0200,0.0.0201,0.0.0202 > /sys/bus/ccwgroup/drivers/qeth/group
```

To assign port names to the CHPIDs (For S/390 and certain microcode levels of z900 and z800 mainframes only, see “Assigning a port name” on page 94):

```
# echo NETWORK1 > /sys/bus/ccwgroup/drivers/qeth/0.0.0400/portname
# echo NETWORK2 > /sys/bus/ccwgroup/drivers/qeth/0.0.0200/portname
```

To make Linux P a primary router for IPv4:

```
# echo primary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0400/route4
# echo primary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0200/route4
```

Linux S configuration:

To create the qeth group devices:

```
# echo 0.0.0404,0.0.0405,0.0.0406 > /sys/bus/ccwgroup/drivers/qeth/group
# echo 0.0.0204,0.0.0205,0.0.0206 > /sys/bus/ccwgroup/drivers/qeth/group
```

To assign port names to the CHPIDs (For S/390 and certain microcode levels of z900 and z800 mainframes only, see “Assigning a port name” on page 94):

```
# echo NETWORK1 > /sys/bus/ccwgroup/drivers/qeth/0.0.0404/portname
# echo NETWORK2 > /sys/bus/ccwgroup/drivers/qeth/0.0.0204/portname
```

To make Linux S a secondary router for IPv4:

```
# echo secondary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0404/route4
# echo secondary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0204/route4
```

See "HiperSockets Network Concentrator" on page 121 for further examples.

Setting the checksumming method

Before you start: The device must be offline while you set the checksumming method.

You can determine how checksumming is performed for incoming IP packages by setting a value for the checksumming attribute of your qeth device. Issue a command of the form:

```
# echo <method> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/checksumming
```

where <*method*> can be any of these values:

hw_checksumming
performs the checksumming in hardware if the CHPID is an OSA-Express CHPID in QDIO mode and your OSA adapter hardware supports checksumming.

If you set "hw_checksumming" for an adapter that does not support it or for a HiperSockets CHPID, the TCP/IP stack performs the checksumming instead of the adapter.

sw_checksumming
performs the checksumming in the TCP/IP stack. This is the default.

no_checksumming
suppresses checksumming.

Examples

- To find out the checksumming setting for a device 0x1a10 read the checksumming attribute:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.1a10/checksumming
sw_checksumming
```

- To enable hardware checksumming for a device 0x1a10 issue:

```
# echo hw_checksumming > /sys/bus/ccwgroup/drivers/qeth/0.0.1a10/checksumming
```

Providing Large Send

You can offload TCP segmentation from the Linux network stack to the OSA-Express2 features. Large Send can lead to enhanced performance and latency for interfaces with predominately large outgoing packets. Issue a command of the form:

```
# echo <value> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/large_send
```

where <*value*> can be any one of:

no No Large Send is provided. The Linux network stack performs the segmentation. This is the default.

TSO
The network adapter provides hardware Large Send. You can use hardware Large Send for an OSA-Express2 that connects to an interface though a real LAN.

You cannot use hardware TCP segmentation for HiperSockets or for connections between systems running on the same OSA-Express2 CHPID. The qeth device driver does not check if the destination IP address is able to receive TCP segmentation offloaded packets. Thus it will send out the packet, which, if systems share an OSA-Express2 CHPID, will lead to unpredictable results for the receiving system.

EDDP
The qeth device driver provides the Large Send. There are no hardware related restrictions for device driver segmentation offload. It can be used with any qeth supported hardware.

Examples

- To enable hardware Large Send for a device 0x1a10 issue:

```
# echo TSO > /sys/bus/ccwgroup/drivers/qeth/0.0.1a10/large_send
```

Using priority queueing

Before you start:

- This section applies to OSA-Express CHPIDs in QDIO mode only.
- The device must be offline while you set the queueing options.

An OSA-Express CHPID in QDIO mode has four output queues (queues 0 to 3) in central storage. The priority queueing feature gives these queues different priorities (queue 0 having the highest priority). Queueing is relevant mainly to high traffic situations. When there is little traffic, queueing has no impact on processing. The qeth device driver can put data on one or more of the queues. By default, the driver uses queue 2 for all data.

You can determine how outgoing IP packages are assigned to queues by setting a value for the priority_queueing attribute of your qeth device. Issue a command of the form:

```
# echo <method> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/priority_queueing
```

where <*method*> can be any of these values:

prio_queueing_prec
to base the queue assignment on the two most significant bits of each packet's IP header precedence field.

prio_queueing_tos
to select a queue according to the IP type of service that is assigned to packets by some applications. The service type is a field in the IP datagram header that can be set with a **setsockopt** call. Table 14 shows how the qeth device driver maps service types to the available queues:

Table 14. IP service types and queue assignment for type of service queueing

Service type	Queue
Low latency	0
High throughput	1
High reliability	2
Not important	3

no_prio_queueing
causes the qeth device driver to use queue 2 for all packets. This is the default.

no_prio_queueing:0
causes the qeth device driver to use queue 0 for all packets.

no_prio_queueing:1
causes the qeth device driver to use queue 1 for all packets.

no_prio_queueing:2
causes the qeth device driver to use queue 2 for all packets. This is equivalent to the default.

no_prio_queueing:3
causes the qeth device driver to use queue 3 for all packets.

Example

To make a device 0xa110 use queueing by type of service issue:

```
# echo prio_queueing_tos > /sys/bus/ccwgroup/drivers/qeth/a110/priority_queueing
```

Setting the Token Ring MAC address format

Before you start:

- This section applies to OSA-Express CHPIDs in QDIO mode with the Token Ring feature only.
- The device must be offline while you set the Token Ring MAC address format.

The qeth group device can interpret MAC addresses in canonical or non-canonical form in a Token Ring. The default interpretation is the non-canonical form.

To set the MAC address format to canonical set the canonical_macaddr device group attribute to "1". To reset the MAC address format to non-canonical set the canonical_macaddr device group attribute to "0". Issue a command of the form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/canonical_macaddr
```

| **Note:** If you are using the layer2 option (see "MAC address handling for IPv4 with the layer2 option" on page 88), the qeth group device uses the default non-canonical MAC address format regardless of how you set the canonical_macaddr attribute.

Example

In this example, a device 0.0.a000 is instructed to interpret the Token Ring MAC addresses as canonical.

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/canonical_macaddr
```

Setting the scope of Token Ring broadcasts

Before you start:

- This section applies to OSA-Express CHPIDs in QDIO mode with the Token Ring feature only.
- The device must be offline while you set the scope of Token Ring broadcasts.

To control the scope of Token Ring broadcasts set the broadcast_mode attribute to one of the following values:

broadcast_local
to restrict Token Ring broadcasts to the local LAN segment.

broadcast_allrings
to allow Token Ring broadcasts to propagate to all rings that are connected via bridges. This is the default.

Issue a command of the form:

```
# echo <value> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/broadcast_mode
```

Note: If you are using the layer2 option (see "MAC address handling for IPv4 with the layer2 option" on page 88), the qeth group device uses the default Token Ring broadcast scope regardless of how you set the broadcast_mode attribute.

Example

In this example, the scope of broadcasts for a device 0.0.a000 is limited to the local LAN segment.

```
# echo broadcast_local > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/broadcast_mode
```

Faking broadcast capability

Before you start:

- This section applies to devices that do not support broadcast only.
- The device must be offline while you enable faking broadcasts.

For devices that support broadcast, the broadcast capability is enabled automatically.

There are processes, for example, the *gated* routing daemon, that require the devices' broadcast capable flag to be set in the Linux network stack. To set this flag for devices that do not support broadcast set the fake_broadcast attribute of the qeth group device to "1". To reset the flag set it to "0".

Issue a command of the form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/fake_broadcast
```

| **Note:** If you are using the layer2 option (see "MAC address handling for IPv4
| with the layer2 option" on page 88), the qeth group device does not fake
| broadcast capabilities, regardless of how you set the fake_broadcast
| attribute.

Example

In this example, a device 0.0.a100 is instructed to pretend that it has broadcast capability.

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/fake_broadcast
```

Setting the layer2 attribute

Before you start: If you are using the layer2 option within a QDIO based guest LAN environment, you cannot define a VLAN with ID "1", because ID "1" is reserved for z/VM use.

Set the value of the device's layer2 attribute to "1" to make the OSA-Express adapter keep the MAC addresses in incoming IPv4 packets and to "0" to make the OSA-Express adapter remove LLC headers. By default, the OSA-Express adapter removes LLC headers from incoming IPv4 packets.

Example: To make the OSA-Express adapter keep MAC addresses in IPv4 packets for a device 0xa110:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a110/layer2
```

Switching on the layer2 option has far-reaching consequences. For more details, see "MAC address handling for IPv4 with the layer2 option" on page 88.

Adding additional hardware-header space

Before you start: The device must be offline while you add additional hardware-header space.

Some software makes use of free space in front of packets. For example, extra space can be beneficial for Linux virtual servers and IP tunneling.

To reserve additional hardware-header space in front of every packet in socket buffers set the add_hhlen attribute to an integer value up to 1024. The integer is the number of bytes to be added. Issue a command of the form:

```
# echo <integer> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/add_hhlen
```

Example

In this example, device 0.0.a000 is instructed to increase the hardware-header space by 8 bytes.

```
# echo 8 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/add_hhlen
```

Specifying the number of inbound buffers

Before you start: The device must be offline while you specify the number of inbound buffers.

By default, the qeth device driver assigns 16 buffers for inbound traffic to each qeth group device. Depending on the amount of available storage and the amount of traffic, you can assign from 8 to 128 buffers.

The Linux memory usage for inbound data buffers for the devices is: (number of buffers) × (buffer size).

The buffer size is equivalent to the frame size which is:

- For an OSA-Express CHPID in QDIO mode: 64 KB
- For HiperSockets: depending on the HiperSockets CHPID definition, 16 KB, 24 KB, 40 KB, or 64 KB

Set the buffer_count attribute to the number of inbound buffers you want to assign. Issue a command of the form:

```
# echo <number> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/buffer_count
```

Example

In this example, 64 inbound buffers are assigned to device 0.0.a000.

```
# echo 64 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/buffer_count
```

Specifying the relative port number

Before you start:

- This section applies to OSA-Express ATM only. In all other cases only a single port is available.
- The device must be offline while you specify the relative port number.

ATM adapters provide one physical port (port 0) and two logical ports (0 and 1) for a single CHPID. By default, the qeth group device uses port 0. To use a different port, issue a command of the form:

```
# echo <integer> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/portno
```

Where *<integer>* is either 0 or 1.

Example

In this example, port 1 is assigned to the qeth group device.

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/portno
```

Finding out the type of your network adapter

You can find out the type of the network adapter through which your device is connected. To find out the type read the device's card_type attribute. Issue a command of the form:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/card_type
```

Example

To find the card_type of a device 0.0.a100 issue:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/card_type
OSD_100
```

Setting a device online or offline

To set a qeth group device online set the online device group attribute to "1". To set a qeth group device offline set the online device group attribute to "0". Issue a command of the form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/online
```

Setting a device online associates it with an interface name (see "Finding out the interface name of a qeth group device").

Example

To set a qeth device with bus ID 0.0.a100 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/online
```

To set the same device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/online
```

Finding out the interface name of a qeth group device

When a qeth group device is set online an interface name is assigned to it. To find out the interface name of a qeth group device for which you know the device bus-ID read the group device's if_name attribute.

Issue a command of the form:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/if_name
```

Tip: you can also read the content of `/proc/qeth` to obtain a mapping for all qeth interfaces and devices.

Example

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/ifname
eth0
```

Finding out the bus ID of a qeth interface

For each network interface, there is a directory in sysfs under `/sys/class/net/`, for example, `/sys/class/net/eth0` for interface eth0. This directory contains a symbolic link "device" to the corresponding device in `/sys/devices`.

Read this link to find the device bus-ID of the device that corresponds to the interface.

| **Tip:** you can also use the **lsqeth** command (see "lsqeth - List qeth based network
| devices" on page 287) or read the content of `/proc/qeth` to obtain a mapping for
| all qeth interfaces and devices.

Example

To find out which device bus-ID corresponds to an interface eth0 issue, for example:

```
# readlink /sys/class/net/eth0/device
../../../devices/qeth/0.0.a100
```

In this example, eth0 corresponds to the device bus-ID 0.0.a100.

Activating an interface

Before you start:

- You need to know the interface name of the qeth group device (see "Finding out the interface name of a qeth group device" on page 104).
- You need to know the IP address you want to assign to the device.

The MTU range for OSA-Express CHPIDs in QDIO mode is 576 – 61440. However, depending on your medium and networking hardware settings, it might be restricted to 1492, 1500, 8992 or 9000. The recommended MTU size for OSA-Express CHPIDs in QDIO mode is 1492 (only for Gigabit Ethernet: 8992 for jumbo frames). Choosing 1500 (or 9000 for Gigabit Ethernet jumbo frames) can cause performance degradation.

On HiperSockets, the maximum MTU size is restricted by the maximum frame size as announced by the licensed internal code (LIC). The maximum MTU is equal to the frame size minus 8 KB. Hence, the possible frame sizes of 16 KB, 24 KB, 40 KB or 64 KB result in maximum MTU sizes of 8 KB, 16 KB, 32 KB or 56 KB, respectively.

The MTU size defaults to the correct settings for both HiperSockets and OSA-Express CHPIDs in QDIO mode. As a result, you need not specify the MTU size when activating the interface.

Note that, on heavily loaded systems, MTU sizes exceeding 8 KB can lead to memory allocation failures for packets due to memory fragmentation. A symptom of this problem are messages of the form ″order-N allocation failed″ in the system log; in addition, network connections will drop packets, in extreme cases to the extent that the network is no longer usable.

As a workaround, use MTU sizes at most of 8 KB (minus header size), even if the network hardware allows larger sizes (for example, HiperSockets or 10 Gigabit Ethernet).

You activate or deactivate network devices with **ifconfig** or an equivalent command. For details of the **ifconfig** command refer to the **ifconfig** man page.

Examples

- This example activates a HiperSockets CHPID:

```
# ifconfig hsi0 192.168.100.10 netmask 255.255.255.0
```

- This example activates an OSA-Express CHPID in QDIO mode:

```
# ifconfig eth0 192.168.100.11 netmask 255.255.255.0 broadcast 192.168.100.255
```

  Or, using the default netmask and its corresponding broadcast address:

```
# ifconfig eth0 192.168.100.11
```

- This example reactivates an interface that had already been activated and subsequently deactivated:

```
# ifconfig eth0 up
```

Confirming that an IP address has been set

The Linux network stack design does not allow feedback about IP address changes. If **ifconfig** or an equivalent command fails to set an IP address on an

OSA-Express network CHPID, a query with **ifconfig** shows the address as being set on the interface although the address is not actually set on the CHPID.

There are usually failure messages of the form “could not set IP address” or “duplicate IP address” in the kernel messages. You can display these messages with **dmesg**. For most distributions you can also find the messages in `/var/log/messages`.

There may be circumstances that prevent an IP address from being set, most commonly if another system in the network has set that IP address already.

If you are not sure whether an IP address was set properly or experience a networking problem, check the messages or logs to see if an error was encountered when setting the address. This also applies in the context of HiperSockets and to both IPv4 and IPv6 addresses. It also applies to whether an IP address has been set for IP takeover, for VIPA, or for proxy ARP.

Duplicate IP addresses

The OSA-Express adapter in QDIO mode recognizes duplicate IP addresses on the same OSA-Express adapter or in the network using ARP and prevents duplicates.

There are several setups that require duplicate addresses:

- To perform IP takeover you need to be able to set the IP address to be taken over. This address exists prior to the takeover. See “Taking over IP addresses” on page 107 for details.
- For proxy ARP you need to register an IP address for ARP that belongs to another Linux instance. See “Configuring a device for proxy ARP” on page 109 for details.
- For VIPA you need to assign the same virtual IP address to multiple devices. See “Configuring a device for virtual IP address (VIPA)” on page 110 for details.

You can use the **qethconf** command (see “qethconf - Configure qeth devices” on page 294) to maintain a list of IP addresses that your device can take over, a list of IP addresses for which your device can handle ARP, and a list of IP addresses that can be used as virtual IP addresses, regardless of any duplicates on the same OSA-Express adapter or in the LAN.

Deactivating an interface

You can deactivate an interface with **ifconfig** or an equivalent command or by setting the network device offline. While setting a device offline involves actions on the attached device, deactivating only stops the interface logically within Linux.

To deactivate an interface with **ifconfig**, Issue a command of the form:

```
# ifconfig <interface_name> down
```

Example

To deactivate eth0 issue:

```
# ifconfig eth0 down
```

Taking over IP addresses

This section describes how to configure for IP takeover if the layer2 option (see “MAC address handling for IPv4 with the layer2 option” on page 88) is not enabled. If you have enabled the layer2 option, you can configure for IP takeover as you would in a distributed server environment.

Taking over an IP addresses overrides any previous allocation of this address to another LPAR. If another LPAR on the same CHPID has already registered for that IP address, this association is removed.

An OSA-Express CHPID in QDIO mode can take over IP addresses from any zSeries operating system. IP takeover for HiperSockets CHPIDs is restricted to taking over addresses from other Linux instances in the same Central Electronics Complex (CEC).

There are three stages to taking over an IP address:

Stage 1: Ensure that your qeth group device is enabled for IP takeover

Stage 2: Activate the address to be taken over for IP takeover

Stage 3: Issue a command to take over the address

Stage 1: Enabling a qeth group device for IP takeover

The qeth group device that is to take over an IP address must be enabled for IP takeover. For HiperSockets, both the device that takes over the address and the device that surrenders the address must be enabled. By default, qeth devices are not enabled for IP takeover.

To enable a qeth group device for IP address takeover set the enable device group attribute to “1”. To switch off the takeover capability set the enable device group attribute to “0”. In sysfs, the enable attribute is located in a subdirectory `ipa_takeover`. Issue a command of the form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/ipa_takeover/enable
```

Example: In this example, a device 0.0.a500 is enabled for IP takeover:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a500/ipa_takeover/enable
```

Stage 2: Activating and deactivating IP addresses for takeover

The qeth device driver maintains a list of IP addresses that each qeth group device can take over. You use the **qethconf** command to display or change this list.

To display the list of IP addresses that are activated for IP takeover issue:

```
# qethconf ipa list
```

To activate an IP address for IP takeover, add it to the list. Issue a command of the form:

```
# qethconf ipa add <ip_address>/<mask_bits> <interface_name>
```

To deactivate an IP address delete it from the list. Issue a command of the form:

```
# qethconf ipa del <ip_address>/<mask_bits> <interface_name>
```

In these commands, *<ip_address>/<mask_bits>* is the range of IP address to be activated or deactivated. See “qethconf - Configure qeth devices” on page 294 for more details on the **qethconf** command.

Example: In this example, there is only one range of IP address that can be taken over by device hsi0.

```
# qethconf ipa list
ipa add 192.168.10.0/24 hsi0
```

The following command adds a range of IP address that can be taken over by device eth0.

```
# qethconf ipa add 192.168.10.1/24 eth0
qethconf: Added 192.168.10.1/24 to /sys/class/net/eth0/device/ipa_takeover/add4.
qethconf: Use "qethconf ipa list" to check for the result
```

Listing the activated IP addresses now shows both ranges of addresses.

```
# qethconf ipa list
ipa add 192.168.10.0/24 hsi0
ipa add 192.168.10.1/24 eth0
```

The following command deletes the range of IP address that can be taken over by device eth0.

```
# qethconf ipa del 192.168.10.1/24 eth0
qethconf: Deleted 192.168.10.1/24 from /sys/class/net/eth0/device/ipa_takeover/del4.
qethconf: Use "qethconf ipa list" to check for the result
```

Stage 3: Issuing a command to take over the address

Before you start:

- Both the device that is to take over the IP address and the device that is to surrender the IP address must be enabled for IP takeover. This rule applies to the devices on both OSA-Express and HiperSockets CHPIDs. (See “Stage 1: Enabling a qeth group device for IP takeover” on page 107).
- The IP address to be taken over must have been activated for IP takeover (see “Stage 2: Activating and deactivating IP addresses for takeover” on page 107).

To complete taking over a specific IP address and remove it from the CHPID or LPAR that previously held it, issue an **ifconfig** or equivalent command.

Example: To make a device hsi0 take over IP address 192.168.10.22 issue:

```
# ifconfig hsi0 192.168.10.22
```

The IP address you are taking over must be different from the one that is already set for your device. If your device already has the IP address it is to take over you must issue two commands: First to set it to any free IP address and then to set it to the address to be taken over.

Example: To make a device hsi0 take over IP address 192.168.10.22 if hsi0 is already configured to have IP address 192.168.10.22 issue:

```
# ifconfig hsi0 0.0.0.0
# ifconfig hsi0 192.168.10.22
```

Be aware of the information in "Confirming that an IP address has been set" on page 105 when using IP takeover.

Configuring a device for proxy ARP

This section describes how to configure for proxy ARP if the layer2 option (see "MAC address handling for IPv4 with the layer2 option" on page 88) is not enabled. If you have enabled the layer2 option, you can configure for proxy ARP as you would in a distributed server environment.

Before you start: This section applies to qeth group devices that have been set up as routers only.

The qeth device driver maintains a list of IP addresses for which a qeth group device handles ARP and issues gratuitous ARP packets. See `http://www.sjdjweis.com/linux/proxyarp/` for more information on proxy ARP.

Use the **qethconf** command to display this list or to change the list by adding and removing IP addresses (see "qethconf - Configure qeth devices" on page 294).

Be aware of the information in "Confirming that an IP address has been set" on page 105 when working with proxy ARP.

Example

Figure 23 shows an environment where proxy ARP is used.

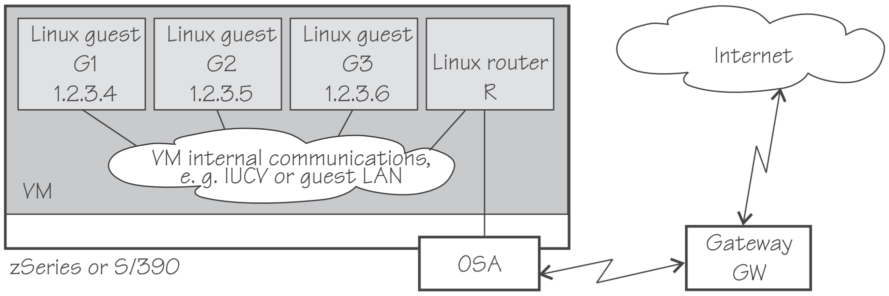


Figure 23. Example of proxy ARP usage

G1, G2, and G3 are Linux guests (connected, for example, via IUCV to a Linux router R), reached from GW (or the outside world) via R. R is the ARP proxy for G1, G2, and G3. That is, R agrees to take care of packets destined for G1, G2, and G3. The advantage of using proxy ARP is that GW does not need to know that G1, G2, and G3 are behind a router.

To receive packets for 1.2.3.4, so that it can forward them to G1 1.2.3.4, R would add 1.2.3.4 to its list of IP addresses for proxy ARP for the interface that connects it to the OSA adapter.

```
# qethconf parp add 1.2.3.4 eth0
qethconf: Added 1.2.3.4 to /sys/class/net/eth0/device/rxip/add4.
qethconf: Use "qethconf parp list" to check for the result
```

After issuing similar commands for the IP addresses 1.2.3.5 and 1.2.3.6 the proxy ARP configuration of R would be:

```
# qethconf parp list
parp add 1.2.3.4 eth0
parp add 1.2.3.5 eth0
parp add 1.2.3.6 eth0
```

Configuring a device for virtual IP address (VIPA)

This section describes how to configure for VIPA if the layer2 option (see “MAC address handling for IPv4 with the layer2 option” on page 88) is not enabled. If you have enabled the layer2 option, you can configure for VIPA as you would in a distributed server environment.

Before you start:

- This section does not apply to HiperSockets.
- Virtual IP address (VIPA) can only be configured if the kernel has been compiled with the common code configuration option CONFIG_DUMMY.

zSeries and S/390 use VIPAs to protect against certain types of hardware connection failure. You can assign VIPAs that are independent from particular adapter. VIPAs can be built under Linux using *dummy* devices (for example, “dummy0” or “dummy1”).

The qeth device driver maintains a list of VIPAs that the OSA-Express adapter accepts for each qeth group device. Use the **qethconf** utility to add or remove VIPAs (see “qethconf - Configure qeth devices” on page 294).

For an example of how to use VIPA, see “Scenario: VIPA – minimize outage due to adapter failure” on page 111.

Be aware of “Confirming that an IP address has been set” on page 105 when working with VIPAs.

Recovering a device

You can use the recover attribute of a qeth group device to recover it in case of failure. For example, error messages in /var/log/messages might inform you of a malfunctioning device. Issue a command of the form:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/recover
```

Example

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/recover
```

Scenario: VIPA – minimize outage due to adapter failure

This chapter describes how to use
- Standard VIPA
- Source VIPA (versions 1.x)
- Source VIPA 2 (version 2.0.0)

VIPA allows you to assign IP addresses that are not associated with a particular adapter. This minimizes outage caused by adapter failure. Standard VIPA is usually sufficient for applications, such as Web Server, that do *not* open connections to other nodes. Source VIPA is used for applications that open connections to other nodes. Source VIPA Extensions enable you to work with multiple VIPAs per destination in order to achieve multipath load balancing.

Notes:
1. The VIPA functionality requires a kernel built with the CONFIG_DUMMY option.
2. See the information in "Confirming that an IP address has been set" on page 105 concerning possible failure when setting IP addresses for OSA-Express features in QDIO mode (qeth driver).
3. The configuration file layout for Source VIPA has changed since the 1.x versions. In the 2.0.0 version a *policy* is included. For details see the README and the man pages provided with the package.

Standard VIPA

Purpose
VIPA is a facility for assigning an IP address to a system, instead of to individual adapters. It is supported by the Linux kernel. The addresses can be in IPv4 or IPv6 format.

Usage
These are the main steps you must follow to set up VIPA in Linux:
1. Create a dummy device with a *virtual IP address*.
2. Ensure that your service (for example, the Apache Web server) listens to the virtual IP address assigned above.
3. Set up *routes* to the virtual IP address, on clients or gateways. To do so, you can use either:
   - Static routing (shown in the example of Figure 24 on page 112).
   - Dynamic routing. For details of how to configure routes, you must refer to the documentation delivered with your *routing daemon* (for example, `zebra` or `gated`).

If outage of an adapter occurs, you must *switch adapters*.
- To do so under static routing, you should:
  1. Delete the route that was set previously.
  2. Create an alternative route to the virtual IP address.
- To do so under dynamic routing, you should refer to the documentation delivered with your *routing daemon* for details.

Example
This example assumes static routing is being used, and shows you how to:
1. Configure VIPA under static routing.

2. Switch adapters when an adapter outage occurs.

Figure 24 shows the network adapter configuration used in the example.

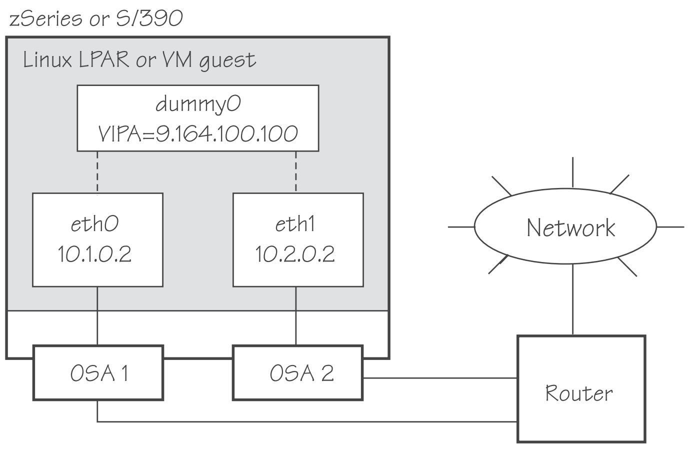


Figure 24. Example of using Virtual IP Address (VIPA)

1. If the dummy component has not been compiled into the kernel, ensure that the dummy module has been loaded. If necessary, load it by issuing:

```
# modprobe dummy
```

2. Create a dummy interface with a virtual IP address, 9.164.100.100:

```
 # ifconfig dummy0 9.164.100.100
```

3. Enable the network devices for this VIPA so that it accepts packets for this IP address.

```
 # qethconf vipa add 9.164.100.100 eth0
qethconf: Added 9.164.100.100 to /sys/class/net/eth0/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
 # qethconf vipa add 9.164.100.100 eth1
qethconf: Added 9.164.100.100 to /sys/class/net/eth1/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
```

For IPv6, the address is specified in IPv6 format:

```
# qethconf vipa add 200200000000000000000000012345678 eth0
qethconf: Added 200200000000000000000000012355678 to /sys/class/net/eth0/device/vipa/add6.
qethconf: Use "qethconf vipa list" to check for the result
# qethconf vipa add 200200000000000000000000012355678 eth1
qethconf: Added 200200000000000000000000012355678 to /sys/class/net/eth1/device/vipa/add6.
qethconf: Use "qethconf vipa list" to check for the result
```

4. Ensure that the addresses have been set:

```
# qethconf vipa list
vipa add 9.164.100.100 eth0
vipa add 9.164.100.100 eth1
```

5. Ensure that your service (such as the Apache Web server) listens to the virtual IP address.

6. Set up a route to the virtual IP address (static routing), so that VIPA can be reached via the gateway with address 10.1.0.2.

   ```
   # route add -host 9.164.100.100 gw 10.1.0.2
   ```

Now we assume an *adapter outage* occurs. We must therefore:

1. Delete the previously-created route.

   ```
   # route delete -host 9.164.100.100
   ```

2. Create the alternative route to the virtual IP address.

   ```
   # route add -host 9.164.100.100 gw 10.2.0.2
   ```

Source VIPA

This version of Source VIPA has been superseded in October 2003 by Source VIPA 2 (version 2.0.0). If you use Source VIPA 2, read "Source VIPA 2" on page 115.

Purpose

Source VIPA provides a functionality specially required in high-performance environments. It is a very flexible means for source address selection to arbitrary applications.

Normally, IP packets are tagged with the IP address of the adapter through which they leave the system. In case of an adapter failure, IP packets of outgoing sockets cannot be routed correctly and thus become ″lost″ in the network. With Source VIPA, they are tagged with the VIPA instead. This is done by dynamically linking the Source VIPA shared object file to the application to be Source-VIPA-enabled before linking the runtime library to it. This catches some socket calls and modifies them to yield a Source VIPA effect. The result is a per-application configuration of Source VIPA.

The Source VIPA solution does not affect kernel stability. Source VIPA is controlled by a configuration file (usually /etc/src_vipa.conf) containing flexible rules when to use Source VIPA, based on destination IP address ranges.

Note: This implementation of Source VIPA applies to IPv4 only.

An alternative but somewhat less flexible approach to Source VIPA is to use the `ip` tool to modify the routing table:

```
ip route your_route_statement src S1.S2.S3.S4
```

Usage

Installation:

```
make
make starter
make install
```

Paths can be changed in the Makefile. Defaults are:

```
SRC_VIPA_PATH=/lib
SRC_VIPA_STARTER_PATH=/usr/local/bin
```

The starter script should be in the execution path when you start the application.

Configuration: `/etc/src_vipa.conf`, or the file pointed to by environment variable SRC_VIPA_CONFIG_FILE, contains lines such as the following:

```
# comment
D1.D2.D3.D4/MASK S1.S2.S3.S4
.INADDR_ANY P1-P2 S1.S2.S3.S4
.INADDR_ANY P S1.S2.S3.S4
```

`D1.D2.D3.D4/MASK` specifies a range of destination addresses and the number of bits set in the subnet mask (MASK). As soon as a socket is opened and connected to these destination addresses and the application does not do an explicit bind to a source address, src_vipa does a bind to S1.S2.S3.S4. Instead of IP addresses in dotted notation, host names can be used and will be resolved using DNS.

`.INADDR_ANY P1-P2 S1.S2.S3.S4`, or the same command with only one port P, will associate sockets with IP addresses causing bind calls with `INADDR_ANY` as a local address to be intercepted if the port the socket is bound to is between P1 and P2 (inclusive). In this case, `INADDR_ANY` will be replaced by S1.S2.S3.S4 (which can be 0.0.0.0).

All `.INADDR_ANY` statements will be read and evaluated in order of appearance. This means that multiple `.INADDR_ANY` statements can be used to have bind calls intercepted for every port outside a certain range. This is useful, for example, for `rlogin`, which uses `bind` to bind to a local port but with `INADDR_ANY` as a source address to use automatic source address selection.

The default behavior for all ports is that the kind of bind calls will not be modified.

Enabling an application: The command:

```
src_vipa.sh <application and parameters>
```

This enables the Source VIPA functionality for the application. The config file is read once at the start of the application. It is also possible to change the starter script and run multiple applications using different Source VIPA settings in separate files pointed to by a SRC_VIPA_CONFIG_FILE environment variable defined and exported prior to invoking the respective application.

Restrictions

LD_PRELOAD security prevents setuid executables to be run under src_vipa; programs of this kind can only be run when the real UID is 0.

Example

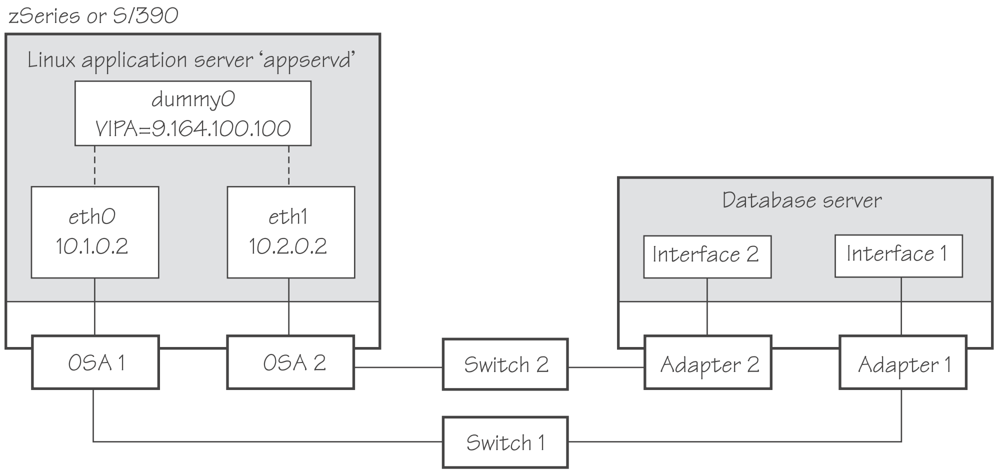


Figure 25. Example of using source VIPA

The command:

```
src_vipa.sh appservd start
```

starts the application server with Source VIPA functionality. Packets leaving 'appservd' are tagged with the source address 9.164.100.100, regardless of the physical interface. In case of an outage, communication can still be maintained with the originating application as long as one of the physical interfaces is functioning. For example, if Switch 1 fails, Switch 2 can maintain the logical connection with 'appservd'.

Source VIPA 2

Purpose

Source VIPA 2 is particularly suitable for high-performance environments. It selects one source address out of a range of source addresses when it replaces the source address of a socket. The reason for using several source addresses lies in the inability of some operating system kernels to do load balancing among several connections with the same source and destination address over several interfaces.

To achieve load balancing, a *policy* has to be selected in the *policy* section of the configuration file of Source VIPA 2 (/etc/src_vipa.conf). This *policy* section also allows to specify several source addresses used for one destination. Source VIPA then applies the source address selection according to the rules of the *policy* selected in the configuration file.

This Source VIPA solution does not affect kernel stability. Source VIPA is controlled by a configuration file containing flexible rules for when to use Source VIPA based on destination IP address ranges.

Note: This implementation of Source VIPA applies to IPv4 only.

Usage

Installation:

```
make
make starter
make install
```

Paths can be changed in the Makefile. Defaults are:

```
SRC_VIPA_PATH=/lib
SRC_VIPA_STARTER_PATH=/usr/local/bin
```

The starter script should be in the execution path when you start the application.

Migration: If you migrate from an earlier version of Source VIPA and do not need multiple VIPAs, the *onevipa policy* followed by your VIPA is the recommended change (see "Policies"). Please check your syslog (usually in `/var/log/messages`) for problems the first time you use the new version.

Configuration: With Source VIPA 2 the configuration file has changed: the *policy* section was added. The default configuration file is /etc/src_vipa.conf.

/etc/src_vipa.conf or the file pointed to by the environment variable SRC_VIPA_CONFIG_FILE, contains lines such as the following:

```
# comment
D1.D2.D3.D4/MASK POLICY S1.S2.S3.S4 [T1.T2.T3.T4 [...]]
.INADDR_ANY P1-P2 POLICY S1.S2.S3.S4 [T1.T2.T3.T4 [...]]
.INADDR_ANY P POLICY S1.S2.S3.S4 [T1.T2.T3.T4 [...]]
```

`D1.D2.D3.D4/MASK` specifies a range of destination addresses and the number of bits set in the subnet mask (MASK). As soon as a socket is opened and connected to these destination addresses and the application does not do an explicit bind to a source address, Source VIPA does a bind to one of the source addresses specified (S, T, [...]) using the *policy* selected in the configuration file to distribute the source addresses. See the *policy* section below for available load distribution policies. Instead of IP addresses in dotted notation, hostnames can also be used and will be resolved using DNS.

`.INADDR_ANY P1-P2 POLICY S1.S2.S3.S4` or `.INADDR_ANY P POLICY S1.S2.S3.S4` causes bind calls with `.INADDR_ANY` as a local address to be intercepted if the port the socket is bound to is between P1 and P2 (inclusive). In this case, `.INADDR_ANY` will be replaced by one of the source addresses specified (S, T, [...]), which can be 0.0.0.0.

All `.INADDR_ANY` statements will be read and evaluated in order of appearance. This means that multiple `.INADDR_ANY` statements can be used to have bind calls intercepted for every port outside a certain range. This is useful, for example, for `rlogin`, which uses the `bind` command to bind to a local port but with `.INADDR_ANY` as a source address to use automatic source address selection. See the *policies* section below for available load distribution policies.

The default behavior for all ports is that the kind of bind calls will not be modified.

Policies: With Source VIPA Extensions you provide a range of dummy source addresses for replacing the source addresses of a socket. The policy selected determines which method is used for selecting the source addresses from the range of dummy addresses..

onevipa
Only the first address of all source addresses specified is used as source address.

random
The source address used is selected randomly from all the specified source addresses.

llr (local round robin)
The source address used is selected in a round robin manner from all the specified source addresses. The round robin takes place on a per-invocation base: each process is assigned the source addresses round robin independently from other processes.

rr:ABC
Stands for round robin and implements a global round robin over all Source VIPA instances sharing the same configuration file. All processes using Source VIPA access an IPC shared memory segment to fulfil a global round robin algorithm. This shared memory segment is destroyed when the last running Source VIPA ends. However, if this process does not end gracefully (for example, is ended by a `kill` command), the shared memory segment (size: 4 bytes) can stay in the memory until it is removed by `ipcrm`. The tool `ipcs` can be used to display all IPC resources and to get the key or id used for `ipcrm`. ABC are UNIX® permissions in octal writing (for example, 700) that are used to create the shared memory segment. This permission mask should be as restrictive as possible. A process having access to this mask can cause an imbalance of the round robin distribution in the worst case.

lc
Attempts to balance the number of connections per source address. This policy always associates the socket with the VIPA that is least in use. If the policy cannot be parsed correctly, the policy is set to round robin per default.

Enabling an application: The command:

```
src_vipa.sh <application and parameters>
```

enables the Source VIPA functionality for the application. The configuration file is read once the application is started. It is also possible to change the starter script and run multiple applications using different Source VIPA settings in separate files. For this, a SRC_VIPA_CONFIG_FILE environment variable pointing to the separate files has to be defined and exported prior to invoking the respective application.

Restrictions

LD_PRELOAD security prevents `setuid` executables to be run under Source VIPA; programs of this kind can only be run when the real UID is 0. The ping utility is usually installed with `setuid` permissions.

The maximum number of VIPAs per destination is currently defined as 8.

Example

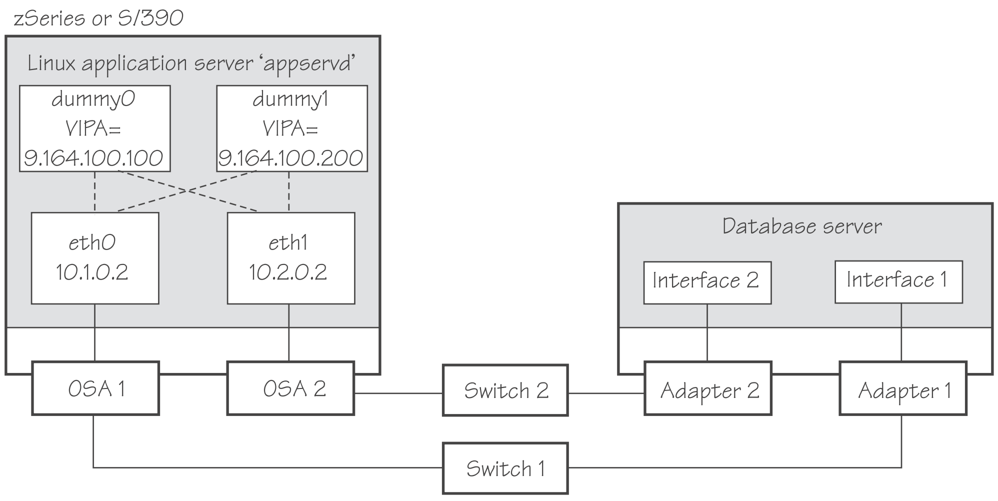


Figure 26. Example of using source VIPA 2

The entry in the Source VIPA configuration file:

```
9.0.0.0/8 lrr 9.164.100.100 9.164.100.200
```

sets up a Source VIPA 2 with a local round robin policy.

Scenario: Virtual LAN (VLAN) support

VLAN technology works according to IEEE Standard 802.1Q by logically segmenting the network into different broadcast domains so that packets are switched only between ports designated for the same VLAN. By containing traffic originating on a particular LAN to other LANs within the same VLAN, switched virtual networks avoid wasting bandwidth, a drawback inherent in traditional bridged/switched networks where packets are often forwarded to LANs that do not require them.

Building a Linux kernel with VLAN and OSA-Express support is a prerequisite for using VLAN under Linux.

Introduction to VLANs

VLANs increase traffic flow and reduce overhead by allowing you to organize your network by traffic patterns rather than by physical location. In a conventional network topology, such as that shown in the following figure, devices communicate across LAN segments in different broadcast domains using routers. Although routers add latency by delaying transmission of data while using more of the data packet to determine destinations, they are preferable to building a single broadcast domain, which could easily be flooded with traffic.

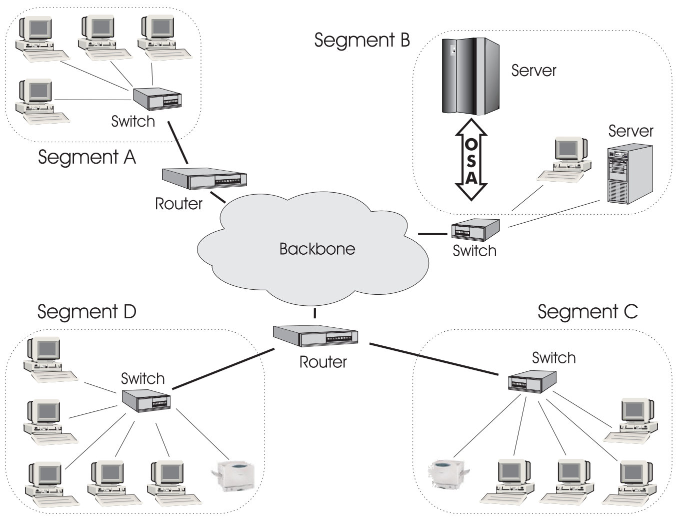


Figure 27. Conventional routed network

By organizing the network into VLANs through the use of Ethernet switches, distinct broadcast domains can be maintained without the latency introduced by multiple routers. As the following figure shows, a single router can provide the interfaces for all VLANs that appeared as separate LAN segments in the previous figure.

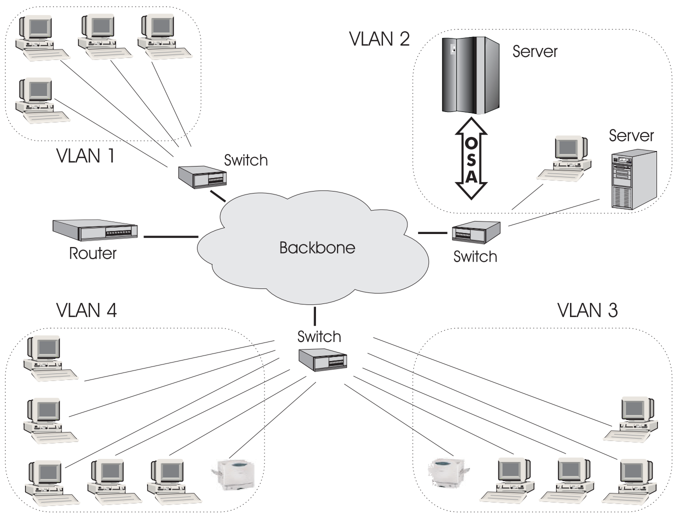


Figure 28. Switched VLAN network

The following figure shows how VLANs can be organized logically, according to traffic flow, rather than being restricted by physical location. If workstations 1-3 communicate mainly with the small server, VLANs can be used to organize only these devices in a single broadcast domain that keeps broadcast traffic within the group. This reduces traffic both inside the domain and outside, on the rest of the network.

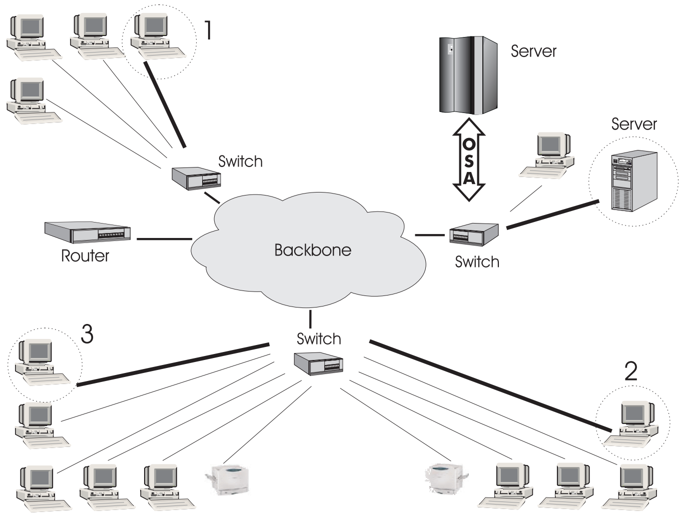


Figure 29. VLAN network organized for traffic flow

Configuring VLAN devices

VLANs are configured using the **vconfig** command. Refer to the **vconfig** man page for details.

Information on the current VLAN configuration is available by listing the files in
`/proc/net/vlan/*`

with `cat` or `more`. For example:

```
bash-2.04# cat /proc/net/vlan/config
VLAN Dev name    | VLAN ID
Name-Type: VLAN_NAME_TYPE_RAW_PLUS_VID_NO_PAD  bad_proto_recvd: 0
eth2.100       | 100  | eth2
eth2.200       | 200  | eth2
eth2.300       | 300  | eth2
bash-2.04# cat /proc/net/vlan/eth2.300
eth2.300  VID: 300       REORDER_HDR: 1  dev->priv_flags: 1
         total frames received:     10914061
          total bytes received:   1291041929
      Broadcast/Multicast Rcvd:            6

      total frames transmitted:     10471684
       total bytes transmitted:   4170258240
            total headroom inc:            0
           total encap on xmit:     10471684
Device: eth2
INGRESS priority mappings: 0:0  1:0  2:0  3:0  4:0  5:0  6:0 7:0
EGRESS  priority Mappings:
bash-2.04#
```

Examples

VLANs are allocated in an existing interface representing a physical Ethernet LAN. The following example creates two VLANs, one with ID 3 and one with ID 5.

```
ifconfig eth1 9.164.160.23 netmask 255.255.224.0 up
vconfig add eth1 3
vconfig add eth1 5
```

The vconfig commands have added interfaces ″eth1.3″ and ″eth1.5″, which you can then configure:

```
ifconfig eth1.3 1.2.3.4 netmask 255.255.255.0 up
ifconfig eth1.5 10.100.2.3 netmask 255.255.0.0 up
```

The traffic that flows out of eth1.3 will be in the VLAN with ID=3 (and will not be received by other stacks that listen to VLANs with ID=4).

The internal routing table will ensure that every packet to 1.2.3.x goes out via eth1.3 and everything to 10.100.x.x via eth1.5. Traffic to 9.164.1xx.x will flow through eth1 (without a VLAN tag).

To remove one of the VLAN interfaces:

```
ifconfig eth1.3 down
vconfig rem eth1.3
```

The following example illustrates the definition and connectivity test for a VLAN comprising five different Linux systems, each connected to a physical Gigabit Ethernet LAN or 10 Gigabit Ethernet via eth1:

```
(LINUX1: LPAR 64bit)
     vconfig add eth1 5
     ifconfig eth1.5 10.100.100.1 broadcast 10.100.100.255 netmask 255.255.255.0 up


(LINUX2: LPAR 31bit)
     vconfig add eth1 5
     ifconfig eth1.5 10.100.100.2 broadcast 10.100.100.255 netmask 255.255.255.0 up


(LINUX3: VM Guest 64bit)
     vconfig add eth1 5
     ifconfig eth1.5 10.100.100.3 broadcast 10.100.100.255 netmask 255.255.255.0 up


(LINUX4: VM Guest 31bit)
     vconfig add eth1 5
     ifconfig eth1.5 10.100.100.4 broadcast 10.100.100.255 netmask 255.255.255.0 up


(LINUX5: Intel)
     vconfig add eth1 5
     ifconfig eth1.5 10.100.100.5 broadcast 10.100.100.255 netmask 255.255.255.0 up

Test the connections:

     ping 10.100.100.[1 - 5]          // Unicast-PING
     ping -I eth1.5 224.0.0.1         // Multicast-PING
     ping -b 10.100.100.255           // Broadcast-PING
```

Further information

More information on VLAN for Linux is available at

```
http://scry.wanfear.com/~greear/vlan.html
```

HiperSockets Network Concentrator

| This section describes how configure a HiperSockets Network Concentrator if the
| layer2 option (see "MAC address handling for IPv4 with the layer2 option" on
| page 88) is not enabled.

Before you start: This section applies to IPv4 only.

The HiperSockets Network Concentrator connects systems to an external LAN within one IP subnet using HiperSockets. HiperSockets Network Concentrator connected systems appear as if they were directly connected to the LAN. This helps to reduce the complexity of network topologies resulting from server consolidation. HiperSockets Network Concentrator allows to migrate systems from the LAN into a zSeries Server environment, or systems connected by a different HiperSockets Network Concentrator into a zSeries Server environment, without changing the network setup. Thus, HiperSockets Network Concentrator helps to simplify network configuration and administration.

Design

A connector Linux system forwards traffic between the external OSA interface and one or more internal HiperSockets interfaces. This is done via IPv4 forwarding for unicast traffic and via a particular bridging code (xcec_bridge) for multicast traffic.

A script named ip_watcher.pl observes all IP addresses registered in the HiperSockets network and sets them as Proxy ARP entries (see “Configuring a device for proxy ARP” on page 109) on the OSA interfaces. The script also establishes routes for all internal systems to enable IP forwarding between the interfaces.

All unicast packets that cannot be delivered in the HiperSockets network are handed over to the connector by HiperSockets. The connector also receives all multicast packets to bridge them.

Setup

The setup principles for configuring the HiperSockets Network Concentrator on a zSeries Linux system are as follows:

leaf nodes

The leaf nodes do not require a special setup. To attach them to the HiperSockets network, their setup should be as if they were directly attached to the LAN. They do not have to be Linux systems.

connector systems

In the following, HiperSockets Network Concentrator IP refers to the subnet of the LAN that is extended into the HiperSockets net.

- If you want to support forwarding of all packet types, define the OSA interface for traffic into the LAN as a multicast router (see “Setting up a Linux router” on page 95).

  If only unicast packages are to be forwarded, there is also the possibility not to identify the OSA interface as multicast router: add the interface name to the `start_hsnc` script and only unicast packets will be forwarded.
- All HiperSockets interfaces involved must be set up as connectors: set the route4 attributes of the corresponding devices to “primary_connector” or to “secondary_connector”. Alternatively, you can add the OSA interface name to the start script as a parameter. This option results in HiperSockets Network Concentrator ignoring multicast packets, which are then not forwarded to the HiperSockets interfaces.
- IP forwarding must be enabled for the connector partition. This can be achieved either manually with the command

  ```
  sysctl -w net.ipv4.ip_forward=1
  ```

Alternatively, distribution-dependent configuration files can be used to activate IP forwarding for the connector partition automatically after booting.

- The network routes for the HiperSockets interface must be removed, a network route for the HiperSockets Network Concentrator IP subnet has to be established via the OSA interface. To achieve this, the IP address 0.0.0.0 can be assigned to the HiperSockets interface while an address used in the HiperSockets Network Concentrator IP subnet is to be assigned to the OSA interface. This sets the network routes up correctly for HiperSockets Network Concentrator.
- To *start* HiperSockets Network Concentrator, run the script `start_hsnc.sh`. You can specify an interface name as optional parameter. This makes HiperSockets Network Concentrator use the specified interface to access the LAN. There is no multicast forwarding in that case.
- To *stop* HiperSockets Network Concentrator, use the command `killall ip_watcher.pl` to remove changes caused by running HiperSockets Network Concentrator.

Availability setups

If a connector system fails during operation, it can simply be restarted. If all the startup commands are executed automatically, it will instantaneously be operational again after booting. Two common availability setups are mentioned here:

One connector partition and one monitoring system
As soon as the monitoring system cannot reach the connector for a specific timeout (for example, 5 seconds), it restarts the connector. The connector itself monitors the monitoring system. If it detects (with a longer timeout than the monitoring system, for example, 15 seconds) a monitor system failure, it restarts the monitoring system.

Two connector systems monitoring each other
In this setup, there is an active and a passive system. As soon as the passive system detects a failure of the active connector, it takes over operation. In order to do this it needs to reset the other system to release all OSA resources for the multicast_router operation. The failed system can then be restarted manually or automatically, depending on the configuration. The passive backup HiperSockets interface can either switch into primary_connector mode during the failover, or it can be setup as secondary_connector. A secondary_connector takes over the connecting functionality, as soon as there is no active primary_connector. This setup has a faster failover time than the first one.

For further information about availability consult the general documentation of Linux on zSeries on availability.

Hints

- The MTU of the OSA and HiperSockets link should be of the same size. Otherwise multicast packets not fitting in the link's MTU are discarded as there is no IP fragmentation for multicast bridging. Warnings are printed to `/var/log/messages` or a corresponding syslog destination.
- The script `ip_watcher.pl` prints error messages to the standard error descriptor of the process.

- `xcec-bridge` logs messages and errors to syslog. On most distributions this creates entries in `/var/log/messages`.
- Registering all internal addresses with the OSA adapter can take several seconds for each address.
- To shut down the HiperSockets Network Concentrator functionality, simply issue `killall ip_watcher.pl`. This removes all routing table and Proxy ARP entries added while using HiperSockets Network Concentrator.

Restrictions

- With the current OSA and HiperSockets hardware design, broadcast packets that are sent out of an interface are echoed back by the hardware of the originating system. This makes it impossible to bridge broadcast traffic without causing bridging loops. Therefore, broadcast bridging is currently disabled.
- Unicast packets are routed by the common Linux IPv4 forwarding mechanisms. As bridging and forwarding are done at the IP Level, the IEEE 802.1q VLAN and the IPv6 protocol are not supported.
- For restrictions regarding multicast and broadcast forwarding, visit the IBM developerWorks Web site at:

  `ibm.com/developerworks/linux/linux390/perf/tuning_rec_networking.shtml.`
- To use HiperSockets Network Concentrator the kernel patches and s390-bit tools from the ″June 2003 stream″ on developerWorks as of 10/31/2003 are required.

Examples

Figure 30 shows a network environment where a Linux instance C acts as a network concentrator that connects other operating system instances on a HiperSockets LAN to an external LAN.

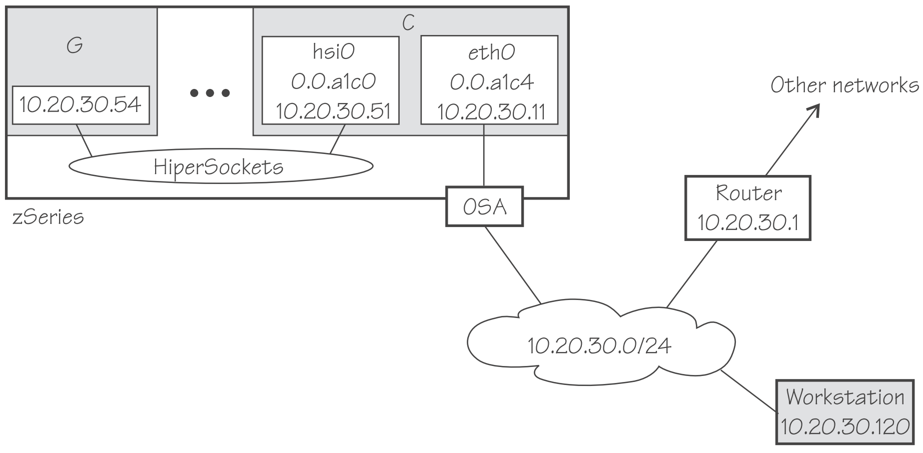


Figure 30. HiperSockets network concentrator setup

Setup for the network concentrator C:

The HiperSockets interface hsi0 (device bus-ID 0.0.a1c0) has IP address 10.20.30.51, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

Issue:

```
# echo primary_connector > /sys/bus/ccwgroup/drivers/qeth/0.0.a1c0/route4
```

The OSA-Express CHPID in QDIO mode interface eth0 (with device bus-ID 0.0.a1c4) has IP address 10.20.30.11, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

Issue:

```
# echo multicast_router > /sys/bus/ccwgroup/drivers/qeth/0.0.a1c4/route4
```

To enable IP forwarding issue:

```
# sysctl -w net.ipv4.ip_forward=1
```

Tip: Refer to your distribution information on how to use configuration files to automatically enable IP forwarding when booting.

To remove the network routes for the HiperSockets interface issue:

```
# route del -net 10.20.30.0 netmask 255.255.255.0 dev hsi0
```

To start the HiperSockets network concentrator run the script `start_hsnc.sh`. Issue:

```
# start_hsnc.sh &
```

Setup for G:
No special setup required. The HiperSockets interface has IP address 10.20.30.54, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

Setup for workstation:
No special setup required. The network interface IP address is 10.20.30.120, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

Figure 31 shows the example of Figure 30 on page 124 with an additional mainframe. On the second mainframe a Linux instance D acts as a HiperSockets network concentrator.

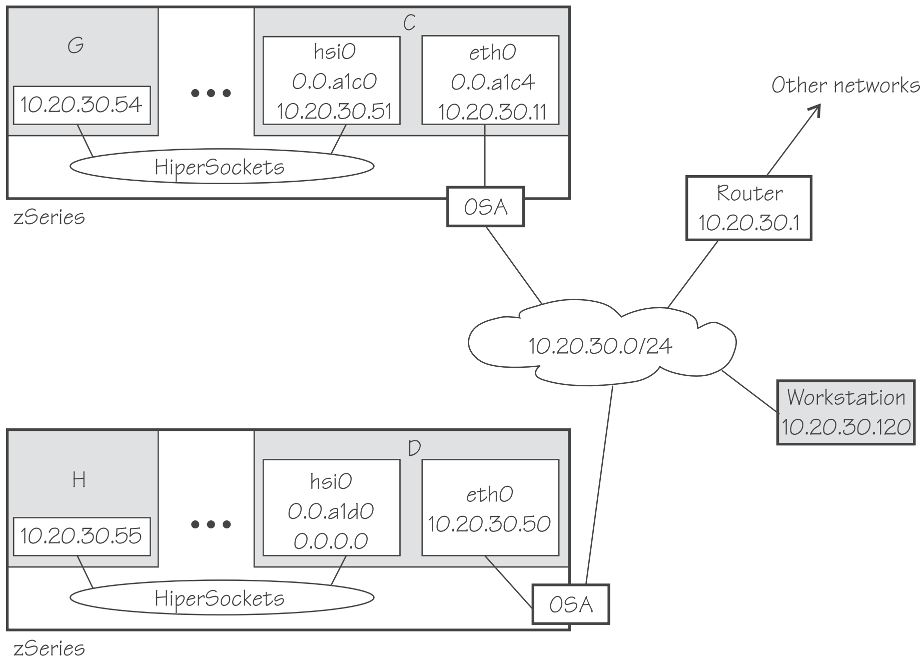


Figure 31. Expanded HiperSockets network concentrator setup

The configuration of C, G, and the workstation remain the same as for Figure 30 on page 124.

Setup for the network concentrator D:

The HiperSockets interface hsi0 has IP address 0.0.0.0.

Assuming that the device bus-ID of the HiperSockets interface is 0.0.a1d0, issue:

```
# echo primary_connector > /sys/bus/ccwgroup/drivers/qeth/0.0.a1d0/route4
```

The OSA-Express CHPID in QDIO mode interface eth0 has IP address 10.20.30.50, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

D is not configured as a multicast router, it therefor only forwards unicast packets.

To enable IP forwarding issue:

```
# sysctl -w net.ipv4.ip_forward=1
```

Tip: Refer to your distribution information on how to use configuration files to automatically enable IP forwarding when booting.

To start the HiperSockets network concentrator run the script `start_hsnc.sh`. Issue:

```
# start_hsnc.sh &
```

Setup for H:
: No special setup required. The HiperSockets interface has IP address 10.20.30.55, and the netmask is 255.255.255.0. The default gateway is 10.20.30.1.

Setting up for DHCP with IPv4

For connections through an OSA-Express adapter in QDIO mode, the OSA-Express adapter offloads ARP, LLC header, and MAC address handling (see “MAC address handling for IPv4” on page 84). Because a HiperSockets connection does not go out on a physical network, there are no ARP, LLC headers, and MAC addresses for packets in a HiperSockets LAN. The resulting problems for DHCP are the same in both cases and the fixes for connections through the OSA-Express adapter also apply to HiperSockets.

Dynamic Host Configuration Protocol (DHCP) is a TCP/IP protocol that allows clients to obtain IP network configuration information (including an IP address) from a central DHCP server. The DHCP server controls whether the address it provides to a client is allocated permanently or is leased temporarily. DHCP specifications are described by RFC 2131“Dynamic Host Configuration Protocol” and RFC 2132 “DHCP options and BOOTP Vendor Extensions”, which are available on the Internet at: `http://www.ietf.org/`.

Two types of DHCP environments have to be taken into account:
- DHCP via OSA-Express adapters in QDIO mode
- DHCP in a z/VM guest LAN

For information on setting up DHCP for Linux for zSeries in a z/VM guest LAN environment, refer to Redpaper *Linux on IBM eServer zSeries and S/390: TCP/IP Broadcast on z/VM Guest LAN*, REDP3596 at: `ibm.com/redbooks/`.

There are three possibilities to get the DHCP client *dhcpcd* and server *dhcp* working properly via OSA-Express adapters in QDIO mode:
- Enabling the qeth *layer2* option (see “MAC address handling for IPv4 with the layer2 option” on page 88). This is the preferred method.
- Enabling the qeth *fake_ll* option (see “Faking LLC headers” on page 86). This is the preferred method for environments that do not support the layer2 option.
- Patching the DHCP client and server packages.

Note: The sample patches in the following sections are for illustration purposes only and not intended for you to use directly. To patch DHCP, you have to write your own patches that are suited to your environment.

Sample DHCP patch

You need to write your own patch that is suited to your environment. The following sample patch is for illustration purposes only. The sample illustrates how you can make the DHCP server *dhcp* (version 3.0rc12) work properly on Linux for zSeries.

DHCP server sample patch for dhcp 3.0rc12

```
diff -ru dhcp-3.0rc12/common/bpf.c dhcp-3.0rc12-qeth/common/bpf.c
--- dhcp-3.0rc12/common/bpf.c Mon Apr  9 06:12:49 2001
+++ dhcp-3.0rc12-qeth/common/bpf.c Wed Feb 26 23:01:10 2003
@@ -184,23 +184,19 @@
    offsets used in if_register_send to patch the BPF program! XXX */

 struct bpf_insn dhcp_bpf_filter [] = {
- /* Make sure this is an IP packet... */
- BPF_STMT (BPF_LD + BPF_H + BPF_ABS, 12),
- BPF_JUMP (BPF_JMP + BPF_JEQ + BPF_K, ETHERTYPE_IP, 0, 8),
-
  /* Make sure it's a UDP packet... */
- BPF_STMT (BPF_LD + BPF_B + BPF_ABS, 23),
+ BPF_STMT (BPF_LD + BPF_B + BPF_ABS, 9),
  BPF_JUMP (BPF_JMP + BPF_JEQ + BPF_K, IPPROTO_UDP, 0, 6),

  /* Make sure this isn't a fragment... */
- BPF_STMT(BPF_LD + BPF_H + BPF_ABS, 20),
+ BPF_STMT(BPF_LD + BPF_H + BPF_ABS, 6),
  BPF_JUMP(BPF_JMP + BPF_JSET + BPF_K, 0x1fff, 4, 0),

  /* Get the IP header length... */
- BPF_STMT (BPF_LDX + BPF_B + BPF_MSH, 14),
+ BPF_STMT (BPF_LDX + BPF_B + BPF_MSH, 0),

  /* Make sure it's to the right port... */
- BPF_STMT (BPF_LD + BPF_H + BPF_IND, 16),
+ BPF_STMT (BPF_LD + BPF_H + BPF_IND, 2),
  BPF_JUMP (BPF_JMP + BPF_JEQ + BPF_K, 67, 0, 1),            /* patch */

  /* If we passed all the tests, ask for the whole packet. */
diff -ru dhcp-3.0rc12/common/lpf.c dhcp-3.0rc12-qeth/common/lpf.c
--- dhcp-3.0rc12/common/lpf.c Tue Apr 24 09:36:00 2001
+++ dhcp-3.0rc12-qeth/common/lpf.c Wed Feb 26 23:19:26 2003
@@ -84,7 +84,7 @@

  /* Make an LPF socket. */
  if ((sock = socket(PF_PACKET, SOCK_PACKET,
-      htons((short)ETH_P_ALL))) < 0) {
+      htons((short)ETH_P_ALL))) < 0) {
   if (errno == ENOPROTOOPT || errno == EPROTONOSUPPORT ||
       errno == ESOCKTNOSUPPORT || errno == EPFNOSUPPORT ||
       errno == EAFNOSUPPORT || errno == EINVAL) {
@@ -234,7 +234,7 @@
        /* Patch the server port into the LPF  program...
     XXX changes to filter program may require changes
     to the insn number(s) used below! XXX */
- dhcp_bpf_filter [8].k = ntohs ((short)local_port);
+ dhcp_bpf_filter [6].k = ntohs ((short)local_port);

  if (setsockopt (info -> rfdesc, SOL_SOCKET, SO_ATTACH_FILTER, &p,
    sizeof p) < 0) {
@@ -349,7 +349,7 @@
  unsigned char ibuf [1536];
  unsigned bufix = 0;

- length = read (interface -> rfdesc, ibuf, sizeof ibuf);
+ length = read (interface -> rfdesc, ibuf+ETHER_HEADER_SIZE, sizeof ibuf);
  if (length <= 0)
   return length;

@@ -365,7 +365,6 @@
  }

  bufix += offset;
- length -= offset;

  /* Decode the IP and UDP headers... */
  offset = decode_udp_ip_header (interface, ibuf, bufix, from,
```

You need to write your own patch that is suited to your environment. The following sample patch is for illustration purposes only. The sample illustrates how you can make the DHCP client *dhcpcd* (version 1.3.22-pl1) work properly on Linux for zSeries.

DHCP client sample patch for dhcpcd 1.3.22-pl1

```
--- client.c Wed Apr 23 21:44:47 2003
+++ client-new.c Wed Apr 23 21:54:24 2003
@@ -505,6 +505,17 @@
    gettimeofday(&current, NULL);
    timeval_subtract(&diff, &current, &begin);
    timeout = j - diff.tv_sec*1000000 - diff.tv_usec + random()%200000;
+/* start of changes here ----------------- */
+         if ( (len<=sizeof(udpipMessage)+sizeof(struct packed_ether_header)) &&
+                         ( *(char*)&UdpIpMsgRecv.ethhdr == 0x45 ) ) {
+                 memmove(((char*)&UdpIpMsgRecv)+
+    sizeof(struct packed_ether_header),
+    &UdpIpMsgRecv,len);
+                 len+=sizeof(struct packed_ether_header);
+                 UdpIpMsgRecv.ethhdr.ether_type = htons(ETHERTYPE_IP);
+}
+/* end of changes here ----------------- */
+
    if ( UdpIpMsgRecv.ethhdr.ether_type != htons(ETHERTYPE_IP) )
      continue;
    /* Use local copy because ipRecv is not aligned.  */
```

Required options for using DHCP on Linux for zSeries and S/390

The following option are required if you are using `dhcpcd` on Linux for zSeries and S/390 without the layer2 option:

- You need to run `dhcpcd` with option **-B**.

  This option instructs the DHCP server to broadcast its response to the DHCP client. Because the OSA-Express adapter in QDIO mode forwards packets to Linux based on IP addresses, a DHCP client that requests an IP address could not receive the response from the DHCP server without this option.
- You need to run `dhcpcd` with option **-I**.

  Specifies the client identifier string. On default `dhcpcd` uses the MAC address of the network interface as default. Hence, without this option, all Linux guests that share the same OSA-Express adapter in QDIO mode would also have the same client identifier.

There are no special options you need for using `dhcp` on Linux for zSeries and S/390.

Setting up for tcpdump with IPv4

For connections through an OSA-Express adapter in QDIO mode, the OSA-Express adapter off-loads ARP, LLC header, and MAC address handling (see “MAC address handling for IPv4” on page 84). Because a HiperSockets connection does not go out on a physical network, there are no ARP, LLC headers, and MAC addresses for packets in a HiperSockets LAN. The resulting problems for tcpdump are the same in both cases and the fixes for connections through the OSA-Express adapter also apply to HiperSockets.

tcpdump uses the packet capture library libpcap. libpcap provides a high level interface to packet capture systems. All packets on the network, even those destined for other hosts, are accessible through this mechanism.

libpcap requires an Ethernet LLC header for the packets it captures. To make it work properly in a Linux for zSeries and S/390 environment you can do either:

- Enable the qeth *layer2* option (for OSA Express only, see "MAC address handling for IPv4 with the layer2 option" on page 88). This is the preferred method.
- Make some changes in the libpcap library.

You need to write your own patch that is suited to your environment. The following sample patch is for illustration purposes only and not intended for you to use directly. The sample patch for libpcap version 0.6.2. illustrates how you can do this:

libpcap 0.6.2. sample patch

```
--- libpcap-0.6.2/pcap-linux.c Fri Jan 31 17:24:51 2003
+++ libpcap-0.6.2/pcap-linux.c.s390qdio Fri Jan 31 17:23:31 2003
@@ -310,6 +310,35 @@
    return -1;
   }
  }
+ /* IBM OSA-Express modifications
+  */
+#define IBM_SRC_MAC   "IBMOSA"
+#define IBM_DST_MAC   "eWorld"
+        do {
+          unsigned short enc_proto;
+          unsigned short proto = 0;
+          enc_proto = *((char*)handle->buffer +
+                        sizeof(unsigned short));
+          if ( (enc_proto == ETH_P_IP) ||
+               (enc_proto == ETH_P_IPV6) )
+            proto = ETH_P_8021Q;
+          else  if ( (*((char*)handle->buffer) >= 0x45) &&
+       (*((char*)handle->buffer) <= 0x4f))
+            proto = ETH_P_IP;
+          else  if ( *((char*)handle->buffer) == 0x60 )
+            proto = ETH_P_IPV6;
+   if (proto) {
+          memmove( ((char*)handle->buffer+sizeof(struct ethhdr)),
+         handle->buffer,packet_len);
+       packet_len += 14;
+       struct ethhdr *hdr = (struct ethhdr *)handle->buffer;
+       memcpy(hdr->h_dest,IBM_DST_MAC,ETH_ALEN);
+       memcpy(hdr->h_source,IBM_SRC_MAC,ETH_ALEN);
+       hdr->h_proto = proto;
+   }
+        } while(0);
+#undef IBM_SRC_MAC
+#undef IBM_DST_MAC

 #ifdef HAVE_PF_PACKET_SOCKETS
  /*
@@ -552,7 +581,8 @@
    /*
     * We have a filter that'll work in the kernel.
     */
-   can_filter_in_kernel = 1;
+/*IBM QDIO device have to filter in the user land*/
+   can_filter_in_kernel = 0;
    break;
   }
  }
```

The first part of the patch adds a fake LLC header to all network packets that do not have one. The second part prevents filtering of network packets in the kernel so that packets are filtered in user mode after a fake LLC header has been added. There is no impact on other network device types, like LCS devices.

Chapter 8. LAN channel station device driver

The LAN channel station device driver (LCS device driver) supports these Open Systems Adapters (OSA) features in non-QDIO mode:

- OSA-2 Ethernet/Token Ring
- OSA-Express
  - Fast Ethernet
  - 1000Base-T Ethernet (z890 and z990)
  - Token Ring

Features

The LCS device driver supports the following devices and functions:

- Auto detects whether the CHPID is connected to Token Ring or Ethernet
- Internet Protocol, version 4 (IPv4) only

What you should know about LCS

This section provides information about LCS group devices and interfaces.

LCS group devices

The LCS device driver requires two I/O subchannels for each LCS interface, a read subchannel and a write subchannel. The corresponding bus-IDs must be configured for control unit type 3088.

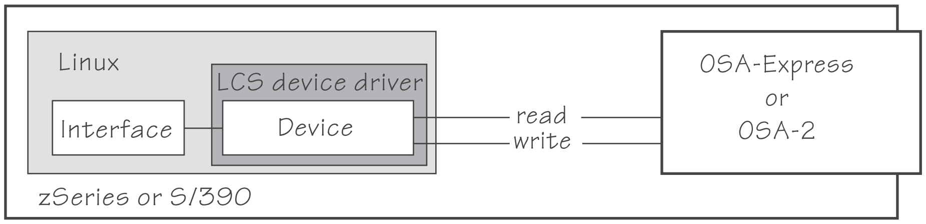


Figure 32. I/O subchannel interface

The device bus-IDs that correspond to the subchannel pair are grouped as one LCS group device. The following rules apply for the device bus-IDs:

read	must be even.
write	must be the device bus-ID of the read subchannel plus one.

LCS interface names

When an LCS group device is set online, the LCS device driver automatically assigns an interface name to it. According to the feature used, the naming scheme uses two base names:

eth<*n*>	for Ethernet features
tr<*n*>	for Token Ring features

where <*n*> is an integer that uniquely identifies the device. When the first device for a base name is set online it is assigned 0, the second is assigned 1, the third 2, and so on. Each base name is counted separately.

For example, the interface name of the first Ethernet feature that is set online is “eth0”, the second “eth1”, and so on. When the first Token Ring feature is set online, it is assigned the interface name “tr0”.

The LCS device driver shares the name space for Ethernet and Token Ring interfaces with the qeth device driver. Each driver uses the name with the lowest free identifier <*n*>, regardless of which device driver occupies the other names. For example, if at the time the first LCS Ethernet feature is set online, there is already one qeth Ethernet feature online, the qeth feature is named “eth0” and the LCS feature is named “eth1”. See also “qeth interface names and device directories” on page 83.

Building a kernel with the LCS device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the LCS device driver.

You need to select the option CONFIG_LCS if you want to work with LCS devices.

```
Networking support
└─S/390 network device drivers
  └─Lan Channel Station Interface                  (CONFIG_LCS)
```

Figure 33. LCS kernel configuration menu option

The CONFIG_LCS option can be compiled into the kernel or as a separate module, lcs.

Depending on the features you intend to support, you need to include at least one the common code options CONFIG_TR and CONFIG_NET_ETHERNET. For multicast support you also require the common code option CONFIG_IP_MULTICAST.

Setting up the LCS device driver

There are no kernel or module parameters for the LCS device driver.

If you have compiled the LCS component as a separate module, you need to load it before you can work with LCS devices. Load the lcs module with the modprobe command to ensure that any other required modules are loaded in the correct order:

```
# modprobe lcs
```

Working with the LCS device driver

This section describes typical tasks that you need to perform when working with LCS devices.

- Creating an LCS group device
- Specifying a timeout for LCS LAN commands
- Setting a device online or offline
- Activating and deactivating an interface

Creating an LCS group device

Before you start: You need to know the device bus-IDs that correspond to the read and write subchannel of your OSA card as defined in the IOCDS of your mainframe.

To define an LCS group device, write the device bus-IDs of the subchannel pair to `/sys/bus/ccwgroup/drivers/lcs/group`. Issue a command of this form:

```
# echo <read_device_bus_id>,<write_device_bus_id> > /sys/bus/ccwgroup/drivers/lcs/group
```

Result: The lcs device driver uses the device bus-ID of the read subchannel to create a directory for a group device:

`/sys/bus/ccwgroup/drivers/lcs/<read_device_bus_id>`

This directory contains a number of attributes that determine the settings of the LCS group device. The following sections describe how to use these attributes to configure an LCS group device.

Example

Assuming that 0.0.d000 is the device bus-ID that corresponds to a read subchannel:

```
# echo 0.0.d000,0.0.d001 > /sys/bus/ccwgroup/drivers/lcs/group
```

This command results in the creation of the following directories in sysfs:

- `/sys/bus/ccwgroup/drivers/lcs/0.0.d000`
- `/sys/bus/ccwgroup/devices/0.0.d000`
- `/sys/devices/cu3088/0.0.d000`

Specifying a timeout for LCS LAN commands

Before you start: The LCS group device must be offline while you specify the timeout.

You can specify a timeout for the interval that the LCS device driver waits for a reply after issuing a LAN command to the LAN adapter. For older hardware the replies may take a longer time. The default is 5 s.

To set a timeout issue a command of this form:

```
# echo <timeout> > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/lancmd_timeout
```

where <*timeout*> is the timeout interval in seconds in the range from 1 to 60.

Example

In this example, the timeout for a device 0.0.d000 is set to 10 s.

```
# echo 10 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/lancmd_timeout
```

Setting a device online or offline

To set an LCS group device online, set the online device group attribute to “1”. To set a LCS group device offline, set the online device group attribute to “0”. Issue a command of this form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/online
```

Setting a device online associates it with an interface name. Setting the device offline preserves the interface name.

Read `/var/log/messages` or issue **dmesg** to find out which interface name has been assigned. You will need to know the interface name to activate the network interface.

For each online interface, there is a symbolic link of the form `/sys/class/net/<interface_name>/device` in sysfs. You can confirm that you have found the correct interface name by reading the link.

Example

To set an LCS device with bus ID 0.0.d000 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/online
# dmesg
...
 lcs: LCS device tr0 without IPv6 support
 lcs: LCS device tr0 with Multicast support
...
```

The interface name that has been assigned to the LCS group device in the example is tr0. To confirm that this is the correct name for our group device issue:

```
# readlink /sys/class/net/tr0/device
../../../devices/lcs/0.0.d000
```

To set the device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/online
```

Activating and deactivating an interface

Before you can activate an interface you need to have set the group device online and found out the interface name assigned by the LCS device driver (see “Setting a device online or offline”).

You activate or deactivate network devices with **ifconfig** or an equivalent command. For details of the **ifconfig** command refer to the **ifconfig** man page.

Examples

- This example activates an Ethernet interface:

```
# ifconfig eth0 192.168.100.10 netmask 255.255.255.0
```

- This example deactivates the Ethernet interface:

```
# ifconfig eth0 down
```

- This example reactivates an interface that had already been activated and subsequently deactivated:

```
# ifconfig eth0 up
```

Chapter 9. CTC device driver

A Channel-to-Channel (CTC) connection is the typical high speed connection between mainframes. The CTC device driver can be used to establish a point-to-point TCP/IP or teletypewriter (TTY) connection between two Linux for zSeries and S/390 instances or between a Linux for zSeries and S/390 instance and another mainframe operating system instance such as z/OS, OS/390, z/VM, or z/VSE.

The CTC device driver supports three types of connections:
- FICON
- ESCON
- Virtual CTC/A

The data packages and the protocols of these connections are the same. The difference between them is the physical channel used to transfer the data.

FICON and ESCON connections can be used to connect a mainframe, an LPAR, or a VM guest to another mainframe or to another LPAR or VM guest. The connected LPARs or VM guests can reside on the same mainframe or on another channel-attached mainframe.

Virtual CTC/A is a software connection between two VM guests on the same VM. Virtual CTC/A is faster than a physical connection.

CTC features

- FICON or ESCON connections between mainframes in basic mode, LPARs or VM guests.
- Virtual CTC/A between VM guests of the same VM system.
- Connections to other Linux instances or other mainframe operating systems.
- TTY connections between Linux instances.

What you should know about CTC connections

This section provides information on CTC group devices and alternative ways for setting them up with device nodes or as interfaces.

CTC group devices

The CTC device driver requires two I/O subchannels for each interface, a read subchannel and a write subchannel. The device bus-IDs that correspond to the two subchannels must be configured for control unit type 3088.

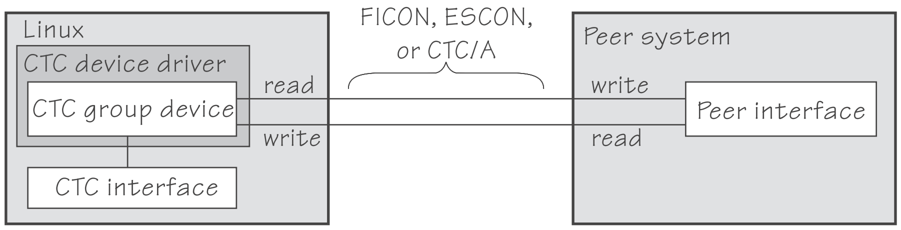


Figure 34. I/O subchannel interface

The device bus-IDs that correspond to the subchannel pair are grouped as one CTC group device.

For communication with traditional mainframe operating systems, the following rules apply to the device bus-IDs:

read must be even.

write must be the device bus-ID of the read subchannel plus one.

For Linux peers there are no special rules for the device bus-IDs.

On the communication peer operating system instance, read and write subchannels are reversed. That is, the write subchannel of the local interface is connected to the read subchannel of the remote interface and vice-versa.

Network connections

If your CTC connection is to a router or VM TCP/IP service machine, you can connect to an external network.

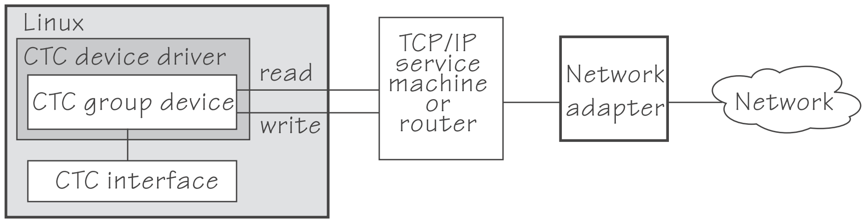


Figure 35. I/O subchannel interface

CTC interfaces and device nodes

When a CTC group device is set online, the CTC device driver automatically assigns an interface name to it. The interface names are of the form ctc<*n*> where <*n*> is an integer that identifies the device. When the first device is set online it is assigned 0, the second is assigned 1, the third 2, and so on.

User space programs can access a CTC group device through:

- A network interface
- A TTY device node (for Linux peers only)

To make a CTC group device accessible as an interface you must activate the interface with **ifconfig** or an equivalent command.

To make a CTC group device accessible as a TTY character device you must create a device node with major number 43. The minor number is equal to the identifier <*n*> of the corresponding interface name.

Table 15 shows the first three interface names with the corresponding standard device node names and major/minor numbers.

Table 15. CTC interfaces and device nodes

Interface name	Standard TTY device node	Major number	Minor number
ctc0	/dev/ttyZ0	43	0
ctc1	/dev/ttyZ1	43	1
ctc2	/dev/ttyZ2	43	2

Your distribution might create the device nodes for you or use udev to create them. If no device nodes are created for you, you can create them yourself with commands of this form:

```
# mknod /dev/ttyZ0 c 43 0
# mknod /dev/ttyZ1 c 43 1
# mknod /dev/ttyZ2 c 43 2
...
```

Device major number 43 is reserved on PC architecture for `/dev/isdn`. Because there is no ISDN support on zSeries and S/390, this major number has been allocated to CTC devices on Linux for zSeries and S/390.

Delay when shutting down a TTY device

When a TTY device is opened the corresponding CTC connection is established.

When a TTY device is closed, shutdown of the connection is delayed for about ten seconds. This delay is intended to avoid unnecessary initialization sequences if programs quickly open and close the device.

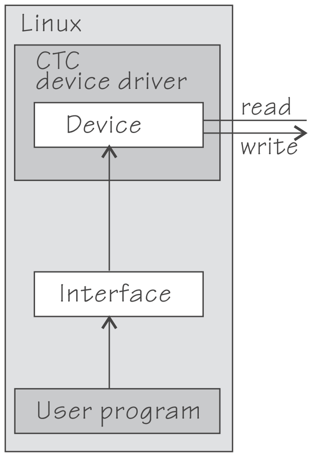
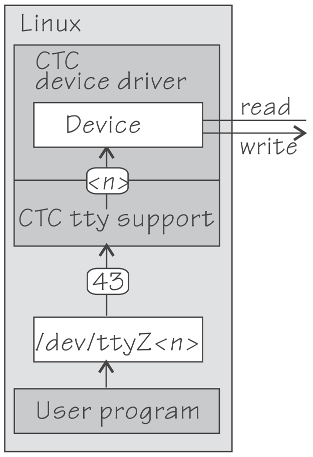
If the CTC device driver has been loaded as a module, it can only be unloaded after first closing all CTC-based TTY devices and then waiting for this delay to expire.

Overview of the steps for setting up a CTC group device

The main steps for setting up a CTC group device are:

- Create a CTC group device.
- Choose a protocol.
- Set the device online. This associates it with an interface name of the form ctc<*n*>.

• Proceed according to the access you want to provide to user spaces:

If you want to provide access through a network interface	**If you want to provide access through a TTY character device**
Activate the interface (see "Activating and deactivating a CTC interface" on page 143).	Provide a device node (see "CTC interfaces and device nodes" on page 138).
 Linux CTC device driver Device read write Interface User program	 Linux CTC device driver Device read write <n> CTC tty support 43 /dev/ttyZ<n> User program
Result: User space programs can access the device by addressing the interface name.	Major number 43 points the Linux kernel to the CTC TTY support and the minor number <*n*> identifies the individual device. **Result:** User space programs can access the device by addressing the device node.

Further information

For more information on FICON, refer to Redpaper *FICON CTC Implementation*, REDP-0158.

Building a kernel with the CTC device driver

This section is intended for those who want to build their own kernel.

You need to select the option CONFIG_CTC if you want to use CTC connections.

```
Networking support
└─S/390 network device drivers
  └─CTC device support                             (CONFIG_CTC)
```

Figure 36. CTC kernel configuration menu option

The CONFIG_CTC option can be compiled into the kernel or as a separate module, ctc.

Setting up the CTC device driver

There are no kernel or module parameters for the CTC device driver.

If you have compiled the CTC component as a separate module, you need to load it before you can work with CTC group devices. Load the ctc module with the modprobe command to ensure that any other required modules are loaded:

```
# modprobe ctc
```

Working with the CTC device driver

This section describes typical tasks that you need to perform when working with CTC devices.

- Creating a CTC group device
- Displaying the channel type
- Setting the protocol
- Setting a device online or offline
- Setting the maximum buffer size
- Activating and deactivating a CTC interface
- Recovering after a crash

Creating a CTC group device

Before you start: You need to know the device bus-IDs that correspond to the local read and write subchannel of your CTC connection as defined in your IOCDS.

To define a CTC group device, write the device bus-IDs of the subchannel pair to `/sys/bus/ccwgroup/drivers/ctc/group`. Issue a command of this form:

```
# echo <read_device_bus_id>,<write_device_bus_id> > /sys/bus/ccwgroup/drivers/ctc/group
```

Result: The CTC device driver uses the device bus-ID of the read subchannel to create a directory for a group device:

`/sys/bus/ccwgroup/drivers/ctc/<read_device_bus_id>`

This directory contains a number of attributes that determine the settings of the CTC group device.

Example

Assuming that device bus-ID 0.0.f000 corresponds to a read subchannel:

```
# echo 0.0.f000,0.0.f001 > /sys/bus/ccwgroup/drivers/ctc/group
```

This command results in the creation of the following directories in sysfs:

- `/sys/bus/ccwgroup/drivers/ctc/0.0.f000`
- `/sys/bus/ccwgroup/devices/0.0.f000`
- `/sys/devices/cu3088/0.0.f000`

Displaying the channel type

Issue a command of this form to display the channel type of a CTC group device:

```
# cat /sys/bus/ccwgroup/drivers/ctc/<device_bus_id>/type
```

where <*device_bus_id*> is the device bus-ID that corresponds to the CTC read channel. Possible values are: CTC/A, ESCON, and FICON.

Example

In this example, the channel type is displayed for a CTC group device with device bus-ID 0.0.f000:

```
# cat /sys/bus/ccwgroup/drivers/ctc/0.0.f000/type
ESCON
```

Setting the protocol

Before you start: The device must be offline while you set the protocol.

To choose a protocol set the protocol attribute to one of the following values:

0 This protocol provides compatibility with peers other than OS/390, or z/OS, for example, a VM TCP service machine. This is the default.

1 This protocol provides enhanced package checking for Linux peers.

2 This protocol provides for a CTC-based TTY connection with a Linux peer.

3 This protocol provides for compatibility with OS/390 or z/OS peers.

Issue a command of this form:

```
# echo <value> > /sys/bus/ccwgroup/drivers/ctc/<device_bus_id>/protocol
```

Example

In this example, a CTC group device 0.0.f000 is set up for compatibility with a z/OS peer.

```
# echo 3 > /sys/bus/ccwgroup/drivers/ctc/0.0.f000/protocol
```

Setting a device online or offline

To set a CTC group device online set the online device group attribute to “1”. To set a CTC group device offline set the online device group attribute to “0”. Issue a command of this form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/ctc/<device_bus_id>/online
```

Setting a device online associates it with an interface name. Setting the device offline preserves the association with the interface name.

Read `/var/log/messages` or issue **dmesg** to find out which interface name has been assigned. You will need to know the interface name to access the CTC group device (see “CTC interfaces and device nodes” on page 138).

For each online interface, there is a symbolic link of the form `/sys/class/net/<interface_name>/device` in sysfs. You can confirm that you have found the correct interface name by reading the link.

Example

To set a CTC device with bus ID 0.0.f100 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f100/online
# dmesg
...
ctc0: read: ch-0.0.f100, write: ch-0.0.f101, proto: 3
...
```

The interface name that has been assigned to the CTC group device in the example is ctc0. To confirm that this is the correct name for our group device issue:

```
# readlink /sys/class/net/ctc0/device
../../../devices/cu3088/0.0.f100
```

To set the same device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/ctc/0.0.f100/online
```

Setting the maximum buffer size

Before you start: The device must be online when setting the buffer size.

You can set the maximum buffer size for a CTC interface. The permissible range of values depends on the MTU settings. It must be in the range <*minimum MTU* + *header size*> to <*maximum MTU* + *header size*>. The header space is typically 8 byte. The default for the maximum buffer size is 32768 byte (32 KB).

Changing the buffer size is accompanied by an MTU size change to the value <*buffer size - header size*>.

To set the maximum buffer size issue a command of this form:

```
# echo <value> > /sys/bus/ccwgroup/drivers/ctc/<device_bus_id>/buffer
```

where <*value*> is the number of bytes you want to set. If you specify a value outside the valid range, the command is ignored.

Example

In this example, the maximum buffer size of a CTC group device 0.0.f000 is set to 16384 byte.

```
# echo 16384 > /sys/bus/ccwgroup/drivers/ctc/0.0.f000/buffer
```

Activating and deactivating a CTC interface

Before you start activating a CTC interface:

- You do not need to activate the CTC interface if you want to use the CTC connection through a device node (see “CTC interfaces and device nodes” on page 138).
- You need to know the interface name (see “Setting a device online or offline” on page 142).

Use **ifconfig** or an equivalent command to activate the interface:

Syntax for activating a CTC interface with the ifconfig command

```
►►──ifconfig── <interface>── <ip_address>── pointopoint── <peer_ip_address>────────►

   ┌─ mtu 32760──────────────┐  ┌─ up─┐
►──┤                         ├──┴─────┴──────────────────────────────────────────►◄
   └─ mtu <max_transfer_unit>┘
```

Where:

<interface>
: is the interface name that was assigned when the CTC group device was set online.

<ip_address>
: is the IP address you want to assign to the interface.

<peer_ip_address>
: is the IP address of the remote side.

<max_transfer_unit>
: is the size of the largest IP packet which may be transmitted. Be sure to use the same MTU size on both sides of the connection. The MTU must be in the range of 576 byte to 65,536 byte (64 KB).

To deactivate an interface issue a command of this form:

```
# ifconfig <interface> down
```

Examples

- This example activates a CTC interface ctc0 with an IP address 10.0.51.3 for a peer with address 10.0.50.1 and an MTU of 32760.
  ```
  # ifconfig ctc0 10.0.51.3 pointopoint 10.0.50.1 mtu 32760
  ```
- This example deactivates ctc0:
  ```
  # ifconfig ctc0 down
  ```

Recovering after a crash

If one side of a CTC connection crashes, you cannot simply reconnect after a reboot. You also need to deactivate the interface on the crashed side's peer. Proceed like this:

1. Reboot the crashed side.
2. Deactivate the interface on the peer (see "Activating and deactivating a CTC interface" on page 143).
3. For TTY devices only: Close and reopen the device.
4. Activate the interface on the crashed side and on the peer (see "Activating and deactivating a CTC interface" on page 143).

   If the connection is between a Linux instance and a non-Linux instance, activate the interface on the Linux instance first. Otherwise you can activate the interfaces in any order.

Scenarios

This section provides some typical scenarios for CTC connections:

- Connecting to a peer in a different LPAR
- Connecting a Linux guest to a peer guest in the same VM
- Setting up a CTC-based TTY connection to a Linux peer

Connecting to a peer in a different LPAR

A Linux instance and a peer run in LPAR mode on the same or on different mainframes and are to be connected with a CTC FICON or CTC ESCON network interface.

Assumptions:

- Locally, the read and write channels have been configured for type 3088 and use device bus-IDs 0.0.f008 and 0.0.f009.
- IP address 10.0.50.4 is to be used locally and 10.0.50.5 for the peer.

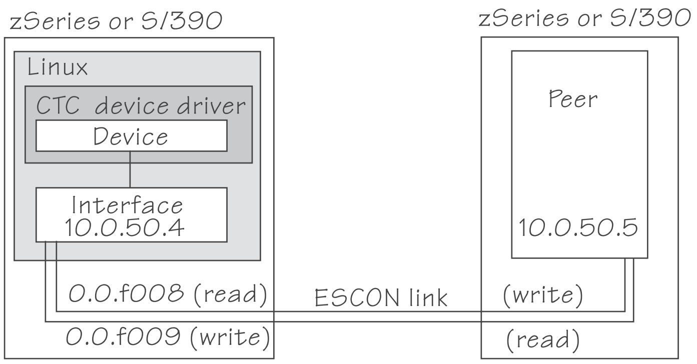


Figure 37. CTC scenario with peer in a different LPAR

1. Create a CTC group device. Issue:

```
# echo 0.0.f008,0.0.f009 > /sys/bus/ccwgroup/drivers/ctc/group
```

2. Confirm that the device uses CTC FICON or CTC ESCON:

```
# cat /sys/bus/ccwgroup/drivers/ctc/0.0.f008/type
ESCON
```

   In this example, ESCON is used. You would proceed the same for FICON.

3. Select a protocol. The choice depends on the peer.

If the peer is ...	Choose ...
Linux	1
z/OS or OS/390	3
Any other operating system	0

   Assuming that the peer is Linux:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f008/protocol
```

4. Set the CTC group device online and find out the assigned interface name:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f008/online
# dmesg
...
ctc0: read: ch-0.0.f008, write: ch-0.0.f009, proto: 1
...
```

In the example, the interface name is ctc0.

5. Assure that the peer interface is configured.
6. Activate the interface locally and on the peer. If you are connecting two Linux instances, either instance can be activated first. If the peer is not Linux, activate the interface on Linux first. To activate the local interface:

```
# ifconfig ctc0 10.0.50.4 pointopoint 10.0.50.5
```

Connecting a Linux guest to a peer guest in the same VM

A Linux instance is running as a VM guest and to be connected to another guest of the same VM using a virtual CTC/A connection.

Assumptions:

- The guest ID of the peer is “guestp”.
- A separate subnet has been obtained from the TCP/IP network administrator. IP addresses 10.0.100.100 and 10.0.100.101 are to be used by the Linux guest and the peer, respectively.

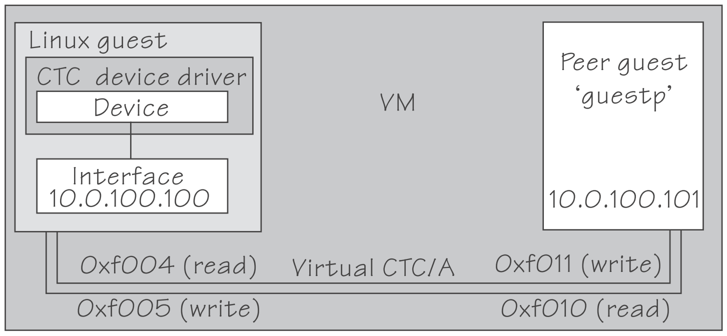


Figure 38. CTC scenario with peer in the same VM

1. Define two virtual channels to your user ID. The channels can be defined in the VM User Directory using directory control `SPECIAL` statements, for example:

```
special f004 ctca
special f005 ctca
```

Alternatively, you can use the CP commands:

```
# define ctca as f004
# define ctca as f005
```

from the console of the running CMS machine (preceded by `#CP` if necessary), or from an `EXEC` file (such as `PROFILE EXEC A`).

2. Assure that the peer interface is configured.

3. Connect the virtual channels. Assuming that the read channel on the peer corresponds to device number 0xf010 and the write channel to 0xf011 issue:

```
# couple f004 to guestp f011
# couple f005 to guestp f010
```

   Be sure that you couple the read channel to the peers write channel and vice-versa.
4. From your booted Linux instance, create a CTC group device. Issue:

```
# echo 0.0.f004,0.0.f005 > /sys/bus/ccwgroup/drivers/ctc/group
```

5. Confirm that the group device is a CTC/A device:

```
# cat /sys/bus/ccwgroup/drivers/ctc/0.0.f004/type
CTC/A
```

6. Select a protocol. The choice depends on the peer.

If the peer is ...	Choose ...
Linux	1
z/OS or OS/390	3
Any other operating system	0

   Assuming that the peer is Linux:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f004/protocol
```

7. Set the CTC group device online and find out the assigned interface name:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f004/online
# dmesg
...
ctc1: read: ch-0.0.f004, write: ch-0.0.f005, proto: 1
...
```

   In the example, the interface name is ctc1.
8. Activate the interface locally and on the peer. If you are connecting two Linux instances, either can be activated first. If the peer is not Linux, activate the local interface first. To activate the local interface:

```
# ifconfig ctc1 10.0.100.100 pointopoint 10.0.100.101
```

   Be sure that the MTU on both sides of the connection is the same. If necessary change the default MTU (see “Activating and deactivating a CTC interface” on page 143).
9. Ensure that the buffer size on both sides of the connection is the same. For the Linux side see “Setting the maximum buffer size” on page 143 if the peer is not Linux, refer to the respective operating system documentation.

Setting up a CTC-based TTY connection to a Linux peer

Two Linux instances that run in LPAR mode are to be connected through a CTC-based TTY device. The LPARs could be on the same or on different mainframes.

Assumptions:

- A physical CTC FICON or CTC ESCON connection is in place connecting the local read channel to the remote write channel and vice-versa.
- Locally, the read and write channels have been configured for type 3088 and use device bus-IDs 0.0.f00a and 0.0.f00b.

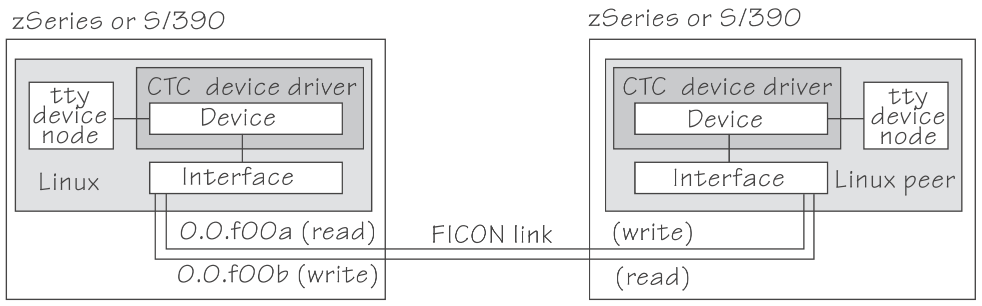


Figure 39. CTC scenario with a TTY connection

1. Create a CTC group device. Issue:

```
# echo 0.0.f00a,0.0.f00b > /sys/bus/ccwgroup/drivers/ctc/group
```

2. Confirm that the device uses CTC FICON or CTC ESCON:

```
# cat /sys/bus/ccwgroup/drivers/ctc/0.0.f00a/type
FICON
```

   In the example, FICON is used. You would proceed the same for ESCON.

3. Select a protocol. Because we want to use TTY select protocol “2”:

```
# echo 2 > /sys/bus/ccwgroup/drivers/ctc/0.0.f00a/protocol
```

4. Set the CTC group device online and find out which interface name has been associated with it:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctc/0.0.f00a/online
#dmesg
...
ctc2: read: ch-0.0.f00a, write: ch-0.0.f00b, proto: 2
...
```

   The associated interface name in the example is ctc2.

5. Assure that a device node exists for ctc2. This example assumes that there is no device node and creates one.

```
# ls /dev/ttyZ*
No such file or directory
# mknod /dev/ttyZ3 c 43 2
```

The local definitions for the connection are completed. The device node can be opened and written to or read from when corresponding definitions have been made on the peer.

Chapter 10. CTCMPC device driver

The CTCMPC device driver is required by Communications Server for Linux to provide Channel-to-Channel (CTC) Multi-Path Channel (MPC) connections. Through CTCMPC connections, Linux can be a communication peer for VTAM on traditional mainframe operating systems.

This section describes how to set up the CTCMPC device driver. Visit `ibm.com/software/network/commserver/linux/` for more information on Communications Server for Linux and on using CTCMPC connections.

Features

The CTCMPC device driver allows Communications Server for Linux to provide:

- ESCON CTC connections (standard CTC and basic CTC) between mainframes in basic mode, LPARs or VM guests.
- Virtual CTC/A connections between VM guests of the same VM system.
- Connections to VTAM on traditional mainframe operating systems.

What you should know about CTCMPC

This section provides information on CTCMPC interfaces.

CTCMPC group devices

The CTCMPC device driver requires two I/O subchannels for each interface, a read subchannel and a write subchannel. The device bus-IDs that correspond to the two subchannels must be configured for control unit type 3088.

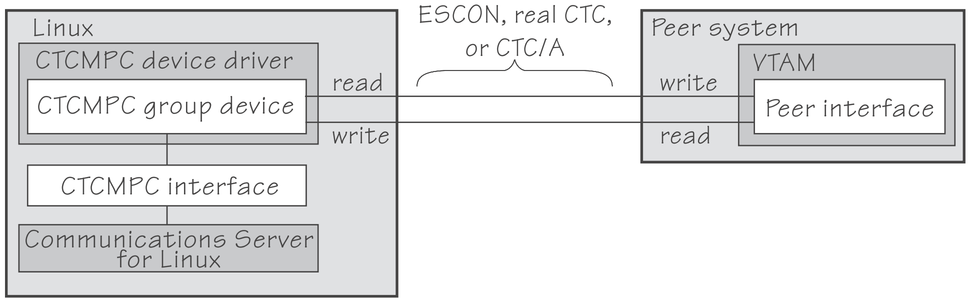


Figure 40. I/O subchannel interface

The device bus-IDs that correspond to the subchannel pair are grouped as one CTCMPC group device.

For communication with traditional mainframe operating systems, the following rules apply to the device bus-IDs:

read	must be even.
write	must be the device bus-ID of the read subchannel plus one.

On the communication peer operating system instance, read and write subchannels are reversed. That is, the write subchannel of the local interface is connected to the read subchannel of the remote interface and vice-versa.

CTCMPC interfaces

When a CTCMPC group device is set online, the CTCMPC device driver automatically assigns an interface name to it. The interface names are of the form mpc<*n*> where <*n*> is an integer that identifies the device. When the first device is set online it is assigned 0, the second is assigned 1, the third 2, and so on.

Building a kernel with the CTCMPC device driver

This section is intended for those who want to build their own kernel.

You need to select the kernel configuration option CONFIG_MPC to be able to use CTCMPC connections.

```
Networking support
   S/390 network device support
   └─CTCMPC device support                          (CONFIG_MPC)
```

Figure 41. CTCMPC kernel configuration menu option

The CTCMPC device driver can be compiled into the kernel or as a separate module, ctcmpc.

Setting up the CTCMPC device driver

You do not need to specify kernel or module parameters for the CTCMPC device driver. If the CTCMPC device driver has been compiled as a separate module, load it with the **modprobe** command to ensure that any other required modules are loaded:

```
# modprobe ctcmpc
```

Working with the CTCMPC device driver

This section describes typical tasks that you need to perform when working with CTCMPC devices.

- Creating a CTCMPC group device
- Setting a device online or offline

Refer to the Communications Server for Linux documentation for information on how to configure and activate CTCMPC interfaces.

Creating a CTCMPC group device

Before you start: You need to know the device bus-IDs that correspond to the local read and write subchannel of your CTCMPC connection as defined in your IOCDS.

To define a CTCMPC group device, write the device bus-IDs of the subchannel pair to `/sys/bus/ccwgroup/drivers/ctcmpc/group`. Issue a command of this form:

```
# echo <read_device_bus_id>,<write_device_bus_id> > /sys/bus/ccwgroup/drivers/ctcmpc/group
```

Result: The CTCMPC device driver uses the device bus-ID of the read subchannel to create a directory for a group device:

`/sys/bus/ccwgroup/drivers/ctcmpc/<read_device_bus_id>`

This directory contains a number of attributes that determine the settings of the CTCMPC group device.

Example

Assuming that device bus-ID 0.0.2000 corresponds to a read subchannel:

```
# echo 0.0.2000,0.0.2001 > /sys/bus/ccwgroup/drivers/ctcmpc/group
```

This command results in the creation of the following directories in sysfs:

- `/sys/bus/ccwgroup/drivers/ctcmpc/0.0.2000`
- `/sys/bus/ccwgroup/devices/0.0.2000`
- `/sys/devices/ctcmpc/0.0.2000`

Setting a device online or offline

To set a CTCMPC group device online, set the online device group attribute to “1”. To set a CTCMPC group device offline, set the online device group attribute to “0”. Issue a command of this form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/ctcmpc/<device_bus_id>/online
```

Setting a device online associates it with an interface name. Setting the device offline preserves the association with the interface name.

Read `/var/log/messages` or issue **dmesg** to find out which interface name has been assigned. You will need to know the interface name to access the CTCMPC group device.

For each online interface, there is a symbolic link of the form `/sys/class/net/<interface_name>/device` in sysfs. You can confirm that you have found the correct interface name by reading the link.

Example

To set a CTCMPC device with bus ID 0.0.2000 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/ctcmpc/0.0.2000/online
# dmesg
...
mpc0: read: ch-0.0.2000, write: ch-0.0.2001, proto: 4
...
```

The interface name that has been assigned to the CTCMPC group device in the example is mpc0. To confirm that this is the correct name for our group device issue:

```
# readlink /sys/class/net/ctcmpc0/device
../../../devices/cu3088/0.0.2000
```

To set the same device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/mpc/0.0.2000/online
```

Chapter 11. NETIUCV device driver

The Inter-User Communication Vehicle (IUCV) is a VM communication facility that enables a program running in one VM guest to communicate with another VM guest, or with a control program, or even with itself.

The Linux for zSeries and S/390 NETIUCV device driver is a network device driver, that uses IUCV to connect Linux guests running on different VM user IDs, or to connect a Linux guest to another VM guest such as a TCP/IP service machine.

Features

The NETIUCV device driver supports the following functions:

- Multiple output paths from a Linux guest
- Multiple input paths to a Linux guest
- Simultaneous transmission and reception of multiple messages on the same or different paths
- Network connections via a TCP/IP service machine gateway
- Internet Protocol, version 4 (IPv4) only

What you should know about IUCV

This section provides information on IUCV devices and interfaces.

IUCV direct and routed connections

The NETIUCV device driver uses TCP/IP over VM virtual communications. The communication peer is a guest of the same VM or the VM control program. No subchannels are involved.

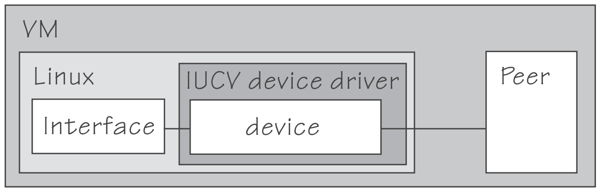


Figure 42. Direct IUCV connection

If your IUCV connection is to a router, the peer can be remote and connected through an external network.

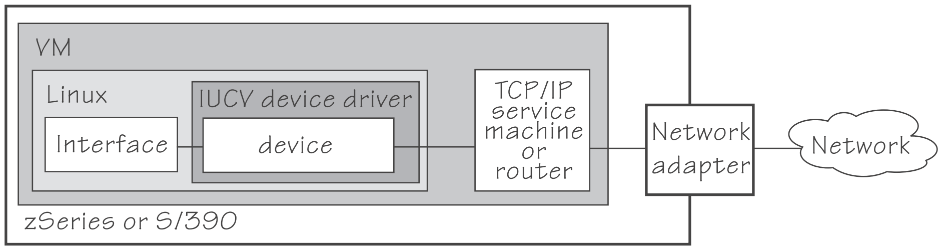


Figure 43. Routed IUCV connection

IUCV interfaces and devices

The NETIUCV device driver uses the base name iucv<*n*> for its interfaces. When the first IUCV interface is created (see "Creating an IUCV device" on page 155) it is assigned the name iucv0, the second is assigned iucv1, the third iucv2, and so on.

For each interface, a corresponding IUCV device is created in sysfs at `/sys/bus/iucv/devices/netiucv<n>` where <*n*> is the same index number that also identifies the corresponding interface.

For example, interface iucv0 corresponds to device name netiucv0, iucv1 corresponds to netiucv1, iucv2 corresponds to netiucv2, and so on.

Further information

The standard definitions in the VM TCP/IP configuration files apply.

For more information of the VM TCP/IP configuration see: *z/VM TCP/IP Planning and Customization*, SC24-6019.

Building a kernel with the NETIUCV device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the NETIUCV device driver.

Figure 44 summarizes the kernel configuration menu options that are relevant to the NETIUCV device driver:

```
Networking support
└─S/390 network device drivers
  └─IUCV support (VM only)                 (CONFIG_IUCV)
    └─IUCV network device support (VM only)    (CONFIG_NETIUCV)
```

Figure 44. IUCV kernel configuration menu option

CONFIG_IUCV
This option is required if you want to use IUCV to connect to other VM guests. It can be compiled into the kernel or as a separate module, iucv.

CONFIG_NETIUCV
This option is required if you want to use NETIUCV device driver to connect to other VM guests. It can be compiled into the kernel or as a separate module, netiucv.

Setting up the NETIUCV device driver

There are no kernel or module parameters for the NETIUCV device driver. This section describes how to load those components that have been compiled as separate modules.

This section also explains how to set up a TCP/IP service machine as a peer for IUCV connections from Linux.

Loading the IUCV modules

If netiucv has been compiled as a separate module, you need to load it before you can work with IUCV devices. Use **modprobe** to load the module to ensure that any other required modules are also loaded.

```
# modprobe netiucv
```

Enabling your VM guest for IUCV

To enable your VM guest for IUCV add the following statements to your VM USER DIRECT entry:

```
IUCV ALLOW
IUCV ANY
```

Working with the NETIUCV device driver

This section describes typical tasks that you need to perform when working with IUCV devices.
- Creating an IUCV device
- Changing the peer
- Setting the maximum buffer size
- Activating an interface
- Deactivating and removing an interface

Creating an IUCV device

To define an IUCV device write the user ID of the peer VM guest to `/sys/bus/iucv/drivers/netiucv/connection`.

Issue a command of this form:

```
# echo <peer_id> > /sys/bus/iucv/drivers/netiucv/connection
```

where *<peer_id>* is the guest ID of the VM guest you want to connect to. The NETIUCV device driver interprets the ID as uppercase.

Result: An interface iucv<*n*> is created and the following corresponding sysfs directories:
- `/sys/bus/iucv/devices/netiucv<n>`
- `/sys/devices/iucv/netiucv<n>`

- /sys/class/net/iucv<*n*>

<*n*> is an index number that identifies an individual IUCV device and its corresponding interface. You can use the attributes of the sysfs entry to configure the device.

To verify that an index number corresponds to a given guest ID read the name attribute. Issue a command of this form:

```
# cat /sys/bus/iucv/drivers/netiucv/netiucv<n>/user
```

Example

To create an IUCV device to connect to a VM guest with a guest user ID “LINUXP” issue:

```
# echo linuxp > /sys/bus/iucv/drivers/netiucv/connection
```

If this is the first IUCV device to be created, the corresponding interface name is iucv0. To confirm that this is the interface that connects to “LINUXP”:

```
# cat /sys/bus/iucv/drivers/netiucv/netiucv0/user
linuxp
```

Changing the peer

Before you start: The interface must not be active when changing the name of the peer VM guest.

You can change the VM guest that an interface connects to. To change the peer VM guest issue a command of this form:

```
# echo <peer_ID> > /sys/bus/iucv/drivers/netiucv/netiucv<n>/user
```

where:

<*peer_ID*>
: is the VM guest ID of the new communication peer. The value must be a valid guest ID. The NETIUCV device driver interprets the ID as uppercase.

<*n*>
: is an index that identifies the IUCV device and the corresponding interface.

Example

In this example, “LINUX22” is set as the new peer VM guest.

```
# echo linux22 > /sys/bus/iucv/drivers/netiucv/netiucv0/user
```

Setting the maximum buffer size

The upper limit for the maximum buffer size is 32768 bytes (32 KB). The lower limit is 580 bytes in general and in addition, if the interface is up and running <*current MTU + header size*>. The header space is typically 4 bytes.

Changing the buffer size is accompanied by an mtu size change to the value <*buffer size - header size*>.

To set the maximum buffer size issue a command of this form:

```
# echo <value> > /sys/bus/iucv/drivers/netiucv/netiucv<n>/buffer
```

where:

<value>
: is the number of bytes you want to set. If you specify a value outside the valid range, the command is ignored.

<n>
: is an index that identifies the IUCV device and the corresponding interface.

Example

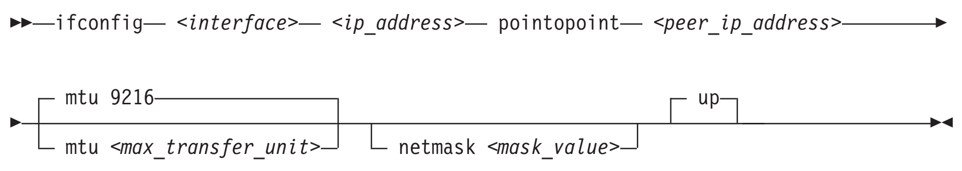
In this example, the maximum buffer size of an IUCV device netiucv0 is set to 16384 byte.

```
# echo 16384 > /sys/bus/iucv/drivers/netiucv/netiucv0/buffer
```

Activating an interface

Use **ifconfig** or an equivalent command to activate an interface.

ifconfig syntax for an IUCV connection


ifconfig <interface> <ip_address> pointopoint <peer_ip_address>
mtu 9216
mtu <max_transfer_unit>
netmask <mask_value>
up

where:

<interface>
: is the interface name.

<ip_address>
: is the IP address of your Linux guest.

<peer_ip_address>
: for direct connections this is the IP address of the communication peer; for routed connections this is the IP address of the TCP/IP service machine or Linux router to connect to.

<max_transfer_unit>
: is the size in byte of the largest IP packets which may be transmitted. The default is 9216. The valid range is 576 through 32764.

<mask_value>
: is a mask to identify the addresses served by this connection. Applies to routed connections only.

For more details, refer to the **ifconfig** man page.

For routed connections, you need to set up a route. Issue commands of this form:

```
# route add -net default <interface>
# inetd
```

Example

This example activates a connection to a TCP/IP service machine with IP address 1.2.3.200 using a maximum transfer unit of 32764 bytes.

```
# ifconfig iucv1 1.2.3.100 pointopoint 1.2.3.200 mtu 32764 netmask 255.255.255.0
# route add -net default iucv1
# inetd
```

Deactivating and removing an interface

You deactivate an interface with **ifconfig** or an equivalent command. Issue a command of this form:

```
# ifconfig <interface> down
```

where <*interface*> is the name of the interface to be deactivated.

You can remove the interface and its corresponding IUCV device by writing the interface name to the NETIUCV device driver's remove attribute. Issue a command of this form:

```
# echo <interface> > /sys/bus/iucv/drivers/netiucv/remove
```

where <*interface*> is the name of the interface to be removed. The interface name is of the form iucv<*n*>.

After the interface has been removed the interface name can be assigned again as interfaces are activated.

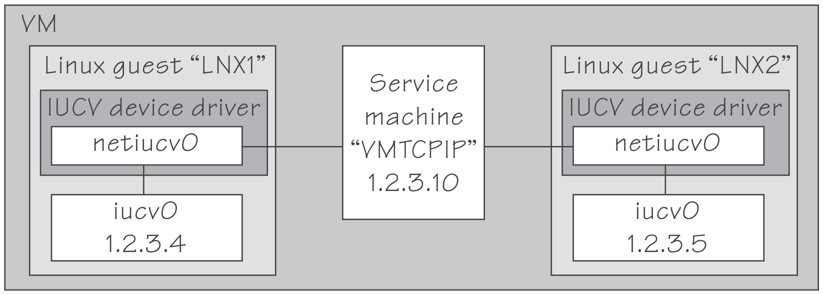
Example

This Example deactivates and removes an interface iucv0 and its corresponding IUCV device:

```
# ifconfig iucv0 down
# echo iucv0 > /sys/bus/iucv/drivers/netiucv/remove
```

Scenario: Setting up an IUCV connection to a TCP/IP service machine

Two Linux guests with guest IDs "LNX1" and "LNX2" are to be connected through a TCP/IP service machine with guest ID "VMTCPIP". Both Linux guests and the service machine all run in the same VM. A separate IP subnet (different from the subnet used on the LAN) has been obtained from the network administrator. IP address 1.2.3.4 is assigned to guest "LNX1", 1.2.3.5 is assigned to guest "LNX2", and 1.2.3.10 is assigned to the service machine.



Setting up the service machine

Proceed like this to set up the service machine:

1. For each guest that is to have an IUCV connection to the service machine add a home entry, device, link, and start statement to the service machine's `PROFILE TCPIP` file. The statements have the form:

   ```
   Home
    <ip_address1> <link_name1>
    <ip_address2> <link_name2>
    ...

   Device <device_name1> IUCV 0 0 <guest_ID1> A
   Link <link_name1> IUCV 0  <device_name1>

   Device <device_name2> IUCV 0 0 <guest_ID2> A
   Link <link_name2> IUCV 0  <device_name2>

   ...

   Start <device_name1>
   Start <device_name2>
   ...
   ```

   where

   <ip_address1>, <ip_address2>
   : is the IP address of a Linux guest.

   <link_name1>, <link_name2>, ...
   : are variables that associate the link statements with the respective home statements.

   <device_name1>, <device_name2>, ...
   : are variables that associate the device statements with the respective link statements and start commands.

   <guest_ID1>, <guest_ID1>, ...
   : are the guest IDs of the connected Linux guests.

   In our example, the `PROFILE TCPIP` entries for our example might look of this form:

   ```
   Home
    1.2.3.4 LNK1
    1.2.3.5 LNK2

   Device DEV1 IUCV 0 0 LNX1 A
   Link LNK1 IUCV 0  DEV1

   Device DEV2 IUCV 0 0 LNX2 A
   Link LNK2 IUCV 0  DEV2
   ```

```
Start DEV1
Start DEV2
...
```

2. Add the necessary VM TCP/IP routing statements (BsdRoutingParms or Gateway). Use an MTU size of 9216 and a point-to-point host route (subnet mask 255.255.255.255). If you use dynamic routing, but do not wish to run routed or gated on Linux, update the VM `ETC GATEWAYS` file to include "permanent" host entries for each Linux guest.
3. Bring these updates online by using `OBEYFILE` or by recycling `TCPIP` and/or `ROUTED` as needed.

Setting up the Linux guest LNX1

Proceed like this to set up the IUCV connection on the Linux guest:

1. Set up the NETIUCV device driver as described in "Setting up the NETIUCV device driver" on page 155.
2. Create an IUCV interface for connecting to the service machine:

   ```
   # echo VMTCPIP /sys/bus/iucv/drivers/netiucv/connection
   ```

   This creates an interface, for example, iucv0, with a corresponding IUCV device and a device entry in sysfs `/sys/bus/iucv/devices/netiucv0`.
3. The peer, LNX2 is set up accordingly. When both interfaces are ready to be connected to, activate the connection.

   ```
   # ifconfig iucv0 1.2.3.4 pointopoint 1.2.3.10 netmask 255.255.255.0
   ```

The peer, LNX2, is set up accordingly.

Chapter 12. CLAW device driver

Common Link Access to Workstation (CLAW) is a point-to-point protocol. A CLAW device is a channel connected device that supports the CLAW protocol. CLAW devices can connect your Linux for zSeries and S/390 instance to a communication peer, for example, on a RISC System/6000® (RS/6000®) or on a Cisco Channel Interface Processor (CIP).

Features

The CLAW device driver supports the following devices and functions:

- The CLAW driver supports up to 256 devices.

What you should know about the CLAW device driver

This section provides information about CLAW group devices and interfaces.

CLAW group devices

The CLAW device driver requires two I/O subchannels for each CLAW interface, a read subchannel and a write subchannel. The corresponding bus-IDs must be configured for control unit type 3088.

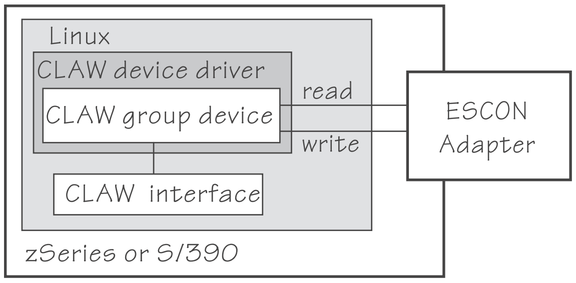


Figure 45. I/O subchannel interface

The device bus-IDs that correspond to the subchannel pair are grouped as one CLAW group device. The device bus-IDs can be any consecutive device bus-IDs where the read subchannel is the lower of the two IDs.

The read subchannel is linked to the write subchannel on the connected RS/6000 or CIP and vise versa.

CLAW interface names

When a CLAW group device is set online, the CLAW device driver automatically assigns an interface name to it. The interface names are of the form claw<*n*> where <*n*> is an integer that identifies the device. When the first device is set online, it is assigned 0, the second is assigned 1, the third 2, and so on.

MTU size

You can set the MTU when you activate your CLAW group device (see "Activating a CLAW group device" on page 165).

The following apply to setting the MTU:

- The default MTU is 4096 byte.
- If the MTU of the attached CLAW interface on the RS/6000 or CIP is less than 4096 byte, it can be advantageous to match the MTU of the CLAW device to this lower value.
- You cannot set an MTU that is greater than the buffer size. The buffer size is 32 kilobyte for connection type PACKED (see “Setting the connection type” on page 164) and 4 kilobyte otherwise.
- The maximum MTU you can set is 4096 byte.

If you are a kernel builder, you can increase the maximum MTU above 4096 byte by changing the CLAW device driver code and recompiling. Be aware that recompiling the kernel is likely to affect any existing service contracts you may have for your kernel.

Building a kernel with the CLAW device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the CLAW device driver.

You need to select the CONFIG_CLAW option if you want to use CLAW connections.

```
Networking support
   S/390 network device drivers
   └─CLAW device support                     (CONFIG_CLAW)
```

Figure 46. CLAW kernel configuration menu option

The CLAW device driver can be compiled into the kernel or as a separate module, claw.

Setting up the CLAW device driver

There are no kernel or module parameters for the CLAW device driver.

If you have compiled the CLAW component as a separate module, you need to load it before you can work with CLAW group devices. Load the claw module with the modprobe command to ensure that any other required modules are loaded:

```
# modprobe claw
```

Working with the CLAW device driver

This section describes typical tasks that you need to perform when working with CLAW devices.

- Creating a CLAW group device
- Setting the host and adapter name
- Setting the connection type

- Setting the number of read and write buffers
- Setting a CLAW group device online or offline
- Activating a CLAW group device

Creating a CLAW group device

Before you start: You need to know the device bus-IDs that correspond to the local read and write subchannel of your CLAW connection as defined in your IOCDS.

To define a CLAW group device, write the device bus-IDs of the subchannel pair to `/sys/bus/ccwgroup/drivers/claw/group`. Issue a command of this form:

```
# echo <read_device_bus_id>,<write_device_bus_id> > /sys/bus/ccwgroup/drivers/claw/group
```

Result: The CLAW device driver uses the device bus-ID of the read subchannel to create a directory for a group device:
`/sys/bus/ccwgroup/drivers/claw/<read_device_bus_id>`

This directory contains a number of attributes that determine the settings of the CLAW group device.

Example

Assuming that device bus-ID 0.0.2d00 corresponds to a read subchannel:

```
# echo 0.0.2d00,0.0.2d01 > /sys/bus/ccwgroup/drivers/claw/group
```

This command results in the creation of the following directories in sysfs:
- `/sys/bus/ccwgroup/drivers/claw/0.0.2d00`
- `/sys/bus/ccwgroup/devices/0.0.2d00`
- `/sys/devices/cu3088/0.0.2d00`

Setting the host and adapter name

Host and adapter names identify the communication peers to one another. The local host name must match the remote adapter name and vise versa.

Set the host and adapter name before you set the CLAW group device online. Changing a name for an online device does not take effect until the device is set offline and back online.

To set the host name issue a command of this form:

```
# echo <host> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/host_name
```

To set the adapter name issue a command of this form:

```
# echo <adapter> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/adapter_name
```

where *<host>* is the host name and *<adapter>* the adapter name. The names can be from 1 to 8 characters and are case sensitive.

Example

In this example, the host name for a claw group device with device bus-ID 0.0.d200 is set to "LNX1" and the adapter name to "RS1".

```
# echo LNX1 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/host_name
# echo RS1 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/adapter_name
```

To make this connection work, the adapter name on the communication peer must be set to "LNX1" and the host name to "RS1".

Setting the connection type

The connection type determines the packing method used for outgoing packets. The connection type must match the connection type on the connected RS/6000 or CIP.

Set the connection type before you set the CLAW group device online. Changing the connection type for an online device does not take effect until the device is set offline and back online.

To set the connection type issue a command of this form:

```
# echo <type> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/api_type
```

where <*type*> can be either of:

IP to use the IP protocol for CLAW.

PACKED
to use enhanced packing with TCP/IP for better performance.

TCPIP to use the TCP/IP protocol for CLAW.

Example

In this example, the connection type "PACKED" is set for a CLAW group device with device bus-ID 0.0.d200.

```
# echo PACKED > /sys/bus/ccwgroup/drivers/claw/0.0.d200/api_type
```

Setting the number of read and write buffers

You can allocate the number of read buffers and the number of write buffers for your CLAW group device separately. Set the number of buffers before you set the CLAW group device online. You can change the number of buffers at any time, but new values for an online device do not take effect until the device is set offline and back online.

To set the number of read buffers issue a command of this form:

```
# echo <number> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/read_buffer
```

To set the number of write buffers issue a command of this form:

```
# echo <number> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/write_buffer
```

where <*number*> is the number of buffers you want to allocate. The valid range of numbers you can specify is the same for read and write buffers. The range depends on your connection type (see “Setting the connection type” on page 164):

- For connection type PACKED you can allocate 2 to 64 buffers of 32 KB.
- For the other connection types you can allocate 2 to 512 buffers of 4 KB.

Example

In this example, 4 read buffers and 5 write buffers are allocated to a claw group device with device bus-ID 0.0.d200.

```
# echo 4 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/read_buffer
# echo 5 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/write_buffer
```

Setting a CLAW group device online or offline

To set a CLAW group device online set the online device group attribute to “1”. To set a CLAW group device offline set the online device group attribute to “0”. Issue a command of this form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/claw/<device_bus_id>/online
```

Setting a device online for the first time associates it with an interface name. Setting the device offline preserves the association with the interface name.

Read `/var/log/messages` or issue **dmesg** to find out which interface name has been assigned. You will need to know the interface name to access the CLAW group device (see “CTC interfaces and device nodes” on page 138).

For each online interface, there is a symbolic link of the form `/sys/class/net/<interface_name>/device` in sysfs. You can confirm that you have found the correct interface name by reading the link.

Example

To set a CLAW device with bus ID 0.0.d200 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/online
# dmesg
claw0:readsize=4096  writesize=4096 readbuffer=4 writebuffer=5 read=0xd200 write=0xd201
claw0:host_name:LNX1 , adapter_name :RS1     api_type: PACKED
```

The interface name that has been assigned to the CLAW group device in the example is claw0. To confirm that this is the correct name for our group device issue:

```
# readlink /sys/class/net/claw0/device
../../../devices/cu3088/0.0.d200
```

To set the same device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/claw/0.0.d200/online
```

Activating a CLAW group device

You can activate a CLAW group device with **ifconfig** or an equivalent command. See “MTU size” on page 161 for information on possible MTU settings.

Example

```
ifconfig claw0 10.22.34.5 netmask 255.255.255.248 dstaddr 10.22.34.6
```

Part 4. z/VM virtual server integration

This section describes device drivers and features that help to effectively run and manage a z/VM-based virtual Linux server farm.

Note

For prerequisites and restrictions for these device drivers and features, refer to the kernel 2.6 April 2004 stream pages on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Chapter 13. z/VM DCSS device driver

The z/VM discontiguous saved segments (DCSS) device driver provides disk-like fixed block access to z/VM discontiguous saved segments.

Features

The DCSS device driver facilitates:

- Initializing and updating ext2 compatible file system images in z/VM saved segments for use with the xip2 file system.
- Implementing a shared read-write RAM disk for Linux guests, for example, for a file system that can be shared among multiple Linux images that run as guest systems under the same z/VM.

What you should know about DCSS

This section provides information on the DCSS device names and nodes.

Important

DCSSs occupy spool space. Be sure that you have enough spool space available (multiple times the DCSS size).

DCSS naming scheme

When the DCSS device driver is loaded, it dynamically allocates a major number to DCSS devices. A different major number might be used when the device driver is reloaded, for example when Linux is rebooted. Check the entry for "dcssblk" in `/proc/devices` to find out which major number is used for your DCSSs.

The standard device names are of the form dcssblk<*n*>, where <*n*> is the corresponding minor number. The first DCSS device that is added is assigned the name dcssblk0, the second dcssblk1, and so on. When a DCSS is removed, its device name and corresponding minor number are free and can be reassigned. A DCSS that is added always receives the lowest free minor number.

Creating device nodes

User space programs access DCSS devices by *device nodes*. Your distribution might create these device nodes for you or provide udev to create them (see "Device nodes provided by udev" on page 4).

If no device nodes are created for you, you need to create them yourself, for example, with the **mknod** command. Refer to the **mknod** man page for further details.

Tip: Use the device names to construct your nodes (see "DCSS naming scheme").

Example: Defining standard DCSS nodes

To create standard DCSS device nodes of the form `/dev/<device_name>` issue commands of this form:

```
# mknod /dev/dcssblk0 b <major> 0
# mknod /dev/dcssblk1 b <major> 1
# mknod /dev/dcssblk2 b <major> 2
...
```

Further information

- For information on DCSS see *z/VM Saved Segments Planning and Administration*, SC24-6056
- For related z/VM information see *CP Command and Utility Reference*, SC24-6008.
- For an example of how the xip2 file system and DCSS can be used see *How to use Execute-in-Place Technology with Linux on z/VM*, SC33-8283, on developerWorks at:

  `ibm.com/developerworks/linux/linux390/april2004_documentation.shtml`

  If you are routed to the top-level page: On the left navigation bar, under Kernel 2.6, click **April 2004 stream**. On the April 2004 stream page, click **Documentation**.

Building a kernel with the DCSS device driver

This section is intended for those who want to build their own kernel.

To build a kernel with DCSS support you need to select option CONFIG_DCSSBLK in the configuration menu:

```
Block devices
   DCSSBLK support                              (CONFIG_DCSSBLK)
```

Figure 47. DCSS kernel configuration menu option

The DCSS support is available as a module, dcssblk, or built-in.

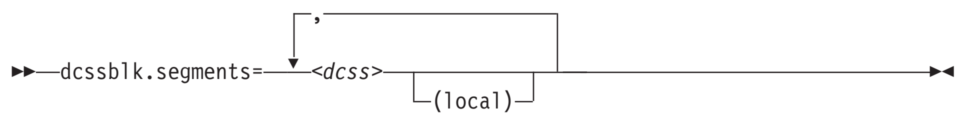
Setting up the DCSS device driver

Kernel parameters

This section describes how to configure the DCSS device driver if the DCSS block device support has been compiled into the kernel. You configure the device driver by adding parameters to the kernel parameter line.

Use the dcssblk.segments kernel parameter to load one or more DCSSs during the boot process (for example, for use as swap devices).

DCSS kernel parameter syntax



where <*dcss*> specifies the name of a DCSS and **(local)** sets the access mode to exclusive-writable after the DCSS has been loaded. The specification for <*dcss*> is converted from ASCII to uppercase EBCDIC.

Example

The following parameter in the kernel parameter line loads three DCSSs during the boot process: DCSS1, DCSS2, and DCSS3. DCSS2 is accessed in exclusive-writable mode and can be included in `/etc/fstab` and used as a swap device.

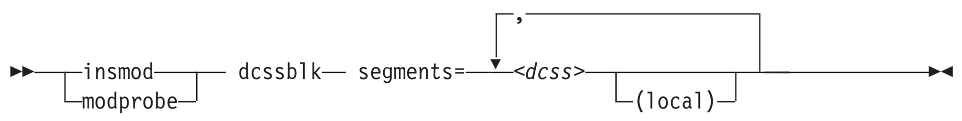
```
dcssblk.segments=dcss1,dcss2(local),dcss3
```

Module parameters

This section describes how to load and configure the DCSS device driver if the DCSS block device support has been compiled as a separate module.

Load the DCSS block device driver with **modprobe** or **insmod**. Use the segments module parameter to load one or more DCSSs when the DCSS device driver is loaded.

DCSS module parameter syntax



where <*dcss*> specifies the name of a DCSS and **(local)** sets the access mode to exclusive-writable after the DCSS has been loaded. The specification for <*dcss*> is converted from ASCII to uppercase EBCDIC.

Example

The following command loads the DCSS device driver and three DCSSs: DCSS1, DCSS2, and DCSS3. DCSS2 is accessed in exclusive-writable mode.

```
modprobe dcssblk segments=dcss1,dcss2(local),dcss3
```

Working with the DCSS device driver

This section describes typical tasks that you need to perform when working with DCSS devices:

- Adding a DCSS
- Finding the minor number for a DCSS
- Setting the access mode
- Saving an updated DCSS
- Removing a DCSS

Adding a DCSS

Before you start:

- You need to have set up a DCSS on z/VM and know the name assigned to the DCSS on z/VM.

- You must have set the mem kernel parameter to cover the upper limit of the DCSS.
- If you use the watchdog device driver, turn off the watchdog before adding or saving a DCSS. Adding or saving a DCSS may result in a watchdog timeout, if it is active.

Restrictions:

- You cannot concurrently access overlapping DCSSs.
- You cannot access a DCSS that overlaps with your guest virtual storage.

To add a DCSS device write the name of the DCSS to /sys/devices/dcssblk/add. Issue a command of this form:

```
# echo <name> > /sys/devices/dcssblk/add
```

where name is the name of the DCSS as defined to z/VM.

Example

To add a DCSS called "MYDCSS" issue:

```
# echo MYDCSS > /sys/devices/dcssblk/add
```

Finding the minor number for a DCSS

When you add a DCSS, a minor number is assigned to it. Unless you use dynamically created device nodes as provided by udev, you might need to know the minor device number that has been assigned to the DCSS (see "DCSS naming scheme" on page 169).

When you add a DCSS, a directory of this form is created in sysfs:

- `/sys/devices/dcssblk/<name>`

where <*name*> is the name of the DCSS.

This directory contains a symbolic link, block, that helps you to find out the standard device name and minor number. The link is of the form `../../../block/dcssblk<n>`, where dcssblk<*n*> is the device name and <*n*> is the minor number.

Example

To find out the minor number assigned to a DCSS "MYDCSS" issue:

```
# readlink /sys/devices/dcssblk/MYDCSS/block
../../../block/dcssblk0
```

In the example, the assigned minor number is "0".

Setting the access mode

You might want to access the DCSS with write access to change the DCSS content. There are two possible write access modes to the DCSS:

shared
In the shared mode, changes to the DCSS are immediately visible to all guests that access the DCSS. Shared is the default.

Note: Writing to a shared DCSS bears the same risks as writing to a shared disk.

exclusive-writable
In the exclusive-writable mode you write to a private copy of the DCSS. The private copy is writable, even if the original DCSS is read-only. The changes in your private copy are invisible to other guests until you save the changes (see "Saving an updated DCSS").

After saving the changes all guests that open the DCSS access the changed copy. z/VM retains a copy of the original DCSS for those guests that continue accessing it, until the last guest has stopped using it.

For either access mode the changes are volatile until they are saved (see "Saving an updated DCSS").

Set the access mode before you mount the DCSS. To set the access mode to exclusive-writable set the DCSS device's shared attribute to "0". To reset the access mode to shared set the DCSS device's shared attribute to "1".

Issue a command of this form:

```
# echo <flag> > /sys/devices/dcssblk/<name>/shared
```

where <*name*> is the name of the DCSS.

You can read the shared attribute to find out the current access mode.

Example

To find out the current access mode of a DCSS "MYDCSS":

```
# cat /sys/devices/dcssblk/MYDCSS/shared
1
```

"1" means that the current access mode is shared. To set the access mode to exclusive-writable issue:

```
# echo 0 > /sys/devices/dcssblk/MYDCSS/shared
```

Saving an updated DCSS

| If you use the watchdog device driver, turn off the watchdog before adding or
| saving a DCSS. Adding or saving a DCSS may result in a watchdog timeout, if it is
| active.

Do not place save requests before you have accessed the DCSS. To place a save request for saving changes to a DCSS permanently on the spool disk write "1" to the DCSS device's save attribute.

Issue a command of this form:

```
# echo 1 > /sys/devices/dcssblk/<name>/save
```

where <*name*> is the name of the DCSS.

Saving is delayed until you close the device.

You can check if a save request is waiting to be performed by reading the contents of the save attribute.

You can cancel a save request by writing "0" to the save attribute.

Example

To check if a save request exists for a DCSS "MYDCSS":

```
# cat /sys/devices/dcssblk/MYDCSS/save
0
```

The "0" means that no save request exists. To place a save request issue:

```
# echo 1 > /sys/devices/dcssblk/MYDCSS/save
```

To purge an existing save request issue:

```
# echo 0 > /sys/devices/dcssblk/MYDCSS/save
```

Removing a DCSS

Before you start: A DCSS device can only be removed when it is not in use.

To remove a DCSS device write the name of the DCSS to `/sys/devices/dcssblk/remove`. Issue a command of this form:

```
# echo <name> > /sys/devices/dcssblk/remove
```

where <*name*> is the name of the DCSS.

If you have created your own device nodes, you can keep the nodes for reuse. Be aware that the major number of the device might change when you unload and reload the DCSS device driver. When the major number of your device has changed, existing nodes become unusable.

Example

To remove a DCSS "MYDCSS" issue:

```
# echo MYDCSS > /sys/devices/dcssblk/remove
```

Changing the contents of a DCSS

The following scenario describes how you can use the DCSS block device driver to change the contents of a DCSS.

Assumptions:

- Our Linux instance runs as a VM guest with class E user privileges.
- A DCSS has been set up and made accessible to our Linux guest.
- The DCSS does not overlap with our guest's main storage and the mem parameter has been set to cover the DCSS's upper limit.
- There is only a single DCSS named "MYDCSS".

- The DCSS block device driver has been set up and is ready to be used.

Perform the following steps to change the contents of a DCSS:

1. Access the DCSS by adding it to the block device driver.

```
# echo MYDCSS > /sys/devices/dcssblk/add
```

2. Ensure that there is a device node for the DCSS block device. If it is not created for you, for example by udev, create it yourself.
   - Find out the major number used for DCSS block devices. Read `/proc/devices`:

   ```
   # cat /proc/devices
   ...
   Block devices
   ...
   254 dcssblk
   ...
   ```

   The major number if our example is 254.
   - Find out the minor number used for MYDCSS. If MYDCSS is the first DCSS that has been added the minor is 0. To be sure you can read a symbolic link that is created when the DCSS is added.

   ```
   # readlink /sys/devices/dcssblk/MYDCSS/block
   ../../../block/dcssblk0
   ```

   The trailing 0 in the standard device name dcssblk0 indicates that the minor number is, indeed, 0.
   - Create the node with the **mknod** command:

   ```
   # mknod /dev/dcssblk0 b 254 0
   ```

3. Set the access mode to exclusive-write.

```
# echo 1 > /sys/devices/dcssblk/MYDCSS/shared
```

4. Mount the file system in the DCSS on a spare mount point.
   Example:

```
# mount /dev/dcssblk0 /mnt
```

5. Update the data in the DCSS.
6. Create a save request to save the changes.

```
# echo 1 > /sys/devices/dcssblk/MYDCSS/save
```

7. Unmount the file system.

```
# unmount /mnt
```

   The changes to the DCSS are now saved. When the last VM guest stops accessing the old version of the DCSS the old version is discarded. Each guest that opens the DCSS accesses the updated copy.
8. Remove the device.

```
# echo MYDCSS > /sys/devices/dcssblk/remove
```

9. If you have created your own device node, you can optionally clean it up.

```
# rmnod /dev/dcssblk0
```

Chapter 14. z/VM *MONITOR record reader device driver

The z/VM *MONITOR record reader device driver gives monitoring software on Linux access to z/VM guest data.

z/VM uses the z/VM monitor system service (*MONITOR) to collect monitor records from agents on its guests. z/VM writes the records to a discontiguous saved segment (DCSS). The z/VM *MONITOR record reader device driver uses IUCV to connect to *MONITOR and accesses the DCSS as a character device.

Features

The z/VM *MONITOR record device driver supports the following devices and functions:

- Read access to the z/VM *MONITOR DCSS.
- Reading *MONITOR records for z/VM 4.4 and later.
- Access to *MONITOR records as described on: `ibm.com/vm/pubs/ctlblk.html`
- Access to the records provided by the Linux monitor stream (see Chapter 15, "Linux monitor stream support for z/VM," on page 185).

What you should know about the z/VM *MONITOR record device driver

The data that is collected by *MONITOR depends on how you have set up the service. The z/VM *MONITOR record device driver only reads data from the monitor DCSS; it does not control the system service.

z/VM only supports a single monitor DCSS. All monitoring software that requires monitor records from z/VM uses the same DCSS to read *MONITOR data. Usually, a DCSS called ″MONDCSS″ is already defined and used by existing monitoring software. If this is the case , you must also use MONDCSS. See "Making the DCSS addressable for your Linux guest" on page 178 for information on how to check if MONDCSS exists.

Further information

- Refer to *Saved Segments Planning and Administration*, SC24-6116 for general information on DCSSs.
- Refer to *z/VM Performance*, SC24-6109 for information on how to create a monitor DCSS.
- Refer to *CP Command and Utility Reference*, SC24-6081 for information on the CP commands used in the context of DCSSs and for controlling the z/VM monitor system service.
- For the layout of the monitor records visit `ibm.com/vm/pubs/mon440/index.html` and refer to Chapter 15, "Linux monitor stream support for z/VM," on page 185.

Building a kernel with the z/VM *MONITOR record device driver

This section is intended for those who want to build their own kernel.

You need to select the kernel configuration option CONFIG_MONREADER to be able to access the z/VM monitor DCSS.

```
Character device drivers --->
   API for reading z/VM monitor service records           (CONFIG_MONREADER)
```

*Figure 48. z/VM *MONITOR record kernel configuration menu options*

The z/VM *MONITOR record reader device driver can be compiled into the kernel or as a separate module, monreader.

You also need IUCV support (see “Building a kernel with the NETIUCV device driver” on page 154).

Setting up the z/VM *MONITOR record reader device driver

This section describes how to set up a Linux guest for accessing an existing monitor DCSS with the z/VM *MONITOR record reader device driver.

Set up the monitor system service and the monitor DCSS on z/VM is beyond the scope of this book. See “Further information” on page 177 for documentation on the monitor system service, DCSS, and related CP commands.

Before you start: Some of the CP commands you need to use for setting up the z/VM *MONITOR record reader device driver require class E authorization.

Providing the required USER DIRECT entries for your z/VM guest

The z/VM guest where your Linux instance is to run must be permitted to establish an IUCV connection to the z/VM monitor system service. Ensure that the guest’s entry in the USER DIRECT file includes the statement:

```
IUCV *MONITOR
```

If the DCSS is restricted you also need the statement:

```
NAMESAVE <dcss>
```

where <*dcss*> is the name of the DCSS that is used for the monitor records. You can find out the name of an existing monitor DCSS by issuing the following command from a CMS session with privilege class E:

```
#cp q monitor
```

Making the DCSS addressable for your Linux guest

You need to know the start and end address of the DCSS. You can find out this information by issuing the following CP command from a CMS session with privilege class E:

```
#cp q nss map
```

the output gives you the start and end addresses of all defined DCSSs in units of 4 kilobyte pages:

```
00: FILE FILENAME FILETYPE MINSIZE BEGPAG ENDPAG TYPE CL #USERS PARMREGS VMGROUP
...
00: 0011 MONDCSS  CPDCSS   N/A     09000  097FF  SC   R   00003 N/A      N/A
...
```

Your guest storage must not overlap with the address range of the DCSS. Depending on the start and end address of your DCSS you can do either:

- Define the guest storage as two or more discontiguous storage extents such that a storage gap covers the entire DCSS address range
- Enable Linux to handle real memory addresses that are beyond the guest storage (considered as real memory by Linux) to cover a DCSS that is located above the guest storage

Defining the guest storage with storage gaps

From a CMS session, use the DEF STORE command to define your guest storage as discontiguous storage extents. Ensure that the storage gap between the extents covers your entire DCSS. Issue a command of this form:

```
DEF STOR CONFIG 0.<storage_gap_beginn> <storage_gap_end>.<storage above gap>
```

where:

<storage_gap_begin>
: is the lower limit of the storage gap. The lower limit must be at least 64 MB and at or below the lower limit of the DCSS.

<storage_gap_end>
: is the upper limit of the storage gap. The upper limit must be above the upper limit of the DCSS.

<storage above gap>
: is the amount of storage above the storage gap. The total guest storage is *<storage_gap_beginn>* + *<storage above gap>*.

All values can be suffixed with M to provide the values in megabyte. Refer to *CP Command and Utility Reference*, SC24-6081 for more information on the DEF STORE command.

Example: To make a DCSS that starts at 144 MB and ends at 152 MB accessible to a z/VM guest with 256 MB guest storage:

```
DEF STORE CONFIG 0.140M 160M.116M
```

The storage gap in the example ranges from 140 MB to 160 MB and thus covers the entire DCSS range. The total guest storage is 140 MB + 116 MB = 256 MB.

Extending the Linux address range

If your guest storage is sufficiently low, your entire DCSS address range might be above the guest storage. You can then use the mem= Linux kernel parameter to make the DCSS accessible to the Linux guest. Add the following to the kernel parameter line:

```
mem=<address>
```

where *<address>* is an address at or above the upper limit of the DCSS. Upper can be in kilobyte or megabyte and must be suffixed with K or M, accordingly.

Example: To make a DCSS that starts at 144 MB and ends at 152 MB accessible to a z/VM guest with 128 MB guest storage:

```
mem=160M
```

For a guest with guest storage 256 MB you would not be able to use this method because then the guest storage would overlap with the DCSS.

Specifying the monitor DCSS name

By default, the z/VM *MONITOR record reader device driver assumes that the monitor DCSS on z/VM is called MONDCSS. If you want to use a different DCSS name you need to specify it. Proceed according to your distribution:

- If your device driver has been compiled into the kernel, specify the DCSS name as a kernel parameter.
- If your device driver has been compiled as a separate module, specify the DCSS name as a module parameter when you load the module.

Kernel parameter

This section describes how you can specify a DCSS name if the z/VM *MONITOR record reader device driver has been compiled into the kernel.

You can specify a DCSS name by adding the mondcss parameter to the kernel parameter line.

z/VM *MONITOR record reader device driver kernel parameter syntax

```
     ┌─monreader.mondcss=MONDCSS─┐
►►───┤                           ├──────────────────────────────────────►◄
     └─monreader.mondcss=<dcss>──┘
```

where *<dcss>* is the name of the DCSS that z/VM uses for the monitor records.

Example: To specify MYDCSS as the DCSS name add the following parameter to the kernel parameter line:

```
mondcss=MYDCSS
```

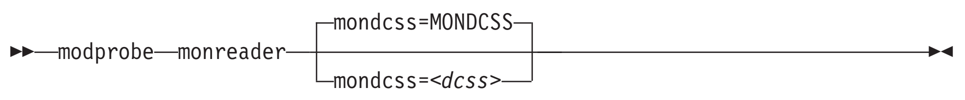
The value is automatically converted to upper case.

Module parameter

This section describes how to load the z/VM *MONITOR record reader device driver if it has been compiled as separate module. It also tells you how to specify a DCSS name, if applicable.

Load the z/VM *MONITOR record reader device driver module with **modprobe** to assure that any other required modules are also loaded. You need IUCV support if you want to use the z/VM *MONITOR record reader device driver (see “Setting up the NETIUCV device driver” on page 155).

z/VM *MONITOR record reader device driver module parameter syntax



where <*dcss*> is the name of the DCSS that z/VM uses for the monitor records.

Example: To load the z/VM *MONITOR record device driver module and specify MYDCSS as the DCSS issue:

```
modprobe monreader mondcss=mydcss
```

Assuring that the required device node exists

You need a device node for a miscellaneous character device to access the monitor DCSS. Your distribution might create this device node for you (for example, by using udev). To find out if there is already a device node issue:

```
# find / -name monreader
```

If there is no device node, you need to create one. To find out the major and minor number for your monitor device read the dev attribute of the device's representation in sysfs:

```
# cat /sys/class/misc/monreader/dev
```

The value of the dev attribute is of the form <*major*>:<*minor*>.

To create issue a command of the form:

```
# mknod <node> c <major> <minor>
```

where <*node*> is your device node.

Example:

To create a device node `/dev/monreader`:

```
# cat /sys/class/misc/monreader/dev
10:63
# mknod /dev/monreader c 10 63
```

In the example, the major number was 10 and the minor 63.

Working with the z/VM *MONITOR record device driver

This section describes how to work with the z/VM *MONITOR record reader device driver.

- Opening and closing the character device
- Reading monitor records

Opening and closing the character device

Only one user can open the character device at any one time. Once you have opened the device you need to close it to make it accessible to other users.

The open function can fail (return a negative value) with one of the following values for errno:

EBUSY
The device has already been opened by another user.

EIO No IUCV connection to the z/VM monitor system service could be established. An error message with an IPUSER SEVER code is printed into syslog. Refer to *z/VM Performance* for details on the codes.

Once the device is opened, incoming messages are accepted and account for the message limit. If you keep the device open indefinitely, expect to eventually reach the message limit (with error code EOVERFLOW).

Reading monitor records

There are two alternative methods for reading:

- Non-blocking read in conjunction with polling
- Blocking read without polling

Reading from the device provides a 12-byte monitor control element (MCE), followed by a set of one or more contiguous monitor records (similar to the output of the CMS utility MONWRITE without the 4K control blocks). The MCE contains information on:

- The type of the following record set (sample/event data)
- The monitor domains contained within it
- The start and end address of the record set in the monitor DCSS

The start and end address can be used to determine the size of the record set, the end address is the address of the last byte of data. The start address is needed to handle ″end-of-frame″ records correctly (domain 1, record 13), that is, it can be used to determine the record start offset relative to a 4K page (frame) boundary.

See ″Appendix A: *MONITOR″ in *z/VM Performance* for a description of the monitor control element layout. The layout of the monitor records can be found on: `ibm.com/vm/pubs/ctlblk.html`

The layout of the data stream provided by the monreader device is as follows:

```
...
<0 byte read>
<first MCE>              \
<first set of records>   |...
...                             |- data set
<last MCE>               |
<last set of records>   /
<0 byte read>
...
```

There may be more than one combination of MCE and a corresponding record set within one data set. The end of each data set is indicated by a successful read with a return value of 0 (0 byte read). Received data is not to be considered valid unless a complete record set is read successfully, including the closing 0-Byte read. You are advised to always read the complete set into a user space buffer before processing the data.

When designing a buffer, allow for record sizes up to the size of the entire monitor DCSS, or use dynamic memory allocation. The size of the monitor DCSS will be printed into syslog after loading the module. You can also use the (Class E privileged) CP command Q NSS MAP to list all available segments and information about them (see "Making the DCSS addressable for your Linux guest" on page 178).

Error conditions are indicated by returning a negative value for the number of bytes read. In case of an error condition, the errno variable can be:

EIO
Reply failed. All data read since the last successful read with 0 size is not valid. Data will be missing. The application must decide whether to continue reading subsequent data or to exit.

EFAULT
Copy to user failed. All data read since the last successful read with 0 size is not valid. Data will be missing. The application must decide whether to continue reading subsequent data or to exit.

EAGAIN
Occurs on a non-blocking read if there is no data available at the moment. There is no data missing or damaged, retry or use polling for non-blocking reads.

EOVERFLOW
Message limit reached. The data read since the last successful read with 0 size is valid but subsequent records might be missing.The application must decide whether to continue reading subsequent data or to exit.

Chapter 15. Linux monitor stream support for z/VM

z/VM is a convenient point for collecting VM guest performance data and statistics for an entire server farm. Linux guests can export such data to z/VM by means of “APPLDATA monitor records”. z/VM regularly collects these records. The records are then available to z/VM performance monitoring tools.

A virtual CPU timer on the Linux guest to be monitored controls when data is collected. The timer only accounts for busy time to avoid unnecessarily waking up an idle guest. The monitor stream support comprises several modules. A base module provides an intra-kernel interface and the timer function. The intra-kernel interface is used by *data gathering modules* that collect actual data and determine the layout of a corresponding APPLDATA monitor record (see “APPLDATA monitor record layout” on page 188).

Building a kernel that is enabled for monitoring

This section is intended for those who want to build their own kernel.

Figure 49 summarizes the kernel configuration menu options that are relevant to the Linux monitor stream support for z/VM:

```
Base setup
   Virtual CPU timer support                         (CONFIG_VIRT_TIMER)
   └─Linux - VM Monitor Stream, base infrastructure (CONFIG_APPLDATA_BASE)
     ├─Monitor memory management statistics        (CONFIG_APPLDATA_MEM)
     ├─Monitor OS statistics                       (CONFIG_APPLDATA_OS)
     └─Monitor overall network statistics          (CONFIG_APPLDATA_NET_SUM)
```

Figure 49. Linux monitor stream kernel configuration menu options

CONFIG_VIRT_TIMER
: This option is a prerequisite for the Linux monitor stream support.

CONFIG_APPLDATA_BASE
: This option provides the base component for the Linux monitor stream support.

CONFIG_APPLDATA_MEM
: This option provides monitoring for memory related data. It can be compiled into the kernel or as a separate module, appldata_mem.

CONFIG_APPLDATA_OS
: This option provides monitoring for operating system related data, for example, CPU usage. It can be compiled into the kernel or as a separate module, appldata_os.

CONFIG_APPLDATA_NET_SUM
: This option provides monitoring for network related data. It can be compiled into the kernel or as a separate module, appldata_net_sum.

Setting up the monitor stream support

There are no kernel or module parameters for the monitor stream support. This section describes how to load those components of the support that have been compiled as separate modules and how to set up your VM guest for the monitor stream support.

Loading data gathering modules

One or more of the data gathering components might have been compiled as separate modules. Use the **insmod** or **modprobe** command to load any required modules. Refer to the respective man pages command details.

Monitor stream support module parameter syntax

```
►►──┬─insmod───┬──┬─appldata_mem─────┬────────────────────────────────────►◄
    └─modprobe─┘  ├─appldata_os──────┤
                  └─appldata_net_sum─┘
```

where appldata_mem, appldata_os, and appldata_net_sum are the modules for gathering memory related data, operating system related data, and network related data.

Enabling your VM guest for data gathering

To enable you Linux guest for data gathering ensure that the Linux guest directory includes the option APPLMON.

Working with the monitor stream support

You control the monitor stream support through the procfs. You can set the timer interval and switch on or off data collection. APPLDATA monitor records are produced if both a particular data gathering module and the monitoring support in general are switched on.

Switching on or off the monitoring support

You switch on or off the monitoring support by writing “1” (on) or “0” (off) to `/proc/sys/appldata/timer`.

To read the current setting issue:

```
# cat /proc/sys/appldata/timer
```

To switch on the monitoring support issue:

```
# echo 1 > /proc/sys/appldata/timer
```

To switch off the monitoring support issue:

```
# echo 0 > /proc/sys/appldata/timer
```

Activating or deactivating individual data gathering modules

You can activate or deactivate the data gathering modules individually. Each data gathering module has a procfs entry that contains a value "1" if the module is active and "0" if the module is inactive. The entries are:

`/proc/sys/appldata/mem` for the memory data gathering module

`/proc/sys/appldata/os` for the CPU data gathering module

`/proc/sys/appldata/net_sum` for the net data gathering module

To check if a module is active look at the content of the corresponding procfs entry.

To activate a data gathering module write "1" to the corresponding procfs entry. To deactivate a data gathering module write "0" to the corresponding procfs entry. Issue a command of this form:

```
# echo <flag> > /proc/sys/appldata/<data_type>
```

where <*data_type*> is one of mem, os, or net_sum.

Note: An active data gathering module produces APPLDATA monitor records only if the monitoring support is switched on (see "Switching on or off the monitoring support" on page 186).

Example

To find out if memory data gathering is active issue:

```
# cat /proc/sys/appldata/mem
0
```

In the example, memory data gathering is off. To activate memory data gathering issue:

```
# echo 1 > /proc/sys/appldata/mem
```

To deactivate the memory data gathering module issue:

```
# echo 0 > /proc/sys/appldata/mem
```

Setting the sampling interval

You can set the time that lapses between consecutive data samples. The time you set is measured by the virtual CPU timer. Because the virtual timer slows down as the guest idles, the time sampling interval in real time can be considerably longer than the value you set.

The value in `/proc/sys/appldata/interval` is the sample interval in milliseconds. The default sample interval is 1000 ms. To read the current value issue:

```
# cat /proc/sys/appldata/interval
```

To set the sample interval to a different value write the new value (in milliseconds) to `/proc/sys/appldata/interval`. Issue a command of this form:

```
# echo <interval> > /proc/sys/appldata/interval
```

where <*interval*> is the new sample interval in milliseconds.

Example

To set the sampling interval to 20 s (20000 ms) issue:

```
# echo 20000 > /proc/sys/appldata/interval
```

APPLDATA monitor record layout

This section describes the layout of the APPLDATA monitor records that can be provided to z/VM. Each of the modules that can be installed with the base module corresponds to a type of record:

- Memory data (see Table 16 on page 189)
- Processor data (see Table 17 on page 190)
- Networking (see Table 18 on page 191)

z/VM can identify the records by their unique product ID. The product ID is a string of this form: "LINUXKRNL<*record ID*>260100". The <*record ID*> is treated as a byte value, not a string. For example, for APPLDATA_MEM_DATA (see Table 16 on page 189) with a record ID of 0x01 <*record ID*> is "1", not "01").

The records contain data of the following types:

u32	unsigned 4 byte integer
u64	unsigned 8 byte integer

Important

On 31-bit Linux systems, the u64 values are actually only 32-bit values. That is, the lower 32 bit wrap around like 32-bit counters and the upper 32 bit are always zero.

Table 16. APPLDATA_MEM_DATA record (Record ID 0x01)

Offset		**Type**	**Name**	**Description**
Decimal	**Hex**			
0	0x0	u64	timestamp	TOD timestamp generated on the Linux side after record update
8	0x8	u32	sync_count_1	After VM collected the record data, sync_count_1 and sync_count_2 should be the same. Otherwise, the record has been updated on the Linux side while VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	
16	0x10	u64	pgpgin	Data read from disk (in KB)
24	0x18	u64	pgpgout	Data written to disk (in KB)
32	0x20	u64	pswpin	Pages swapped in
40	0x28	u64	pswpout	Pages swapped out
48	0x30	u64	sharedram	Shared RAM in KB, currently set to 0 by Linux kernel (2.4 and 2.6)
56	0x38	u64	totalram	Total usable main memory size in KB
64	0x40	u64	freeram	Available memory size in KB
72	0x48	u64	totalhigh	Total high memory size in KB
80	0x50	u64	freehigh	Available high memory size in KB
88	0x58	u64	bufferram	Memory reserved for buffers, free cache in KB
96	0x60	u64	cached	Size of used cache, without buffers in KB
104	0x68	u64	totalswap	Total swap space size in KB
112	0x70	u64	freeswap	Free swap space in KB
120	0x78	u64	pgalloc	Page allocations
128	0x80	u64	pgfault	Page faults (major+minor)
136	0x88	u64	pgmajfault	Page faults (major only)

Table 17. APPLDATA_OS_DATA record (Record ID 0x02)

Offset		Type	Name	Description
Decimal	Hex			
0	0x0	u64	timestamp	TOD timestamp generated on the Linux side after record update
8	0x8	u32	sync_count_1	After VM collected the record data, sync_count_1 and sync_count_2 should be the same. Otherwise, the record has been updated on the Linux side while VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	
16	0x10	u32	nr_cpus	Number of virtual CPUs
20	0x14	u32	per_cpu_size	Size of the data struct (= 16) for each CPU
24	0x18	u32	cpu_offset	Offset of the first CPU data struct (= 48)
28	0x1C	u32	nr_running	Number of runnable threads
32	0x20	u32	nr_threads	Number of threads
36	0x24	3 × u32	avenrun[3]	Average number of running processes during the last 1 (1st value), 5 (2nd value) and 15 (3rd value) minutes. These values are ″fake fix-point″, each composed of 10 bits integer and 11 bits fractional part. See note 1 at the end of this table.
48	0x30	u32	nr_iowait	Number of blocked threads (waiting for I/O)
52	0x34	See note 2.	per_cpu_size	Time spent in user/kernel/idle/nice mode for every CPU. See note 3 at the end of this table.
52	0x34	u32	per_cpu_user	Timer ticks spent in user mode (CPU0)
56	0x38	u32	per_cpu_nice	Timer ticks spent with modified priority (CPU0)
60	0x3C	u32	per_cpu_system	Timer ticks spent in kernel mode (CPU0)
64	0x40	u32	per_cpu_idle	Timer ticks spent in idle mode (CPU0)
68	0x44	u32	per_cpu_irq	Timer ticks spent in interrupts
72	0x48	u32	per_cpu_softirq	Timer ticks spent in softirqs
76	0x4C	u32	per_cpu_iowait	Timer ticks spent while waiting for I/O

Notes:

1. The following C-Macros are used inside Linux to transform these into values with 2 decimal places:

```
#define LOAD_INT(x) ((x) >> 11)
#define LOAD_FRAC(x) LOAD_INT(((x) & ((1 << 11) - 1)) * 100)
```

2. nr_cpus * per_cpu_data
3. per_cpu_size through per_cpu_iowait are repeated for each CPU

Table 18. APPLDATA_NET_SUM_DATA record (Record ID 0x03)

Offset		Type	Name	Description
Decimal	Hex			
0	0x0	u64	timestamp	TOD timestamp generated on the Linux side after record update
8	0x8	u32	sync_count_1	After VM collected the record data, sync_count_1 and sync_count_2 should be the same. Otherwise, the record has been updated on the Linux side while VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	
16	0x10	u32	nr_interfaces	Number of interfaces being monitored
20	0x14	u32	padding	Unused. The next value is 64-bit aligned, so these 4 byte would be padded out by compiler
24	0x18	u64	rx_packets	Total packets received
32	0x20	u64	tx_packets	Total packets transmitted
40	0x28	u64	rx_bytes	Total bytes received
48	0x30	u64	tx_bytes	Total bytes transmitted
56	0x38	u64	rx_errors	Number of bad packets received
64	0x40	u64	tx_errors	Number of packet transmit problems
72	0x48	u64	rx_dropped	Number of incoming packets dropped because of insufficient space in Linux buffers
80	0x50	u64	tx_dropped	Number of outgoing packets dropped because of insufficient space in Linux buffers
88	0x58	u64	collisions	Number of collisions while transmitting

Programming interfaces

The monitor stream support base module exports two functions:

- appldata _register_ops() to register data gathering modules
- appldata_unregister_ops() to undo the registration of data gathering modules

Both functions receive a pointer to a struct appldata_ops as parameter. Additional data gathering modules that want to plug into the base module must provide this data structure. You can find the definition of the structure and the functions in arch/s390/appldata/appldata.h in the Linux source tree.

See "APPLDATA monitor record layout" on page 188 for an example of APPLDATA data records that are to be sent to z/VM.

Tip: include the timestamp, sync_count_1, and sync_count_2 fields at the beginning of the record as shown for the existing APPLDATA record formats.

Chapter 16. z/VM recording device driver

The z/VM recording device driver can be used by Linux systems that run as z/VM guests. The device driver enables the Linux guest to read from the CP recording services and, thus, act as a z/VM wide control point.

The z/VM recording device driver uses the z/VM RECORDING command to collect records and IUCV to transmit them to the Linux guest.

Features

The z/VM recording device driver supports the following devices and functions:

- Reading records from the CP error logging service, *LOGREC.
- Reading records from the CP accounting service, *ACCOUNT.
- Reading records from the CP diagnosic service, *SYMPTOM.
- Automatic and explicit record collection (see "Starting and stopping record collection" on page 196).

What you should know about the z/VM recording device driver

The z/VM recording device driver is a character device driver that is grouped under the IUCV category of device drivers (see "Device categories" on page 9). There is one device for each recording service. The devices are created for you if the z/VM recording device driver is included in the kernel or they are created when the z/VM recording device driver is loaded as a module.

z/VM recording device nodes

Each recording service has a fixed minor number and a name that corresponds to the name of the service as shown in Table 19:

Table 19. Device names and minor numbers

z/VM recording service	Standard device name	Minor number
*LOGREC	logrec	0
*ACCOUNT	account	1
*SYMPTOM	symptom	2

The major device number for the z/VM recording device driver is assigned dynamically. Read the dev attribute of any one of the z/VM recording devices to find out the major number. The dev attribute is of the form <*major*>:<*minor*>.

Example:

To read the dev attribute of the logrec device:

```
# cat /sys/class/vmlogrdr/logrec/dev
254:0
```

While vmlogrdr registers its driver and device structures with the iucv bus, it also needs to register a class and a class device under /sys/class. The dev attribute is member of that class device. In the example, the major number 254 has been assigned and the minor number is 0 as expected.

Creating device nodes for the z/VM recording devices

You access z/VM recording data through device nodes. The required device nodes might be provided for you by udev or by your distribution.

If there are no device nodes, use a command of this form to create a node:

```
mknod -m 440 /dev/<file> c <major> <minor>
```

where:

<file>
: is the file name that you assign to the device node.

<major>
: is the major number that has been dynamically assigned to the z/VM recording device driver (see "z/VM recording device nodes" on page 193).

<minor>
: is the minor number of the recording service for which you are creating the device node.

Example: Using the standard device names (see Table 19 on page 193) and assuming that the major number 254 has been assigned to the z/VM recording device driver you could create the device nodes like this:

```
# mknod -m 440 /dev/logrec c 254 0
# mknod -m 440 /dev/account c 254 1
# mknod -m 440 /dev/symptom c 254 2
```

Reading records

The read function returns one record at a time. If there is no record, the read function waits until a record becomes available.

Each record begins with a 4 byte field containing the length of the remaining record. The remaining record contains the binary z/VM data followed by the four bytes X'454f5200' to mark the end of the record. Theses bytes build the zero terminated ASCII string "EOR", which is useful as an eye catcher.

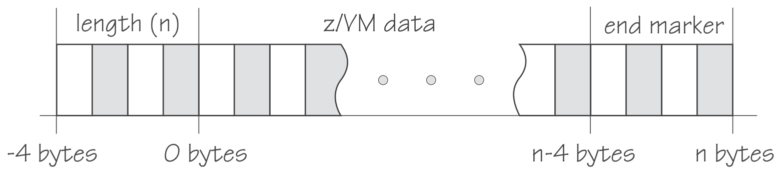


Figure 50. Record structure

Figure 50 illustrates the structure of a complete record as returned by the device. If the buffer assigned to the read function is smaller than the overall record size, multiple reads are required to obtain the complete record.

The format of the z/VM data (*LOGREC) depends on the record type described in the common header for error records HDRREC.

For more information on the z/VM record layout, refer to the *CMS and CP Data Areas and Control Blocks* documentation at `ibm.com/vm/pubs/ctlblk.html`.

Further information

For general information about CP recording system services refer to *z/VM CP Programming Services*, SC24-6001.

Building a kernel with the z/VM recording device driver

This section is intended for those who want to build their own kernel.

To build a Linux kernel that supports the z/VM recording device driver you need a kernel that includes the IUCV device driver (see Chapter 11, "NETIUCV device driver," on page 153). You also need to select the CONFIG_VMLOGRDR configuration menu option:

```
Character device drivers
   Support for the z/VM recording system services          (CONFIG_VMLOGRDR)
```

Figure 51. z/VM recording kernel configuration menu option

The z/VM recording device driver can be compiled into the kernel or as a separate module, vmlogrdr.

Setting up the z/VM recording device driver

This section provides information on the guest authorization you need to be able to collect records and on how to load the device driver if it has been compiled as a module.

Authorizing the Linux guest

The Linux guest must be authorized to use the z/VM RECORDING command. Depending on the z/VM environment, this could be either of the following authorization classes: A, B, C, E, or F.

The guest must also be authorized to connect to those IUCV services it needs to use.

Loading the z/VM recording device driver

There are no kernel or module parameters for the z/VM recording device driver.

If you have compiled the z/VM recording device driver as a separate module, you need to load it before you can work with z/VM recording devices. Load the vmlogrdr module with the modprobe command to ensure that any other required modules are loaded in the correct order:

```
# modprobe vmlogrdr
```

Working with z/VM recording devices

This section describes typical tasks that you need to perform when working with z/VM recording devices.

- Starting and stopping record collection
- Purging existing records
- Querying the VM recording status
- Opening and closing devices
- Reading records

Starting and stopping record collection

By default, record collection for a particular z/VM recording service begins when the corresponding device is opened and stops when the device is closed.

You can use a device's autorecording attribute to be able to open and close a device without also starting or stopping record collection. You can use a device's recording attribute to start and stop record collection regardless of whether the device is opened or not.

Be aware that you cannot start record collection if a device is open and there are already existing records. Before you can start record collection for an open device you must read or purge any existing records for this device (see "Purging existing records" on page 197).

To be able to open a device without starting record collection and to close a device without stopping record collection write "0" to the devices autorecording attribute. To restore the automatic starting and stopping of record collection write "1" to the devices autorecording attribute. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdr/<device>/autorecording
```

where *<flag>* is either 0 or 1, and *<device>* is one of: logrec, symptom, or account.

To explicitly switch on record collection write "1" to the devices recording attribute. To explicitly switch off record collection write "0" to the devices recording attribute. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdr/<device>/recording
```

where *<flag>* is either 0 or 1, and *<device>* is one of: logrec, symptom, or account.

You can read the both the autorecording and the recording attribute to find the current settings.

Examples

- In this example, first the current setting of the autorecording attribute of the logrec device is checked, then automatic recording is switched off:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/logrec/autorecording
1
# echo 0 > /sys/bus/iucv/drivers/vmlogrdr/logrec/autorecording
```

- In this example record collection is started explicitly and later stopped for the account device. The example also shows commands to confirm that record collection is on or off:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/account/recording
0
# echo 1 > /sys/bus/iucv/drivers/account/recording
# cat /sys/bus/iucv/drivers/vmlogrdr/account/recording
1
...
# echo 0 > /sys/bus/iucv/drivers/account/recording
# cat /sys/bus/iucv/drivers/vmlogrdr/account/recording
0
```

Purging existing records

By default, existing records for a particular z/VM recording service are purged automatically when the corresponding device is opened or closed.

You can use a device’s autopurge attribute to prevent records from being purged when a device is opened or closed. You can use a device’s purge attribute to purge records for a particular device at any time without having to open or close the device.

To be able to open or close a device without purging existing records write “0” to the devices autopurge attribute. To restore automatic purging of existing records write “1” to the devices autopurge attribute. You can read the autopurge attribute to find the current setting. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdr/<device>/autopurge
```

where *<flag>* is either 0 or 1, and *<device>* is one of: logrec, symptom, or account.

To purge existing records for a particular device without opening or closing the device write “1” to the devices purge attribute. Issue a command of this form:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdr/<device>/purge
```

where *<device>* is one of: logrec, symptom, or account.

Examples

- In this example, the setting of the autopurge attribute for the logrec device is checked first, then automatic purging is switched off:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/logrec/autopurge
1
# echo 0 > /sys/bus/iucv/drivers/vmlogrdr/logrec/autopurge
```

- In this example, the existing records for the symptom device are purged:

```
# echo 1 > /sys/bus/iucv/drivers/symptom/purge
```

Querying the VM recording status

You can use the record_status attribute of the z/VM recording device driver representation in sysfs to query the VM recording status.

Example

This example runs the vm cp command QUERY RECORDING and returns the complete output of that command. This list will not necessarily have an entry for all three services and there might be additional entries for other guests.

```
$ cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
```

This will result in output similar to the following:

```
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001774  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT OFF   00000000  020     LINUX31    INACTIVE
```

where the lines represent:

- The service
- The recording status
- The number of queued records
- The number of records that will result in a message to the operator
- The guest that is or was connected to that service and the current status of that connection

A detailed description of the QUERY RECORDING command can be found in the *z/VM CP Command and Utility Reference*, SC24-6008.

Opening and closing devices

You can open, read, and release the device. You cannot open the device multiple times. Each time the device is opened it must be released before it can be opened again.

You can use a device's autorecord attribute (see "Starting and stopping record collection" on page 196) to enable automatic record collection while a device is open.

You can use a device's autopurge attribute (see "Purging existing records" on page 197) to enable automatic purging of existing records when a device is opened and closed.

Scenario: Connecting to the *ACCOUNT service.

This scenario demonstrates autorecording, turning autorecording off, purging records, and starting recording.

1. Query the status of VM recording. As root, issue the following command:

   ```
   # cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
   ```

   The results depend on the system, but should be similar to the following:

```
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001812  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT OFF   00000000  020     LINUX31    INACTIVE
```

2. Open /dev/account with an appropriate application. This will connect the guest to the *ACCOUNT service and start recording. The entry for *ACCOUNT on guest LINUX31 will change to ACTIVE and ON:

```
 # cat /sys/bus/iucv/drivers/vmlogrdr/recording_status

RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001812  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT ON    00000000  020     LINUX31    ACTIVE
```

3. Switch autopurge and autorecord off:

```
 # echo 0 > /sys/bus/iucv/drivers/vmlogrdr/account/autopurge
```

```
 # echo 0 > /sys/bus/iucv/drivers/vmlogrdr/account/autorecording
```

4. Close the device by ending the application that reads from it and check the recording status. Note that while the connection is INACTIVE, RECORDING is still ON:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001812  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT ON    00000000  020     LINUX31    INACTIVE
```

5. The next status check shows that some event created records on the *ACCOUNT queue:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001821  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT ON    00000009  020     LINUX31    INACTIVE
```

6. Switch recording off:

```
# echo 0 > /sys/bus/iucv/drivers/vmlogrdr/account/recording
```

```
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       000000000 002     EREP       ACTIVE
ACCOUNT ON    00001821  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT OFF   00000009  020     LINUX31    INACTIVE
```

7. Try to switch it on again, and check whether it worked by checking the recording status:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdr/account/recording
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       000000000 002     EREP       ACTIVE
ACCOUNT ON    00001821  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT OFF   00000009  020     LINUX31    INACTIVE
```

Recording did not start, in the message logs you may find a message:

```
 vmlogrdr: recording response: HCPCRC8087I Records are queued for user LINUX31 on the
*ACCOUNT recording queue and must be purged or retrieved before recording can be turned on.
```

Note that this kernel message has priority 'debug' so it might not be written to any of your log files.

8. Now remove all the records on your *ACCOUNT queue either by starting an application that reads them from /dev/account or by explicitly purging them:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdr/account/purge
```

```
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT     LMT     USERID     COMMUNICATION
EREP ON       00000000  002     EREP       ACTIVE
ACCOUNT ON    00001821  020     DISKACNT   INACTIVE
SYMPTOM ON    00000000  002     OPERSYMP   ACTIVE
ACCOUNT OFF   00000000  020     LINUX31    INACTIVE
```

9. Now we can start recording, check status again:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdr/account/recording
```

```
# cat /sys/bus/iucv/drivers/vmlogrdr/recording_status
RECORDING     COUNT      LMT     USERID     COMMUNICATION
EREP ON       00000000   002     EREP       ACTIVE
ACCOUNT ON    00001821   020     DISKACNT   INACTIVE
SYMPTOM ON    00000000   002     OPERSYMP   ACTIVE
ACCOUNT ON    00000000   020     LINUX31    INACTIVE
```

Chapter 17. Watchdog device driver

The watchdog device driver provides Linux user space watchdog applications with access to the z/VM watchdog timer.

Watchdog applications can be used to set up automated restart mechanisms for Linux guests. Watchdog based restart mechanisms are an alternative to a networked heartbeat in conjunction with STONITH (see "STONITH support (snipl for STONITH)" on page 304).

A watchdog application that communicates directly with the z/VM control program (CP) does not require a third operating system to monitor a heartbeat. The watchdog device driver enables you to set up a restart mechanism of this form.

Features

The watchdog device driver provides:
- Access to the z/VM 5.1 watchdog timer.
- An API for watchdog applications (see).

Building a kernel with the watchdog device driver

This section is intended for those who want to build their own kernel.

You need to select the kernel configuration option CONFIG_ZVM_WATCHDOG to be able to use the watchdog device driver.

```
Character device drivers --->
   Watchdog Cards  --->
      z/VM Watchdog Timer                        (CONFIG_ZVM_WATCHDOG)
```

Figure 52. Watchdog kernel configuration option

The watchdog device driver can be compiled into the kernel or as a separate module, vmwatchdog.

CONFIG_ZVM_WATCHDOG depends on the common code option CONFIG_WATCHDOG.

What you should know about the watchdog device driver

The watchdog function comprises of the watchdog timer that runs on z/VM and a watchdog application that runs on the Linux guest being controlled. While the Linux guest operates satisfactory, the watchdog application reports a positive status to the z/VM watchdog timer at regular intervals. The watchdog application uses a miscellaneous character device to pass these status reports to the z/VM timer (Figure 53 on page 202).

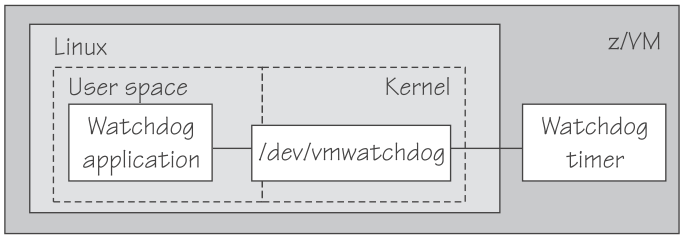


Figure 53. Watchdog application and timer

The watchdog application typically derives its status by monitoring, critical network connections, file systems, and processes on the Linux guest. If a given time elapses without a positive report being received by the watchdog timer, the watchdog timer assumes that the Linux guest is in an error state. The watchdog timer then triggers a predefined action from CP against the Linux guest. Examples of possible actions are: shutting down Linux, rebooting Linux, or initiating a system dump.

Note: Loading or saving a DCSS can take a long time during which the virtual machine does not respond, depending on the size of the DCSS. This may cause a watchdog to timeout and restart the guest. You are advised not to use the watchdog in combination with loading or saving DCSSs.

Your distribution might contain a watchdog application. You can also obtain a watchdog application from:

`http://www.ibiblio.org/pub/Linux/system/daemons/watchdog/`

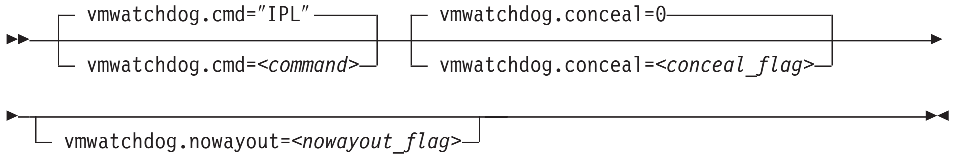
Setting up the watchdog device driver

This section describes the parameters that you can use to configure the watchdog device driver and how to assure that the required device node exists.

Kernel parameters

This section describes how to configure the watchdog device driver by adding parameters to the kernel parameter line if the watchdog support has been compiled into the kernel.

watchdog kernel parameter syntax


vmwatchdog.cmd="IPL"
vmwatchdog.cmd=<command>
vmwatchdog.conceal=0
vmwatchdog.conceal=<conceal_flag>
vmwatchdog.nowayout=<nowayout_flag>

where:

<command>
: is the command to be issued by CP if the Linux guest fails. The default "IPL" reboots the guest with the previous boot parameters.

Instead of rebooting the same system, you could also boot from alternate IPL device (for example, a dump device). You can also specify multiple commands to be issued, separated by newline characters. For more information on CP commands refer to *z/VM CP Command and Utility Reference*, SC24-6008.

The specification for <*command*>:

- Can be up to 256 characters long
- Needs to be enclosed by quotes if it contains any blanks or newline characters
- Is converted from ASCII to uppercase EBCDIC

<*conceal_flag*>
turns on and off the protected application environment where the guest is protected from unexpectedly entering CP READ. "0" turns off the protected environment, "1" enables it. The default is "0".

For details, refer to the "SET CONCEAL" section of *z/VM CP Command and Utility Reference*, SC24-6008.

<*nowayout_flag*>
determines what happens when the watchdog device node is closed by the watchdog application.

If the flag is set to "1", the z/VM watchdog timer keeps running and triggers the command specified for <*command*> if no positive status report is received within the given time interval. If the flag is set to "0", the z/VM watchdog timer is stopped and the Linux guest continues without the watchdog support.

The default is determined by the common code kernel configuration option CONFIG_WATCHDOG_NOWAYOUT.

Example

The following kernel parameters determine that, on failure, the Linux guest is to be IPLed from a device with devno 0xb1a0. The protected application environment is not enabled. If the watchdog application becomes inactive, the z/VM watchdog timer does not cause the guest to be IPLed.

```
vmwatchdog.cm="ipl b1a0" vmwatchdog.nowayout=0
```

Module parameters

This section describes how to load and configure the watchdog device driver if it has been compiled as separate module.

watchdog module parameter syntax

```
                               ┌─ cmd="IPL CLEAR"─┐
►►──modprobe──vmwatchdog───────┼──────────────────┼──────────────────────────►
                               └─ cmd=<command>───┘

   ┌─ conceal=0──────────────┐
►──┼─────────────────────────┼──┬────────────────────────────┬──────────────►◄
   └─ conceal=<conceal_flag>─┘  └─ nowayout=<nowayout_flag>──┘
```

The variables have the same meaning as in "Kernel parameters" on page 202.

Example

The following command loads the watchdog module and determines that, on failure, the Linux guest is to be IPLed from a device with devno 0xb1a0. The protected application environment is not enabled. If the watchdog application becomes inactive, so the z/VM watchdog timer does not cause the guest to be IPLed.

```
modprobe vmwatchdog cmd="ipl b1a0" nowayout=0
```

Assuring that a device node exists

The watchdog application on Linux needs a misc character device to communicate with the z/VM watchdog timer. This device node is typically called `/dev/vmwatchdog`. If your distribution does not create the device node for you (for example, with udev), you need to create a node.

To check if there is already a node issue:

```
# find / -name watchdog
```

If your distribution provides the watchdog device driver as a separate module, be sure to load the module before you check for the node.If there is no node, use major number 10 and minor number 130 to create one. Issue

```
# mknod /dev/watchdog c 10 130
```

External programming interfaces

This section provides information for those who want to program watchdog applications that work with the watchdog device driver.

For information on the API refer to the following files in the Linux source tree:

- `/Documentation/watchdog/watchdog-api.txt`
- `inlcude/linux/watchdog.h`

Part 5. Generic features

This part describes:

- Chapter 18, “Console device drivers”
- Chapter 19, “Generic cryptographic device driver”
- Chapter 20, “Channel measurement facility”
- Chapter 21, “Control program identification”
- Chapter 22, “OSA-Express SNMP subagent support”

It also provides a summary of the zSeries and S/390-specific kernel configuration options you can find in the Linux kernel configuration menu. Some of these options provide additional features that are not otherwise described in this book.

- Chapter 23, “Other features kernel builders should know about,” on page 245

Note

For prerequisites and restrictions for these device drivers and features refer to the kernel 2.6 April 2004 stream pages on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click "**April 2004 stream**"**- Recommended level**.

Chapter 18. Console device drivers

The Linux for zSeries and S/390 console device drivers support devices for basic Linux control, for example, for booting Linux.

The control device can be a 3270 terminal or a zSeries- or S/390-mainframe's *hardware console*. The device driver accesses the hardware console through the service-call logical processor (SCLP) interface.

If Linux is running as a VM guest or on a P/390, the control device can also be a 3215 terminal.

Note that "terminal" and "console" have special meanings in Linux, which should not be confused with the zSeries and S/390 usage.

The Hardware Management Console (HMC) is a Web application that provides access to the zSeries or S/390 Service Element (SE) which is in overall control of the mainframe hardware.

A mainframe *terminal* is any device which gives a user access to applications running on the mainframe. This could be a real device such as a 3215 linked to the system through a controller, or it can be a terminal emulator on a networked device.

The Linux console and the Linux terminals are different applications which both run on zSeries and S/390 *terminals*. Linux terminals are devices through which users interact with Linux and Linux applications. The Linux console is a device that handles user interactions with the Linux kernel. The Linux console traffic is directed to one of the Linux terminals.

In this chapter, we use console and terminal to refer to a Linux console or terminal, unless indicated otherwise.

Console features

The console device drivers support the following devices and functions:

- Supports an SCLP console
- Supports a 3215 terminal for the United States code page (037)
- Supports a 3270 terminal
- Provides a line mode or full-screen mode typewriter terminal
- Provides Linux console output on a designated terminal

What you should know about console devices

This section provides information on console device names and nodes, on different modes of console devices, and considerations when running the console in specific environments.

Console modes

The console can be a line-mode terminal or a full-screen mode terminal.

On a full-screen mode terminal, pressing any key immediately results in data being sent to the TTY routines. Also, terminal output can be positioned anywhere on the screen. This allows for advanced interactive capability when using terminal based applications.

On a line-mode terminal, the user first types a full line and then presses Enter to let the system know that a line has been completed. The device driver then issues a read to get the completed line, adds a new line and hands over the input to the generic TTY routines.

Console device names

Table 20 summarizes the supported console devices, with their names, and device numbers:

Table 20. Supported console devices

Device driver	Device name	Major	Minor
Line-mode hardware console	ttyS0	4	64
Full-screen mode hardware console	ttyS1	4	65
3215 terminal	ttyS0	4	64
3270 terminal	tty3270	227	0

Note: The specifications for the line-mode hardware console and the 3215 device are identical. The device name and numbers are assigned to whatever device is present or to the device you specify with the conmode parameter (see “conmode parameter” on page 214). You cannot have both devices simultaneously.

You require a device node to make a console device available to other programs (see “Assuring device nodes” on page 215).

Using the hardware console

The following applies to both the line-mode terminal and the full-screen mode terminal on the hardware console:

- There can only be one active terminal session on an HMC.
- Security hint: Always end a terminal session by explicitly logging off (for example, type “exit” and press Enter). Simply closing the terminal window leaves the session active and the next user opening the window resumes the existing session without a logon.
- Slow performance of the hardware console is often due to a busy console or increased network traffic.

The following applies to the full-screen mode terminal only:

- Output that is written by Linux while the terminal window is closed is not displayed. Therefore, a newly opened terminal window is always blank. For most applications, like login or shell prompts, it is sufficient to press Enter to obtain a new prompt.
- The terminal window only shows 24 lines and does not provide a scroll bar. To scroll up press Shift+PgUp, to scroll down press Shift+PgDn.

Magic sysrequest function

This section applies to systems where the common code kernel option CONFIG_MAGIC_SYSRQ has been activated only.

The two characters "^-" followed by a third character invoke the *magic sysrequest* function. The various debugging and emergency functions that can be performed are specified by the third character.

This feature can be switched on or off during runtime by echoing "1" (on) or "0" (off) to `/proc/sys/kernel/sysrq`. The possible sequences are:

Table 21. Magic sysrequest commands

Enter	To
`^-b`	Re-IPL immediately.
`^-s`	Emergency sync all file systems.
`^-u`	Emergency remount all mounted file systems read-only.
`^-t`	Show task info.
`^-m`	Show memory.
`^-` followed by a digit (0 to 9)	Set the console log level.
`^-e`	Terminate all tasks.
`^-i`	Kill all tasks except init.

Console special characters on line-mode terminals

The line-mode console does not have a control key. That makes it impossible to enter control characters directly. To be able to enter at least some of the more important control characters, the character "^" has a special meaning in the following cases:

Table 22. Control characters

For the key combination	Type this	Usage
`Ctrl+C`	`^c`	Cancel the process that is currently running in the foreground of the terminal.
`Ctrl+D`	`^d`	Generate an end of file (EOF) indication.
`Ctrl+Z`	`^z`	Stop a process.
n/a	`^n`	Suppresses the automatic generation of a new line. This makes it possible to enter single characters, for example those characters that are needed for yes/no answers in the ext2 file system utilities.

If you are running under VM using the hardware console emulation, you will have to use the **CP VINPUT** command to simulate the Enter and Spacebar keys.

The Enter key is simulated by entering:

```
#CP VINPUT VMSG \n
```

The Spacebar key is simulated by entering two blanks followed by "\n":

```
#CP VINPUT VMSG  \n
```

VM console line edit characters

When running under VM, the control program (CP) defines five characters as line editing symbols. Use the **CP QUERY TERMINAL** command to see the current settings. The defaults for these depend on the terminal emulator you are using, and can be reassigned by the CP system operator or by yourself using the **CP TERMINAL** command to change the setting of LINEND, TABCHAR, CHARDEL, LINEDEL or ESCAPE. Table 23 shows the most commonly used settings:

Table 23. Line edit characters

Character	Symbol	Usage
#	LINEND	The end of line character allows you to enter several logical lines at once.
|	TABCHAR	The logical tab character.
@	CHARDEL	The character delete symbol deletes the preceding character.
[or ¢	LINEDEL	The line delete symbol deletes everything back to and including the previous LINEND symbol or the start of the input. "[" is common for ASCII terminals and "¢" for EBCDIC terminals.
"	ESCAPE	The escape character allows you to enter a line edit symbol as a normal character.

To enter the line edit symbols # | @ [" (or # | @ ¢ ") you need to type the character pairs "# "| "@ "["" (or "# "| "@ "¢ ""). In particular, to enter the quote character you must type it twice.

Example

If you type the character string:

```
#CP HALT#CP ZIPL 190[#CP IPL 1@290 PARM vmpoff=""MSG OP REBOOT"#IPL 290""
```

the actual commands received by CP are:

```
CP HALT
CP IPL 290 PARM vmpoff="MSG OP REBOOT#IPL 290"
```

Using VInput

VINPUT is a VM CP command. It can be abbreviated to **VI** but must not be confused with the Linux command **vi**.

If you use the hardware console driver running under VM (as a line-mode terminal, full-screen mode is not supported), it is important to consider how the input is handled. Instead of writing into the suitable field within the graphical user interface at the service element or HMC, you have to use the **VINPUT** command provided by VM. The following examples are written at the input line of a 3270 terminal or terminal emulator (for example, x3270).

If you are in the CP READ mode, omit the leading "#CP" from the commands.

Priority and non-priority commands

VINPUT commands require a VMSG (non-priority) or PVMSG (priority) specification. Operating systems that honour this specification process priority commands with a higher priority than non-priority commands.

The hardware console driver is capable to accept both if supported by the hardware console within the specific machine or virtual machine.

Linux does not distinguish priority and non-priority commands.

Example: The specifications:

```
#CP VMSG LS -L
```

and

```
#CP PVMSG LS -L
```

are equivalent.

Case conversion

All lowercase characters are converted by VM to uppercase. To compensate for this, the console device driver converts all input to lowercase.

Linux and bash are case sensitive and require some specifications with uppercase characters. To allow uppercase characters to be passed to Linux, the hardware console uses an escape character "%" under VM to distinguish between uppercase and lowercase characters. Characters enclosed by two "%" are treated as uppercase.

This behavior and the escape character "%" are adjustable at build-time by editing the driver sources.

Examples: If you type `VInput VMSG echo $PATH`, the device driver gets `ECHO $PATH` and converts it into `echo $path`.

- The first line is your input line, the second the line processed by CP and the third the command processed by bash:

  ```
  #cp vinput vmsg ls -l
  CP VINPUT VMSG LS -L
  ls -l
  ```

- The following input would result in a bash command with a variable $path that is not defined in lowercase:

  ```
  #cp vinput vmsg echo $PATH
  CP VINPUT VMSG ECHO $PATH
  echo $path
  ...
  ```

  To obtain the correct bash command enclose a the uppercase string with the conversion escape character:

  ```
  #cp vinput vmsg echo $%PATH%
  CP VINPUT VMSG ECHO $%PATH%
  echo $PATH
  ...
  ```

Using the escape character

To include the escape character in the command passed to Linux, you need to type it twice. If you are using the standard settings according to "VM console line edit characters" on page 210, you need to specify two quotes to pass a single quote to Linux.

Example: The following command passes an string in quotes to be echoed.

```
#cp vinput pvmsg echo ""%H%ello, here is ""$0
CP VINPUT PVMSG ECHO "%H%ELLO, HERE IS "$0
echo "Hello, here is "$0
Hello, here is -bash
```

In the example, $0 resolves to the name of the current process.

Using the end of line character

To include the end of line character in the command passed to Linux, you need to specify it with a leading escape character. If you are using the standard settings according to "VM console line edit characters" on page 210, you need to specify "# to pass # to Linux.

If you specify the end of line character without a leading escape character, VM CP interprets it as an end of line character that ends the **VINPUT** command.

Example: In this example a number sign is intended to mark the begin of a comment in the bash command but is misinterpreted as the beginning of a second command:

```
#cp vinput pvmsg echo ""%N%umber signs start bash comments"" #like this one
CP VINPUT PVMSG ECHO "%N%UMBER SIGNS START BASH COMMENTS"
LIKE THIS ONE
HCPCMD001E Unknown CP command: LIKE
...
```

The escape character prevents the number sign from being interpreted as an end of line character:

```
#cp vinput pvmsg echo ""%N%umber signs start bash comments"" "#like this one
VINPUT PVMSG ECHO "%N%UMBER SIGNS START BASH COMMENTS" #LIKE THIS ONE
echo "Number signs start bash comments" #like this one
Number signs start bash comments
```

Console 3270 emulation

If you are accessing the VM console from Linux by using the x3270 emulator, add the following settings to the .Xdefaults file to get the correct code translation:

```
! X3270 keymap and charset settings for Linux
x3270.charset: us-intl
x3270.keymap: circumfix
x3270.keymap.circumfix: :<key>asciicircum: Key("^")\n
```

Further information

For more information on VINPUT refer to *z/VM CP Command and Utility Reference*, SC24-6008.

Building a kernel with the console device drivers

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the console device drivers.

Figure 54 summarizes the kernel configuration menu options that are relevant to the console device drivers:

```
Character device drivers
   Support for locally attached 3270 tubes        (CONFIG_TN3270)
   └─Support for console on                       (CONFIG_TN3270_CONSOLE)
       3270 line mode terminal
   Support for locally attached 3215 tubes        (CONFIG_TN3215)
   └─Support for console on                       (CONFIG_TN3215_CONSOLE)
     3215 line mode terminal
   Support for SCLP                               (CONFIG_SCLP)
   ├─Support for SCLP line mode terminal          (CONFIG_SCLP_TTY)
   │ └─Support for console on                     (CONFIG_SCLP_CONSOLE)
   │   SCLP line mode terminal
   └─Support for SCLP VT220-compatible terminal   (CONFIG_SCLP_VT220_TTY)
     └─Support for console on                     (CONFIG_SCLP_VT220_CONSOLE)
       SCLP VT220-compatible terminal
```

Figure 54. Console kernel configuration menu options

CONFIG_TN3270
Allows an IBM 3270 line-mode terminal to run a Linux system console.

CONFIG_TN3270_CONSOLE
Prints kernel errors and kernel warnings to the IBM 3270 line-mode terminal in addition to the normal output.

CONFIG_TN3215
Allows an IBM 3215 line-mode terminal to run a Linux system console.

CONFIG_TN3215_CONSOLE
Prints kernel errors and kernel warnings to the IBM 3215 line-mode terminal in addition to the normal output.

CONFIG_SCLP
Includes support for the IBM SCLP interface to the service element. This option is required to enable Linux to respond to “signal quiesce” requests.

CONFIG_SCLP_TTY
Allows an SCLP line-mode terminal to run a Linux system console.

CONFIG_SCLP_CONSOLE
Prints kernel errors and kernel warnings to the SCLP line-mode hardware console in addition to the normal output on the TTY device.

CONFIG_SCLP_VT220_TTY
Allows an SCLP VT220-compatible terminal in full-screen mode to run a Linux system console.

CONFIG_SCLP_VT220_CONSOLE
Prints kernel errors and kernel warnings to the full-screen hardware console in addition to the normal output on the TTY device.

All console device driver components are compiled into the kernel.

Setting up the console device drivers

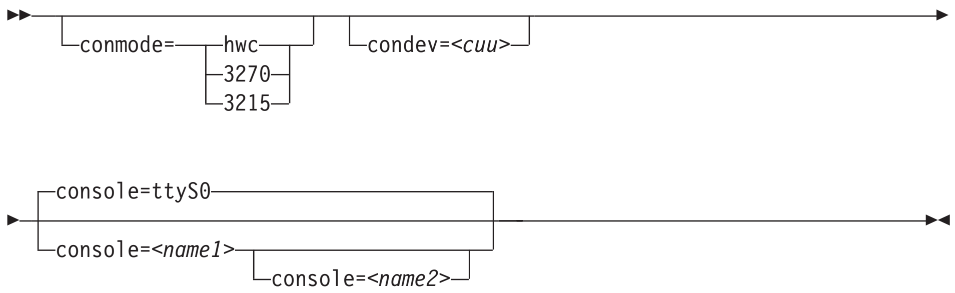
This section describes the kernel parameters, commands, and `/etc/inittab` entries that you can use to configure the console device drivers. Because all console device driver components are compiled into the kernel, there are no module parameters.

Console kernel parameter syntax

There are three kernel parameters for the console:

conmode	to override the default console of an environment.
condev	to define a 3215 device to a P/390.
console	to activate a console and designate a *preferred* console.

Console kernel parameter syntax



Note: If you specify multiple parameter=value pairs, separate them with a blank.

where:

<cuu>
: is the device 'Control Unit and Unit' number, and may be expressed in hexadecimal form (preceded by `0x`) or in decimal form.

<name1>
: is the standard name of the active console (ttyS0 | ttyS1).

<name2>
: is the standard name of the second console if both are to be active (ttyS0 | ttyS1). If both consoles are specified, this is the preferred console.

conmode parameter

The device drivers for the 3215 terminal, for the 3270 terminal, and for the hardware console can be compiled into the Linux kernel. If more than one driver is present, the default console device driver is chosen at runtime according to the environment:

Table 24. Default console device driver

LPAR or native	hardware console device driver or 3270 device driver
VM	3215 or 3270 console device driver, depending on the guest's console settings (the `CONMODE` field in the output of `#CP QUERY TERMINAL`).
P/390	3215 console device driver

Use the conmode parameter to override the default.

Example: To use the hardware console in a z/VM environment specify:

```
conmode=hwc
```

condev parameter

This kernel parameter applies only to the 3215 console device driver if used on a P/390. This supplies the device driver with the device number of the 3215 device. The reason that this parameter is needed is that there is no guaranteed method of recognizing a 3215 device attached to a P/390.

Example: To instruct the device driver to use device number 0x001F for the 3215 terminal specify:

```
condev=0x001f
```

or:

```
condev=31
```

console parameter

The console parameter applies only if there is more than one console device available (for example, when using the SCLP console device driver).

Only active consoles receive Linux operating system messages and only one console can be the *preferred* console. The preferred console is used as initial input and output device, beginning at the stage of the boot process when the 'init'-script is called. Messages issued by programs that are run at this stage are therefore only displayed on the preferred console. On default, ttyS0 is active and used as the preferred console.

Use the console parameter to activate ttyS1 instead of ttyS0, or to activate both ttyS0 and ttyS1 and designate one of them as the preferred console.

Examples:

- To activate the full-screen console device driver instead of the line-mode console driver, add the following line to the kernel command line:

  ```
  console=ttyS1
  ```
- To activate both consoles, provide a specification for both drivers, for example:

  ```
  console=ttyS0 console=ttyS1
  ```

  The last statement determines the preferred console, `ttyS1` in the example.

Assuring device nodes

User space programs access console devices by *device nodes*. If your distribution does not create these device nodes early in the boot process, Linux will not boot and you will not have a command prompt from where you can create the nodes yourself.

In this case, you can create the nodes from a support system that has access to the failed system's devices. For example, you can use the following commands to create the nodes:

```
# mknod /dev/ttyS0 c 4 64
# mknod /dev/ttyS1 c 4 65
# mknod /dev/tty3270 c 227 0
```

Setting up a line-mode terminal

The line-mode terminals are primarily intended for booting Linux. The preferred user access to a running Linux for zSeries and S/390 is through a networked terminal emulation such as telnet or ssh. The 3215 and 3270 console device drivers always provide a line-mode terminal. The hardware console device driver can provide a line-mode terminal or a VT220-like full-screen mode terminal.

Tip: If the terminal does not provide the expected output, ensure that dumb is assigned to the TERM environment variable. For example, issue the following command on the bash shell:

```
# export TERM=dumb
```

Setting up a full-screen mode terminal

The full-screen terminal, can be used for full-screen text editors, such as vi, and terminal-based full-screen system administration tools. Only the hardware console device driver can provide a VT220-like full-screen mode terminal.

Tip: If the terminal does not provide the expected output, ensure that linux is assigned to the TERM environment variable. For example, issue the following command on the bash shell:

```
# export TERM=linux
```

To set TERM=linux at startup add a line of this form to the /etc/inittab file:

```
<id>:2345:respawn:/sbin/agetty -L 9600 ttyS1 linux
```

where *<id>* is a unique identifier for the entry in the inittab file.

Be sure not to provide multiple entries for ttyS1. For more details see the man page for the inittab file.

Enabling a terminal for user log-ins

To allow user log-ins from a terminal, add a line of this form to the /etc/inittab file:

```
<id>:2345:respawn:/sbin/mingetty <dev> --noclear
```

where:

<id> is a unique identifier for the entry in the inittab file.

<dev> is the device name (see Table 20 on page 208).

Your Linux system's /etc/inittab file might already have an entry for a terminal. Be sure not to provide multiple entries for the same device. See Table 20 on page 208 for the device node names. If an existing entry uses a different name and you are not sure how it maps to the names of Table 20, you can comment it out and replace it. When referring to the device node in a command or parameter, always use the names of Table 20.

For more details see the man page for the inittab file.

Example

To enable a device `ttyS0` for user log-ins specify, for example:

```
1:2345:respawn:/sbin/mingetty ttyS0 --noclear
```

Setting a TTY device online or offline

You can use the **chccwdev** command ("chccwdev - Set a CCW device online" on page 263) to set a TTY device online or offline. Alternatively, you can write "1" to the device's online attribute to set it online, or "0" to set it offline.

Note: Setting a CCW device online and offline in this context is only useful with additional TTYs attached through the 3270 TTY device driver and not for the console device.

Examples

- To set a TTY device `ttyS0` online issue:

  ```
  # chccwdev -e ttyS0
  ```

  or

  ```
  # echo 1 > /sys/bus/ccw/drivers/3270/ttyS0/online
  ```

- To set a TTY device `ttyS0` online issue offline issue:

  ```
  # chccwdev -d ttyS0
  ```

  or

  ```
  # echo 0 > /sys/bus/ccw/drivers/3270/ttyS0/online
  ```

Chapter 19. Generic cryptographic device driver

z90crypt is a generic character device driver for a cryptographic device. The device driver routes work to any of the supported physical cryptographic devices installed on the system.

The z90crypt device driver controls PCICCs, PCICAs PCIXCCs (MCL2 and MCL3), or CEX2C in a Linux environment. VM hides PCICCs and PCIXCCs from its guests if a PCICA is also available. For VM guests, PCIXCC cards are supported as of z/VM 5.1.

Features

The cryptographic device driver supports the following devices and functions:

- PCI Cryptographic Coprocessor (PCICC)
- PCI Cryptographic Accelerator (PCICA)
- PCI-X Cryptographic Coprocessor (PCIXCC)

  The cryptographic device driver distinguishes PCIXCCs according to the licensed internal code (LIC) level:
  - PCIXCC (MCL3) as of LIC EC J12220 level 29
  - PCIXCC (MCL2) with a LIC prior to EC J12220 level 29
- Crypto Express2 Coprocessor (CEX2C)

The cryptographic device driver supports these cryptographic operations:

- Encryption, with a public or private key, by arithmetic operations involving very large numbers

  RSA exponentiation operation using either a modulus-exponent (Mod-Expo) or Chinese-Remainder Theorem (CRT) key.
- Decryption, closely related to encryption, with the counterpart of the key used for encryption

What you should know about z90crypt

This section provides information on the software you need to use z90crypt and when z90crypt uses cryptographic hardware.

Required software components

To run programs that use the z90crypt device driver, you need:

- The device driver module (z90crypt)
- The libica library (except for programs that circumvent libica)

To support applications that use the PKCS #11 API you also need:

- The openCryptoki library

The openCryptoki library requires the libica library. Applications can either directly use the libica library or use libica indirectly through the openCryptoki PKCS #11 API. Applications can also interface directly with the z90crypt driver module. Figure 55 on page 220 illustrates the software relationships:

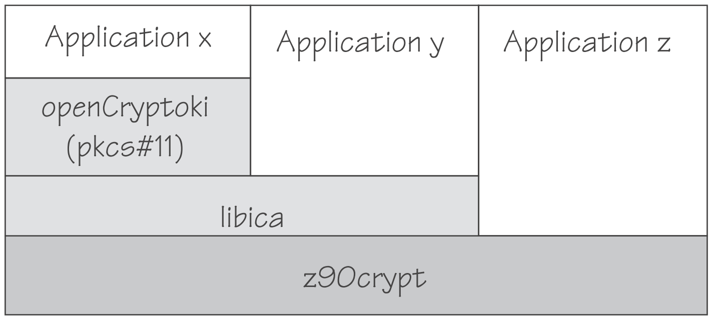


Figure 55. z90crypt device driver interfaces

In Figure 55 “Application x” is an application that uses the PKCS #11 API while “Application y” directly uses the libica library. “Application z” directly uses the z90crypt interfaces (see “External programming interfaces” on page 225).

See “Setting up the z90crypt device driver” on page 221 for information on how to set up the different components.

Hardware offload

The libica library can perform the generation of public/private key pairs, encryption and decryption, signing and signature verification, through software.

If cryptographic hardware is available, the encryption and decryption operations, which may include signing and signature verification, are performed in hardware, with enhanced performance, provided that the padding requirements are handled correctly (see “Padding”). If the padding is not done correctly, the cryptographic operations are performed in software.

Although libica can perform the cryptographic operations in software if no cryptographic hardware is available, it does not work without the z90crypt device driver.

Padding

If you have a PCICC only, or are attempting to use a CRT key on a system with PCIXCC (MCL2) only, you need to ensure that your data is PKCS-1.2 padded. In this case, the z90crypt device driver or the cryptographic hardware might change the padding.

If you have at least one PCICA, PCIXCC (MCL3), or CEX2C, or if you are only using Mod-Expo keys with a PCIXCC (MCL2), you do not need to ensure PKCS-1.2 padding. In this case the padding remains unchanged.

Load balancing

The z90crypt device driver assigns work to cryptographic devices according to device type in the following order of preference:
1. CEX2C, PCICA, and PCIXCC (MCL3)
2. PCIXCC (MCL2)
3. PCICC

For small work loads, a particular job is assigned to the first device that offers the required capabilities. The device order is according to the physical arrangement of the cryptographic cards (see “Checking hardware status” on page 224).

Further information

- For information on RSA–PKCS 1.2-padding visit `http://www.rsasecurity.com/rsalabs/pkcs/pkcs-1/`.
- For information on how to set up cryptographic hardware on your mainframe refer to *zSeries Crypto Guide Update*, SG24-6870.
- For CP commands related to cryptographic devices refer to *z/VM CP Command and Utility Reference*, SC24-6008.

Building a kernel with the z90crypt device driver

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the z90crypt device driver.

You need to select the option CONFIG_Z90CRYPT if you want to use a PCI-attached cryptographic adapter.

```
Cryptographic devices
    Support for PCI-attached cryptographic adapters        (CONFIG_Z90CRYPT)
```

Figure 56. z90crypt kernel configuration menu option

The CONFIG_Z90CRYPT option can be compiled into the kernel or as a separate module, z90crypt.

See also “Setting up for the 31-bit compatibility mode” on page 223 if you want to build a 64-bit system with 31-bit compatibility.

Setting up the z90crypt device driver

This section describes the z90crypt module and kernel parameters, and how to install additional components required by the device driver.

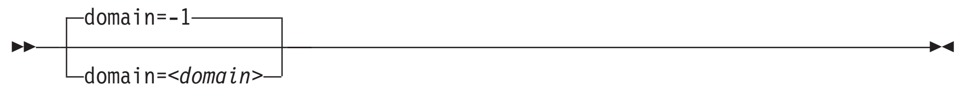
This section also describes how to create the required device node. It further describes how to set up the cryptographic devices on your LPAR, and where applicable, VM, to make it available to your Linux instance.

Kernel parameters

This section describes how to configure the z90crypt device driver if z90crypt has been compiled into the kernel. You can configure the device driver by adding the domain parameter to the kernel parameter line.

You need to specify the domain parameter only if you are running Linux in an LPAR for which multiple cryptographic domains have been defined.

z90crypt kernel parameter syntax



where *<domain>* is an integer in the range from 0 to 15 that identifies the cryptographic domain for the Linux instance.

The specification “domain=-1” causes the device driver to attempt to autodetect the domain to use. This is the default.

Example

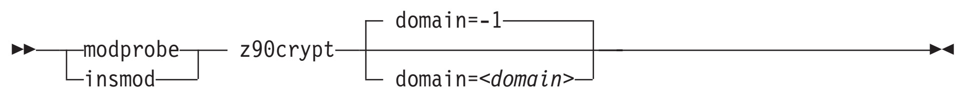
The following kernel parameter line specification makes the z90crypt device driver assume that it operates within the cryptographic domain “1”:

```
domain=1
```

Module parameters

This section describes how to load and configure the z90crypt device driver if it has been compiled as a separate module.

z90crypt module syntax



where *<domain>* is an integer in the range from 0 to 15 that identifies the cryptographic domain for the Linux instance. Omit the domain parameter if only one cryptographic domain is defined for the LPAR where your Linux instance runs.

The specification “domain=-1” causes the device driver to attempt to autodetect the domain to use. This is the default.

Refer to the respective man page for details on **modprobe** or **insmod**.

Examples

- This example loads the z90crypt device driver module if Linux runs in an LPAR with only one cryptographic domain:

```
# modprobe z90crypt
```

- This example loads the z90crypt device driver module and makes the z90crypt device driver assume that it operates within the cryptographic domain “1”:

```
# modprobe z90crypt domain=1
```

The libica library

You can obtain the libica library from the SourceForge Web site at:

`http://sourceforge.net/projects/opencryptoki`

You can find the release details with the module under the **Files** category.

Both a 31-bit and a 64-bit version are available. The 64-bit version includes the 31-bit compatibility code.

openCryptoki

You can obtain the openCryptoki library from the SourceForge Web site at:

`http://sourceforge.net/projects/opencryptoki`

You can find the release details with the module on the **Files** category.

To be able to configure openCryptoki (with pkcsconf) user root must be a member of group pkcs11.

Setting up for the 31-bit compatibility mode

31-bit applications can access the 64-bit z90crypt driver by using the 31-bit compatibility mode.

Assuring that you have a device node

User space programs address cryptographic devices through a single device node. Both the major and minor number can be dynamic, depending on your Linux distribution and configuration. To provide the node you need either udev or hotplug support.

Using udev

If udev (see "Device nodes provided by udev" on page 4) support is enabled, z90crypt is assigned to the miscellaneous devices. The major device number is then that of the misc devices. You can find it as the value for the entry "misc" in `/proc/devices`.

The minor number is dynamically assigned and you can find it in `/proc/misc` as the value for the entry "z90crypt".

If the device node `/dev/z90crypt` is not created for you, you can create it yourself by issuing a command of this form:

```
# mknod /dev/z90crypt c <misc_major> <dynamic_minor>
```

Using hotplug support

If udev is not available and your distribution does not create a node for you, enable option Z90CRYPT_USE_HOTPLUG in z90common to ensure that a dynamic major number is assigned to the z90crypt device driver.

After booting, and if applicable, loading the device driver you can find out which major number has been assigned. The major number is the value for the entry "z90crypt" in `/proc/devices`. In this case the minor is always "0".

You can then create the device node by issuing a command of this form:

```
# mknod /dev/z90crypt c <dynamic_major> 0
```

Working with the z90crypt device driver

Typically, cryptographic devices are not directly accessed by users but through user programs. This section describes the following tasks:

- Checking hardware status
- Deactivating and activating devices under z90crypt

Checking hardware status

You can get the hardware status using the `cat` function, for example, if you issue:

```
# cat /proc/driver/z90crypt
```

you should have an output similar to the following:

```
z90crypt version: 1.3.2
Cryptographic domain: 6
Total device count: 5
PCICA count: 2
PCICC count: 0
PCIXCC MCL2 count: 0
PCIXCC MCL3 count: 1
CEX2C count: 0
requestq count: 0
pendingq count: 0
Total open handles: 0


Online devices: 1: PCICA, 2: PCICC, 3: PCIXCC (MCL2), 4: PCIXCC (MCL3), 5: CEX2C
           1140000000000000 0000000000000000 0000000000000000 0000000000000000


Waiting work element counts
           1000000000000000 0000000000000000 0000000000000000 0000000000000000


Per-device successfully completed request counts
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
    00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
```

Mask “Online devices” represents the physical arrangements of the cryptographic cards. In the example, there are PCICA cards in the first and in the second position, and a PCIXCC (MCL3) card in the third position.

Mask “Waiting work element counts” represents the same arrangement of physical cards. In this mask, the values represent units of outstanding work. In the example, there is one work element for the card in the first position and no work element for the cards in the second and third position.

Mask “Per-device successfully completed request counts” represents the same arrangement of physical cards as before. In this mask, the values represent units of successfully completed work. If a request fails for any reason, it is not counted.

Deactivating and activating devices under z90crypt

For test or error analysis purposes, you might want to deactivate a cryptographic device. You can do this by editing the `/proc/driver/z90crypt` file with your preferred text editor. Proceed like this to deactivate a cryptographic device:

1. Open `/proc/driver/z90crypt` with your editor. You will see several lines including two lines like this:

   ```
   Online devices: 1: PCICA, 2: PCICC, 3: PCIXCC (MCL2), 4: PCIXCC (MCL3), 5: CEX2C
       1140000000000000 0000000000000000 0000000000000000 0000000000000000
   ```

   The lower line represents the physical arrangement of the cryptographic devices with digits 1, 2, 3, 4, and 5 representing PCICA, PCICC, PCIXCC (MCL2), PCIXCC (MCL3), and CEX2C cards, respectively.
2. Overwrite the digit that represents the card you want to deactivate with a character `d`. To deactivate the card in the second position, of our example overwrite the second `1`:

   ```
   Online devices: 1: PCICA, 2: PCICC, 3: PCIXCC (MCL2), 4: PCIXCC (MCL3), 5: CEX2C
       1d40000000000000 0000000000000000 0000000000000000 0000000000000000
   ```

3. Close and save `/proc/driver/z90crypt`. Confirm that you want to save your changes even if the content of the file has changed since you opened it.

To enable a deactivated device proceed like this:

1. Open `/proc/driver/z90crypt` with your editor. You will see two lines like this:

   ```
   Online devices: 1: PCICA, 2: PCICC, 3: PCIXCC (MCL2), 4: PCIXCC (MCL3), 5: CEX2C
       1d40000000000000 0000000000000000 0000000000000000 0000000000000000
   ```

   Each `d` in the second line represents a deactivated device. In our example, the device in the second position has been deactivated.
2. Overwrite the `d` that represents the device you want to enable with an `e`:

   ```
   Online devices: 1: PCICA, 2: PCICC, 3: PCIXCC (MCL2), 4: PCIXCC (MCL3), 5: CEX2C
       1e40000000000000 0000000000000000 0000000000000000 0000000000000000
   ```

3. Close and save `/proc/driver/z90crypt`. Confirm that you want to save your changes even if the content of the file has changed since you opened it. The device driver replaces the `e` with the digit for the actual device.

External programming interfaces

This section provides information for those who want to circumvent libica and directly access the z90crypt device driver.

Refer to `drivers/s390/crypto/z90crypt.h` in the Linux kernel source tree, for different structures that you might want to use.

Outline of decryption program

The following steps are required:

1. Get a device handle for z90crypt.

   Example:

   ```
   dh= open("/dev/z90crypt", 0_RDWR)
   ```

2. Create and load one of the following structures

- ica_rsa_modexpo (see “The ica_rsa_modexpo structure”)
- ica_rsa_modexpo_crt (see “The ica_rsa_modexpo_crt structure”)

  Both structures are defined in z90crypt.h. In the structure, you define the private key to be used and set the input buffer pointer to the data you want to decrypt and the output buffer pointer for the decrypted data.

3. Invoke ioctl to activate z90crypt:

   ```
   <rc>= ioctl(dh, <function code>, <structure name>)
   ```

   where:

<function code>	is ICARSAMODEXPO for structure type ica_rsa_modexpo or ICARSACRT for structure type ica_rsa_modexpo_crt
<structure name>	is the variable for the structure you created, of the type ica_rsa_modexpo or ica_rsa_modexpo_crt
<rc>	is the variable for the return code

   Example:

   ```
   myrc = ioctl(dh, ICARSAMODEXPO, &mycryptmex);
   ```

4. Obtain the decrypted and decoded data from the output buffer in the structure.

   See “Padding” on page 220 about when the original data must have been PKCS 1.2 encoded – that is, when the decrypted data must have the correct padding.

The ica_rsa_modexpo structure

The ica_rsa_modexpo structure is defined in the z90crypt header file, z90crypt.h.

The (private) key consists of the exponent in *b_key and the modulus in *n_modulus. Both of these are hexadecimal representations of large numbers. The length L of *n_modulus must be in the range 64 – 256.

Both the input data and the exponent b_key must be of the same length L as the modulus. If they are shorter than the modulus, they must be padded on the left with zeroes. The output data length must be at least L.

The ica_rsa_modexpo_crt structure

The ica_rsa_modexpo_crt structure is defined in the z90crypt header file, z90crypt.h.

The ica_rsa_modexpo_crt structure is similar to the ica_rsa_modexpo structure but has been defined so that the Chinese Remainder Theorem (CRT) can be used in decryption. z90crypt performs better if the CRT definition is used. The key-definition fields are all in hexadecimal representation. They have these meanings and limitations:

- *bp_key and *bq_key are the prime factors of the modulus. In z90crypt the modulus is (*bp_key) × (*bq_key). The resulting length L of the modulus, in hexadecimal representation, must be found before these fields are defined.
- *np_prime and *nq_prime are exponents used for *bp_key and *bq_key respectively.
- *u_mult_inv is a coefficient used in the z90crypt implementation of decryption by CRT.

- *bp_key, *np_prime, and *u_mult_inv must all be of length 8 + L/2
- *bq_key and *nq_prime must both be of length L/2

The input data length must be L, and the output data length must be at least L

Querying the hardware status

There is an ioctl interface for checking on underlying hardware in z90crypt. There are a number of ioctls for each status needed. These ioctls are defined in the header file z90crypt.h. When control returns, you will have the information you requested.

Example:

```
<rc> = ioctl(<dh>, Z90STAT_TOTALCOUNT, &<int_variable>);
```

where:

<rc>	is the variable for the ioctl return code
<dh>	is the variable for the z90crypt device handle
<int_variable>	is the variable you want to use for the returned information, in the example, the total count of installed cards that are recognized by z90crypt.

Returns from ioctl

0 means everything went well and the result is in your output buffer.

A return code of -1 indicates an error code. Error codes greater than 128, are described in `drivers/s390/crypto/z90crypt.h`. For all other error codes, refer to `/usr/include/asm/errno.h`

Chapter 20. Channel measurement facility

The zSeries and S/390 architecture provides a channel measurement facility to collect statistical data about I/O on the channel subsystem. Data collection can be enabled for all CCW and CCW group devices. User space applications can access this data through the sysfs.

Features

The channel measurement facility provides the following features:

- Basic channel measurement format for concurrently collecting data on up to 4096 devices.
- Extended channel measurement format for concurrently collecting data on an unlimited number of devices.
- Data collection for all channel-attached devices, except those using QDIO (that is, except qeth and SCSI-over-Fibre channel attached devices)

Building a kernel with the channel measurement facility

This section is intended for those who want to build their own kernel.

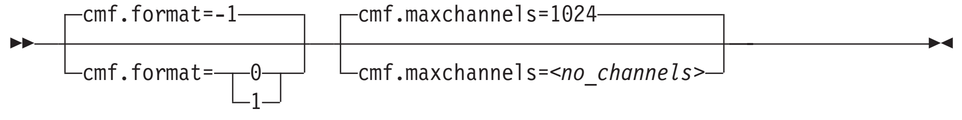
The channel measurement facility is always included in the Linux 2.6 kernel. You do not need to select any options.

If you want to access DASD data with applications written for the kernel 2.4 DASD channel measurement facility, see “the CONFIG_DASD_CMB option” on page 29 for required options.

Setting up the channel measurement facility

You can configure the channel measurement facility by adding parameters to the kernel parameter file.

Channel measurement facility kernel parameters



Note: If you specify both parameter=value pairs, separate them with a blank.

where:

cmf.format
defines the format, “0” for basic and “1” for extended, of the channel measurement blocks. The default, “-1”, uses the extended format for z990 and later mainframes and the basic format for earlier mainframes.

cmf.maxchannels=<*no_channels*>
limits the number of devices for which data measurement can be enabled concurrently with the basic format. The maximum for <*no_channels*> is 4096. For the extended format, there is no limit and any value you specify is ignored.

Working with the channel measurement facility

This section describes typical tasks you need to perform when working with the channel measurement facility.

- Enabling, resetting, and switching off data collection
- Reading data

Enabling, resetting, and switching off data collection

Before you start: You need root authority to enable data collection.

Use a device's cmb_enable attribute to enable, reset, or switch off data collection. To enable data collection, write "1" to the cmb_enable attribute. If data collection has already been enabled, this resets all collected data to zero.

Issue a command of this form:

```
# echo 1 > /sys/bus/ccw/devices/<device_bus_id>/cmb_enable
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

When data collection is enabled for a device, a subdirectory `/sys/bus/ccw/devices/<device_bus_id>/cmb` is created that contains several attributes. These attributes contain the collected data (see "Reading data").

To switch off data collection issue a command of this form:

```
# echo 0 > /sys/bus/ccw/devices/<device_bus_id>/cmb_enable
```

When data collection for a device is switched off, the subdirectory `/sys/bus/ccw/devices/<device_bus_id>/cmb` and its content are deleted.

Example

In this example, data collection for a device `/sys/bus/ccw/devices/0.0.b100` is already active and reset:

```
# cat /sys/bus/ccw/devices/0.0.b100/cmb_enable
1
# echo 1 > /sys/bus/ccw/devices/0.0.b100/cmb_enable
```

Reading data

While data collection is enabled for a device, the directories that represent it in sysfs contain a subdirectory, cmb, with several read-only attributes. These attributes hold the collected data. To read one of the attributes issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device-bus-id>/cmb/<attribute>
```

where `/sys/bus/ccw/devices/<device-bus-id>` is the directory that represents the device, and <*attribute*> the attribute to be read. Table 25 summarizes the available attributes.

Table 25. Attributes with collected I/O data

Attribute	Value
ssch_rsch	An integer representing the ssch rsch count value.
sample_count	An integer representing the sample count value.
avg_device_connect_time	An integer representing the average device connect time, in nanoseconds, per sample.
avg_function_pending_time	An integer representing the average function pending time, in nanoseconds, per sample.
avg_device_disconnect_time	An integer representing the average device disconnect time, in nanoseconds, per sample.
avg_control_unit_queuing_time	An integer representing the average control unit queuing time, in nanoseconds, per sample.
avg_initial_command_response_time	An integer representing the average initial command response time, in nanoseconds, per sample.
avg_device_active_only_time	An integer representing the average device active only time, in nanoseconds, per sample.
avg_device_busy_time	An integer representing the average value device busy time, in nanoseconds, per sample.
avg_utilization	A percent value representing the fraction of time that has been spent in device connect time plus function pending time plus device disconnect time during the measurement period.
avg_sample_interval	An integer representing the average time, in nanoseconds, between two samples during the measurement period. Can be “-1” if no measurement data has been collected.

Example

To read the avg_device_busy_time attribute for a device `/sys/bus/ccw/devices/0.0.b100`:

```
# cat /sys/bus/ccw/devices/0.0.b100/avg_device_busy_time
21
```

Chapter 21. Control program identification

This section applies to Linux instances in LPAR mode only.

If your Linux instance runs in LPAR mode, you can use the control program identification (CPI) module, sclp_cpi, to assign a name to your Linux instance. The system name is used, for example, to identify the Linux instance on the HMC.

Building a kernel with CPI support

This section is intended for those who want to build their own kernel. It describes the options you must select in the Linux configuration menu to include the CPI support.

Figure 57 summarizes the kernel configuration menu options that are relevant to the CPI support:

```
Character device drivers
   Support for SCLP                                (CONFIG_SCLP)
   └─Control-Program Identification                (CONFIG_SCLP_CPI)
```

Figure 57. CPI kernel configuration menu options

CONFIG_SCLP
: This option includes support for the IBM SCLP interface to the service element. It is required for CPI.

CONFIG_SCLP_CPI
: This option allows control program identification through the SCLP interface. Compile it as a separate module, sclp_cpi.

Assigning a name to your Linux instance

You provide the name as a parameter when you load the CPI module.

CPI module parameter syntax

```
►►──┬─insmod───┬── sclp_cpi── system_name=<system>──┬─────────────────────────┬──────────►◄
    └─modprobe─┘                                    └─ sysplex_name=<sysplex>─┘
```

where:

<system>	is an 8-character system name. The specification is converted to uppercase.
<sysplex>	is an 8-character sysplex name. Reserved for future use.

Be sure to specify the system name correctly. You cannot change the name after you have loaded the module. A different name can be specified when loading sclp_cpi after a reboot.

Example

To assign system name “LNXA” to a Linux instance running in LPAR mode issue:

```
insmod sclp_cpi system_name=LNXA
```

Chapter 22. OSA-Express SNMP subagent support

The OSA-Express Simple Network Management Protocol (SNMP) subagent (osasnmpd) supports management information bases (MIBs) provided the following OSA-Express features in QDIO mode only:

- OSA-Express
  - Fast Ethernet
  - 1000Base-T Ethernet
  - Gigabit Ethernet
  - Token Ring
  - ATM (running Ethernet LAN emulation)
- OSA-Express2
  - Gigabit Ethernet
  - 10 Gigabit Ethernet

This subagent capability through the OSA-Express features is also called *Direct SNMP* to distinguish it from another method of accessing OSA SNMP data through OSA/SF, a package for monitoring and managing OSA features that does not run on Linux.

To use the osasnmpd subagent you need:

- An OSA-Express feature running in QDIO mode with the latest textual MIB file for the appropriate LIC level (recommended)
- The qeth device driver for OSA-Express (QDIO) and HiperSockets
- The osasnmpd subagent from s390-tools
- One of:
  - net-snmp package 5.1.x or higher
  - ucd-snmp package 4.2.x (recommended 4.2.3 or higher)

What you need to know about osasnmpd

The osasnmpd subagent requires a master agent to be installed on a Linux system. You get the master agent from either the net-snmp or the ucd-snmp package. The subagent uses the Agent eXtensibility (AgentX) protocol to communicate with the master agent.

net-snmp/ucd-snmp is an Open Source project that is owned by the Open Source Development Network, Inc. (OSDN). For more information on net-snmp/ucd-snmp visit:

`http://net-snmp.sourceforge.net/`

When the master agent (snmpd) is started on a Linux system, it binds to a port (default 161) and awaits requests from SNMP management software. Subagents can connect to the master agent to support MIBs of special interest (for example, OSA-Express MIB). When the osasnmpd subagent is started, it retrieves the MIB objects of the OSA-Express features currently present on the Linux system. It then registers with the master agent the object IDs (OIDs) for which it can provide information.

An OID is a unique sequence of dot-separated numbers (for example, .1.3.6.1.4.1.2) that represents a particular information. OIDs form a hierarchical structure. The longer the OID, that is the more numbers it is made up of, the more specific is the information that is represented by the OID. For example, .1.3.6.1.4.1.2 represents all IBM-related network information while ..1.3.6.1.4.1.2.6.188 represents all OSA-Express-related information.

A MIB corresponds to a number of OIDs. MIBs provide information on their OIDs including textual representations the OIDs. For example, the textual representation of .1.3.6.1.4.1.2 is .iso.org.dod.internet.private.enterprises.ibm.

The structure of the MIBs might change when updating the OSA-Express licensed internal code (LIC) to a newer level. If MIB changes are introduced by a new LIC level, you need to download the appropriate MIB file for the LIC level (see "Downloading the IBM OSA-Express MIB" on page 237), but you do not need to update the subagent. Place the updated MIB file in a directory that is searched by the master agent.

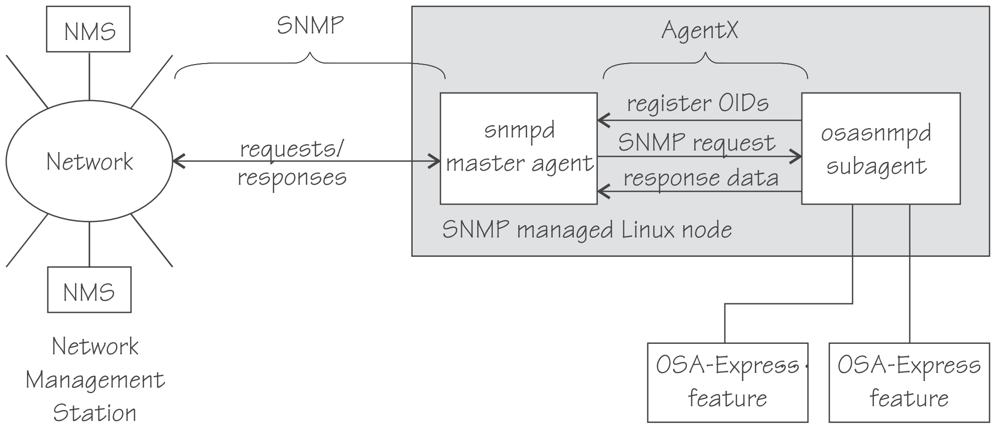


Figure 58. OSA-Express SNMP agent flow

Example: This example shows the processes running after the snmpd master agent and the osasnmpd subagent have been started. When you start osasnmpd, a daemon called osasnmpd-2.6 starts. In the example, PID 687 is the SNMP master agent and PID 729 is the OSA-Express SNMP subagent process:

```
ps -ef | grep snmp

USER       PID
root       687     1  0 11:57 pts/1    00:00:00 snmpd
root       729   659  0 13:22 pts/1    00:00:00 osasnmpd-2.6
```

When the master agent receives an SNMP request for an OID that has been registered by a subagent, the master agent uses the subagent to collect any requested information and to perform any requested operations. The subagent returns any requested information to the master agent. Finally, the master agent returns the information to the originator of the request.

Setting up osasnmpd

This section describes the following setup tasks you need to perform if you want to use the osasnmpd subagent:

- Downloading the IBM OSA-Express MIB
- Configuring access control

Downloading the IBM OSA-Express MIB

Perform the following steps to download the IBM OSA-Express MIB. The MIB file is valid only for hardware that supports the OSA-Express adapter.

1. Go to `ibm.com/servers/resourcelink/`

   A user ID and password are required. You can apply for a user ID if you do not yet have one.
2. Sign in.
3. Select "Library" from the left-hand navigation area.
4. Under "Library shortcuts", select "Open Systems Adapter (OSA) Library".
5. Follow the link for "OSA-Express Direct SNMP MIB module".
6. Select and download the MIB for your LIC level.
7. Rename the MIB file to the name specified in the MIBs definition line and use the extension .txt.

   Example: If the definition line in the MIB looks like this:

   ```
   ==>IBM-OSA-MIB DEFINITIONS ::= BEGIN
   ```

   Rename the MIB to IBM-OSA-MIB.txt.
8. Place the MIB into `/usr/share/snmp/mibs`.

   If you want to use a different directory, be sure to specify the directory in the snmp.conf configuration file (see step 10 on page 239).

Result: You can now make the OID information from the MIB file available to the master agent. This allows you to use textual OIDs instead of numeric OIDs when using master agent commands.

See also the FAQ (How do I add a MIB to the tools?) for the master agent package at

`http://net-snmp.sourceforge.net/FAQ.html`

Configuring access control

During subagent startup or when network interfaces are added or removed, the subagent has to query OIDs from the interfaces group of the standard MIB-II. To start successfully, the subagent requires at least read access to the standard MIB-II on the local node.

This section gives an example of how you can use the snmpd.conf and snmp.conf configuration files to assign access rights using the View-Based Access Control Mechanism (VACM). The following access rights are assigned on the local node:

- General read access for the scope of the standard MIB-II
- Write access for the scope of the OSA-Express MIB
- Public local read access for the scope of the interfaces MIB

The example is intended for illustration purposes only. Depending on the security requirements of your installation, you might need to define your access differently. Refer to the snmpd man page for a more information on how you can assign access rights to snmpd.

1. Refer to your distribution documentation to find out where you can find a template for snmpd.conf and where you need to place it. Some of the possible locations are:
   - `/usr/local/share/snmp`
   - `/etc/snmp`
   - `/usr/share/snmp`
2. Open snmpd.conf with your preferred text editor.
3. Find the security name section and include a line of this form to map a community name to a security name:

   ```
   com2sec <security-name> <source> <community-name>
   ```

   where:

   <security-name>
   is given access rights through further specifications within snmpd.conf.

   <source>
   is the IP-address or DNS-name of the accessing system, typically a Network Management Station.

   <community-name>
   is the community string used for basic SNMP password protection.

   Example:

   ```
   #       sec.name    source       community
   com2sec osasec      default      osacom
   com2sec pubsec      localhost    public
   ```
4. Find the group section. Use the security name to define a group with different versions of the master agent for which you want to grant access rights. Include a line of this form for each master agent version:

   ```
   group <group-name> <security-model> <security-name>
   ```

   where:

   <group-name>
   is a group name of your choice.

   <security-model>
   is the security model of the SNMP version.

   <security-name>
   is the same as in step 3.

   Example:

   ```
   #        groupName    securityModel    securityName
   group    osagroup     v1               osasec
   group    osagroup     v2c              osasec
   group    osagroup     usm              osasec
   group    osasnmpd     v2c              pubsec
   ```

   Group "osasnmpd" with community "public" is required by osasnmpd to determine the number of network interfaces.
5. Find the view section and define your views. A view is a subset of all OIDs. Include lines of this form:

   ```
   view  <view-name>  <included|excluded>   <scope>
   ```

where:

<view-name>
: is a view name of your choice.

<included|excluded>
: indicates whether the following scope is an inclusion or an exclusion statement.

<scope>
: specifies a subtree in the OID tree.

Example:

```
#    name       incl/excl    subtree                mask(optional)
view allview    included     .1
view osaview    included     .1.3.6.1.4.1.2
view ifmibview  included     interfaces
```

View "allview" encompasses all OIDs while "osaview" is limited to IBM OIDs. The numeric OID provided for the subtree is equivalent to the textual OID ".iso.org.dod.internet.private.enterprises.ibm" View "ifmibview" is required by osasnmpd to determine the number of network interfaces.

Tip: Specifying the subtree with a numeric OID leads to better performance than using the corresponding textual OID.

6. Find the access section and define access rights. Include lines of this form:

```
access <group-name> "" any noauth exact <read-view> <write-view> none
```

where:

<group-name>
: is the group you defined in step 4 on page 238.

<read-view>
: is a view for which you want to assign read-only rights.

<write-view>
: is a view for which you want to assign read-write rights.

Example:

```
#      group    context sec.model sec.level prefix read      write   notif
access osagroup ""      any       noauth    exact  allview   osaview none
access osasnmpd ""      v2c       noauth    exact  ifmibview none    none
```

The access line of the example gives read access to the "allview" view and write access to the "osaview". The second access line gives read access to the "ifmibview".

7. Also include the following line to enable the AgentX support:

```
master agentx
```

By default, AgentX support is compiled into the net-snmp master agent 5.1.x and, as of version 4.2.2, also into the ucd-snmp master agent.

8. Save and close snmpd.conf.
9. Open snmp.conf with your preferred text editor.
10. Include a line of this form to specify the directory to be searched for MIBs:

```
mibdirs +<mib-path>
```

Example:

```
mibdirs +/usr/share/snmp/mibs
```

11. Include a line of this form to make the OSA-Express MIB available to the master agent:

```
mibs +<mib-name>
```

where <*mib-name*> is the stem of the MIB file name you assigned in "Downloading the IBM OSA-Express MIB" on page 237.

Example:

```
mibs +IBM-OSA-MIB
```

12. Define defaults for the version and community to be used by the snmp commands. Add lines of this form:

```
defVersion   <version>
defCommunity <community-name>
```

where <*version*> is the SNMP protocol version and <*community-name*> is the community you defined in step 3 on page 238.

Example:

```
defVersion   2c
defCommunity osacom
```

These default specifications simplify issuing master agent commands.

13. Save and close snmp.conf.

Working with the osasnmpd subagent

This section describes the following tasks:

- Starting the osasnmpd subagent
- Checking the log file
- Issuing queries
- Stopping osasnmpd

Starting the osasnmpd subagent

You start the osasnmpd subagent using the **osasnmpd** command:

```
# osasnmpd
```

The osasnmpd subagent starts a daemon called osasnmpd-2.6.

For command options see "osasnmpd – Start OSA-Express SNMP subagent" on page 291.

If you restart the master agent, you must also restart the subagent. When the master agent is started, it does not look for already running subagents. Any running subagents must also be restarted to be register with the master agent.

Checking the log file

Warnings and messages are written to the log file of either the master agent or the OSA-Express subagent. It is good practise to check these files at regular intervals.

Example: This example assumes that the default subagent log file is used. The lines in the log file show the messages after a successful OSA-Express subagent initialization.

```
# cat /var/log/osasnmpd.log
IBM OSA-E NET-SNMP 5.1.x subagent version  1.3.0
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.2.1.10.7.2.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.1.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.3.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.4.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.8.
OSA-E microcode level is 611 for interface eth0
Initialization of OSA-E subagent successful...
```

Issuing queries

This section provides some examples of what SNMP queries might look like. For more comprehensive information on the master agent commands refer to the snmpcmd man page.

The commands can use either numeric or textual OIDs. While the numeric OIDs might provide better performance, the textual OIDs are more meaningful and give a hint on which information is requested.

The query examples in this section gather information on an interface, eth0, for which the **lsqeth** (see “lsqeth - List qeth based network devices” on page 287) output looks like this:

```
# lsqeth eth0
Device name                     : eth0
---------------------------------------------
        card_type               : OSD_100
        cdev0                   : 0.0.f200
        cdev1                   : 0.0.f201
        cdev2                   : 0.0.f202
        chpid                   : 6B
        online                  : 1
        portname                : OSAPORT
        portno                  : 0
        route4                  : no
        route6                  : no
        checksumming            : sw checksumming
        state                   : UP (LAN ONLINE)
        priority_queueing       : always queue 0
        detach_state            : 0
        fake_ll                 : 0
        fake_broadcast          : 0
        buffer_count            : 16
        add_hhlen               : 0
        layer2                  : 0
```

The CHPID for the eth0 of our example is 0x6B.

- To list the ifIndex and interface description relation (on one line):

  ```
  # snmpget -v 2c -c osacom localhost interfaces.ifTable.ifEntry.ifDescr.6
  interfaces.ifTable.ifEntry.ifDescr.6 = eth0
  ```

  Using this GET request you can see that eth0 has the ifIndex 6 assigned.
- To find the CHPID numbers for your OSA devices:

  ```
  # snmpwalk -OS -v 2c -c osacom localhost .1.3.6.1.4.1.2.6.188.1.1.1.1
  IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
  IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
  IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
  ```

The first line of the command output, with index number 6, corresponds to CHPID 0x6B of our eth0 example. The example assumes that the community osacom has been authorized as described in “Configuring access control” on page 237.

If you have provided defaults for the SNMP version and the community (see step 12 on page 240), you can omit the -v and -c options:

```
# snmpwalk -OS localhost .1.3.6.1.4.1.2.6.188.1.1.1.1
IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
```

You can obtain the same output by substituting the numeric OID .1.3.6.1.4.1.2.6.188.1.1.1.1 with its textual equivalent:

```
.iso.org.dod.internet.private.enterprises.ibm.ibmProd.ibmOSAMib.ibmOSAMibObjects.ibmOSAExpChannelTable.ibmOSAExpChannelEntry.ibmOSAExpChannelNumber
```

You can shorten this somewhat unwieldy OID to the last element, ibmOsaExpChannelNumber:

```
# snmpwalk -OS localhost ibmOsaExpChannelNumber
IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
```

- To find the port type for the interface with index number 6:

```
# snmpwalk -OS localhost .1.3.6.1.4.1.2.6.188.1.4.1.2.6
IBM-OSA-MIB::ibmOsaExpEthPortType.6 = INTEGER: fastEthernet(81)
```

fastEthernet(81) corresponds to card type OSD_100.

Using the short form of the textual OID:

```
# snmpwalk -OS localhost ibmOsaExpEthPortType.6
IBM-OSA-MIB::ibmOsaExpEthPortType.6 = INTEGER: fastEthernet(81)
```

Specifying the index, 6 in the example, limits the output to the interface of interest.

Stopping osasnmpd

The subagent can be stopped by sending either a SIGINT or SIGTERM signal to the thread. Avoid stopping the subagent with **kill -9** or with **kill -SIGKILL**. These commands do not allow the subagent to unregister the OSA-Express MIB objects from the SNMP master agent. This can cause problems when restarting the subagent.

If you have saved the subagent PID to a file when you started it, you can consult this file for the PID (see 291). Otherwise you can issue a **ps** command to find it out.

Example: The osasnmpd subagent starts a daemon called osasnmpd-2.6. To stop osasnmpd, issue the kill command for either the daemon or its PID:

```
# ps -ef | grep snmp

USER       PID
root       687     1  0 11:57 pts/1    00:00:00 snmpd
root       729   659  0 13:22 pts/1    00:00:00 osasnmpd-2.6
# killall osasnmpd-2.6
# kill 729
```

Chapter 23. Other features kernel builders should know about

This section is intended for those who want to build their own kernel. It summarizes the zSeries and S/390-specific kernel configuration options, including those options that do not correspond to a particular device driver or feature.

The options described in this section are sorted into two groups:

- "General architecture-specific options" on page 246
- "Device driver-related options" on page 252

For each group there is an overview of the options in the order in which you find them in the kernel configuration menu (see Figure 59 on page 247 and Figure 60 on page 253). Each overview is followed by an alphabetically sorted list of the options with a description.

Dependencies between options

Simple dependencies, where an option depends on another option that directly precedes it in the configuration menu, are shown in the overviews (Figure 59 on page 247 and Figure 60 on page 253). The dependent option is shown indented and graphically joined (└─) to the option it depends on. Options that have more complex dependencies are marked with an asterisk (*).

The option descriptions that follow the overviews include more detailed information on the dependencies. This more detailed information is provided in boolean format as it appears in the Kconfig files in the Linux source tree, with the CONFIG_ prefix omitted.

Common code options are not included in this summary. Refer to the Linux source tree for descriptions of common code options. To locate the description of an option in the Linux source tree, open a command prompt and change the working current directory at the root of the Linux source tree. Issue a command of this form:

```
# grep -rl --include='Kconfig' '^config <OPTION>' *
```

where *<option>* is the option you are looking for.

Note: In the Kconfig files, the options do not have a the CONFIG_ prefix. Be sure to omit the CONFIG_ when searching for the option.

Example: To locate the Kconfig file with the description of the common code kernel configuration option CONFIG_EXPERIMENTAL issue:

```
# grep -rl --include='Kconfig' '^config EXPERIMENTAL' *
init/Kconfig
```

General architecture-specific options

Figure 59 on page 247 provides an overview of the general architecture-specific options in the order in which you find them in the kernel configuration menu. The following pages provide explanations for each option in alphabetical order. For device driver-specific options see “Device driver-related options” on page 252.

```
    ...
Base setup --->
    --- Processor type and features ---
    64 bit kernel                                                   (CONFIG_ARCH_S390X)
    Processor type (selection)
         • S/390 model G5 and G6                                    (CONFIG_MARCH_G5)
         • IBM eServer zSeries model z800 and z900                  (CONFIG_MARCH_Z900)
         • IBM eServer zSeries model z990                           (CONFIG_MARCH_Z990)
    Symmetric multi-processing support                              (CONFIG_SMP)
    └─ Maximum number of CPUs (2-64)                                (CONFIG_NR_CPUS)
    IEEE FPU emulation                                              (CONFIG_MATHEMU)*
    Kernel support for 31 bit emulation                             (CONFIG_S390_SUPPORT)*
    └─ Kernel support for 31 bit ELF binaries                       (CONFIG_BINFMT_ELF32)
    --- I/O subsystem configuration ---
    Process warning machine checks                                  (CONFIG_MACHCHK_WARNING)
    QDIO support                                                    (CONFIG_QDIO)
    ├─ Performance statistics in /proc                              (CONFIG_QDIO_PERF_STATS)
    └─ Extended debugging information                               (CONFIG_QDIO_DEBUG)
    --- Misc ---
    Preemptible Kernel                                              (CONFIG_PREEMPT)
    Builtin IPL record support                                      (CONFIG_IPL)
    └─ IPL method generated into head.S (selection)
         • tape                                                     (CONFIG_IPL_TAPE)
         • vm_reader                                                (CONFIG_IPL_VM)
    ...
    Show crashed user process info                                  (CONFIG_PROCESS_DEBUG)
    Pseudo page fault support                                       (CONFIG_PFAULT)
    VM shared kernel support                                        (CONFIG_SHARED_KERNEL)
    Cooperative memory management                                   (CONFIG_CMM)
    └─ /proc interface to cooperative memory management             (CONFIG_CMM_PROC)
    IUCV special message interface to cooperative memory management (CONFIG_CMM_IUCV)*
    Virtual CPU timer support                                       (CONFIG_VIRT_TIMER)
    └─ Linux - VM Monitor Stream, base infrastructure               (CONFIG_APPLDATA_BASE)*
       ├─ Monitor memory management statistics                      (CONFIG_APPLDATA_MEM)
       ├─ Monitor OS statistics                                     (CONFIG_APPLDATA_OS)
       └─ Monitor overall network statistics                        (CONFIG_APPLDATA_NET_SUM)
    No HZ timer ticks in idle                                       (CONFIG_NO_IDLE_HZ)
    └─ HZ timer in idle off by default                              (CONFIG_NO_IDLE_HZ_INIT)
    ...
Kernel hacking --->
    Kernel debugging                                                (CONFIG_DEBUG_KERNEL)
    ├─ Magic SysRq key                                              (CONFIG_MAGIC_SYSRQ)
    ├─ Debug memory allocations                                     (CONFIG_DEBUG_SLAB)
    ├─ Load all symbols for debugging/kksymoops                     (CONFIG_KALLSYMS)
    └─ Compile the kernel with debug info                           (CONFIG_DEBUG_INFO)
    Sleep-inside-spinlock checking                                  (CONFIG_DEBUG_SPINLOCK_SLEEP)
    ...
Profiling support --->
    Profiling support                                               (CONFIG_PROFILING)
    └─ OProfile system profiling                                    (CONFIG_OPROFILE)
```

Figure 59. Device driver related kernel configuration menu options. The └ symbols indicate dependencies on preceding options. Options with more complex dependencies are marked with an asterisk (*).

The following is an alphabetically sorted list with details on the general architecture-specific options summarized in Figure 59 on page 247. For device driver specific options see “Device driver-related options” on page 252.

CONFIG_APPLDATA_BASE
: This provides a kernel interface for creating and updating z/VM APPLDATA monitor records. The monitor records are updated at certain time intervals, once the timer is started. Writing 1 or 0 to /proc/appldata/timer starts(1) or stops(0) the timer, i.e. enables or disables monitoring on the Linux side. A custom interval value (in seconds) can be written to /proc/appldata/interval.

  Defaults are 60 seconds interval and timer off. The /proc entries can also be read from, showing the current settings.

  Depends on PROC_FS && VIRT_TIMER=y.

  PROC_FS is a common code option.

CONFIG_APPLDATA_MEM
: This provides memory management related data to the Linux - VM Monitor Stream, like paging/swapping rate, memory utilisation, etc. Writing 1 or 0 to /proc/appldata/memory creates(1) or removes(0) a z/VM APPLDATA monitor record, i.e. enables or disables monitoring this record on the z/VM side.

  Default is disabled. The /proc entry can also be read from, showing the current settings.

  This can also be compiled as a module, which will be called appldata_mem.o.

  Depends on APPLDATA_BASE.

CONFIG_APPLDATA_NET_SUM
: This provides network related data to the Linux - VM Monitor Stream, currently there is only a total sum of network I/O statistics, no per-interface data. Writing 1 or 0 to /proc/appldata/net_sum creates(1) or removes(0) a z/VM APPLDATA monitor record, i.e. enables or disables monitoring this record on the z/VM side.

  Default is disabled. This can also be compiled as a module, which will be called appldata_net_sum.o.

  Depends on APPLDATA_BASE.

CONFIG_APPLDATA_OS
: This provides OS related data to the Linux - VM Monitor Stream, like CPU utilisation, etc. Writing 1 or 0 to /proc/appldata/os creates(1) or removes(0) a z/VM APPLDATA monitor record, i.e. enables or disables monitoring this record on the z/VM side.

  Default is disabled. This can also be compiled as a module, which will be called appldata_os.o.

  Depends on APPLDATA_BASE.

CONFIG_ARCH_S390X
: Select this option if you have a 64 bit IBM zSeries machine and want to use the 64 bit addressing mode.

CONFIG_BINFMT_ELF32
: This allows you to run 32-bit Linux/ELF binaries on your zSeries in 64 bit mode. Everybody wants this; say Y.

Depends on S390_SUPPORT.

CONFIG_CMM
: Select this option, if you want to enable the kernel interface to reduce the memory size of the system. This is accomplished by allocating pages of memory and put them ″on hold″. This only makes sense for a system running under VM where the unused pages will be reused by VM for other guest systems. The interface allows an external monitor to balance memory of many systems. Everybody who wants to run Linux under VM should select this option.

CONFIG_CMM_IUCV
: Select this option to enable the special message interface to the cooperative memory management.

  Depends on CMM && (SMSGIUCV=y || CMM=SMSGIUCV).

CONFIG_CMM_PROC
: Select this option to enable the /proc interface to the cooperative memory management.

  Depends on CMM.

CONFIG_DEBUG_INFO
: If you say Y here the resulting kernel image will include debugging info resulting in a larger kernel image. Say Y here only if you plan to use gdb to debug the kernel. If you don't debug the kernel, you can say N.

  Depends on DEBUG_KERNEL.

CONFIG_DEBUG_KERNEL
: Say Y here if you are developing drivers or trying to debug and identify kernel problems.

CONFIG_DEBUG_SLAB
: Say Y here to have the kernel do limited verification on memory allocation as well as poisoning memory on free to catch use of freed memory.

  Depends on DEBUG_KERNEL.

CONFIG_DEBUG_SPINLOCK_SLEEP
: If you say Y here, various routines which may sleep will become very noisy if they are called with a spinlock held.

CONFIG_IPL
: If you want to use the produced kernel to IPL directly from a device, you have to merge a bootsector specific to the device into the first bytes of the kernel. You will have to select the IPL device.

CONFIG_IPL_TAPE | CONFIG_IPL_VM
: Select ″tape″ if you want to IPL the image from a Tape.

  Select ″vm_reader″ if you are running under VM/ESA and want to IPL the image from the emulated card reader.

  Depends on IPL.

CONFIG_KALLSYMS
: Say Y here to let the kernel print out symbolic crash information and symbolic stack backtraces. This increases the size of the kernel somewhat, as all symbols have to be loaded into the kernel image.

  Depends on DEBUG_KERNEL.

CONFIG_MACHCHK_WARNING
Select this option if you want the machine check handler on IBM S/390 or zSeries to process warning machine checks (e.g. on power failures). If unsure, say ″Y″.

CONFIG_MAGIC_SYSRQ
If you say Y here, you will have some control over the system even if the system crashes for example during kernel debugging (e.g., you will be able to flush the buffer cache to disk, reboot the system immediately or dump some status information). This is accomplished by pressing various keys while holding SysRq (Alt+PrintScreen). It also works on a serial console (on PC hardware at least), if you send a BREAK and then within 5 seconds a command keypress. The keys are documented in <file:Documentation/sysrq.txt>. Don’t say Y unless you really know what this hack does.

Depends on DEBUG_KERNEL.

CONFIG_MARCH_G5 | CONFIG_MARCH_Z900 | CONFIG_MARCH_Z990
Select CONFIG_MARCH_G5 to build a 31 bit kernel that works on all S/390 and zSeries machines.

Select CONFIG_MARCH_Z900 to optimize for zSeries machines. This will enable some optimizations that are not available on older 31 bit only CPUs.

Select CONFIG_MARCH_Z990 to enable optimizations for model z890/z990. This will be slightly faster but does not work on older machines such as the z900.

MARCH_G5 depends on ARCH_S390X=’n’.

CONFIG_MATHEMU
This option is required for IEEE compliant floating point arithmetic on older S/390 machines. Say Y unless you know your machine doesn’t need this.

Depends on MARCH_G5.

CONFIG_NO_IDLE_HZ
Switches the regular HZ timer off when the system is going idle. This helps z/VM to detect that the Linux system is idle. VM can then ″swap-out″ this guest which reduces memory usage. It also reduces the overhead of idle systems.

The HZ timer can be switched on/off via /proc/sys/kernel/hz_timer. hz_timer=0 means HZ timer is disabled. hz_timer=1 means HZ timer is active.

CONFIG_NO_IDLE_HZ_INIT
The HZ timer is switched off in idle by default. That means the HZ timer is already disabled at boot time.

Depends on NO_IDLE_HZ.

CONFIG_NR_CPUS
This allows you to specify the maximum number of CPUs which this kernel will support. The maximum supported value is 64 and the minimum value which makes sense is 2.

This is purely to save memory - each supported CPU adds approximately sixteen kilobytes to the kernel image.

Depends on SMP.

CONFIG_OPROFILE
OProfile is a profiling system capable of profiling the whole system, include the kernel, kernel modules, libraries, and applications.

If unsure, say N.

Depends on PROFILING.

CONFIG_PFAULT
Select this option, if you want to use PFAULT pseudo page fault handling under VM. If running native or in LPAR, this option has no effect. If your VM does not support PFAULT, PAGEEX pseudo page fault handling will be used. Note that VM 4.2 supports PFAULT but has a bug in its implementation that causes some problems. Everybody who wants to run Linux under VM != VM4.2 should select this option.

CONFIG_PREEMPT
This option reduces the latency of the kernel when reacting to real-time or interactive events by allowing a low priority process to be preempted even if it is in kernel mode executing a system call. This allows applications to run more reliably even when the system is under load.

Say N if you are unsure.

CONFIG_PROCESS_DEBUG
Say Y to print all process fault locations to the console. This is a debugging option; you probably do not want to set it unless you are an S390 port maintainer.

CONFIG_PROFILING
Say Y here to enable the extended profiling support mechanisms used by profilers such as OProfile.

CONFIG_QDIO
This driver provides the Queued Direct I/O base support for the IBM S/390 (G5 and G6) and eServer zSeries (z800, z900 and z990).

For details please refer to the documentation provided by IBM at <http://www10.software.ibm.com/developerworks/opensource/linux390>

To compile this driver as a module, choose M here: the module will be called qdio.

If unsure, say Y.

CONFIG_QDIO_DEBUG
Say Y here to get extended debugging output in /proc/s390dbf/qdio... Warning: this option reduces the performance of the QDIO module.

If unsure, say N.

Depends on QDIO.

CONFIG_QDIO_PERF_STATS
Say Y here to get performance statistics in /proc/qdio_perf

If unsure, say N.

Depends on QDIO.

CONFIG_S390_SUPPORT
Select this option if you want to enable your system kernel to handle system-calls from ELF binaries for 31 bit ESA. This option (and some other stuff like libraries and such) is needed for executing 31 bit applications. It is safe to say ″Y″.

Depends on ARCH_S390X.

CONFIG_SHARED_KERNEL
Select this option, if you want to share the text segment of the Linux kernel between different VM guests. This reduces memory usage with lots of guests but greatly increases kernel size. You should only select this option if you know what you are doing and want to exploit this feature.

CONFIG_SMP
This enables support for systems with more than one CPU. If you have a system with only one CPU, like most personal computers, say N. If you have a system with more than one CPU, say Y.

If you say N here, the kernel will run on single and multiprocessor machines, but will use only one CPU of a multiprocessor machine. If you say Y here, the kernel will run on many, but not all, singleprocessor machines. On a singleprocessor machine, the kernel will run faster if you say N here.

See also the <file:Documentation/smp.txt> and the SMP-HOWTO available at <http://www.tldp.org/docs.html#howto>.

Even if you don't know what to do here, say Y.

CONFIG_VIRT_TIMER
This provides a kernel interface for virtual CPU timers. Default is disabled.

Device driver-related options

Figure 60 on page 253 provides an overview of the device driver-related options in the order in which you find them in the kernel configuration menu. The following pages provide explanations for each option in alphabetical order. For architecture-specific options see "General architecture-specific options" on page 246.

```
Block devices --->
    ...
    --- S/390 block device drivers ---
    XPRAM disk support                                           (CONFIG_BLK_DEV_XPRAM)
    DCSSBLK support                                              (CONFIG_DCSSBLK)
    Support for DASD devices                                     (CONFIG_DASD)
    ├─ Profiling support for dasd devices                        (CONFIG_DASD_PROFILE)
    ├─ Support for ECKD Disks                                    (CONFIG_DASD_ECKD)
    └─ Support for FBA  Disks                                    (CONFIG_DASD_FBA)
    Support for DIAG access to Disks                             (CONFIG_DASD_DIAG)*
    Compatibility interface for DASD channel measurement blocks  (CONFIG_DASD_CMB)*
    ...
Character device drivers --->
        ...
    Watchdog cards --->
        ...
        --- Watchdog Device Drivers ---
        ...
        z/VM Watchdog Timer                                      (CONFIG_ZVM_WATCHDOG)*
    --- S/390 character device drivers ---
    Support for locally attached 3270 tubes                      (CONFIG_TN3270)
    └─ Support for console on 3270 line mode terminal            (CONFIG_TN3270_CONSOLE)*
    Support for 3215 line mode terminal                          (CONFIG_TN3215)
    └─ Support for console on 3215 line mode terminal            (CONFIG_TN3215_CONSOLE)
    Support for SCLP                                             (CONFIG_SCLP)
    ├─ Support for SCLP line mode terminal                       (CONFIG_SCLP_TTY)
    │  └─ Support for console on SCLP line mode terminal         (CONFIG_SCLP_CONSOLE)
    ├─ Support for SCLP VT220-compatible terminal                (CONFIG_SCLP_VT220_TTY)
    │  └─ Support for console on SCLP VT220-compatible terminal  (CONFIG_SCLP_VT220_CONSOLE)
    └─ Control-Program Identification                            (CONFIG_SCLP_CPI)
    S/390 tape device support                                    (CONFIG_S390_TAPE)
    --- S/390 tape interface support ---
    ├─ Support for tape block devices                            (CONFIG_S390_TAPE_BLOCK)
    --- S/390 tape hardware support ---
    └─ Support for 3480/3490 tape hardware                       (CONFIG_S390_TAPE_34XX)
    Support for the z/VM recording system services (VM only)     (CONFIG_VMLOGRDR)*
    API for reading z/VM monitor service records                 (CONFIG_MONREADER)*
Cryptographic devices --->
    Support for PCI-attached cryptographic adapters              (CONFIG_Z90CRYPT)
Networking support --->
    ...
  S/390 network device drivers (Depends on  NETDEVICES && ARCH_S390) --->
    Lan Channel Station Interface                                (CONFIG_LCS)*
    CTC device support                                           (CONFIG_CTC)*
    MPC SNA device support                                       (CONFIG_MPC)*
    IUCV support (VM only)                                       (CONFIG_IUCV)
    ├─ IUCV network device support (VM only)                     (CONFIG_NETIUCV)
    └─ IUCV special message support (VM only)                    (CONFIG_SMSGIUCV)
    CLAW device support                                          (CONFIG_CLAW)*
    Gigabit Ethernet device support                              (CONFIG_QETH)*
    --- Gigabit Ethernet default settings ---
    IPv6 support for gigabit ethernet                            (CONFIG_QETH_IPV6)*
    VLAN support for gigabit ethernet                            (CONFIG_QETH_VLAN)*
    Performance statistics in /proc                              (CONFIG_QETH_PERF_STATS)*
```

Figure 60. Kernel configuration menu options. The └─ symbols indicate dependencies on preceding options. Options with more complex dependencies are marked with an asterisk (*).

The following is an alphabetically sorted list with details on the device driver-related options summarized in Figure 60 on page 253. For architecture-specific options see “General architecture-specific options” on page 246.

CONFIG_BLK_DEV_XPRAM
: Select this option if you want to use your expanded storage on S/390 or zSeries as a disk. This is useful as a _fast_ swap device if you want to access more than 2G of memory when running in 31 bit mode. This option is also available as a module which will be called xpram. If unsure, say ″N″.

CONFIG_CLAW
: This driver supports channel attached CLAW devices. CLAW is Common Link Access for Workstation. Common devices that use CLAW are RS/6000s, Cisco Routers (CIP) and 3172 devices. To compile as a module choose M here: The module will be called claw.ko to compile into the kernel choose Y

  Depends on the common code option NETDEVICES.

CONFIG_CTC
: Select this option if you want to use channel-to-channel networking on IBM S/390 or zSeries. This device driver supports real CTC coupling using ESCON. It also supports virtual CTCs when running under VM. It will use the channel device configuration if this is available. This option is also available as a module which will be called ctc.ko. If you do not know what it is, it’s safe to say ″Y″.

  Depends on the common code option NETDEVICES.

CONFIG_DASD
: Enable this option if you want to access DASDs directly utilizing S/390s channel subsystem commands. This is necessary for running natively on a single image or an LPAR.

CONFIG_DASD_CMB
: This driver provides an additional interface to the channel measurement facility, which is normally accessed though sysfs, with a set of ioctl functions specific to the dasd driver. This is only needed if you want to use applications written for linux-2.4 dasd channel measurement facility interface.

  Depends on DASD.

CONFIG_DASD_DIAG
: Select this option if you want to use Diagnose250 command to access Disks under VM. If you are not running under VM or unsure what it is, say ″N″.

  Depends on DASD && ARCH_S390X = ’n’.

CONFIG_DASD_ECKD
: ECKD devices are the most commonly used devices. You should enable this option unless you are very sure to have no ECKD device.

  Depends on DASD.

CONFIG_DASD_FBA
: Select this option to be able to access FBA devices. It is safe to say ″Y″.

  Depends on DASD.

CONFIG_DASD_PROFILE
Enable this option if you want to see profiling information in /proc/dasd/statistics.

Depends on DASD.

CONFIG_DCSSBLK
Support for dcss block device

CONFIG_IUCV
Select this option if you want to use inter-user communication under VM or VIF. If unsure, say ″Y″ to enable a fast communication link between VM guests. At boot time the user ID of the guest needs to be passed to the kernel. Note that both kernels need to be compiled with this option and both need to be booted with the user ID of the other VM guest.

CONFIG_LCS
Select this option if you want to use LCS networking on IBM S/390 or zSeries. This device driver supports Token Ring (IEEE 802.5), FDDI (IEEE 802.7) and Ethernet. This option is also available as a module which will be called lcs.ko. If you do not know what it is, it’s safe to say ″Y″.

Depends on NETDEVICES && (NET_ETHERNET || TR || FDDI).

NETDEVICES, NET_ETHERNET, TR, and FDDI are common code options.

CONFIG_MONREADER
Character device driver for reading z/VM monitor service records

Depends on IUCV.

CONFIG_MPC
This driver supports channel-to-channel MPC SNA devices. MPC is a SNA protocol device used by Comm Server for Linux. If you don’t have Comm Server for Linux you don’t need the device. To compile as a module choose M here: The module will be called ctcmpc.ko to compile into the kernel choose Y If you do not need SNA MPC device just say N

Depends on the common code option NETDEVICES.

CONFIG_NETIUCV
Select this option if you want to use inter-user communication vehicle networking under VM or VIF. It enables a fast communication link between VM guests. Using ifconfig a point-to-point connection can be established to the Linux for zSeries and S7390 system running on the other VM guest. This option is also available as a module which will be called netiucv.ko. If unsure, say ″Y″.

Depends on IUCV && NETDEVICES.

NETDEVICES is a common code option.

CONFIG_QETH
This driver supports the IBM S/390 and zSeries OSA Express adapters in QDIO mode (all media types), HiperSockets interfaces and VM GuestLAN interfaces in QDIO and HIPER mode.

For details please refer to the documentation provided by IBM at <http://www10.software.ibm.com/developerworks/opensource/linux390>

To compile this driver as a module, choose M here: the module will be called qeth.ko.

Depends on NETDEVICES && IP_MULTICAST && QDIO.

NETDEVICES and IP_MULTICAST are common code options.

CONFIG_QETH_IPV6
If CONFIG_QETH is switched on, this option will include IPv6 support in the qeth device driver.

Depends on (QETH = IPV6) || (QETH && IPV6 = 'y').

IPV6 is a common code option.

CONFIG_QETH_PERF_STATS
When switched on, this option will add a file in the proc-fs (/proc/qeth_perf_stats) containing performance statistics. It may slightly impact performance, so this is only recommended for internal tuning of the device driver.

Depends on QETH.

CONFIG_QETH_VLAN
If CONFIG_QETH is switched on, this option will include IEEE 802.1q VLAN support in the qeth device driver.

Depends on (QETH = VLAN_8021Q) || (QETH && VLAN_8021Q = 'y').

VLAN_8021Q is a common code option.

CONFIG_S390_TAPE
Select this option if you want to access channel-attached tape devices on IBM S/390 or zSeries. If you select this option you will also want to select at least one of the tape interface options and one of the tape hardware options in order to access a tape device. This option is also available as a module. The module will be called tape390 and include all selected interfaces and hardware drivers.

CONFIG_S390_TAPE_34XX
Select this option if you want to access IBM 3480/3490 magnetic tape subsystems and 100% compatibles. It is safe to say "Y" here.

Depends on S390_TAPE.

CONFIG_S390_TAPE_BLOCK
Select this option if you want to access your channel-attached tape devices using the block device interface. This interface is similar to CD-ROM devices on other platforms. The tapes can only be accessed read-only when using this interface. Have a look at Documentation/s390/TAPE for further information about creating volumes for and using this interface. It is safe to say "Y" here.

Depends on S390_TAPE.

CONFIG_SCLP
Include support for the SCLP interface to the service element.

CONFIG_SCLP_CONSOLE
Include support for using an IBM HWC line-mode terminal as the Linux system console.

Depends on SCLP_TTY.

CONFIG_SCLP_CPI
This option enables the hardware console interface for system identification. This is commonly used for workload management and gives you a nice name for the system on the service element. Please select this option as a module since built-in operation is completely untested. You

should only select this option if you know what you are doing, need this feature and intend to run your kernel in LPAR.

Depends on SCLP.

CONFIG_SCLP_TTY
Include support for IBM SCLP line-mode terminals.

Depends on SCLP.

CONFIG_SCLP_VT220_CONSOLE
Include support for using an IBM SCLP VT220-compatible terminal as a Linux system console.

Depends on SCLP_VT220_TTY.

CONFIG_SCLP_VT220_TTY
Include support for an IBM SCLP VT220-compatible terminal.

Depends on SCLP.

CONFIG_SMSGIUCV
Select this option if you want to be able to receive SMSG messages from other VM guest systems.

Depends on IUCV.

CONFIG_TN3215
Include support for IBM 3215 line-mode terminals.

CONFIG_TN3215_CONSOLE
Include support for using an IBM 3215 line-mode terminal as a Linux system console.

Depends on TN3215.

CONFIG_TN3270
Include support for IBM 3270 line-mode terminals.

CONFIG_TN3270_CONSOLE
Include support for using an IBM 3270 line-mode terminal as a Linux system console. Available only if 3270 support is compiled in statically.

Depends on TN3270=y.

CONFIG_VMLOGRDR
Select this option if you want to be able to receive records collected by the z/VM recording system services, eg. from *LOGREC, *ACCOUNT or *SYMPTOM. This driver depends on the IUCV support driver.

Depends on IUCV.

CONFIG_Z90CRYPT
Select this option if you want to use a PCI-attached cryptographic adapter like the PCI Cryptographic Accelerator (PCICA) or the PCI Cryptographic Coprocessor (PCICC). This option is also available as a module called z90crypt.ko.

CONFIG_ZVM_WATCHDOG
IBM s/390 and zSeries machines running under z/VM 5.1 or later provide a virtual watchdog timer to their guest that cause a user define Control Program command to be executed after a timeout.

To compile this driver as a module, choose M here. The module will be called vmwatchdog.

| Depends on WATCHDOG && ARCH_S390.
| WATCHDOG is a common code option.

Part 6. Commands and kernel parameters

This part describes commands for configuring and booting Linux for zSeries and S/390. It also describes kernel parameters that are not specific to a particular device driver. Device driver-specific kernel parameters are described in the "Setting up" section of the respective device driver chapter.

Note

For prerequisites and restrictions refer to the kernel 2.6 April 2004 stream pages on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_recommended.shtml`

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Chapter 24. Useful Linux commands

This chapter describes commands to configure and work with the Linux for zSeries and S/390 device drivers and features.

- chccwdev
- dasdfmt
- dasdview
- fdasd
- lscss
- lsdasd
- lsqeth
- lstape
- osasnmpd
- qetharp
- qethconf
- snipl
- tape_display
- tunedasd
- zipl

You can obtain these commands on developerWorks at:
`ibm.com/developerworks/linux/linux390/index.shtml.`

snipl is provided as a separate package under “Useful add-ons”.

All other commands are included in the s390-tools package for the Linux 2.6 April 2004 stream.

Note: For tools related to taking and analyzing system dumps, see *Linux for zSeries and S/390 Using the Dump Tools*.

Generic command options

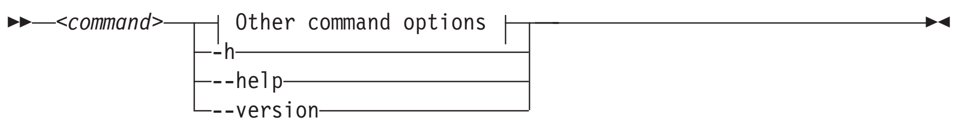
The following options are supported by all commands described in this section and, for simplicity, have been omitted from some of the syntax diagrams:

-h or **--help**
to display help information for the command.

--version
to display version information for the command.

The syntax for these options is:

Common command options



where command can be any of the commands described in this section.

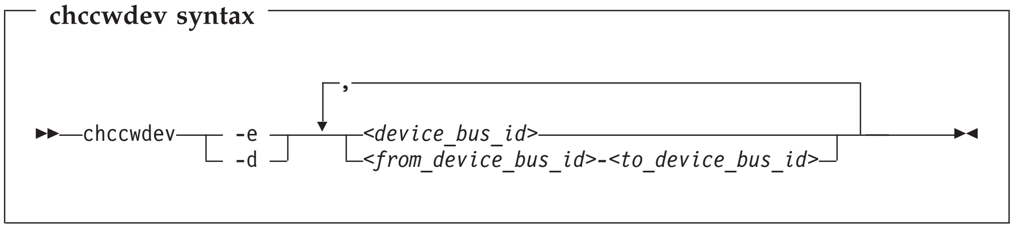
See “Understanding syntax diagrams” on page xiii for general information on reading syntax diagrams.

chccwdev - Set a CCW device online

Purpose

This command is used to set CWW devices (See "Device categories" on page 9) online or offline.

Format



Where:

-e or **--online**
: sets the device online.

-d or **--offline**
: sets the device offline.

<device_bus_id>
: identifies the device to be set online or offline. *<device_bus_id>* is a device number with a leading "0.0.".

<from_device_bus_id>-<to_device_bus_id>
: identifies a range of devices.

Examples

- To set a CCW device 0.0.b100 online issue:

```
# chccwdev -e 0.0.b100
```

- To set all CCW devices in the range 0.0.b200 through 0.0.b2ff online issue:

```
# chccwdev -e 0.0.b200-0.0.b2ff
```

- To set a CCW device 0.0.b100 and all CCW devices in the range 0.0.b200 through 0.0.b2ff offline issue:

```
# chccwdev -d 0.0.b100,0.0.b200-0.0.b2ff
```

dasdfmt - Format a DASD

Purpose

This tool is used to give a low-level format to ECKD-type direct access storage devices (DASD). Note that this is a software format. To give a hardware format to raw DASD you must use another zSeries or S/390 device support facility such as ICKDSF, either in stand-alone mode or through another operating system.

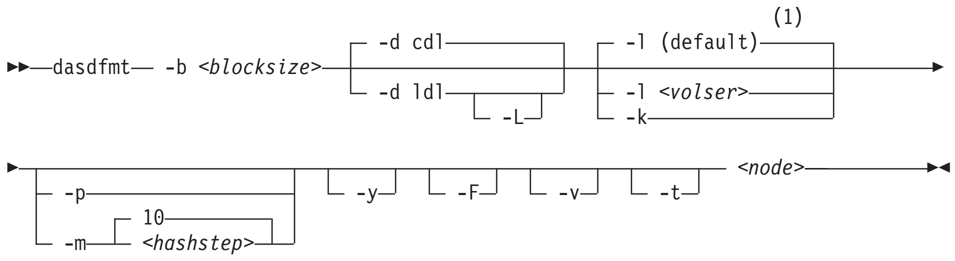
dasdfmt uses an ioctl call to the DASD driver to format tracks. A blocksize (hard sector size) can be specified. Remember that the formatting process can take quite a long time (hours for large DASD). Use the -p option to monitor the progress.

CAUTION:
As on any platform, formatting irreversibly destroys data on the target disk. Be sure not to format a disk with vital data unintentionally.

Before you start: You must have root permissions.

Format

dasdfmt syntax



Notes:

1 If neither the -l option nor the -k option are specified, a VOLSER is generated from the device number through which the volume is accessed.

Where:

-b <*block_size*> or **--blocksize=**<*block_size*>
: One of the following block sizes in bytes: 512, 1024, 2048, or 4096.

  If you do not specify a value for the block size, you are prompted. You can then press Enter to accept 4096 or specify a different value.

  Tip: Set <*block_size*> to 1024 or higher (ideally 4096) because the ext2fs file system uses 1 KB blocks and 50% of capacity is unusable if the DASD block size is 512 bytes.

<*node*>
: Specifies the device node of the device to be formatted, for example, `/dev/dasdzzz`. See "DASD naming scheme" on page 24 for more details on device nodes).

-d <*disklayout*> or **--disk_layout=**<*disklayout*>
: Formats the device with the compatible disk layout (cdl) or the Linux disk layout (ldl).

-L or **--no_label**
: Valid for `-d ldl` only, where it suppresses the default LNX1 label.

-l <*volser*> or **--label=**<*volser*>
: Specifies the volume serial number (see "VOLSER" on page 21) to be written to the disk. If the VOLSER contains special characters, it must be enclosed in single quotes. In addition, any '$' character in the VOLSER must be preceded by a backslash ('\').

| **-k** or **--keep_serial**
| : Keeps the volume serial number when writing the volume 5 Label (see
| "VOLSER" on page 21). This is useful, for example, if the volume serial
| number has been written with a VM tool and should not be overwritten.

-p or **--progressbar**
: Prints a progress bar. Do not use this option if you are using a line-mode terminal console driver (for example, a 3215 terminal device driver or a line-mode hardware console device driver).

-m <*hashstep*> or **--hashmarks=**<*hashstep*>
: Prints a hash mark (#) after every <*hashstep*> cylinders are formatted. <*hashstep*> must be in the range 1 to 1000. The default is 10.

  The -m option is useful where the console device driver is not suitable for the progress bar (-p option).

-y
: Starts formatting immediately without prompting for confirmation.

-F or **--force**
: Formats the device without checking if it is mounted.

-v
: Prints out extra information messages.

-t or **--test**
: Runs the command in test mode. Analyzes parameters and prints out what would happen, but does not modify the disk.

-V or **--version**
: Prints the version number of **dasdfmt** and exits.

-h or **--help**
: Prints out an overview of the syntax. Any other parameters are ignored.

Examples

- To format a 100 cylinder VM minidisk with the standard Linux disk layout and a 4 KB blocksize with device node `/dev/dasdc`:

```
# dasdfmt -b 4096 -d ldl -p /dev/dasdc
Drive Geometry: 100 Cylinders * 15 Heads =  1500 Tracks

I am going to format the device /dev/dasdc in the following way:
   Device number of device : 0x192
   Labelling device        : yes
   Disk label              : LNX1
   Disk identifier         : 0X0192
   Extent start (trk no)   : 0
   Extent end (trk no)     : 1499
   Compatible Disk Layout  : no
   Blocksize               : 4096

--->> ATTENTION! <<---
All data of that device will be lost.
Type "yes" to continue, no will leave the disk untouched: yes
Formatting the device. This may take a while (get yourself a coffee).

cyl   100 of   100 |##################################################| 100%

Finished formatting the device.
Rereading the partition table... ok
#
```

- To format the same disk with the compatible disk layout (using the default value of the -d option).

```
# dasdfmt -b 4096 -p /dev/dasdc
Drive Geometry: 100 Cylinders * 15 Heads =  1500 Tracks

I am going to format the device /dev/dasdc in the following way:
   Device number of device : 0x192
   Labelling device        : yes
   Disk label              : VOL1
   Disk identifier         : 0X0192
   Extent start (trk no)   : 0
   Extent end (trk no)     : 1499
   Compatible Disk Layout  : yes
   Blocksize               : 4096

--->> ATTENTION! <<---
All data of that device will be lost.
Type "yes" to continue, no will leave the disk untouched: yes
Formatting the device. This may take a while (get yourself a coffee).

cyl   100 of   100 |##################################################| 100%

Finished formatting the device.
Rereading the partition table... ok
#
```

dasdview - Display DASD structure

Purpose

dasdview displays this DASD information on the system console:

- The volume label.
- VTOC details (general information, and FMT1, FMT4, FMT5 and FMT7 labels).
- The content of the DASD, by specifying:
  - Starting point
  - Size

  You can display these values in hexadecimal, EBCDIC, and ASCII format.

If you specify a start point and size, you can also display the contents of a disk dump.

(See "The IBM label partitioning scheme" on page 20 for further information on partitioning.)

Before you start: You need root permissions.

Format

dasdview syntax

```
                  ┌─ -b 0────────┐   ┌─ -s 128───┐   ┌─ -1─┐
►►──dasdview──┬─┴──────────────┴───┴───────────┴───┴─────┴─┬── <node>──────────►◄
              │   └─ -b <begin>─┘   └─ -s <size>─┘   └─ -2─┘ │
              ├─ -i ──────────────────────────────────────────┤
              ├─ -x ──────────────────────────────────────────┤
              ├─ -j ──────────────────────────────────────────┤
              ├─ -l ──────────────────────────────────────────┤
              └─ -t <spec>────────────────────────────────────┘
```

Where:

-b *<begin>* or **--begin=***<begin>*
: Display disk content on the console, starting from *<begin>*. The content of the disk are displayed as hexadecimal numbers, ASCII text and EBCDIC text. If *<size>* is not specified (see below), **dasdview** will take the default size (128 bytes). You can specify the variable *<begin>* as:

  ```
  <begin>[k|m|b|t|c]
  ```

  The default for *<begin>* is 0.

  dasdview displays a disk dump on the console using the DASD driver. The DASD driver might suppress parts of the disk, or add information that is not relevant. This might occur, for example, when displaying the first two tracks of a disk that has been formatted as **cdl**. In this situation, the DASD driver will pad shorter blocks with zeros, in order to maintain a constant blocksize. All Linux applications (including **dasdview**) will process according to this rule.

  Here are some examples of how this option can be used:

```
-b 32   (start printing at Byte 32)
-b 32k  (start printing at kByte 32)
-b 32m  (start printing at MByte 32)
-b 32b  (start printing at block 32)
-b 32t  (start printing at track 32)
-b 32c  (start printing at cylinder 32)
```

-s <*size*> or **--size=**<*size*>
: Display a disk dump on the console, starting at <*begin*>, and continuing for **size** = <*size*>). The content of the dump are displayed as hexadecimal numbers, ASCII text, and EBCDIC text. If a start value (*begin*) is not specified, **dasdview** will take the default. You can specify the variable <*size*> as:

```
size[k|m|b|t|c]
```

The default for <*size*> is 128 bytes.

Here are some examples of how this option can be used:

```
-s 16   (use a 16 Byte size)
-s 16k  (use a 16 kByte size)
-s 16m  (use a 16 MByte size)
-s 16b  (use a 16 block size)
-s 16t  (use a 16 track size)
-s 16c  (use a 16 cylinder size)
```

-1
: Display the disk dump using format 1 (as 16 Bytes per line in hexadecimal, ASCII and EBCDIC). A line number is not displayed. You can only use option **-1** together with **-b** or **-s**.

Option **-1** is the default.

-2
: Display the disk dump using format 2 (as 8 Bytes per line in hexadecimal, ASCII and EBCDIC). A decimal and hexadecimal byte count are also displayed. You can only use option **-2** together with **-b** or **-s**.

-i or **--info**
: Display basic information such as device node, device bus-id, device type, or geometry data.

-x or **--extended**
: Display the information obtained by using **-i** option, but also open count, subchannel identifier, and so on.

-j
: Print volume serial number (volume identifier).

-l or **--label**
: Display the volume label.

-t <*spec*> or **--vtoc=**<*spec*>
: Display the VTOC's table-of-contents, or a single VTOC entry, on the console. The variable <*spec*> can take these values:

info	Display overview information about the VTOC, such as a list of the data set names and their sizes.
f1	Display the contents of all *format 1* data set control blocks (DSCBs).
f4	Display the contents of all *format 4* DSCBs.
f5	Display the contents of all *format 5* DSCBs.
f7	Display the contents of all *format 7* DSCBs.
all	Display the contents of *all* DSCBs.

<*node*>
: Specifies the device node of the device for which you want to display

information, for example, `/dev/dasdzzz`. See “DASD naming scheme” on page 24 for more details on device nodes).

-h or **--help** or **-?**
Display short usage text on console. To view the man page, enter **man dasdview**.

-v or **--version**
Display version number on console, and exit.

Examples

- To display basic information about a DASD:

```
# dasdview -i -f /dev/dasdzzz
```

This displays:

```
--- general DASD information --------------------------------------------------
device node            : /dev/dasdzzz
busid                  : 0.0.0193
type                   : ECKD
device type            : hex 3390       dec 13200

--- DASD geometry -------------------------------------------------------------
number of cylinders    : hex 64         dec 100
tracks per cylinder    : hex f          dec 15
blocks per track       : hex c          dec 12
blocksize              : hex 1000       dec 4096
#
```

- To include extended information:

```
# dasdview -x -f /dev/dasdzzz
```

This displays:

```
--- general DASD information --------------------------------------------------
device node            : /dev/dasdzzz
busid                  : 0.0.0193
type                   : ECKD
device type            : hex 3390       dec 13200

--- DASD geometry -------------------------------------------------------------
number of cylinders    : hex 64         dec 100
tracks per cylinder    : hex f          dec 15
blocks per track       : hex c          dec 12
blocksize              : hex 1000       dec 4096

--- extended DASD information -------------------------------------------------
real device number     : hex 452bc08    dec 72530952
subchannel identifier  : hex e          dec 14
CU type  (SenseID)     : hex 3990       dec 14736
CU model (SenseID)     : hex e9         dec 233
device type  (SenseID) : hex 3390       dec 13200
device model (SenseID) : hex a          dec 10
open count             : hex 1          dec 1
req_queue_len          : hex 0          dec 0
chanq_len              : hex 0          dec 0
status                 : hex 5          dec 5
label_block            : hex 2          dec 2
FBA_layout             : hex 0          dec 0
characteristics_size   : hex 40         dec 64
confdata_size          : hex 100        dec 256

characteristics        : 3990e933 900a5f80  dff72024 0064000f
                         e000e5a2 05940222  13090674 00000000
                         00000000 00000000  24241502 dfee0001
                         0677080f 007f4a00  1b350000 00000000

configuration_data     : dc010100 4040f2f1  f0f54040 40c9c2d4
                         f1f3f0f0 f0f0f0f0  f0c6c3f1 f1f30509
                         dc000000 4040f2f1  f0f54040 40c9c2d4
                         f1f3f0f0 f0f0f0f0  f0c6c3f1 f1f30500
                         d4020000 4040f2f1  f0f5c5f2 f0c9c2d4
                         f1f3f0f0 f0f0f0f0  f0c6c3f1 f1f3050a
                         f0000001 4040f2f1  f0f54040 40c9c2d4
                         f1f3f0f0 f0f0f0f0  f0c6c3f1 f1f30500
                         00000000 00000000  00000000 00000000
                         00000000 00000000  00000000 00000000
                         00000000 00000000  00000000 00000000
                         00000000 00000000  00000000 00000000
                         00000000 00000000  00000000 00000000
                         00000000 00000000  00000000 00000000
                         800000a1 00001e00  51400009 0909a188
                         0140c009 7cb7efb7  00000000 00000800
#
```

- To display volume label information:

```
# dasdview -l -f /dev/dasdzzz
```

This displays:

```
--- volume label ---------------------------------------------------------------
volume label key        : ascii  'åÖÖñ'
                        : ebcdic 'VOL1'
                        : hex    e5d6d3f1

volume label identifier : ascii  'åÖÖñ'
                        : ebcdic 'VOL1'
                        : hex    e5d6d3f1

volume identifier       : ascii  'ðçðñùó'
                        : ebcdic '0X0193'
                        : hex    f0e7f0f1f9f3

security byte           : hex    40


VTOC pointer            : hex    0000000101
                                 (cyl 0, trk 1, blk 1)

reserved                : ascii  '@@@@@'
                        : ebcdic '     '
                        : hex    4040404040

CI size for FBA         : ascii  '@@@@'
                        : ebcdic '    '
                        : hex    40404040

blocks per CI (FBA)     : ascii  '@@@@'
                        : ebcdic '    '
                        : hex    40404040

labels per CI (FBA)     : ascii  '@@@@'
                        : ebcdic '    '
                        : hex    40404040

reserved                : ascii  '@@@@'
                        : ebcdic '    '
                        : hex    40404040

owner code for VTOC     : ascii  '@@@@@@@@@@@@@@'
                          ebcdic '              '
                          hex    40404040 40404040  40404040 4040

reserved                : ascii  '@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@'
                          ebcdic '                               '
                          hex    40404040 40404040  40404040 40404040
                                 40404040 40404040  40404040 40
#
```

- To display partition information:

```
# dasdview -t info -f /dev/dasdzzz
```

This displays:

```
--- VTOC info ---------------------------------------------------------------
The VTOC contains:
  3 format 1 label(s)
  1 format 4 label(s)
  1 format 5 label(s)
  0 format 7 label(s)
Other S/390 and zSeries operating systems would see the following data sets:
 +----------------------------------------------+--------------+--------------+
 | data set                                     | start        | end          |
 +----------------------------------------------+--------------+--------------+
 | LINUX.V0X0193.PART0001.NATIVE                |          trk |          trk |
 | data set serial number : '0X0193'            |            2 |          500 |
 | system code            : 'IBM LINUX    '     |      cyl/trk |      cyl/trk |
 | creation date          :  year 2001, day 317 |        0/  2 |       33/  5 |
 +----------------------------------------------+--------------+--------------+
 | LINUX.V0X0193.PART0002.NATIVE                |          trk |          trk |
 | data set serial number : '0X0193'            |          501 |          900 |
 | system code            : 'IBM LINUX    '     |      cyl/trk |      cyl/trk |
 | creation date          :  year 2001, day 317 |       33/  6 |       60/  0 |
 +----------------------------------------------+--------------+--------------+
 | LINUX.V0X0193.PART0003.NATIVE                |          trk |          trk |
 | data set serial number : '0X0193'            |          901 |         1499 |
 | system code            : 'IBM LINUX    '     |      cyl/trk |      cyl/trk |
 | creation date          :  year 2001, day 317 |       60/  1 |       99/ 14 |
 +----------------------------------------------+--------------+--------------+
#
```

- To display VTOC information:

```
# dasdview -t f4 -f /dev/dasdzzz
```

This displays:

```
--- VTOC format 4 label -------------------------------------------------------
DS4KEYCD    : 0404040404040404040404040404040404040404040404040404040404040404...
DS4IDFMT    : dec 244, hex f4
DS4HPCHR    : 0000000105 (cyl 0, trk 1, blk 5)
DS4DSREC    : dec 7, hex 0007
DS4HCCHH    : 00000000 (cyl 0, trk 0)
DS4NOATK    : dec 0, hex 0000
DS4VTOCI    : dec 0, hex 00
DS4NOEXT    : dec 1, hex 01
DS4SMSFG    : dec 0, hex 00
DS4DEVAC    : dec 0, hex 00
DS4DSCYL    : dec 100, hex 0064
DS4DSTRK    : dec 15, hex 000f
DS4DEVTK    : dec 58786, hex e5a2
DS4DEVI     : dec 0, hex 00
DS4DEVL     : dec 0, hex 00
DS4DEVK     : dec 0, hex 00
DS4DEVFG    : dec 48, hex 30
DS4DEVTL    : dec 0, hex 0000
DS4DEVDT    : dec 12, hex 0c
DS4DEVDB    : dec 0, hex 00
DS4AMTIM    : hex 0000000000000000
DS4AMCAT    : hex 000000
DS4R2TIM    : hex 0000000000000000
res1        : hex 0000000000
DS4F6PTR    : hex 0000000000
DS4VTOCE    : hex 01000000000100000001
              typeind    : dec 1, hex 01
              seqno      : dec 0, hex 00
              llimit     : hex 00000001 (cyl 0, trk 1)
              ulimit     : hex 00000001 (cyl 0, trk 1)
res2        : hex 00000000000000000000
DS4EFLVL    : dec 0, hex 00
DS4EFPTR    : hex 0000000000 (cyl 0, trk 0, blk 0)
res3        : hex 000000000000000000
#
```

- To print the contents of a disk to the console starting at block 2 (volume label):

```
# dasdview -b 2b -s 128 -f /dev/dasdzzz
```

This displays:

```
+----------------------------------------+------------------+------------------+
| HEXADECIMAL                            | EBCDIC           | ASCII            |
|  01....04 05....08  09....12 13....16  | 1.............16 | 1.............16 |
+----------------------------------------+------------------+------------------+
|  E5D6D3F1 E5D6D3F1  F0E7F0F1 F9F34000  | VOL1VOL10X0193?. | ??????????????@. |
|  00000101 40404040  40404040 40404040  | ................ | ................ |
|  40404040 40404040  40404040 40404040  | ???????????????? | @@@@@@@@@@@@@@@@ |
|  40404040 40404040  40404040 40404040  | ???????????????? | @@@@@@@@@@@@@@@@ |
|  40404040 40404040  40404040 40404040  | ???????????????? | @@@@@@@@@@@@@@@@ |
|  40404040 88001000  10000000 00808000  | ????h........... | @@@@?........... |
|  00000000 00000000  00010000 00000200  | ................ | ................ |
|  21000500 00000000  00000000 00000000  | ?............... | !............... |
+----------------------------------------+------------------+------------------+
#
```

- To display the contents of a disk on the console starting at block 14 (first FMT1 DSCB) using format 2:

```
# dasdview -b 14b -s 128 -2 -f /dev/dasdzzz
```

This displays:

```
 +---------------+---------------+----------------------+----------+----------+
 |     BYTE      |     BYTE      |     HEXADECIMAL      |  EBCDIC  |  ASCII   |
 |    DECIMAL    |  HEXADECIMAL  |  1 2 3 4   5 6 7 8   | 12345678 | 12345678 |
 +---------------+---------------+----------------------+----------+----------+
 |         57344 |          E000 |  D3C9D5E4  E74BE5F0  | LINUX.V0 | ?????K?? |
 |         57352 |          E008 |  E7F0F1F9  F34BD7C1  | X0193.PA | ?????K?? |
 |         57360 |          E010 |  D9E3F0F0  F0F14BD5  | RT0001.N | ??????K? |
 |         57368 |          E018 |  C1E3C9E5  C5404040  | ATIVE??? | ?????@@@ |
 |         57376 |          E020 |  40404040  40404040  | ???????? | @@@@@@@@ |
 |         57384 |          E028 |  40404040  F1F0E7F0  | ????10X0 | @@@@???? |
 |         57392 |          E030 |  F1F9F300  0165013D  | 193.???? | ???.?e?= |
 |         57400 |          E038 |  63016D01  0000C9C2  | ??_?..IB | c?m?..?? |
 |         57408 |          E040 |  D440D3C9  D5E4E740  | M?LINUX? | ?@?????@ |
 |         57416 |          E048 |  40404065  013D0000  | ??????.. | @@@e?=.. |
 |         57424 |          E050 |  00000000  88001000  | ....h.?. | ....?.?. |
 |         57432 |          E058 |  10000000  00808000  | ?....??. | ?....??. |
 |         57440 |          E060 |  00000000  00000000  | ........ | ........ |
 |         57448 |          E068 |  00010000  00000200  | .?....?. | .?....?. |
 |         57456 |          E070 |  21000500  00000000  | ?.?..... | !.?..... |
 |         57464 |          E078 |  00000000  00000000  | ........ | ........ |
 +---------------+---------------+----------------------+----------+----------+
#
```

- To see what is at block 1234 (in this example there is nothing there):

```
# dasdview -b 1234b -s 128 -f /dev/dasdzzz
```

This displays:

```
+----------------------------------------+-------------------+-------------------+
| HEXADECIMAL                            | EBCDIC            | ASCII             |
|  01....04 05....08  09....12 13....16  | 1.............16 | 1.............16 |
+----------------------------------------+-------------------+-------------------+
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
|  00000000 00000000  00000000 00000000  | ................ | ................ |
+----------------------------------------+-------------------+-------------------+
#
```

- To try byte 0 instead:

```
# dasdview -b 0 -s 64 -f /dev/dasdzzz
```

This displays:

```
+----------------------------------------+-------------------+-------------------+
| HEXADECIMAL                            | EBCDIC            | ASCII             |
|  01....04 05....08  09....12 13....16  | 1.............16 | 1.............16 |
+----------------------------------------+-------------------+-------------------+
|  C9D7D3F1 000A0000  0000000F 03000000  | IPL1............ | ????............ |
|  00000001 00000000  00000000 40404040  | ................ | ................ |
|  40404040 40404040  40404040 40404040  | ???????????????? | @@@@@@@@@@@@@@@@ |
|  40404040 40404040  40404040 40404040  | ???????????????? | @@@@@@@@@@@@@@@@ |
+----------------------------------------+-------------------+-------------------+
#
```

fdasd – Partition a DASD

Purpose

The compatible disk layout allows you to split DASD into several partitions. Use **fdasd** to manage partitions on a DASD. You can use **fdasd** to create, change and delete partitions, and also to change the volume serial number.

- **fdasd** checks that the volume has a valid volume label and VTOC. If either is missing or incorrect, **fdasd** recreates it.
- In interactive mode, you are given a menu through which you can display DASD information, add or remove partitions, or change the volume identifier.
- Your changes are not written to disk until you type the "write"option on the menu. You may quit without altering the disk at any time prior to this. The items written to the disk will be the volume label, the "format 4" DSCB, a "format 5" DSCB, sometimes a "format 7" DSCB depending on the DASD size, and one to three "format 1" DSCBs.

Note: To partition a SCSI disk, use **fdisk** rather than **fdasd**.

Before you start:

- You must have root permissions.
- The disk must be formatted with **dasdfmt** with the (default) `-d cdl` option.

For more information on partitions see "The IBM label partitioning scheme" on page 20.

Attention: Careless use of **fdasd** can result in loss of data.

Format

fdasd syntax

```
►►──fdasd──┬───────────┬──┬─┤ partitioning options ├─┬── <node>────────────►◄
           └─--verbose─┘  └─-p──────────────────────┘
```

partitioning options:

```
                    (1)
    ┌─-l (default)──────┐
├───┼───────────────────┼──┬──────────────────────────────┬──────────────┤
    ├─ -l <volser>──────┤  └──┬─ -a───────────────┬──┬────┘
    └─ -k───────────────┘     └─ -c <conf_file>───┘  └─ -s─┘
```

Notes:

1 In conjunction with the -a option or the -c option, the default VOLSER is generated from the device number through which the volume is accessed. Otherwise, the default is to keep the current VOLSER (-k option).

Where:

--verbose
Prints additional messages that are normally suppressed.

-l *<volser>* or **--label=***<volser>*
Specifies the volume serial number (see "VOLSER" on page 21). If the VOLSER contains special characters, it must be enclosed in single quotes. In addition, any '$' character in the VOLSER must be preceded by a backslash ('\').

-k or **--keep_serial**
Keeps the volume serial number when writing the volume 5 Label (see "VOLSER" on page 21). This is useful, for example, if the volume serial number has been written with a VM tool and should not be overwritten.

-a or **--auto**
Auto-create one partition using the whole disk in non-interactive mode.

-c *<conf_file>* or **--config** *<conf_file>*
This option enables you to create several partitions, controlled by the plain text configuration file *<conf_file>*. Using this option, **fdasd** automatically switches to non-interactive mode and creates all the partitions specified in *<conf_file>*. The configuration file *<conf_file>* contains the following line for each partition you want to create:

```
[x,y]
```

where x is the keyword **first**, for the first possible track on disk, or a track number. y is either the keyword **last**, for the last possible track on disk, or a track number.

The following sample configuration file allows you to create three partitions:

```
[first,1000]
[1001,2000]
[2001,last]
```

-s or **--silent**
Suppresses messages. This is appropriate only in non-interactive mode (options -a or -c).

-p or **--table**
Prints the partition table and exits.

<node>
Is the device node of the DASD you want to partition, for example, `/dev/dasdzzz`. See "DASD naming scheme" on page 24 for more details on device nodes).

-h or **-?** or **--help**
Displays help on command line arguments.

-v or **--version**
Displays the version of **fdasd**.

Processing

fdasd menu

If you call **fdasd** in the interactive mode (that is without the **-a** or **-c** option), the following menu appears:

```
Command action
   m print this menu
   p print the partition table
   n add a new partition
   d delete a partition
   v change volume serial
   t change partition type
   r re-create VTOC and delete all partitions
   u re-create VTOC re-using existing partition sizes
   s show mapping (partition number - data set name)
   q quit without saving changes
   w write table to disk and exit

Command (m for help):
```

Menu commands:

m Re-displays the **fdasd** command menu.

p Displays the following information about the DASD:
- Number of cylinders
- Number of tracks per cylinder
- Number of blocks per track
- Block size
- Volume label
- Volume identifier
- Number of partitions defined

and the following information about each partition (including the free space area):
- Linux node
- Start track
- End track
- Number of tracks
- Partition id
- Partition type (1 = filesystem, 2 = swap)

n Adds a new partition to the DASD. You will be asked to give the start track and the length or end track of the new partition.

d Deletes a partition from the DASD. You will be asked which partition to delete.

v Changes the volume identifier. You will be asked to enter a new volume identifier. See "VOLSER" on page 21 for the format.

t Changes the partition type. You will be asked to identify the partition to be changed. You will then be asked for the new partition type (Linux native or swap). Note that this type is a guideline; the actual use Linux makes of the partition depends on how it is defined with the `mkswap` or `mk`*`xx`*`fs` tools. The main function of the partition type is to describe the partition to other operating systems so that, for example, swap partitions can be skipped by backup programs.

r Recreates the VTOC and thereby deletes all partitions.

u Recreates all VTOC labels without removing all partitions. Existing partition sizes will be reused. This is useful to repair damaged labels or migrate partitions created with older versions of **fdasd**.

s Displays the mapping of partition numbers to data set names. For example:

```
Command (m for help): s

disk             : /dev/dasdzzz
volume label     : VOL1
volume identifier: 0X0193

WARNING: This mapping may be NOT up-to-date,
         if you have NOT saved your last changes!

/dev/dasdzzz1  -  LINUX.V0X0193.PART0001.NATIVE
/dev/dasdzzz2  -  LINUX.V0X0193.PART0002.NATIVE
/dev/dasdzzz3  -  LINUX.V0X0193.PART0003.NATIVE
```

q Quits **fdasd** without updating the disk. Any changes you have made (in this session) will be discarded.

w Writes your changes to disk and exits. After the data is written Linux will reread the partition table.

Examples

Example using the menu

This section gives an example of how to use **fdasd** to create two partitions on a VM minidisk, change the type of one of the partitions, save the changes and check the results.

In this example, we will format a VM minidisk with the compatible disk layout. The minidisk has device number 193.

1. Call **fdasd**, specifying the minidisk:

   ```
   # fdasd /dev/dasdzzz
   ```

   `fdasd` reads the existing data and displays the menu:

   ```
   reading volume label: VOL1
   reading vtoc : ok

   Command action
      m print this menu
      p print the partition table
      n add a new partition
      d delete a partition
      v change volume serial
      t change partition type
      r re-create VTOC and delete all partitions
      u re-create VTOC re-using existing partition sizes
      s show mapping (partition number - data set name)
      q quit without saving changes
      w write table to disk and exit
   Command (m for help):
   ```

2. Use the `p` option to verify that no partitions have yet been created on this DASD:

```
Command (m for help): p

Disk /dev/dasdzzz:
     100 cylinders,
     15 tracks per cylinder,
     12 blocks per track
   4096 bytes per block
volume label: VOL1, volume identifier: 0X0193
maximum partition number: 3

             -----------tracks----------
             Device start    end   length   Id   System
                        2   1499     1498        unused
```

3. Define two partitions, one by specifying an end track and the other by specifying a length. (In both cases the default start tracks are used):

```
Command (m for help): n
First track (1 track = 48 KByte) ([2]-1499):
Using default value 2
Last track or +size[c|k|M] (2-[1499]): 700
You have selected track 700
```

```
Command (m for help): n
First track (1 track = 48 KByte) ([701]-1499):
Using default value 701
Last track or +size[c|k|M] (701-[1499]): +400
You have selected track 1100
```

4. Check the results using the p option:

```
Command (m for help): p

Disk /dev/dasdzzz:
     100 cylinders,
     15 tracks per cylinder,
     12 blocks per track
   4096 bytes per block
volume label: VOL1, volume identifier: 0X0193
maximum partition number: 3

       -----------tracks----------
       Device    start    end    length   Id   System
/dev/dasdzzz1        2    700       699    1   Linux native
/dev/dasdzzz2      701   1100       400    2   Linux native
                  1101   1499       399        unused
```

5. Change the type of a partition:

```
Command (m for help): t

Disk /dev/dasdzzz:
     100 cylinders,
      15 tracks per cylinder,
      12 blocks per track
    4096 bytes per block
volume label: VOL1, volume identifier: 0X0193
maximum partition number: 3

       -----------tracks----------
       Device   start   end   length   Id   System
/dev/dasdzzz1       2   700      699    1   Linux native
/dev/dasdzzz2     701  1100      400    2   Linux native
                 1101  1499      399        unused

change partition type
partition id (use 0 to exit):
```

Enter the ID of the partition you want to change; in this example partition 2:

```
partition id (use 0 to exit): 2
```

6. Enter the new partition type; in this example type 2 for swap:

```
current partition type is: Linux native

    1 Linux native
    2 Linux swap

new partition type: 2
```

7. Check the result:

```
Command (m for help): p


Disk /dev/dasdzzz:
     100 cylinders,
      15 tracks per cylinder,
      12 blocks per track
    4096 bytes per block
volume label: VOL1, volume identifier: 0X0193
maximum partition number: 3

       -----------tracks----------
       Device   start   end   length   Id   System
/dev/dasdzzz1       2   700      699    1   Linux native
/dev/dasdzzz2     701  1100      400    2   Linux swap
                 1101  1499      399        unused
```

8. Write the results to disk using the `w` option:

```
Command (m for help): w
writing VTOC...
rereading partition table...
#
```

Example using options

You can partition using the **-a** or **-c** option without entering the menu mode. This is useful for partitioning using scripts, if you need to partition several hundred DASDs, for example.

With the **-a** parameter you can create one large partition on a DASD:

```
# fdasd -a /dev/dasdzzz
auto-creating one partition for the whole disk...
writing volume label...
writing VTOC...
rereading partition table...
#
```

This will create a partition as follows:

```
        Device      start      end   length   Id  System
  /dev/dasdzzz1         2     1499     1498    1  Linux native
```

Using a configuration file you can create several partitions. For example, the following configuration file, `config`, creates three partitions:

```
[first,500]
[501,1100]
[1101,last]
```

Submitting the command with the -c option creates the partitions:

```
# fdasd -c config /dev/dasdzzz
parsing config file 'config'...
writing volume label...
writing VTOC...
rereading partition table...
#
```

This creates partitions as follows:

```
       Device      start      end   length   Id  System
 /dev/dasdzzz1         2      500      499    1  Linux native
 /dev/dasdzzz2       501     1100      600    2  Linux native
 /dev/dasdzzz3      1101     1499      399    3  Linux native
```

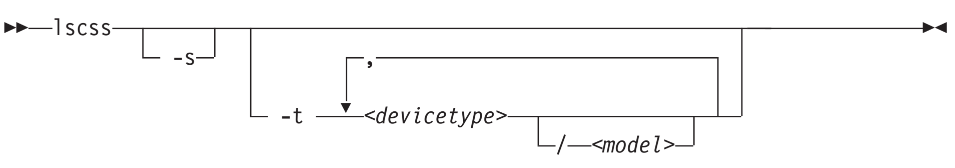
lscss - List subchannels

Purpose

This command is used to gather subchannel information from sysfs and display it in a summary format.

Format

lscss syntax



Where:

-s or **--short**
strips the "0.0." from the device bus IDs in the command output.

-t or **--devtype**
limits the output to information on the specified device types and, if provided, the specified model.

<devicetype>
specifies a device type.

<model>
is a specific model of the specified device type.

Examples

- This command lists all subchannels:

```
# lscss
Device   Subchan. DevType CU Type Use PIM PAM POM CHPIDs
----------------------------------------------------------------------
0.0.5C44 0.0.0000 3390/0A 3990/E9 yes C0  C0  FF  40410000 00000000
0.0.5C45 0.0.0001 3390/0A 3990/E9 yes C0  C0  FF  40410000 00000000
0.0.F5B4 0.0.0002 1732/01 1731/01 yes 80  80  FF  71000000 00000000
0.0.F5B5 0.0.0003 1732/01 1731/01 yes 80  80  FF  71000000 00000000
0.0.F5B6 0.0.0004 1732/01 1731/01 yes 80  80  FF  71000000 00000000
0.0.0191 0.0.0005 3390/0A 3990/E9     C0  C0  FF  40410000 00000000
0.0.0009 0.0.0006 0000/00 3215/00     80  80  FF  00000000 00000000
0.0.000C 0.0.0007 0000/00 2540/00     80  80  FF  00000000 00000000
0.0.000D 0.0.0008 0000/00 2540/00     80  80  FF  00000000 00000000
0.0.000E 0.0.0009 0000/00 1403/00     80  80  FF  00000000 00000000
0.0.0190 0.0.000A 3390/0A 3990/E9     C0  C0  FF  40410000 00000000
0.0.019D 0.0.000B 3390/0A 3990/E9     C0  C0  FF  40410000 00000000
0.0.019E 0.0.000C 3390/0A 3990/E9     C0  C0  FF  40410000 00000000
0.0.0592 0.0.000D 3390/0A 3990/E9     C0  C0  FF  40410000 00000000
0.0.0480 0.0.000E 3480/04 3480/01     80  80  FF  10000000 00000000
0.0.0A38 0.0.000F 3590/11 3590/50     80  80  FF  10000000 00000000
```

- This command lists subchannels with an attached 3480 model 04 or 3590 tape device and strips the "0.0." from the device and subchannel bus-IDs in the command output:

```
# lscss -s -t 3480/04,3590
Device   Subchan. DevType CU Type Use PIM PAM POM CHPIDs
----------------------------------------------------------------------
0480     000E     3480/04 3480/01     80  80  FF  10000000 00000000
0A38     000F     3590/11 3590/50     80  80  FF  10000000 00000000
```

lsdasd - List DASD devices

Purpose

This command is used to gather information on DASD devices from sysfs and display it in a summary format.

Format

lsdasd syntax

```
►►──lsdasd──┬────┬──┬────┬──┬────┬──┬──────────────────┬──────────────────►◄
            └─-a─┘  └─-s─┘  └─-v─┘  └─<device_bus_id>─┘
```

Where:

-a or **--offline**
: includes devices that are currently offline.

-s or **--short**
: strips the "0.0." from the device bus IDs in the command output.

-v or **--verbose**
: prints additional messages while the command is running.

<device_bus_id>
: limits the output to information on the specified device only.

Examples

- The following command lists all DASD (the sample output shows only five):

```
# lsdasd
0.0.b104(ECKD) at ( 94: 0) is dasda : active at blocksize: 4096, 601020 blocks, 2347 MB
0.0.b105(ECKD) at ( 94: 4) is dasdb : active at blocksize: 4096, 601020 blocks, 2347 MB
0.0.b106(ECKD) at ( 94: 8) is dasdc : active at blocksize: 4096, 601020 blocks, 2347 MB
0.0.b107(ECKD) at ( 94:12) is dasdd : active at blocksize: 4096, 601020 blocks, 2347 MB
0.0.b108(ECKD) at ( 94:16) is dasde : active at blocksize: 4096, 601020 blocks, 2347 MB
```

- The following command shows information only for the DASD with device number 0xb106 and strips the "0.0." from the bus IDs in the output:

```
# lsdasd -s 0.0.b106
b106(ECKD) at ( 94: 8) is dasdc : active at blocksize: 4096, 601020 blocks, 2347 MB
```

lsqeth - List qeth based network devices

Purpose

This command is used to gather information on qeth-based network devices from sysfs and display it in a summary format.

Before you start: To be able to use this command you must also have installed **qethconf** (see “qethconf - Configure qeth devices” on page 294). You install **qethconf** and **lsqeth** with the same packet.

Format

lsqeth syntax

```
►►──lsqeth──┬──────┬──┬─────────────┬──────────────────────────────►◄
            ├─ -p──┤  └─<interface>─┘
            └─ -c──┘
```

Where:

-p or **--proc**
: displays the interface information in the same format as `cat /proc/qeth`. This option can generate input to tools that expect qeth information in `/proc/qeth` format.

-c or **--ccw**
: displays the interface information in the `/etc/ccwgroup.conf` format. This option can capture a current qeth configuration in a format that conforms to the `/etc/ccwgroup.conf` syntax. If your distribution uses `/etc/ccwgroup.conf`, adding this information to it makes the configuration persistent across reboots.

<interface>
: limits the output to information on the specified interface only.

Examples

- The following command lists information on interface eth0 in the default format:

```
# lsqeth eth0
Device name                     : eth0
---------------------------------------------
        card_type               : OSD_100
        cdev0                   : 0.0.f5a2
        cdev1                   : 0.0.f5a3
        cdev2                   : 0.0.f5a4
        chpid                   : B5
        online                  : 1
        portname                :
        portno                  : 0
        route4                  : no
        route6                  : no
        checksumming            : sw checksumming
        state                   : UP (LAN ONLINE)
        priority_queueing       : always queue 2
        detach_state            : 0
        fake_ll                 : 0
        fake_broadcast          : 0
        buffer_count            : 16
        add_hhlen               : 0
```

- The following command lists information on all qeth-based interfaces in `/proc/qeth` format:

```
# lsqeth -c
devices                    CHPID interface  cardtype       port chksum prio-q'ing rtr4 rtr6 fsz   cnt
-------------------------- ----- ---------- -------------- ---- ------ ---------- ---- ---- ----- -----
0.0.833f/0.0.8340/0.0.8341 xFE   hsi0       HiperSockets   0    sw     always_q_2 no   no   n/a   16
0.0.f5a2/0.0.f5a3/0.0.f5a4 xB5   eth0       OSD_100        0    sw     always_q_2 no   no   n/a   16
0.0.fba2/0.0.fba3/0.0.fba4 xB0   eth1       OSD_100        0    sw     always_q_2 no   no   n/a   16
```

- The following command lists information on all qeth-based interfaces in `/etc/ccwgroup.conf` format:

```
# lsqeth -c
# Definitions for HiperSockets interface hsi0
group qeth 0.0.833f 0.0.8340 0.0.8341

# Definitions for OSD_100 interface eth0
group qeth 0.0.f5a2 0.0.f5a3 0.0.f5a4

# Definitions for OSD_100 interface eth1
group qeth 0.0.fba2 0.0.fba3 0.0.fba4
ipa_takeover/add4 10.0.0.4/24
ipa_takeover/add6 fe80:0000:0000:0000:0000:0000:0000:0001/10
```

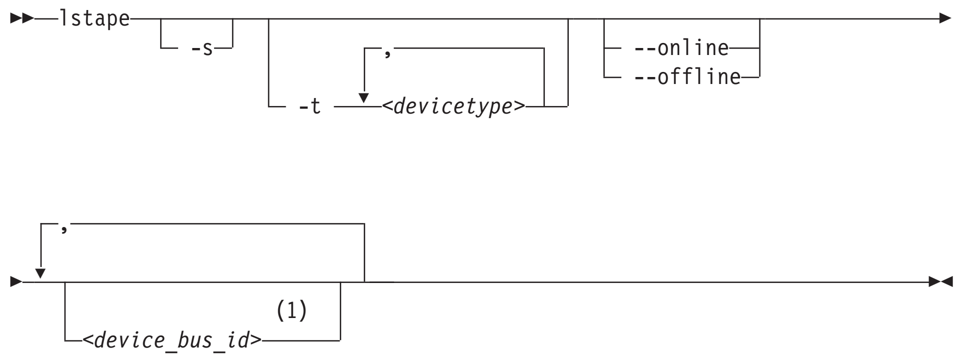
lstape - List tape devices

Purpose

This command is used to gather information on tape devices from sysfs (see "Displaying tape information" on page 69) and display it in a summary format.

Format

lstape syntax



Notes:

1 specify the first device bus-ID with a leading blank.

Where:

-s or **--shortid**
: strips the "0.0." from the device bus-IDs in the command output.

-t or **--type**
: limits the output to information on the specified type or types of tape devices only.

--online | --offline
: limits the output to information on online or offline tape devices only.

<device_bus_id>
: limits the output to information on the specified tape device or devices only.

-h or **--help**
: prints a short help text.

Examples

- This command displays information on all available tapes.

```
# lstape
TapeNo  BusID      CuType/Model DevType/DevMod  BlkSize State   Op      MedState
0       0.0.0132   3590/50      3590/11         auto    IN_USE  ---     LOADED
1       0.0.0110   3490/10      3490/40         auto    UNUSED  ---     UNLOADED
2       0.0.0133   3590/50      3590/11         auto    IN_USE  ---     LOADED
3       0.0.012a   3480/01      3480/04         auto    UNUSED  ---     UNLOADED
N/A     0.0.01f8   3480/01      3480/04         N/A     OFFLINE ---     N/A
```

- This command limits the output to tapes of type 3480 and 3490.

```
# lstape -t 3480,3490
TapeNo  BusID      CuType/Model DevType/DevMod  BlkSize State   Op      MedState
1       0.0.0110   3490/10      3490/40         auto    UNUSED  ---     UNLOADED
3       0.0.012a   3480/01      3480/04         auto    UNUSED  ---     UNLOADED
N/A     0.0.01f8   3480/01      3480/04         N/A     OFFLINE ---     N/A
```

- This command limits the output to those tapes of type 3480 and 3490 that are currently online.

```
# lstape -t 3480,3490 --online
TapeNo  BusID      CuType/Model DevType/DevMod  BlkSize State   Op      MedState
1       0.0.0110   3490/10      3490/40         auto    UNUSED  ---     UNLOADED
3       0.0.012a   3480/01      3480/04         auto    UNUSED  ---     UNLOADED
```

- This command limits the output to tapes to the device with device bus-ID 0.0.012a and strips the “0.0.” from the device bus-ID in the output.

```
# lstape -s 0.0.012a
TapeNo  BusID      CuType/Model DevType/DevMod  BlkSize State   Op      MedState
3       012a       3480/01      3480/04         auto    UNUSED  ---     UNLOADED
```

osasnmpd – Start OSA-Express SNMP subagent

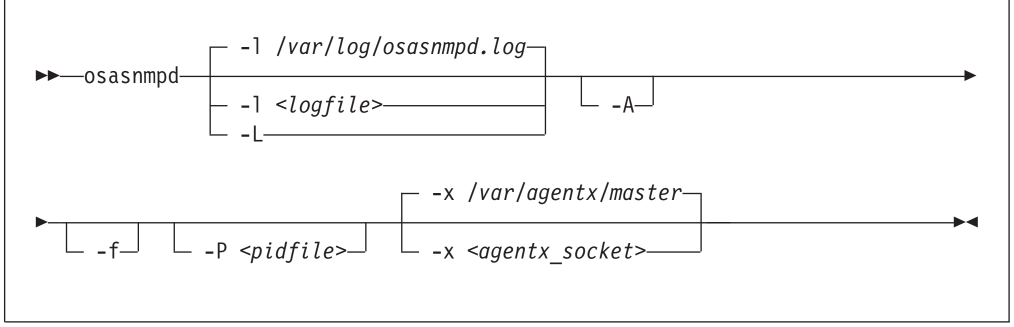
Purpose

The **osasnmpd** command is used to start the OSA-Express Simple Network Management Protocol (SNMP) subagent (osasnmpd).

See Chapter 22, "OSA-Express SNMP subagent support," on page 235 for information on osasnmpd.

Format

osasnmpd syntax



-l *<logfile>*
: specifies a file for logging all subagent messages and warnings, including stdout and stderr. If no path is specified, the log file is created in the current directory. The default log file is `/var/log/osasnmpd.log`.

-L print messages and warnings to stdout/stderr.

-A appends to an existing log file rather than replacing it.

-f prevents forking from the calling shell.

-P *<pidfile>*
: saves the process ID of the subagent in a file *<pidfile>*. If a path is not specified, the current directory is used.

-x *<agentx_socket>*
: specifies the socket to be used for the AgentX connection. The default socket is `/var/agentx/master`.

The socket can either be a UNIX domain socket path, or the address of a network interface. If a network address of the form `inet-addr:port` is specified, the subagent uses the specified port. If a net address of the form `inet-addr` is specified, the subagent uses the default AgentX port, 705.

-h or **--help**
: displays help information for the command.

-v or **--version**
: displays version information for the command.

Examples

To start the osasnmpd subagent with all default settings:

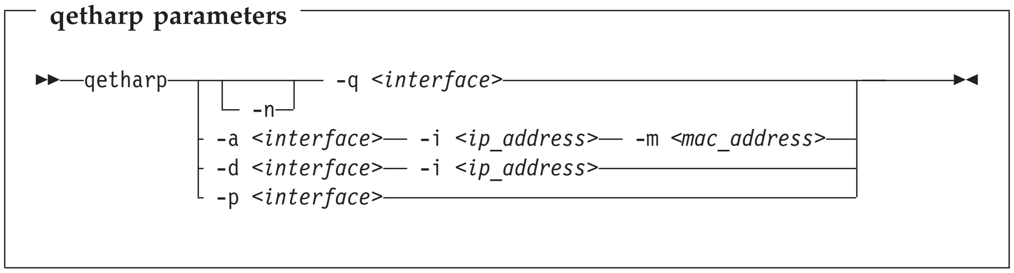
```
# osasnmpd
```

qetharp - Query and purge OSA and HiperSockets ARP data

Purpose

The **qetharp** command is used to query and purge address data such as MAC and IP addresses from the ARP cache of the OSA and HiperSockets hardware.

Format



qetharp parameters

```
►►──qetharp──┬──┬────┬── -q <interface>──────────────────────────┬──────►◄
             │  └ -n ┘                                            │
             ├ -a <interface>── -i <ip_address>── -m <mac_address>┤
             ├ -d <interface>── -i <ip_address>───────────────────┤
             └ -p <interface>─────────────────────────────────────┘
```

The meanings of the parameters of this command are as follows:

-q or **--query**
Shows the address resolution protocol (ARP) information found in the ARP cache of the OSA or HiperSockets, which depends on *interface*. If it is an OSA device, it shows the ARP entries stored in the OSA feature's ARP cache, otherwise, the ones from the HiperSockets ARP cache. If the IP address is an IPv4 address, qetharp tries to determine the symbolic host name. If it fails, the IP address will be shown. In case of IPv6, there is currently no attempt to determine host names, so that the IP address will be shown directly.

-n or **--numeric**
Shows numeric addresses instead of trying to determine symbolic host names. This option can only be used in conjunction with the -q option.

<interface>
The qeth interface to which the command applies.

-a or **--add**
Adds a static ARP entry to the OSA adapter card.

<ip_address>
IP address to be added to the OSA adapter card.

-d or **--delete**
Deletes a static ARP entry from the OSA adapter card.

<mac_address>
MAC address to be added to the OSA adapter card.

-p or **--purge**
Flushes the ARP cache of the OSA, causing the hardware to regenerate the addresses. This option works only with OSA devices. qetharp returns immediately.

-v or **--verbose**
Shows version information and exits

-h or **--help**
Shows usage information and exits

Examples

- Show all ARP entries of the OSA defined as eth0:

```
# qetharp -q eth0
```

- Show all ARP entries of the OSA defined as eth0, without resolving host names:

```
# qetharp -nq eth0
```

- Flush the OSA’s ARP cache for eth0:

```
# qetharp -p eth0
```

- Add a static entry for eth0 and IP address 1.2.3.4 to the OSA’s ARP cache, using MAC address aa:bb:cc:dd:ee:ff:

```
# qetharp -a eth0 -i 1.2.3.4 -m aa:bb:cc:dd:ee:ff
```

- Delete the static entry for eth0 and IP address 1.2.3.4 from the OSA’s ARP cache, using MAC address aa:bb:cc:dd:ee:ff:

```
# qetharp -d eth0 -i 1.2.3.4
```

qethconf - Configure qeth devices

Purpose

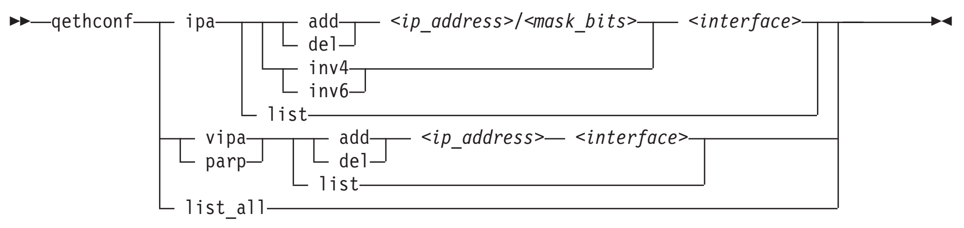
The qethconf configuration tool is a bash shell script that simplifies configuring qeth devices (see Chapter 7, “qeth device driver for OSA-Express (QDIO) and HiperSockets,” on page 81) for:

- IP address takeover
- VIPA (virtual IP address)
- Proxy ARP

From the arguments that are specified, **qethconf** assembles the corresponding function command and redirects it to the respective sysfs attributes. You can also use **qethconf** to list the already defined entries.

Format

qethconf syntax



The meanings of the parameters of this command are as follows:

ipa
Configure qeth for IP address takeover (IPA).

vipa
Configure qeth for virtual IP address (VIPA).

parp
Configure qeth for proxy ARP.

add
Add an IP address or address range.

del
Delete an IP address or address range.

inv4
Invert the selection of address ranges for IPv4 address takeover. This makes the list of IP addresses that has been specified with `qethconf add` and `qethconf del` an exclusion list.

inv6
Invert the selection of address ranges for IPv6 address takeover. This makes the list of IP addresses that has been specified with `qethconf add` and `qethconf del` an exclusion list.

list
List existing definitions for specified qeth function.

list_all
List existing definitions for IPA, VIPA, and proxy ARP.

<ip_address>
IP address. Can be specified in one of these formats:
- IP version 4 format, for example, `192.168.10.38`
- IP version 6 format, for example, `FE80::1:800:23e7:f5db`
- 8- or 32-character hexadecimals prefixed with `-x`, for example, `-xc0a80a26`

<mask_bits>
Number of bits that are set in the network mask. Allows you to specify an address range.

Example: A *<mask_bits>* of 24 corresponds to a network mask of `255.255.255.0`.

<interface>
Name of the interface associated with the specified address or address range.

Examples

- List existing proxy ARP definitions:

```
# qethconf parp list
parp add 1.2.3.4 eth0
```

- Assume responsibility for packages destined for 1.2.3.5:

```
# qethconf parp add 1.2.3.5 eth0
qethconf: Added 1.2.3.5 to /sys/class/net/eth0/device/rxip/add4.
qethconf: Use "qethconf parp list" to check for the result
```

Confirm the new proxy ARP definitions:

```
# qethconf parp list
parp add 1.2.3.4 eth0
parp add 1.2.3.5 eth0
```

- Configure eth0 for IP address takeover for all addresses that start with 192.168.10:

```
# qethconf ipa add 192.168.10.0/24 eth0
qethconf: Added 192.168.10.0/24 to /sys/class/net/eth0/device/ipa_takeover/add4.
qethconf: Use "qethconf ipa list" to check for the result
```

Display the new IP address takeover definitions:

```
# qethconf ipa list
ipa add 192.168.10.0/24 eth0
```

- Configure VIPA for eth1:

```
# qethconf vipa add 10.99.3.3 eth1
qethconf: Added 10.99.3.3 to /sys/class/net/eth1/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
```

Display the new VIPA definitions:

```
# qethconf vipa list
vipa add 10.99.3.3 eth1
```

- List all existing IPA, VIPA, and proxy ARP definitions.

```
# qethconf parp list_all
parp add 1.2.3.4 eth0
parp add 1.2.3.5 eth0
ipa add 192.168.10.0/24 eth0
vipa add 10.99.3.3 eth1
```

snipl – Simple network IPL (Linux image control for LPAR and VM)

Purpose

snipl (**s**imple **n**etwork **IPL**) is a command line tool for *remotely controlling Linux images* using either:

- Basic zSeries and S/390 support element (SE) functions for systems running in **LPAR mode,** or
- Basic z/VM system management functions for systems running as a **z/VM guest** (z/VM 4.4 or higher).

Note: Be aware that incautious use of **snipl** can result in loss of data.

LPAR mode

In LPAR mode, **snipl** allows you to:

- *Load* an LPAR.
- *Send* and *retrieve* operating system messages.
- *Activate*, *reset*, or *deactivate* an LPAR for I/O-fencing purposes.

Using **snipl** in LPAR mode allows you to overcome the limitations of the SE graphical interface when **snipl** is used for I/O-fencing from within a clustered environment of Linux systems that run in LPAR mode.

snipl uses the network management application programming interfaces (API) provided by the SE, which establishes an SNMP network connection and uses the SNMP protocol to send and retrieve data. The API is called “hwmcaapi”. It has to be available as shared library.

To establish a connection (using a valid community), the IP address of the initiating system and the community has to be configured in the *SNMP configuration* task of the SE. Also, SNMP support must be configured in the SE *settings* task. If **snipl** in LPAR mode repeatedly reports a timeout, the target SE is most likely inaccessible or not configured properly. For details on how to configure the SE, refer to the *Application Programming Interfaces* book.

For further details, refer to *zSeries Application Programming Interfaces*, SB10-7030, or *S/390 Application Programming Interfaces*, SC28-8141, which is obtainable from the following Web site:

```
ibm.com/servers/resourcelink/
```

z/VM mode

In z/VM mode, **snipl** allows you to remotely control basic z/VM system management functions. You can:

- *Activate*, *reset*, or *deactivate* an image for I/O-fencing purposes.

snipl in z/VM mode uses the system management application programming interfaces (APIs) of z/VM (version 4.4 or higher). To communicate with the z/VM host, **snipl** establishes a network connection and uses the RPC protocol to send and retrieve data.

To establish a connection to the VM host, the VSMSERVE server must be configured and the `vmsapi` service must be registered on the target VM host. Also, there has to be an account for the specified user ID on the host. If **snipl** in VM mode repeatedly reports "RPC: Port mapper failure - RPC timed out", it is most likely that the target z/VM host is inaccessible, or the service is not registered, or the configuration of the VSMSERVE server is not correct.

Note: The configuration of VSMSERVE requires DIRMAINT authorization.

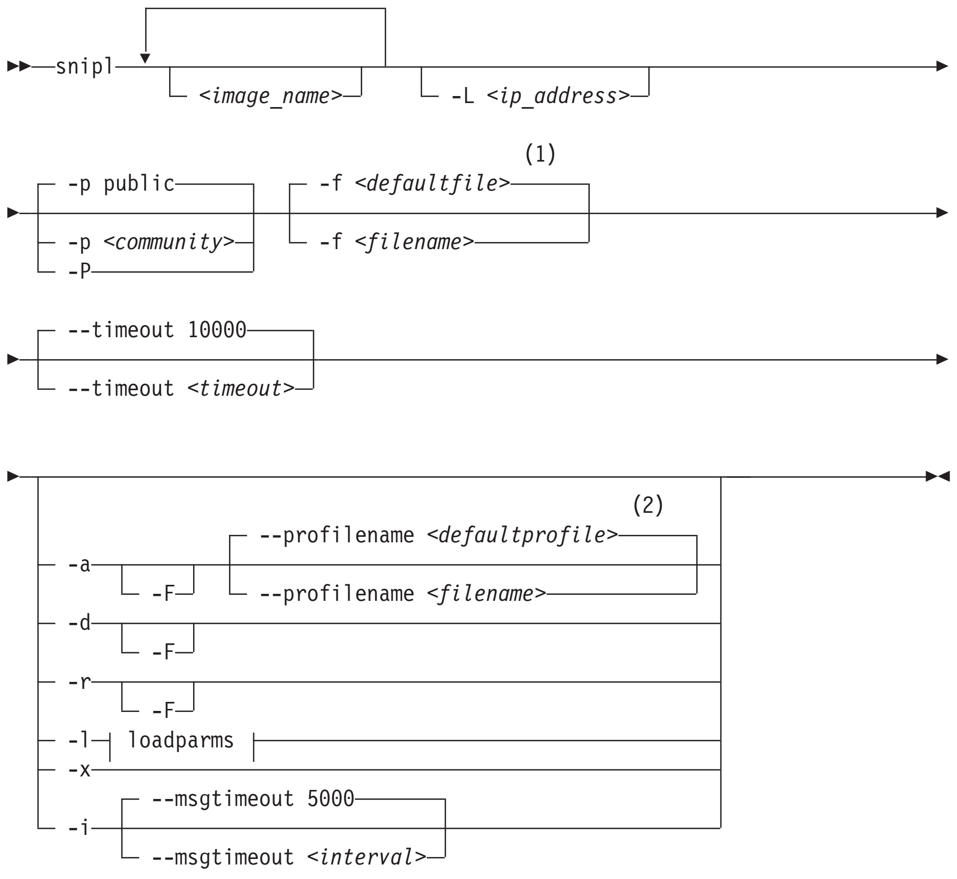
For details about configuration of the VSMSERVE server on z/VM refer to *z/VM: Systems Management Application Programming*, SC24-6063 obtainable from the following Web site:

```
ibm.com/vm/
```

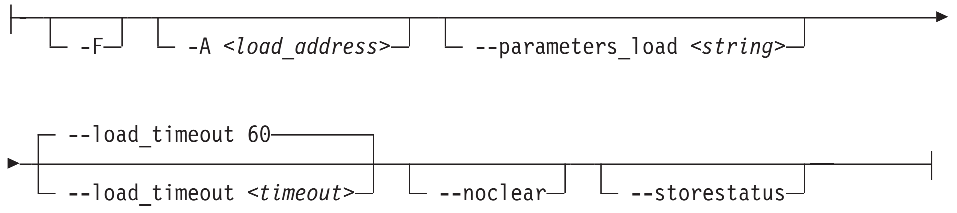
Usage

Command line syntax (LPAR mode)

snipl command (LPAR mode)



loadparms:



Notes:

1 See description of the **-f** option.

2 See description of the **--profilename** option.

Command line syntax (VM mode)

snipl command (VM mode)

```
                 ┌──────────────┐
                 ▼              │
►►──snipl────────┬──────────────┬─────┬──────────────────┬──────────────────►
                 └─<image_name>─┘     └─-V <ip_address>──┘

►──┬───────────────────────────────────────┬──┬──────────────────┬──────────►
   └─-u <userid>──┬─-p <password>─┬────────┘  └─-f <filename>────┘
                  └─-P────────────┘

►──┬─-a───────────┬─────────────────────────────────────────────────────────►◄
   ├─-d──┬─────┬──┤
   │     └─-F──┘  │
   ├─-r───────────┤
   └─-x───────────┘
```

Options and Parameters

<image_name>
: Specifies the name of the targeted LPAR or z/VM guest. This parameter is required for *--activate*, *--deactivate*, *--reset*, *--load*, and *--dialog*. If the same command is to be performed on more than one image of a given server, more than one *<image_name>* can be specified. Exception: A *--dialog* can only be started with one image.

-V *<ip_address>* or **--vmserver** *<ip_address>*
: Specifies the server to be of type VM. Use this option if the system is running in VM mode. Also specifies the IP-address/host-name of targeted VM-host. This option can also be defined in the configuration file and thus may also be omitted.

-L *<ip_address>* or **--lparserver** *<ip_address>*
: Specifies the server to be of type LPAR. Use this option if the system is running in LPAR mode. Specifies the IP-address/hostname of targeted SE. This option can also be defined in the configuration file and thus may also be omitted.

-u *<userid>* or **--userid** *<userid>*
: VM only: Specifies the userid used to access the VM-host. If none is given, the configuration file can be used to determine the userid for a given IP-address or VM-guest-name.

-p *<community>* | *<password>* or **--password** *<community>* | *<password>*

- For LPAR mode, the option specifies the *<community>* (HMC term for password) of the initiating host system. The default for *<community>* is "public". The value entered here must match the entry contained in the SNMP configuration settings on the SE.
- For VM mode, specifies the password for the given user ID.

If no password is given, the configuration file can be used to determine the password for a given IP address, LPAR, or VM guest name.

-P or **--promptpassword**
Lets **snipl** prompt for a password in protected entry mode.

-f <*filename*> or **--configfilename** <*filename*>
Specifies the name of a configuration file containing HMC/SE IP-addresses together with their community (=password) and VM IP-address together with their userid and password followed by a list of controlled `LPARnames` or `VM-guest-names`. Default *user-specific filename* is `$HOME/.snipl.conf` and *default system-wide filename* is `/etc/snipl.conf`. Without available configuration file all required options have to be specified with the command. The structure of the configuration file is described below.

-x or **--listimages**
Lists all available images for the specified server.

- For VM this may be specified with *image*, *server*, *server+user* or *image+user* according to the uniqueness in the configuration file. In case of VM the returned list is retrieved from the configuration file only.
- For LPAR just the *server name* is used to retrieve the actual images. The information is directly retrieved from the SE.

-a or **--activate**
Issues an activate command for the targeted LPAR or VM guest.

-d or **--deactivate**
Issues a deactivate command for the target LPAR or VM guest.

-r or **--reset**
Issues a reset command for the targeted LPAR(s) or VM guest(s).

-l or **--load**
LPAR only: Issues a load command for the target LPAR.

-i or **--dialog**
LPAR only: This option starts an operating system message dialog with the targeted LPAR. It allows the user to enter arbitrary commands, which are sent to the targeted LPAR. In addition, `dialog` starts a background process, which continuously retrieves operating system messages. The output of this polling process is sent to `stdout`. The operating system messages dialog is aborted by pressing `CTRL-D`. This also kills the polling process. After the dialog is terminated, **snipl** exits.

-t <*timeout*> or **--timeout** <*timeout*>
LPAR only: Specifies the timeout in milliseconds for general management API calls. The default is 10000 ms.

-m <*interval*> or **--msgtimeout** <*interval*>
LPAR only: Specifies – in conjunction with `--dialog` – the interval in milliseconds for management API calls that retrieve operating system messages. The default value is set to 5000 ms.

-F or **--force**
Forces the imageoperation.

- VM: in conjunction with `--deactivate` non graceful deactivation of the image.
- LPAR: In conjunction with `--activate`, `--deactivate`, `--reset` and `--load` allows unconditional execution of the command regardless of the state of the image.

--profilename <*filename*>
: LPAR only: In conjunction with `--activate` the option specifies the profile name used on the activate command for LPAR mode. If none is provided, the HMC/SE default profile name for the given image is used.

-A <*loadaddress*> or **--address_load** <*loadaddress*>
: LPAR only: In conjunction with `--load` specifies the load address in 4 hexadecimal digits. If none is provided, the address of the previous load is used as load address.

--parameters_load <*string*>
: LPAR only: In conjunction with `--load` specifies a parameter string for loading. If none is given, the parameter string of the previous load is used. This parameter is used for instance for `IPL` of z/OS and z/VM.

--noclear
: LPAR only: In conjunction with `--load` denies memory clearing before loading. The memory is cleared by default.

--load_timeout <*timeout*>
: LPAR only: In conjunction with `--load` specifies the maximum time for load completion, in seconds. The value must be between 60 and 600 seconds. The default value is 60 seconds.

--storestatus
: LPAR only: In conjunction with `--load` requests status before loading. The status is not stored by default.

-v or **--version**
: Prints version of **snipl** and exits.

-h or **--help**
: Prints usage and exits.

Structure of the configuration file

A configuration file contains a list of addresses (IP-addresses of an SE or a z/VM host), and the host type (LPAR vs. VM). The configuration file also contains a list of image names available for control on the subswitch.

- For LPAR, the list of image names can also be retrieved from the SE.
- For z/VM the list can only be retrieved by users with appropriate z/VM access rights. Therefore, a local list must be available.

The following is an example for the structure of the **snipl** configuration file:

```
Server = <IP-address>
type = <host-type>
password = <password>
image = <imagename>
image = <imagename>
image = <imagename>
Server = <IP-address>
type = <host-type>
user = <username>
password = <password>
image = <imagename>
image = <imagename>
image = <imagename>
image = <imagename>
```

Blanks and n/ are separators. The keywords are not case-sensitive.

snipl command examples

LPAR mode: Activate:

```
# snipl LPARLNX1 -L 9.164.70.100 -a -P
Enter password: Warning : No default configuration file could be found/opened.
processing......
LPARLNX1: acknowledged.
```

LPAR mode: Load: Load using configuration file:

```
# snipl LPARLNX1 -f xcfg -l -A 5119
processing......
LPARLNX1: acknowledged.
```

z/VM mode: Activate using configuration file:

```
# snipl -f xcfg -a vmlnx2 vmlnx1
* ImageActivate : Image vmlnx1 Request Successful
* ImageActivate : Image vmlnx2 Image Already Active
```

Connection errors and exit codes

If a connection error occurs (e.g.*timeout*, or *communication failure*), **snipl** sends an *error code* of the management API and a *message* to `stderr`. For

- `snipl --vmserver` the shell exit code is set to ″1000 + error code″
- `snipl --lparserver` the shell exit code is set to ″2000 + error code″

Return codes like

```
LPARLNX1: not acknowledged – command was not successful – rc is 135921664
```

are described in "Appendix B" of the HWMCAAPI document *zSeries Application Programming Interfaces*, SB10–7030. You can obtain this publication from the following Web site: `ibm.com/servers/resourcelink/`.

Additionally, the following **snipl** error codes exist. They are accompanied by a short message on `stderr`:

1	An unknown option is specified.
2	An option with an invalid value is specified.
3	An option is specified more than once.
4	Conflicting options are specified.
5	No command option is specified.
6	Server is not specified and cannot be determined.
7	No image is specified.
8	User-ID is not specified and cannot be determined.
9	Password is not specified and cannot be determined.
10	A specified image name does not exist on the server used.
20	An error occurred while processing the configuration file.
22	Operation `--dialog`: More than one image name is specified.
30	An error occurred while loading one of the libraries *libhwmcaapi.so* or *libvmsmapi.so*
40	Operation `--dialog` encounters a problem while starting another process.

41	Operation `--dialog` encounters a problem with `stdin` attribute setting.
50	Response from HMC/SE is cannot be interpreted.
60	Response buffer is too small for HMC/SE response.
90	A storage allocation failure occurred.

If no error occurs, a shell exit code of 0 is returned upon completion of **snipl**.

Recovery

Currently, **snipl** does not
- recover connection failures.
- recover errors in API call execution.

In these cases, it is sufficient to *restart* the tool. Should the problem persist, a networking failure is most likely. In this case, increase the timeout values for `snipl --lparserver`.

STONITH support (snipl for STONITH)

The STONITH implementation is part of the Heartbeat framework of the High Availability Project (`http://linux-ha.org/`) and STONITH is generally used as part of this framework. It can also be used independently, however. A general description of the STONITH technology can be found at: `http://linux-ha.org/stonith.html`.

The STONITH support for **snipl** can be regarded as a driver for one or more virtual power switches controlling a set of Linux images located on LPARs or z/VM instances as z/VM guests. A single LPAR or z/VM host can be seen as a VPS subswitch. STONITH requires the availability of a list of the controllable images by a switch. For this Linux Image Control VPS, the set of controlled images is retrieved from different locations depending on access rights and configuration.

The format of the **snipl** for STONITH configuration file corresponds with the configuration file format of **snipl**, see “Structure of the configuration file” on page 302.

Before you start: The setup requirements for using the STONITH plug-in differ, depending on the environment into which you want to implement it.
- **snipl** for STONITH in LPAR mode:

  The SE must be configured to allow the initiating host system to access the network management API. Direct communication with the HMC is not supported.

  For details, refer to either of these publications, as applicable:

  zSeries Application Programming Interfaces, SB10-7030

  S/390 Application Programming Interfaces, SC28-8141

  You can obtain these publications from the following Web site: `ibm.com/servers/resourcelink/`
- **snipl** for STONITH in VM mode:

  To communicate with the z/VM host, **snipl** establishes a network connection and uses the Remote Procedure Call (RPC) protocol to send and retrieve data.

  Communication with z/VM requires prior configuration of the VSMSERVE server on z/VM. For details, refer to:

  z/VM: Systems Management Application Programming, SC24–6063

You can obtain this publication from the following Web site: `ibm.com/vm/`

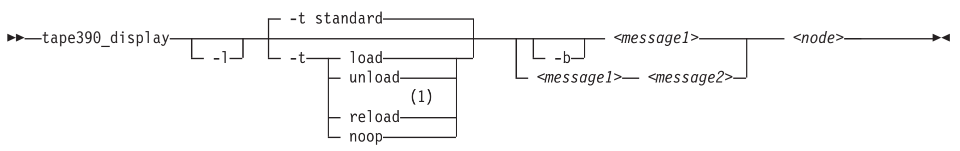
tape390_display - display messages on tape devices and load tapes

Purpose

This command is used to display messages on a physical tape device's display unit, optionally in conjunction with loading a tape.

Format

tape390_display syntax



Notes:

1 With reload, two messages must be specified and option -b is not permitted.

where:

-l or **--load**
: instructs the tape unit to load the next indexed tape from the automatic tape loader (if installed); ignored if there is no loader installed or if the loader is not in "system" mode. The loader "system" mode allows the operating system to handle tape loads.

-t or **--type**
: The possible values have the following meanings:

  standard
  : displays the message or messages until the physical tape device processes the next tape movement command.

  load
  : displays the message or messages until a tape is loaded; if a tape is already loaded, the message is ignored.

  unload
  : displays the message or messages while a tape is loaded; if no tape is loaded, the message is ignored.

  reload
  : displays the first message while a tape is loaded and the second message when the tape is removed. If no tape is loaded, the first message is ignored and the second message is displayed immediately. The second message is displayed until the next tape is loaded.

  noop
  : is intended for test purposes only. It accesses the tape device but does not display the message or messages.

-b or **--blink**
: causes <*message1*> to be displayed repeatedly for 2 seconds with a half-second pause in between.

<message1>
: is the first or only message to be displayed. The message can be up to 8 byte.

<message2>
: is a second message to be displayed alternately with the first, at 2 second intervals. The message can be up to 8 byte.

<node>
: is a device node of the target tape device

-h or **--help**
: prints help text

Notes:

1. Symbols that can be displayed include:

   Alphabetic characters:
   A through Z (uppercase only) and spaces. Lowercase letters are converted to uppercase.

   Numeric characters:
   0 1 2 3 4 5 6 7 8 9

   Special characters:
   @ $ # , . / ′ ( ) * & + - = % : _ < > ? ;

   The following are included in the 3490 hardware reference but might not display on all devices: | ¢
2. If only one message is defined, it remains displayed until the tape device driver next starts to move or the message is updated.
3. If the messages contain spaces or shell-sensitive characters, they must be enclosed in quotation marks.

Examples

The following examples assume that you are using standard devices nodes and not device nodes created by udev:

- Alternately display “BACKUP” and “COMPLETE” at two second intervals until device /dev/ntibm0 processes the next tape movement command:
```
tape390_display BACKUP COMPLETE /dev/ntibm0
```
- Display the message “REM TAPE” while a tape is in the physical tape device followed by the message“NEW TAPE” until a new tape is loaded:
```
tape390_display --type reload "REM TAPE" "NEW TAPE" /dev/ntibm0
```
- Attempts to unload the tape and load a new tape automatically, the messages are the same as in the previous example:
```
tape390_display -l -t reload "REM TAPE" "NEW TAPE" /dev/ntibm0
```

tunedasd - Adjust DASD performance

Purpose

tunedasd is used to:

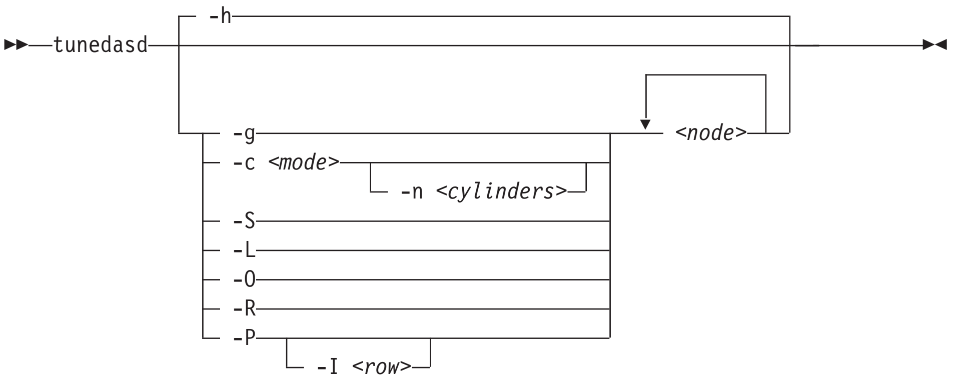
- Display and reset DASD performance statistics
- Query and set a DASD's cache mode
- Reserve and release DASD
- Breaking the lock of a known DASD (for accessing a boxed DASD while booting Linux see "Accessing DASD by force" on page 35)

Before you start:

- You must have root permissions.
- For the performance statistics:
  - Your kernel needs to have been compiled with the kernel configuration option CONFIG_DASD_PROFILE (see "Building a kernel with the DASD device driver" on page 28).
  - Data gathering must have been switched on by writing "on" to `/proc/dasd/statistics`.

Format

tunedasd syntax



Where:

<node>
: Specifies a device node for the DASD to which the command is to be applied.

-g or **--get_cache**
: Gets the current caching mode of the storage controller. This option applies to ECKD only.

-c *<mode>* or **--cache** *<mode>*
: Sets the caching mode on the storage controller to *<mode>*. This option applies to ECKD only.

Today's ECKD devices support the following behaviors):

normal	for normal cache replacement.

bypass	to bypass cache.
inhibit	to inhibit cache.
sequential	for sequential access.
prestage	for sequential prestage.
record	for record access.

For details, refer to *IBM TotalStorage Enterprise Storage Server System/390 Command Reference 2105 Models E10, E20, F10, and F20*, SC26-7295.

-n <*cylinders*> or **--no_cyl** <*cylinders*>
Specifies the number of cylinders to be cached. This option applies to ECKD only.

-S or **--reserve**
Reserves the device. This option applies to ECKD only.

-L or **--release**
Releases the device. This option applies to ECKD only.

-O or **--slock**
Unconditionally reserves the device. This option applies to ECKD only.

Note: This option is to be used with care as it breaks any existing reserve by another operating system.

-R or **--reset_prof**
reset the profile information of the device.

-P or **--profile**
Prints a usage profile of the device.

-I <*row*> or **--profile_item** <*row*>
Prints the usage profile item specified by <*row*>. <*row*> can be one of:

reqs	number of DASD I/O requests
sects	number of 512 byte sectors
sizes	histogram of sizes
total	histogram of I/O times
totsect	histogram of I/O times per sector
start	histogram of I/O time till ssch
irq	histogram of I/O time between ssch and irq
irqsect	histogram of I/O time between ssch and irq per sector
end	histogram of I/O time between irq and end
queue	number of requests in the DASD internal request queue at enqueueing

-v or **--version**
displays version information.

-h or **--help**
displays help information.

Examples

- This example first queries the current setting for the cache mode of a DASD with device node `/dev/dasdzzz` and then sets it to 1 cylinder “prestage”.

```
# tunedasd -g /dev/dasdzzz
normal (0 cyl)
# tunedasd -c prestage -n 2 /dev/dasdzzz
Setting cache mode for device </devdasdzzz>...
Done.
# tunedasd -g /dev/dasdzzz
prestage (2 cyl)
```

- In this example two device nodes are specified. The output is printed for each node in the order in which the nodes where specified.

```
# tunedasd -g /dev/dasdzzz /dev/dasdzzy
prestage (2 cyl)
normal (0 cyl)
```

- The following command prints the usage profile of a DASD.

```
# tunedasd -P /dev/dasdzzz

19617 dasd I/O requests
with 4841336 sectors(512B each)

    __<4    ___8    __16    __32    __64    _128    _256    _512    __1k    __2k    __4k    __8k    _16k    _32k    _64k    128k
    _256    _512    __1M    __2M    __4M    __8M    _16M    _32M    _64M    128M    256M    512M    __1G    __2G    __4G    _>4G
Histogram of sizes (512B secs)
       0       0     441      77      78      87     188   18746       0       0       0       0       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O times (microseconds)
       0       0       0       0       0       0       0       0     235     150     297   18683     241       3       4       4
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O times per sector
       0       0       0   18736     333     278      94      78      97       1       0       0       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O time till ssch
   19234      40      32       0       2       0       0       3      40      53     128      85       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O time between ssch and irq
       0       0       0       0       0       0       0       0     387     208     250   18538     223       3       4       4
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O time between ssch and irq per sector
       0       0       0   18803     326     398      70      19       1       0       0       0       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
Histogram of I/O time between irq and end
   18520     735     246      68      43       4       1       0       0       0       0       0       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
# of req in chanq at enqueuing (1..32)
       0   19308     123      30      25     130       0       0       0       0       0       0       0       0       0       0
       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
```

- The following command prints a row of the usage profile of a DASD. The output is on a single line as indicated by the (cont...) (... cont) in the illustration:

```
# tunedasd -P -I irq /dev/dasdzzz
         0|        0|        0|        0|        0|        0|        0|        0|      503|      271|(cont...)
 (... cont)      267|    18544|      224|        3|        4|        4|        0|        0|        0|(cont...)
 (... cont)        0|        0|        0|        0|        0|        0|        0|        0|        0|(cont...)
 (... cont)        0|        0|        0|        0|
```

zipl – zSeries initial program loader

Purpose

zipl can be used to *prepare* a device for one of the following purposes:

- Booting Linux (as a Linux program loader)
- Dumping

  For more information on the dump tools that **zipl** installs and on using the dump functions, refer to *Linux for zSeries and S/390 Using the Dump Tools*.
- Loading a data file to initialize a discontiguous saved segment (DCSS)

You can simulate a **zipl** command to test a configuration before you apply the command to an actual device (see "dry-run" on page 314).

zipl supports the following devices:

- Enhanced Count Key Data (ECKD) DASDs with fixed block Linux disk layout (ldl)
- ECKD DASDs with z/OS-compliant compatible disk layout (cdl)
- Fixed Block Access (FBA) DASDs
- Magnetic tape subsystems compatible with IBM3480, IBM3490, or IBM3590 (boot and dump devices only)
- SCSI with PC-BIOS disk layout

Usage

zipl base functions

The **zipl** base functions can be invoked with one of the following options on the command line or in a configuration file:

Table 26. zipl base functions

Base function	Command line short option	Command line long option	Configuration file option
Install a boot loader See "Preparing a boot device" on page 315 for details.	`-i`	`--image`	`image=`
Prepare a DASD or tape dump device See "Preparing a DASD or tape dump device" on page 317 for details.	`-d`	`--dumpto`	`dumpto=`
Prepare a SCSI dump device See "Preparing a dump device on a SCSI disk" on page 318 for details.	`-D`	`--dumptofs`	`dumptofs=`

Table 26. zipl base functions (continued)

Base function	Command line short option	Command line long option	Configuration file option
Prepare a device to load a file to initialize discontiguous named saved segments See "Installing a loader to initialize a discontiguous named saved segment (DCSS)" on page 321 for details.	`-s`	`--segment`	`segment=`
Install a menu configuration See "Installing a menu configuration" on page 329 for details.	`-m`	`--menu`	(None)

zipl modes

zipl operates in one of two modes:

Command-line mode

If a **zipl** command is issued with a base function other than installing a menu configuration (see "Installing a menu configuration" on page 329), the entire configuration must be defined using command-line parameters.

Configuration-file mode

If a **zipl** command is issued either without a base function or to install a menu configuration, a configuration file is accessed.

zipl syntax overview

```
►►──zipl──┬────┬──┬───────────┬──┤ parameters when omitting base function ├──────►◄
          └─-V─┘  └─--dry-run─┘  ├─-i──┤ i_parameters ├─────────────────────────┤
                                 ├─-D──┤ D_parameters ├─────────────────────────┤
                                 ├─-s──┤ s_parameters ├─────────────────────────┤
                                 ├─-d──┤ d_parameters ├─────────────────────────┤
                                 └─-m──┤ m_parameters ├─────────────────────────┘
```

parameters when omitting base function:

```
                            (1)                (2)
   ┌─-c /etc/zipl.conf──────┐   ┌─[default]───────┐
├──┼────────────────────────┼───┼─────────────────┼──────────────────────────►
   └─-c <config_file>───────┘   └─<configuration>─┘

►──┬────────────────────────┬─┬─────┬──┬────┬──────────────────────────────┤
   │                     (3)│ │  (4)│  └─-n─┘
   └─-P <parameters>────────┘ └─-a──┘
```

Notes:

1 You can change the default configuration file with the ZIPLCONF environment variable.

2 If no configuration is specified, **zipl** uses the configuration specified in the [defaultboot] section of the configuration file (see "Configuration file structure" on page 324).

3 In conjunction with a boot configuration or with a SCSI dump configuration only.

4 In conjunction with a boot configuration or a menu configuration only.

Where:

-c *<config_file>*
: specifies the configuration file to be used.

<configuration>
: specifies a single configuration section in a configuration file.

-P *<parameters>*

can optionally be used to provide:

kernel parameters
in conjunction with a boot configuration section. See "How kernel parameters from different sources are combined" on page 316 for information on how kernel parameters specified with the -P option are combined with any kernel parameters specified in the configuration file.

SCSI system dumper parameters
in conjunction with a SCSI dump configuration section. See "How SCSI system dumper parameters from different sources are combined" on page 320

page 318 for information on how parameters specified with the -P option are combined with any parameters specified in the configuration file.

If you provide multiple parameters, separate them with a blank and enclose them within single quotes (') or double quotes (").

-a in conjunction with a boot configuration section, adds kernel image, kernel parameter file, and initial RAM disk to the bootmap file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. Specifying this option significantly increases the size of the bootmap file created in the target directory.

-n suppresses confirmation prompts that require operator responses to allow unattended processing (for example, when processing DASD or tape dump configuration sections).

-V provides verbose command output.

| **--dry-run**
| simulates a **zipl** command. Use this option to test a configuration without
| overwriting data on your device.

| During simulation, **zipl** performs all command processing and issues error
| messages where appropriate. Data is temporarily written to the target directory
| and is cleared up when the command simulation is completed.

-v displays version information.

-h displays help information.

The basic functions and their parameters are described in detail in the following sections.

See “Parameters” on page 322 for a summary of the short and long command line options and their configuration file equivalents.

Examples:

- To process the default configuration in the default configuration file (`/etc/zipl.conf`, unless specified otherwise with the environment variable ZIPLCONF) issue:

```
# zipl
```

- To process the default configuration in a configuration file `/etc/myxmp.conf` issue:

```
# zipl -c /etc/myxmp.conf
```

- To process a configuration [myconf] in the default configuration file issue:

```
# zipl myconf
```

- To process a configuration [myconf] in a configuration file `/etc/myxmp.conf` issue:

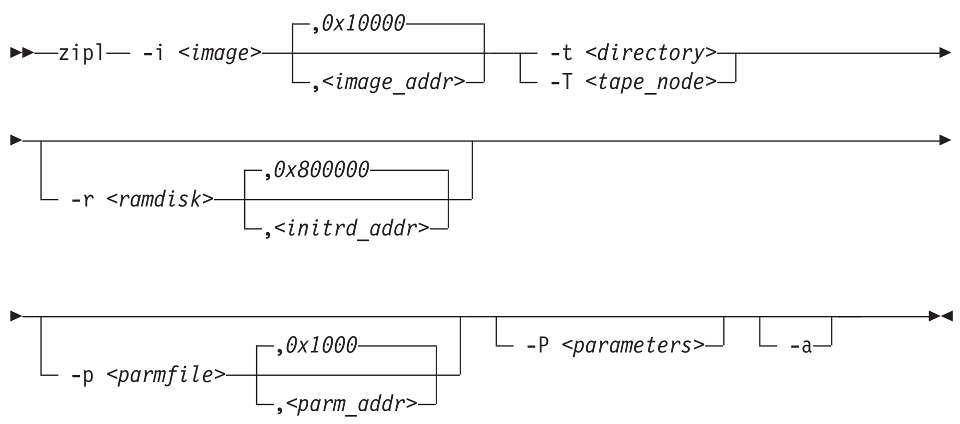
```
# zipl -c /etc/myxmp.conf myconf
```

| - To simulate processing a configuration [myconf] in a configuration file
| `/etc/myxmp.conf` issue:

```
# zipl -dry-run -c /etc/myxmp.conf myconf
```

Preparing a boot device

zipl command line syntax for preparing a boot device



```
                          ┌─,0x10000──────┐
►►──zipl── -i <image>─────┼───────────────┼──┬─ -t <directory>─┬──────────────►
                          └─,<image_addr>─┘  └─ -T <tape_node>─┘

►──┬────────────────────────────────────────────┬──────────────────────────────►
   │                   ┌─,0x800000──────┐       │
   └─ -r <ramdisk>─────┼────────────────┼───────┘
                       └─,<initrd_addr>─┘

►──┬──────────────────────────────────────────┬──┬───────────────────┬──┬────┬─►◄
   │                    ┌─,0x1000──────┐      │  └─ -P <parameters>─┘  └─-a─┘
   └─ -p <parmfile>─────┼──────────────┼──────┘
                        └─,<parm_addr>─┘
```

To prepare a device as a boot device you must specify:

The location *<image>*
: of the Linux kernel image on the file system.

A target *<directory>* or *<tape_node>*
: **zipl** installs the boot loader code on the device containing the specified directory *<directory>* or to the specified tape device *<tape_node>*.

Optionally, you can also specify:

A kernel image address *<image_addr>*
: to which the kernel image is loaded at IPL time. The default address is 0x10000.

The RAM disk location *<ramdisk>*
: of an initial RAM disk image (initrd) on the file system.

A RAM disk image address *<initrd_addr>*
: to which the RAM disk image is loaded at IPL time. The default address is 0x800000.

Kernel parameters
: to be used at IPL time. If you provide multiple parameters, separate them with a blank and enclose them within single quotes (') or double quotes (").

  You can specify parameters *<parameters>* directly on the command line. Instead or in addition, you can specify a location *<parmfile>* of a kernel parameter file on the file system. See “How kernel parameters from different sources are combined” on page 316 for a discussion of how **zipl** combines multiple kernel parameter specifications.

A parameter address *<parm_addr>*
: to which the kernel parameters are loaded at IPL time. The default address is 0x1000.

An option -a
: to add the kernel image, kernel parameter file, and initial RAM disk to the bootmap file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. This option is available on the command line only. Specifying this option significantly increases the size of the bootmap file created in the target directory.

See "Parameters" on page 322 for a summary of the parameters including the long options you can use on the command line.

Figure 61 summarizes how you can specify a boot configuration within a configuration file section. Required specifications are shown in bold. See "" on page 324 for a more comprehensive discussion of the configuration file.

```
[<section_name>]
image=<image>,<image_addr>
ramdisk=<ramdisk>,<initrd_addr>
parmfile=<parmfile>,<parm_addr>
parameters=<parameters>
# Next line for devices other than tape only
target=<directory>
# Next line for tape devices only
tape=<tape_node>
```

Figure 61. zipl syntax for preparing a boot device — configuration file mode

Example: The following command identifies the location of the kernel image as `/boot/mnt/image-2`, identifies the location of an initial RAM disk as `/boot/mnt/initrd`, specifies a kernel parameter file `/boot/mnt/parmf-2`, and writes the required boot loader code to `/boot`. At IPL time, the initial RAM disk is to be loaded to address 0x900000 rather than the default address 0x800000. Kernel image, initial RAM disk and the kernel parameter file are to be copied to the bootmap file on the target directory `/boot` rather than being referenced.

```
# zipl -i /boot/mnt/image-2 -r /boot/mnt/initrd,0x900000 -p /boot/mnt/parmf-2 -t /boot -a
```

An equivalent section in a configuration file might look like this:

```
[boot2]
image=/boot/mnt/image-2
ramdisk=/boot/mnt/initrd,0x900000
paramfile=/boot/mnt/parmf-2
target=/boot
```

There is no configuration file equivalent for option -a. To use this option for a boot configuration in a configuration file it needs to be specified with the **zipl** command that processes the configuration.

If the configuration file is called `/etc/myxmp.conf`:

```
# zipl -c /etc/myxmp.conf boot2 -a
```

How kernel parameters from different sources are combined: **zipl** allows for multiple sources of kernel parameters when preparing boot devices.

In command-line mode there are two possible sources of kernel parameters that are processed in the order:

1. Kernel parameter file (specified with the -p or --parmfile option)
2. Parameters specified on the command line (specified with the -P or --parameters option)

In configuration file mode there are three possible sources of kernel parameters that are processed in the order:

1. Kernel parameter file (specified with the parmfile= option)
2. Parameters specified in the configuration section (specified with the parameters= option)
3. Parameters specified on the command line (specified with the -P or --parameters option)

Parameters from different sources are concatenated and passed to the kernel in one string. At IPL time, the combined kernel parameter string is loaded to address 0x1000, unless an alternate address is provided with a parameter file specification.

Preparing a DASD or tape dump device

zipl command line syntax for preparing a DASD or tape dump device

```
►►──zipl── -d  <dump_device>──┬────────┬──┬────┬──────────────────────►◄
                              └─,<size>┘  └ -n┘
```

To prepare a DASD or tape dump device you must specify:

The device node *<dump_device>*
of the DASD partition or tape device to be prepared as a dump device. **zipl** deletes all data on the partition or tape and installs the boot loader code there.

Notes:

1. If the dump device is an ECKD disk with fixed-block layout (ldl), a dump overwrites the dump utility. You must reinstall the dump utility before you can use the device for another dump.
2. If the dump device is a tape, FBA disk, or ECKD disk with the compatible disk layout (cdl), you do not need to reinstall the dump utility after every dump.

Optionally, you can also specify:

An option -n
to suppress confirmation prompts to allow unattended processing (for example, from a script). This option is available on the command line only.

A limit *<size>*
for the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary.

If you limit the dump size below the amount of memory used by the system to be dumped, the resulting dump is incomplete.

DASD or tape dump devices are not formatted with a file system so no target directory can be specified. Refer to *Linux for zSeries and S/390 Using the Dump Tools* for details on how to process these dumps.

See “Parameters” on page 322 for a summary of the parameters including the long options you can use on the command line.

Figure 62 summarizes how you can specify a DASD or tape dump configuration in a configuration file. See “” on page 324 for a more comprehensive discussion of the configuration file.

```
[<section_name>]
dumpto=<dump_device>,<size>
```

Figure 62. zipl syntax for preparing a DASD or tape dump device — configuration file mode

Example: The following command prepares a DASD partition `/dev/dasdc1` as a dump device and suppresses confirmation prompts that require an operator response:

```
# zipl -d /dev/dasdc1 -n
```

An equivalent section in a configuration file might look like this:

```
[dumpdasd]
dumpto=/dev/dasdc1
```

There is no configuration file equivalent for option -n. To use this option for a DASD or tape dump configuration in a configuration file it needs to be specified with the **zipl** command that processes the configuration.

If the configuration file is called `/etc/myxmp.conf`:

```
# zipl -c /etc/myxmp.conf dumpdasd -n
```

Preparing a dump device on a SCSI disk

Before you start: At least one partition, the *target partition*, must be available to **zipl**.

zipl command line syntax for preparing a SCSI dump device

```
►►──zipl── -D <dump_partition>──┬──────────┬── -t <directory>──────────►
                                └─,<size>──┘

►──┬───────────────────┬──┬────────────────┬─────────────────────────►◄
   └─ -P <parameters>──┘  └─ -p <parmfile>─┘
```

The target partition contains the target directory and is accessed to load the SCSI system dumper tool at IPL time. Dumps are written as files to a *dump partition*.

The dump and target partition can but need not be the same partition. Preferably, dump and target partition are two separate partitions.

The target and dump partitions must be formatted with a file system supported by the SCSI Linux system dumper tool. Unlike DASD and tape, creating a dump device on SCSI disk does not destroy the contents of the target partition. Refer to *Linux for zSeries and S/390 Using the Dump Tools* for more details.

To prepare a SCSI disk as a dump device, you must specify:

The dump partition <*dump_partition*>
: to which the dumps are written.

A target <*directory*>
: to which the SCSI system dumper components are written. **zipl** uses the target directory to determine the dump device (target partition).

Optionally, you can also specify:

SCSI system dumper parameters
: You can specify parameters <*parameters*> directly on the command line. Instead or in addition, you can specify a location <*parmfile*> of a parameter file on the file system. See "How SCSI system dumper parameters from different sources are combined" on page 320 for a discussion of how multiple parameter specifications are combined.

  dump_dir=/<*directory*>
  : Path to the directory (relative to the root of the dump partition) where the dump file is to be written. This directory is specified with a leading slash. The directory must exist when the dump is initiated.

    Example: If the dump partition is mounted as `/dumps`, and the parameter "dump_dir=/mydumps" is defined, the dump directory would be accessed as "/dumps/mydumps".

    The default is "/" (the root directory of the partition).

  dump_compress=gzip|none
  : Dump compression option. Compression can be time-consuming on slower systems with a large amount of memory.

    The default is "none".

  dump_mode=interactive|auto
  : Action taken if there is no room on the file system for the new dump file. "interactive" prompts the user to confirm that the dump with the lowest number is to be deleted. "auto" automatically deletes this file.

    The default is "interactive".

  If you provide multiple parameters, separate them with a blank and enclose them within single quotes (') or double quotes (").

A limit <*size*>
: for the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary.

  If you limit the dump size below the amount of memory used by the system to be dumped, the resulting dump is incomplete.

See “Parameters” on page 322 for a summary of the parameters including the long options you can use on the command line.

Figure 63 summarizes how you can specify a SCSI dump configuration in a configuration file. Required specifications are shown in bold. See “” on page 324 for a more comprehensive discussion of the configuration file.

```
[<section_name>]
dumptofs=<dump_partition>
parmfile=<parmfile>,<parm_addr>
parameters=<parameters>
target=<directory>
```

Figure 63. zipl syntax for preparing a SCSI dump device — configuration file mode

Example: The following command prepares a SCSI partition /dev/sda2 as a dump device and a directory /boot as the target directory. Dumps are to be written to a directory mydumps, relative to the mount point, there is to be no compression and automatic deletion of the oldest dump if there is not enough space to for the new dump.

```
# zipl -D /dev/sda2 -P 'dumpdir=/mydumps dump_compress=none dump_mode=auto' -t /boot
```

An equivalent section in a configuration file might look like this:

```
[dumpscsi]
dumptofs=/dev/sda2
parmeters='dumpdir=/mydumps dump_compress=none dump_mode=auto'
target=/boot
```

In both the command line and configuration file examples the parameter specifications “dump_compress=none dump_mode=auto” could be omitted because they correspond to the defaults.

If the configuration file is called `/etc/myxmp.conf`, the **zipl** command that processes the configuration would be:

```
# zipl -c /etc/myxmp.conf dumpscsi
```

How SCSI system dumper parameters from different sources are combined: **zipl** allows for multiple sources of SCSI system dumper parameters.

In command-line mode there are two possible sources of parameters that are processed in the order:

1. Parameter file (specified with the -p or --parmfile option)
2. Parameters specified on the command line (specified with the -P or --parameters option)

In configuration file mode there are three possible sources of parameters that are processed in the order:

1. Parameter file (specified with the parmfile= option)
2. Parameters specified in the configuration section (specified with the parameters= option)

3. Parameters specified on the command line (specified with the -P or --parameters option)

Parameters from different sources are concatenated and passed to the SCSI system dumper in one string. If the same parameter is specified in multiple sources, the value that is encountered last is honored. At IPL time, the combined parameter string is loaded to address (0x1000).

Installing a loader to initialize a discontiguous named saved segment (DCSS)

zipl command line syntax for loading a DCSS

```
►►──zipl── -s <segment_file>,<seg_addr>── -t <directory>──────────────────►◄
```

To prepare a device for loading a data file to initialize discontiguous named saved segments, you must specify:

The source file *<segment_file>*
to be loaded at IPL time.

The segment address *<seg_addr>*
to which the segment is to be written at IPL time.

A target *<directory>*
zipl installs the boot loader code on the device containing the specified directory *<directory>*.

After the segment has been loaded, the system is put into the *disabled wait state*. No Linux instance is started.

See "Parameters" on page 322 for a summary of the parameters including the long options you can use on the command line.

Figure 64 summarizes how you can specify a file to be loaded to a DCSS within a configuration file section. See "" on page 324 for a more comprehensive discussion of the configuration file.

```
[<section_name>]
segment=<segment_file>,<seg_addr>
target=<directory>
```

Figure 64. zipl syntax for loading a DCSS — configuration file mode

Example: The following command prepares a device for loading a file `/boot/segment` to a DCSS at address 0x40000000 when IPLed. The boot loader code is written to `/boot`:

```
# zipl -s /boot/segment,0x40000000 -t /boot
```

An equivalent section in a configuration file might look like this:

```
[segment]
segment=/boot/segment,0x40000000
target=/boot
```

If the configuration file is called `/etc/myxmp.conf`, the **zipl** command that processes the configuration would be:

```
# zipl -c /etc/myxmp.conf segment
```

Parameters

This section provides an overview of the options and how to specify them on the command line or in the configuration file.

Command line short option **Command line long option** **Configuration file option**	**Explanation**
-c *<config_file>* --config=*<config_file>* n/a	Specifies the configuration file. You can change the default configuration file `/etc/zipl.conf` with the environment variable ZIPLCONF.
<configuration> n/a n/a	Specifies a configuration section to be read and processed from the configuration file.
-i *<image>*[,*<image_addr>*] **--image=***<image>*[,*<image_addr>*] **image=***<image>*[,*<image_addr>*]	Specifies the location of the Linux kernel image on the file system and, optionally, in memory after IPL. The default memory address is 0x10000. See “Preparing a boot device” on page 315 for details.
-r *<ramdisk>*[,*<initrd_addr>*] **--ramdisk**=*<ramdisk>*[,*<initrd_addr>* **ramdisk**=*<ramdisk>*[,*<initrd_addr>*	Specifies the location of the initial RAM disk (initrd) on the file system and, optionally, in memory after IPL. The default memory address is 0x800000.
-p *<parmfile>*[,*<parm_addr>*] **--parmfile**=*<parmfile>*[,*<parm_addr>*] **parmfile**=*<parmfile>*[,*<parm_addr>*]	In conjunction with a boot configuration, specifies the location of a kernel parameter file. In conjunction with a SCSI dump configuration, specifies the location of a parameter file with SCSI system dumper parameters (see “Preparing a dump device on a SCSI disk” on page 318). You can specify multiple sources of kernel or SCSI system dumper parameters. See “How SCSI system dumper parameters from different sources are combined” on page 320 and “How kernel parameters from different sources are combined” on page 316 for more information. The optional *<parm_addr>* specifies the memory address where the combined kernel parameter list is to be loaded at IPL time. This specification is ignored for SCSI dump configuration, SCSI system dumper parameters are always loaded to the default address 0x1000.

Command line short option Command line long option Configuration file option	Explanation
-P *<parameters>* **--parameters**=*<parameters>* **parameters**=*<parameters>*	In conjunction with a boot configuration, specifies kernel parameters. In conjunction with a SCSI dump configuration, specifies SCSI system dumper parameters (see "Preparing a dump device on a SCSI disk" on page 318) Individual parameters are single keywords or have the form *key=value*, without spaces. If you provide multiple parameters, separate them with a blank and enclose them within single quotes (') or double quotes ("). You can specify multiple sources of kernel or SCSI system dumper parameters. See "How SCSI system dumper parameters from different sources are combined" on page 320 and "How kernel parameters from different sources are combined" on page 316 for more information.
-d *<dump_device>*[,*<size>*] **--dumpto**=*<dump_device>*[,*<size>*] **dumpto**=*<dump_device>*[,*<size>*]	Specifies the DASD partition or tape device to which a dump is to be written after IPL. The optional size specification limits the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary. If you limit the dump size below the amount of memory used by the system to be dumped, the resulting dump is incomplete. If no limit is provided, all of the available physical memory is dumped. See "Preparing a DASD or tape dump device" on page 317 and *Linux for zSeries and S/390 Using the Dump Tools* for details.
-D *<dump_partition>*[,*<size>*] or **--dumptofs**=*<dump_partition>*[,*<size>*] **dumptofs**=*<dump_partition>*[,*<size>*]	Specifies the partition to which a SCSI dump file is to be written. This partition must be formatted with a file system supported by the SCSI Linux system dumper tool (for example, ext2 or ext3). The dump partition must be on the same physical SCSI disk as the target partition. It can but need not be the partition that also contains the target directory (target partition). The optional size specification limits the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary. If you limit the dump size below the amount of memory used by the system to be dumped, the resulting dump is incomplete. If no limit is provided, all of the available physical memory is dumped. See "Preparing a dump device on a SCSI disk" on page 318 and *Linux for zSeries and S/390 Using the Dump Tools* for details.
-s *<segment_file>*,*<seg_addr>* or **--segment**=*<segment_file>*,*<seg_addr>* **segment**=*<segment_file>*,*<seg_addr>*	Specifies the segment file to load at IPL time and the memory location for the segment. See "Installing a loader to initialize a discontiguous named saved segment (DCSS)" on page 321 for details.
-t *<directory>* **--target**=*<directory>*	Specifies the target directory where **zipl** creates boot-relevant files. The boot loader is installed on the disk containing the target directory. For a SCSI dump device, this partition must have been formatted with a file system supported by the SCSI system dumper (for example, ext2 or ext3).

Command line short option **Command line long option** **Configuration file option**	**Explanation**
-T <*tape_node*> **--tape**=<*tape_node*> **tape**=<*tape_node*>	Specifies the tape device where **zipl** installs the boot loader code.
-m <*menu_name*> **--menu**=<*menu_name*> n/a	Specifies the name of the menu that defines a menu configuration in the configuration file (see “Menu configurations” on page 325).
-n **--noninteractive** n/a	Suppresses all confirmation prompts (for example, when preparing a DASD or tape dump device).
-a **--add-files** n/a	Causes kernel image , kernel parameter file, and initial RAM disk to be added to the bootmap file in the target directory rather than being referenced from this file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. Specifying this option significantly increases the size of the bootmap file created in the target directory.
-V **--verbose** n/a	Provides more detailed command output.
-v **--version** n/a	Prints version information.
-h **--help** n/a	Displays help information.

If you call **zipl** in configuration file mode without specifying a configuration file, the default `/etc/zipl.conf` is used. You can change the default configuration file with the environment variable ZIPLCONF.

Configuration file structure

A configuration file contains:

[defaultboot]
: a default section that defines what is to be done if the configuration file is called without a section specification.

[<*configuration*>**]**
: one or more sections that describe IPL configurations.

:<*menu_name*>
: optionally, one or more menu sections that describe menu configurations.

A configuration file section consists of a section identifier and one or more option lines. Option lines are valid only as part of a section. Blank lines are permitted, and lines beginning with ’#’ are treated as comments and ignored. Option specifications consist of keyword=value pairs. There can but need not be blanks before and after the equal sign (=) of an option specification.

Default section

The default section consists of the section identifier **[defaultboot]** followed by a single option line. The option line specifies one of these mutually exclusive options:

default=<*section_name*>
: where <*section_name*> is one of the IPL configurations described in the configuration file. If the configuration file is called without a section specification, an IPL device is prepared according to this IPL configuration.

defaultmenu=<*menu_name*>
: where <*menu_name*> is the name of a menu configuration described in the configuration file. If the configuration file is called without a section specification, IPL devices are prepared according to this menu configuration.

Examples:

- This default specification points to a boot configuration “boot1” as the default.

```
[defaultboot]
default=boot1
```

- This default specification points to a menu configuration with a menu “menu1” as the default.

```
[defaultboot]
defaultmenu=menu1
```

IPL configurations

An IPL configuration has a section identifier that consists of a section name within square brackets and is followed by one or more option lines. Each configuration includes one of the following mutually exclusive options that determine the type of IPL configuration:

image=<*image*>
: Defines a boot configuration. See “Preparing a boot device” on page 315 for details.

dumpto=<*dump_device*>
: Defines a DASD or tape dump configuration. See “Preparing a DASD or tape dump device” on page 317 for details.

dumptofs=<*dump_partition*>
: Defines a SCSI dump configuration. See “Preparing a dump device on a SCSI disk” on page 318 for details.

segment=<*segment_file*>
: Defines a DCSS load configuration. See “Installing a loader to initialize a discontiguous named saved segment (DCSS)” on page 321 for details.

Menu configurations

For DASD and SCSI devices, you can define a menu configuration. A menu configuration has a section identifier that consists of a menu name with a leading colon. The identifier is followed by one or more lines with references to IPL configurations in the same configuration file and one or more option lines.

target=<*directory*>
: specifies a device where a boot loader is installed that handles multiple IPL configurations. For menu configurations, the target options of the referenced IPL configurations are ignored.

<*i*>**=**<*configuration*>
specifies a menu item. A menu includes one and more lines that specify the menu items.

<*configuration*> is the name of an IPL configuration that is described in the same configuration file. You can specify multiple boot configurations. For SCSI target devices, you can also specify one or more SCSI dump configurations. You cannot include DASD dump configurations as menu items.

<*i*> is the configuration number. The configuration number sequentially numbers the menu items beginning with "1" for the first item. When initiating an IPL from a menu configuration, you can specify the configuration number of the menu item you want to use.

default=<*n*>
specifies the configuration number of one of the configurations in the menu to define it as the default configuration. If this option is omitted, the first configuration in the menu is the default configuration.

prompt=<*flag*>
in conjunction with a DASD target device, determines whether the menu is displayed when an IPL is performed. Menus cannot be displayed for SCSI target devices.

For prompt=1 the menu is displayed, for prompt=0 it is suppressed. If this option is omitted, the menu is not displayed. Independent of this parameter, the operator can force a menu to be displayed by specifying "prompt" in place of a configuration number for an IPL configuration to be used.

If the menu of a menu configuration is not displayed, the operator can either specify the configuration number of an IPL configuration or the default configuration is used.

timeout=<*seconds*>
in conjunction with a DASD target device and a displayed menu, specifies the time in seconds, after which the default configuration is IPLed, if no configuration has been specified by the operator. If this option is omitted or if "0" is specified as the timeout, the menu stays displayed indefinitely on the operator console and no IPL is performed until the operator specifies an IPL configuration.

Example: Figure 65 on page 327 shows a sample configuration file that defines multiple configuration sections and two menu configurations.

```
[defaultboot]
defaultmenu=menu1

# First boot configuration (DASD)
[boot1]
ramdisk=/boot/initrd
parameters='root=/dev/ram0 ro'
image=/boot/image-1
target=/boot

# Second boot configuration (SCSI)
[boot2]
image=/boot/mnt/image-2
ramdisk=/boot/mnt/initrd,0x900000
parmfile=/boot/mnt/parmf-2
target=/boot

# Third boot configuration (DASD)
[boot3]
image=/boot/mnt/image-3
ramdisk=/boot/mnt/initrd
parmfile=/boot/mnt/parmf-3
target=/boot

# Configuration for dumping to tape
[dumptape]
dumpto=/dev/rtibm0

# Configuration for dumping to DASD
[dumpdasd]
dumpto=/dev/dasdc1

# Configuration for dumping to SCSI disk
# Separate IPL and dump partitions
[dumpscsi]
target=/boot
dumptofs=/dev/sda2
parameters="dump_dir=/mydumps dump_compress=none dump_mode=auto"

# Menu containing the SCSI boot and SCSI dump configurations
:menu1
1=dumpscsi
2=boot2
target=/boot
default=2

# Menu containing two DASD boot configurations
:menu2
1=boot1
2=boot3
target=/boot
default=1
prompt=1
timeout=30

# Configuration for initializing a DCSS
[segment]
segment=/boot/segment,0x800000
target=/boot
```

Figure 65. /etc/zipl.conf example

The following commands assume that the configuration file of our sample is the default configuration file.

- Call **zipl** to use the default configuration file settings:

```
# zipl
```

Result: zipl reads the default option from the [defaultboot] section and selects the :menu1 section. It then installs a menu configuration with a boot configuration and a SCSI dump configuration.

- Call **zipl** to install a menu configuration (see also "Installing a menu configuration" on page 329):

```
# zipl -m menu2
```

Result: zipl selects the :menu2 section. It then installs a menu configuration with two DASD boot configurations. "Example for a DASD menu configuration on VM" on page 350 and "Example for a DASD menu configuration (LPAR)" on page 355 illustrate what this menu looks like when it is displayed.

- Call **zipl** to install a boot loader for boot configuration [boot2]:

```
# zipl boot2
```

Result: zipl selects the [boot2] section. It then installs a boot loader that will load copies of `/boot/mnt/image-2`, `/boot/mnt/initrd`, and `/boot/mnt/parmf-2`.

- Call **zipl** to prepare a tape that can be IPLed for a tape dump:

```
# zipl dumptape
```

Result: zipl selects the `[dumptape]` section and prepares a dump tape on `/dev/rtibm0`.

- Call **zipl** to prepare a DASD dump device:

```
# zipl dumpdasd -n
```

Result: zipl selects the `[dumpdasd]` section and prepares the dump device `/dev/dasdc1`. Confirmation prompts that require an operator response are suppressed.

- Call **zipl** to prepare a SCSI dump device:

```
# mount /dev/sda1 /boot
# mount /dev/sda2 /dumps
# mkdir /dumps/mydumps
# zipl dumpscsi
# umount /dev/sda1
# umount /dev/sda2
```

Result: zipl selects the `[dumpscsi]` section and prepares the dump device `/dev/sda1`. The associated dump file will be created uncompressed in directory /mydumps on the dump partition. If space is required, the lowest-numbered dump file in the directory will be deleted.

- Call **zipl** to install a loader to initialize named saved segments:

```
# zipl segment
```

Result: zipl installs segment loader that will load the contents of file `/boot/segment` to address 0x800000 at IPL time and then put the processor into the disabled wait state.

Installing a menu configuration

To prepare a menu configuration you need a configuration file that includes at least one menu.

zipl syntax for installing a menu configuration

```
                                         (1)
                            ┌─ -c /etc/zipl.conf──┐
►►──zipl── -m <menu_name>───┼─────────────────────┼───┬──────┬─────────►◄
                            └─ -c <config_file>───┘   └─ -a──┘
```

Notes:

1 You can change the default configuration file with the ZIPLCONF environment variable.

Where:

-m or **--menu**
specifies the menu that defines the menu configuration in the configuration file.

<config_file>
specifies the configuration file where the menu configuration is defined. The default, `/etc/zipl.conf`, can be changed with the ZIPLCONF environment variable.

-a or **--add-files**
specifies that the kernel image file, parmfile, and initial RAM disk image are added to the bootmap files in the respective target directories rather than being referenced. Use this option if the files are spread across disks to ensure that the files are available at IPL time. Specifying this option significantly increases the size of the bootmap file created in the target directory.

Example: Using the example of a configuration file in "Example" on page 326, you could install a menu configuration with:

```
# zipl -m menu1
```

Chapter 25. Selected kernel parameters

There are two different ways of passing parameters to Linux:

- Passing parameters to your kernel at startup time (the parameter line)
- Configuring your boot loader to always pass those parameters

The kernel can only handle a parameter line file that is no larger than 896 bytes.

Device driver-specific kernel parameters are described in the setting up section of the respective device driver chapter. The following parameters affect Linux for zSeries and S/390 in particular and are beyond the scope of an individual device driver:

- cio_ignore
- cio_msg
- ipldelay
- maxcpus
- mem
- noinitrd
- ramdisk_size
- ro
- root
- vmhalt
- vmpoff

cio_ignore

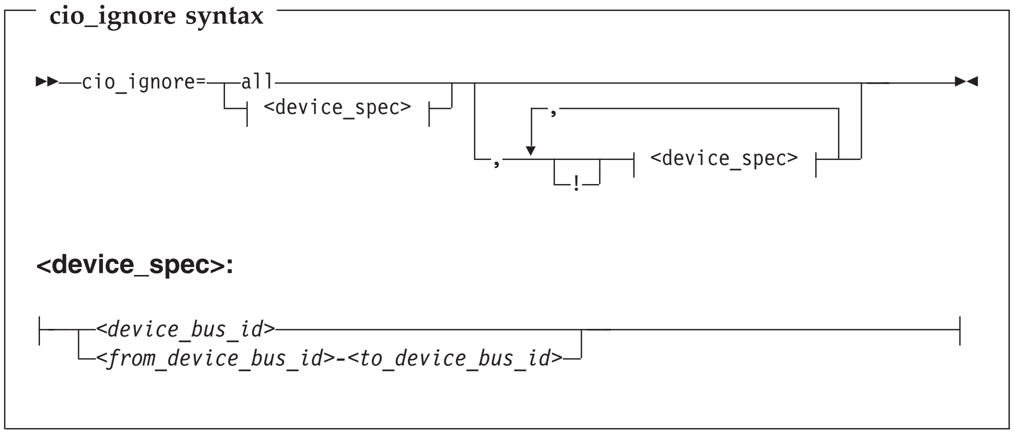
Usage

When Linux for z/Series or Linux for S/390 instance boots, it senses and analyses all available devices. You can use the cio_ignore kernel parameter to specify a list of devices that are to be ignored. The following applies to ignored devices:

- Ignored devices are not sensed and analyzed. The device cannot be used unless it has been analyzed.
- Ignored devices are not represented in sysfs.
- Ignored devices do not occupy storage in the kernel.
- The subchannel to which an ignored device is attached is treated as if no device were attached.

See also "Changing the list of devices to be ignored" on page 333.

Format



Where:

all states that all devices are to be ignored.

<device_bus_id>
: is a device bus ID, that is, "0.0." followed by a device number.

<from_device_bus_id>-<to_device_bus_id>
: are two device bus IDs that specify the first and the last device in a range of devices.

! makes the following term an exclusion statement. This operator is used to exclude individual devices or ranges of devices from a preceding more general specification of devices.

Examples

- This example specifies that all devices in the range 0.0.b100 through 0.0.b1ff, and the device 0.0.a100 are to be ignored.

```
cio_ignore=0.0.b100-0.0.b1ff,0.0.a100
```

- This example specifies that all devices are to be ignored.

```
cio_ignore=all
```

- This example specifies that all devices but the range 0.0.b100 through 0.0.b1ff, and the device 0.0.a100 are to be ignored.

  ```
  cio_ignore=all,!0.0.b100-0.0.b1ff,!0.0.a100
  ```
- This example specifies that all devices in the range 0.0.1000 through 0.0.1500 are to be ignored, except for those in the range 0.0.1100 through 0.0.1120.

  ```
  cio_ignore=0.0.1000-0.0.1500,!0.0.1100-0.0.1120
  ```

  This is equivalent to the following specification:

  ```
  cio_ignore=0.0.1000-0.0.10ff,0.0.1121-0.0.1500
  ```

Changing the list of devices to be ignored

When Linux boots, it senses the available devices and analyses them. You can use the cio_ignore kernel parameter (see “cio_ignore” on page 332) to provide a list of devices that are to be excluded from sensing and analyzing.

After booting Linux you can display the list of devices to be ignored by issuing:

```
# cat /proc/cio_ignore
```

You can add devices to this list or remove devices from the list:

- When you remove a device from the list, the device is sensed and analyzed and, where possible, the corresponding device driver is informed. The device then becomes available to the system.
- When you add a device that has already been sensed and analyzed, there is no immediate effect. However, if such a device disappears with a machine check, it is ignored when it reappears.

To remove devices from the list of devices to be ignored issue a command of this form:

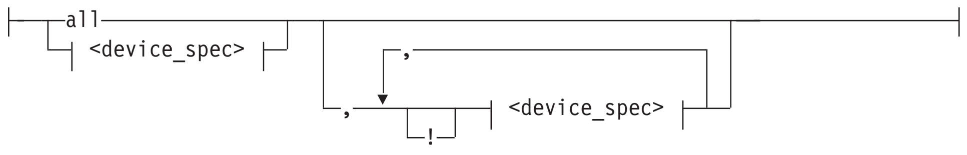
```
# echo free <device_list> > /proc/cio_ignore
```

To add devices to the list of devices to be ignored issue a command of this form:

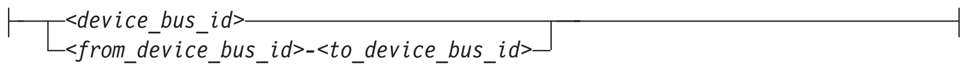
```
# echo add <device_list> > /proc/cio_ignore
```

In these commands, <*device_list*> follows this syntax:

<device_list>:



<device_spec>:



Where the keywords and variables have the same meaning as in “Format” on page 332.

Examples:

- This command removes all devices from the list of devices to be ignored.

```
# echo free all > /proc/cio_ignore
```

- This command adds all devices in the range 0.0.b100 through 0.0.b1ff and device 0.0.a100 to the list of devices to be ignored.

```
# echo add 0.0.b100-0.0.b1ff,0.0.a100 > /proc/cio_ignore
```

- This command lists the ranges of devices that are ignored by common I/O:

```
# cat /proc/cio_ignore
0.0.0000-0.0.a0ff
0.0.a101-0.0.b0ff
0.0.b200-0.0.ffff
```

- This command removes all devices in the range 0.0.b100 through 0.0.b1ff and device 0.0.a100 from the list of devices to be ignored.

```
# echo free 0.0.b100-0.0.b1ff,0.0.a100 > /proc/cio_ignore
```

- This command removes the device with bus ID 0.0.c104 from the list of devices to be ignored.

```
# echo free 0.0.c104 > /proc/cio_ignore
```

- This command adds the device with bus ID 0.0.c104 to the list of devices to be ignored.

```
# echo add 0.0.c104 > /proc/cio_ignore
```

cio_msg

Usage

Specifies whether I/O messages are to be sent to the console on boot-up.

These messages are usually suppressed (`cio_msg=no`) because on large machines with many attached devices the I/O layer generates a large number of these messages which can flood the console for a significant period of time. If you do need those messages (for example for debugging), you can switch them on manually using `cio_msg=yes`.

Format

cio_msg syntax

```
       ┌cio_msg=no──┐
►►─────┴cio_msg=yes─┴──────────────────────────────────────────────►◄
```

Examples

This example switches I/O messages to the console on boot:

```
cio_msg=yes
```

ipldelay

Usage

When you do a power on reset (POR), some activation and loading is done. This can cause Linux not to find the OSA-2 card. If you have problems with your OSA-2 card after booting, you might want to insert a delay to allow the POR, microcode load and initialization to take place in the OSA-2 card. The recommended delay time is two minutes. For example, `30s` means a delay of thirty seconds between the boot and the initialization of the OSA-2 card, `2m` means a delay of two minutes. The value <*time*> must be a number followed by either `s` or `m`.

Format

ipldelay syntax

```
►►──ipldelay=<time>──┬─m─┬──────────────────────────────────────────────►◄
                     └─s─┘
```

Examples

This example delays the initialization of the card by 2 minutes:

```
ipldelay=2m
```

This example delays the initialization of the card by 30 seconds:

```
ipldelay=30s
```

maxcpus

Usage

Specifies the maximum number of CPUs that Linux can use.

Format

maxcpus syntax

```
►►──maxcpus=<number>──────────────────────────────────────────────►◄
```

Examples

```
maxcpus=2
```

mem

Usage

Restricts memory usage to the size specified. The specified size must be suffixed either with M for megabyte or K for kilobyte.

Format

mem syntax

```
►►──mem=<size>──┬─M─┬──────────────────────────────────────────►◄
                └─K─┘
```

Examples

```
mem=64M
```

Restricts the memory Linux can use to 64 MB.

```
mem=123456K
```

Restricts the memory Linux can use to 123456 KB.

noinitrd

Usage

The noinitrd statement is required when the kernel was compiled with initial RAM disk support enabled. This command bypasses using the initial ramdisk.

This can be useful if the kernel was used with a RAM disk for the initial startup, but the RAM disk is not required when booted from a DASD.

Format

noinitrd syntax

```
►►──noinitrd──────────────────────────────────────────────────────────►◄
```

ramdisk_size

Usage

Specifies the size of the ramdisk in kilobytes.

Format

ramdisk_size syntax

```
►►──ramdisk_size=<size>──────────────────────────────────────────────►◄
```

Examples

```
ramdisk_size=32000
```

ro

Usage

Mounts the root file system read-only.

Format

ro syntax

```
►►──ro──────────────────────────────────────────────────────►◄
```

root

Usage

Tells Linux what to use as the root when mounting the root file system.

Format

root syntax

```
►►──root=<rootdevice>──────────────────────────────────────────────►◄
```

Examples

This example makes Linux use `/dev/dasda1` when mounting the root file system:

```
root=/dev/dasda1
```

vmhalt

Usage

Specifies a command to be issued to CP after a system halt. This command is only applicable if the system runs as a VM guest.

Format

vmhalt syntax

```
►►──vmhalt=<COMMAND>──────────────────────────────────────────────►◄
```

Examples

This example specifies that an initial program load of CMS should follow the Linux "`halt`" command:

```
vmhalt="I CMS"
```

Note: The command must be entered in uppercase.

vmpoff

Usage

Specifies a command to be issued to CP after a system power off. This command is only applicable if the system runs as a VM guest.

Format

vmpoff syntax

```
►►──vmpoff=<COMMAND>──────────────────────────────────────────────►◄
```

Examples

This example specifies that CP should clear the guest machine after the Linux `"power off"` or `"halt -p"` command:

```
vmpoff="SYSTEM CLEAR"
```

Note: The command must be entered in uppercase.

Appendix. Booting Linux

This chapter provides a general overview of how to boot Linux in an LPAR or as a z/VM guest.

IPL and booting

On zSeries or S/390, you usually start booting Linux by performing an Initial Program Load (IPL). Figure 66 summarizes the main steps.

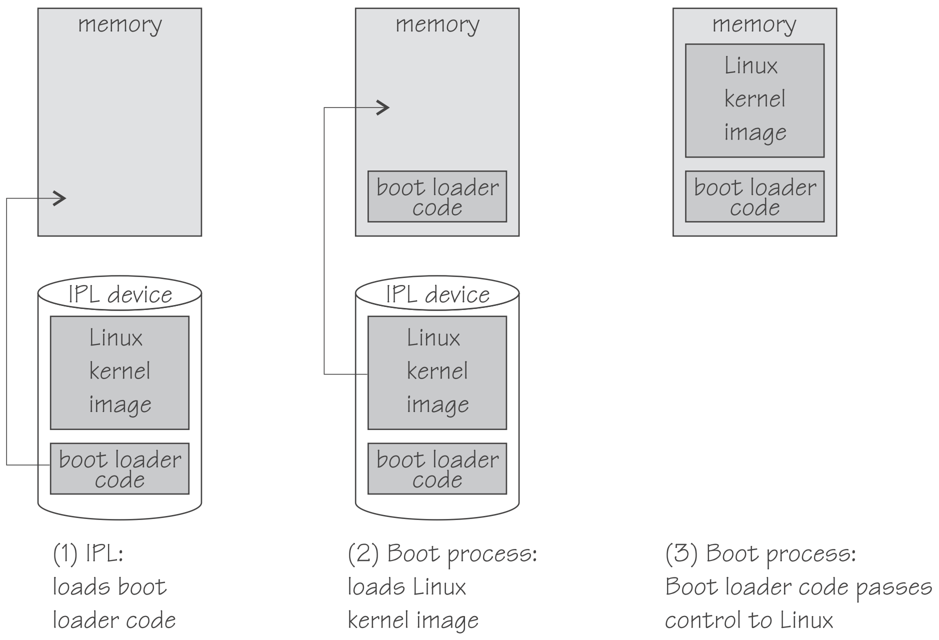


Figure 66. IPL and boot process

The IPL process accesses the IPL device and loads the Linux boot loader code to the mainframe memory. The boot loader code then gets control and loads the Linux kernel. At the end of the boot process Linux gets control.

If your Linux instance is to run in an LPAR, you can circumvent the IPL and use the service element (SE) to copy the Linux kernel to the mainframe memory (see "Loading Linux from a CD-ROM or from an FTP server" on page 356).

Apart from starting a boot process, an IPL can also be used for:

- Writing out system storage (dumping)

  Refer to *Linux for zSeries and S/390 Using the Dump Tools* for more information on dumps.
- Loading a discontiguous saved segment (DCSS)

  Refer to *How to use Execute-in-Place Technology with Linux on z/VM*, SC33-8283, for more information on DCSSs.

You can find the latest copies of these documents on developerWorks at:

`ibm.com/developerworks/linux/linux390/april2004_documentation.shtml`

If you are routed to the top-level page: On the left navigation bar, under Kernel 2.6, click **April 2004 stream**. On the April 2004 stream page, click **Documentation**.

The **zipl** tool allows you to prepare DASD, SCSI, and tape devices as IPL devices for booting Linux, for dumping, or for loading a DCSS. See "zipl – zSeries initial program loader" on page 311 for more information on **zipl**.

Control point and boot medium

The control point from where you can start the boot process depends on the environment where your Linux is to run. If your Linux is to run in LPAR mode, the control point is the mainframe's Support Element (SE) or an attached Hardware Management Console (HMC). If your Linux is to run as a VM guest, the control point is the control program (CP) of the hosting z/VM.

The media that can be used as boot devices also depend on where Linux is to run. Table 27 provides an overview of the possibilities:

Table 27. Boot media

	DASD	tape	SCSI	VM reader	CD-ROM/FTP
VM guest	✓	✓	✓	✓	
LPAR	✓	✓	✓		✓

DASDs, tapes on channel-attached tape devices, and SCSI disks that are attached through an FCP channel can be used for both LPAR and VM guests. The VM reader is available only in a VM environment.

If your Linux runs in LPAR mode, you can also boot from a CD-ROM drive on the SE or HMC, or you can obtain the boot data from a remote FTP server.

Menu configurations

If you use **zipl** to prepare a DASD or SCSI boot device, you can define a menu configuration. A boot device with a menu configuration can hold the code for multiple boot configurations. For SCSI devices, the menu can also include one or more SCSI system dumpers.

Each boot and dump configuration in a menu is associated with a configuration number. At IPL time, you can specify a configuration number to select the configuration to be used.

For menu configurations on DASD, you can display a menu with the configuration numbers (see "Example for a DASD menu configuration on VM" on page 350 and "Example for a DASD menu configuration (LPAR)" on page 355). For menu configurations on SCSI devices, you need to know the configuration numbers without being able to display the menus.

See "Menu configurations" on page 325 for information on how to define menu configurations.

Boot data

Generally, you need the following to boot Linux:

- A kernel image
- Boot loader code
- Kernel parameters
- An initial RAM disk image

For sequential I/O boot devices (VM reader and tape) the order in which this data is provided is significant. For random access devices there is no required order.

Kernel image

You can obtain the kernel image from a Linux 2.6 distribution for S/390 and zSeries.

Alternatively, you can compile your own kernel. You can find the S/390 and zSeries specific patches and OCO modules on developerWorks at:

```
ibm.com/developerworks/linux/linux390/april2004_recommended.shtml
```

If you are routed to the top-level page: On the left navigation bar, click **Kernel 2.6** . On the 2.6 page, click ″**April 2004 stream**″**- Recommended level**.

Important

Be aware that both compiling your own kernel or recompiling an existing distribution usually means that you have to maintain your kernel yourself.

Boot loader code

A kernel image is usually compiled to contain boot loader code for a particular boot device. For example, there are Linux configuration menu options to compile boot loader code for tape or for the VM reader into the kernel image.

If your kernel image does not include any boot loader code or if you want to boot a kernel image from a device that does not correspond to the included boot loader code, you can provide alternate boot loader code separate from the kernel image.

You can use **zipl** to prepare boot devices with separate DASD, SCSI, or tape boot loader code. You can then boot from DASD, SCSI, or tape regardless of the boot loader code in the kernel image.

Kernel parameters

The kernel parameters are in form of an ASCII text string of up to 895 characters. If the boot device is tape or the VM reader, the string can also be encoded in EBCDIC.

Individual kernel parameters are single keywords or keyword/value pairs of the form keyword=<*value*> with no blank. Blanks are used to separate consecutive parameters.

If you use the **zipl** command to prepare your boot device, you can provide kernel parameters on the command line, in a parameter file, and in a **zipl** configuration file. See “zipl – zSeries initial program loader” on page 311 or refer to the **zipl** and zipl.conf man pages for details.

If you are using a menu configuration on a DASD boot device, you can display the menu and provide additional kernel parameters as you select a boot configuration.

The following kernel parameters are typically used for booting Linux for zSeries and S/390:

conmode=<*mode*>, **condev=**<*cuu*>, and **console=**<*name*>
: to set up the Linux console. See “Console kernel parameter syntax” on page 214 for details.

dasd=<*devices*>
: to set specific DASDs online during the boot process. You need to specify this parameter if a DASD is required for the boot process (for example, as the boot device).

noinitrd
: to suppress an initial RAM disk. Specify this parameter if your boot configuration includes an initial RAM disk but you do not want to use it.

ramdisk_size=<*size*>
: to specify the size of the initial RAM disk.

ro to mount the root file system read-only.

root=<*rootdevice*>
: to specify the device to be mounted as the root file system.

zfcp.device=<*device_bus_id*>,<*wwpn*>,<*fcp_lun*>
: is required if a SCSI device is required for IPL (for example, as the root disk). See “Device driver kernel parameters” on page 44 for details.

Initial RAM disk image

An initial RAM disk holds files, programs, or modules that are not included in the kernel image but are required for booting.

For example, booting from DASD requires the DASD device driver. If you want to boot from DASD but the DASD device driver has not been compiled into your kernel, you need to provide the DASD device driver module on an initial RAM disk. If your image contains all files, programs, and modules that are needed for booting, you do not need an initial RAM disk.

Distributions often provide specific RAM disk images to go with their kernel images.

Booting a z/VM Linux guest

You boot a z/VM Linux guest by issuing CP commands from a guest CMS session.

This section provides summary information for booting Linux in a VM guest. For more detailed information on z/VM guest environments for Linux refer to Redpaper *Building Linux Systems under IBM VM* at `ibm.com/redbooks/redpapers/pdfs/redp0120.pdf`.

Using tape

Before you start:

- You need a tape that is prepared as a boot device.

A tape boot device must contain the following in the specified order:

1. Tape boot loader code (optional — required only if the kernel image has not been compiled for booting from tape)

   The tape boot loader code is included in the s390-tools package on developerWorks.
2. Tape mark
3. Kernel image
4. Tape mark
5. Kernel parameters (optional)
6. Tape mark
7. Initial RAM disk (optional)
8. Tape mark
9. Tape mark

All tape marks are required even if an optional item is omitted. For example, if you do not provide an initial RAM disk image, the end of the boot information is marked with three consecutive tape marks. **zipl** prepared tapes conform to this layout.

Perform these steps to start the boot process:

1. Establish a CMS session with the VM guest where you want to boot Linux.
2. Ensure that the boot device is accessible to your VM guest.
3. Ensure that the correct tape is inserted and rewound.
4. Issue a command of this form:

   ```
   #cp i <devno>
   ```

   where *<devno>* is the device number of the boot device as seen by the guest.

Using DASD

Before you start:

- You need a DASD boot device prepared with **zipl** (see "Preparing a boot device" on page 315).

Perform these steps to start the boot process:

1. Establish a CMS session with the VM guest where you want to boot Linux.
2. Ensure that the boot device is accessible to your VM guest.
3. Issue a command of this form:

   ```
   #cp i <devno> loadparm <n>
   ```

   where:

   i *<devno>*
      specifies the device number of the boot device as seen by the guest.

loadparm <*n*>

is applicable to menu configurations only. Omit this parameter if you are not working with a menu configuration.

Configuration number "0" specifies the default configuration. Depending on the menu configuration, omitting this option might display the menu or select the default configuration. Specifying "prompt" instead of a configuration number forces the menu to be displayed.

Displaying the menu allows you to specify additional kernel parameters (see "Example for a DASD menu configuration on VM"). These additional kernel parameters are appended to the parameters you might have provided in a parameter file. The combined parameter string must not exceed 895 bytes.

See "Menu configurations" on page 325 for more details on menu configurations.

Example for a DASD menu configuration on VM

This example illustrates how menu2 in the sample configuration file in Figure 65 on page 327 displays on the VM console:

```
00: zIPL v1.3.0 interactive boot menu
00:
00:  0. default (boot1)
00:
00:  1. boot1
00:  2. boot3
00:
00: Note: VM users please use '#cp vi vmsg <input>'
00:
00: Please choose (default will boot in 30 seconds):
```

You choose a configuration by specifying its configuration number. For example, to boot configuration boot3, issue:

```
#cp vi vmsg 2
```

You can also specify additional kernel parameters by appending them to this command. For example:

```
#cp vi vmsg 2 maxcpus=1 mem=64m
```

Using SCSI

Before you start:

- You need a SCSI boot device prepared with **zipl** (see "Preparing a boot device" on page 315).

Perform these steps to start the boot process:

1. Establish a CMS session with the VM guest where you want to boot Linux.
2. Ensure that the FCP channel that provides access to the SCSI boot disk is accessible to your VM guest.
3. Specify the SCSI boot disk's target port and LUN for the LOADDEV environment variable. In conjunction with a menu configuration, you can also specify the boot configuration (boot program in VM terminology) to be used. Issue a command of this form:

```
#cp set loaddev portname <wwpn> lun <lun> bootprog <n>
```

where:

<wwpn>
: is the world wide port name (WWPN) of the target port. Specify the WWPN in hexadecimal format with a blank separating the first 8 from the final 8 digits.

<lun>
: is the LUN of the SCSI boot disk. Specify the LUN in hexadecimal format with a blank separating the first 8 from the final 8 digits.

<n>
: in conjunction with a menu configuration, *<n>* is the configuration number that identifies which boot configuration is to be used. Omitting the bootprog parameter or specifying the value "0" selects the menu's default configuration.

  See "Menu configurations" on page 325 for more details on menu configurations.

Examples:

- For a WWPN 0x5005076300c20b8e and a LUN 0x5241000000000000:

  ```
  #cp set loaddev portname 50050763 00c20b8e lun 52410000 00000000
  ```

- To select a configuration with configuration number "2" from a menu configuration for a WWPN 0x5005076300c20b8e and a LUN 0x5242000000000000:

  ```
  #cp set loaddev portname 50050763 00c20b8e lun 52420000 00000000 bootprog 2
  ```

4. Issue a command of this form:

   Example:

   ```
   #cp i <devno>
   ```

   where *<devno>* is the device number of the FCP channel that provides access to the SCSI boot disk.

Using the VM reader

This section provides a summary of how to boot Linux from a VM reader. For more details refer to Redpaper *Building Linux Systems under IBM VM* at `ibm.com/redbooks/redpapers/pdfs/redp0120.pdf`.

Before you start:

You need the following files, all in record format "fixed 80":
- Linux kernel image with built-in VM reader boot loader code
- Kernel parameters (optional)
- Initial RAM disk image (optional)

Proceed like this to boot Linux from a VM reader:

1. Establish a CMS session with the guest where you want to boot Linux.

2. Transfer the kernel image, kernel parameters, and the initial RAM disk image to your guest. You can obtain the files from a shared minidisk or use:
   - The VM send file facility.
   - An FTP file transfer in binary mode.

   Files that are sent to your reader contain a file header that you need to remove before you can use them for booting. Receive files that you obtain through your VM reader to a minidisk.
3. Set up the reader as a boot device.
   a. Ensure that your reader is empty.
   b. Direct the output of the punch device to the reader. Issue:
   ```
   #cp spool pun * rdr
   ```
   c. Use the punch device to transfer each of the required files to the reader. Be sure to use the "no header" option to omit the file headers.
      First transfer the kernel image.
      Second transfer the kernel parameters.
      Third transfer the initial RAM disk image, if present.

   For each file, issue a command of this form:
   ```
   #cp pun <file_name> <file_type> <file_mode> (noh
   ```
   d. Optionally, ensure that the contents of the reader remain fixed.
   ```
   #cp change rdr all keep nohold
   ```
   If you omit this step, all files are deleted from the reader during the IPL that follows.
4. Issue the IPL command:
   ```
   #cp i 000c clear
   ```
   where 0x000c is the device number of the reader.

Booting Linux in LPAR mode

You can boot Linux in LPAR mode from a Hardware Management Console (HMC) or Support Element (SE). The following description refers to an HMC, but the same steps also apply to an SE.

Booting from DASD, tape, or SCSI

Before you start:
- You need a boot device prepared with **zipl** (see "Preparing a boot device" on page 315).
- For booting from a SCSI boot device, you need to have the SCSI IPL feature (FC9904) installed.

Perform these steps to boot from a DASD, tape, or SCSI boot device:
1. Click the Groups icon in the "Views" area of the HMC to display the "Groups Work Area" (Figure 67 on page 353).

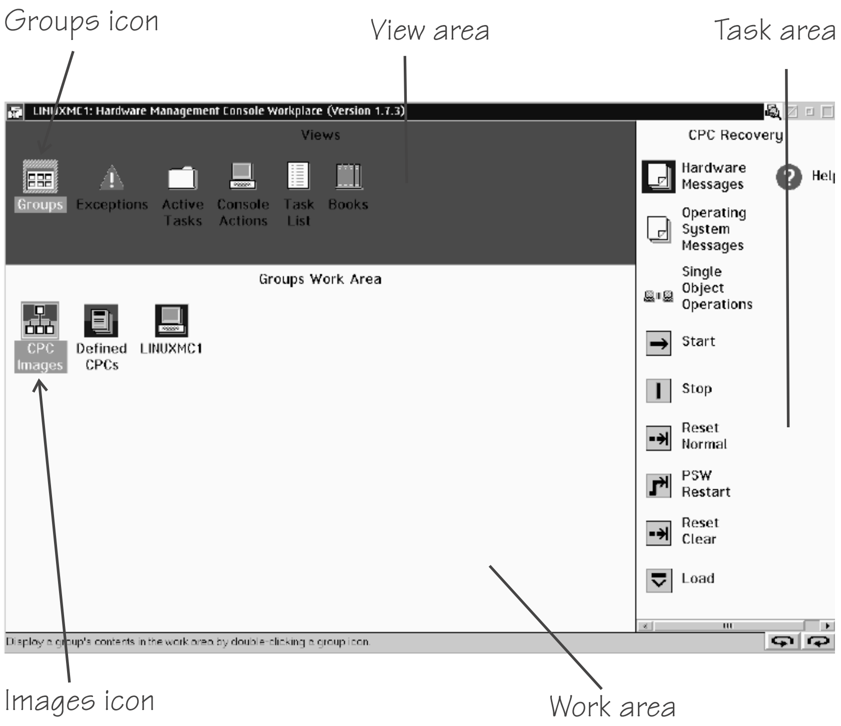


Figure 67. Groups Work Area on the HMC

2. Click the Images icon in the “Groups Work Area” to display the “CPC Images Work Area” with all defined images (Figure 68).

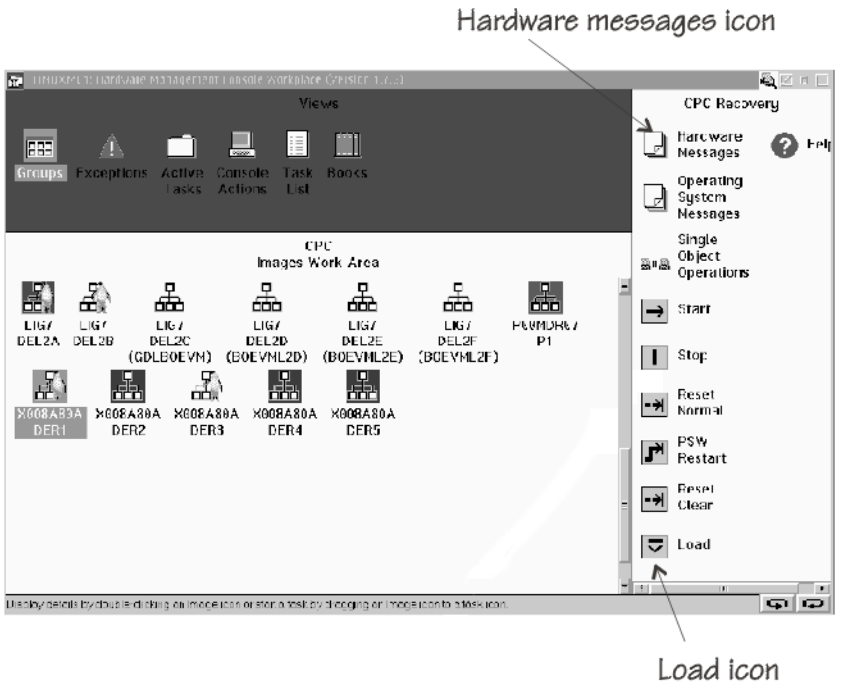


Figure 68. CPC Images Work Area on the HMC

3. Select the image you want to boot.
4. Click the Load icon in the task area to display the Load panel.
5. Proceed according to your boot device.

For booting from tape:

a. Select **Load type** "Normal".

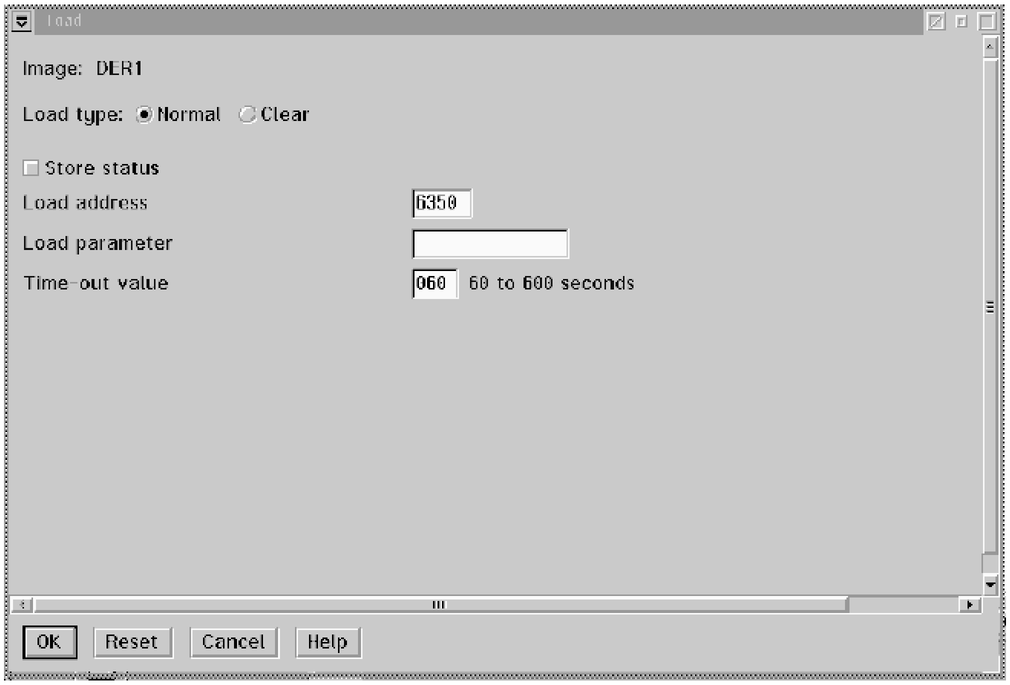


Image: DER1

Load type: [✓ Normal] Clear

Store status

Load address 6350

Load parameter

Time-out value 060 60 to 600 seconds

Figure 69. Load panel for booting from DASD or tape

b. Type the device number of the tape boot device in the **Load address** field.

For booting from DASD:

a. Select **Load type** "Normal" (see Figure 69).

b. Type the device number of the DASD boot device in the **Load address** field.

c. If the boot configuration is part of a **zipl** created menu configuration, type the configuration number that identifies your DASD boot configuration within the menu in the **Load parameter** field.

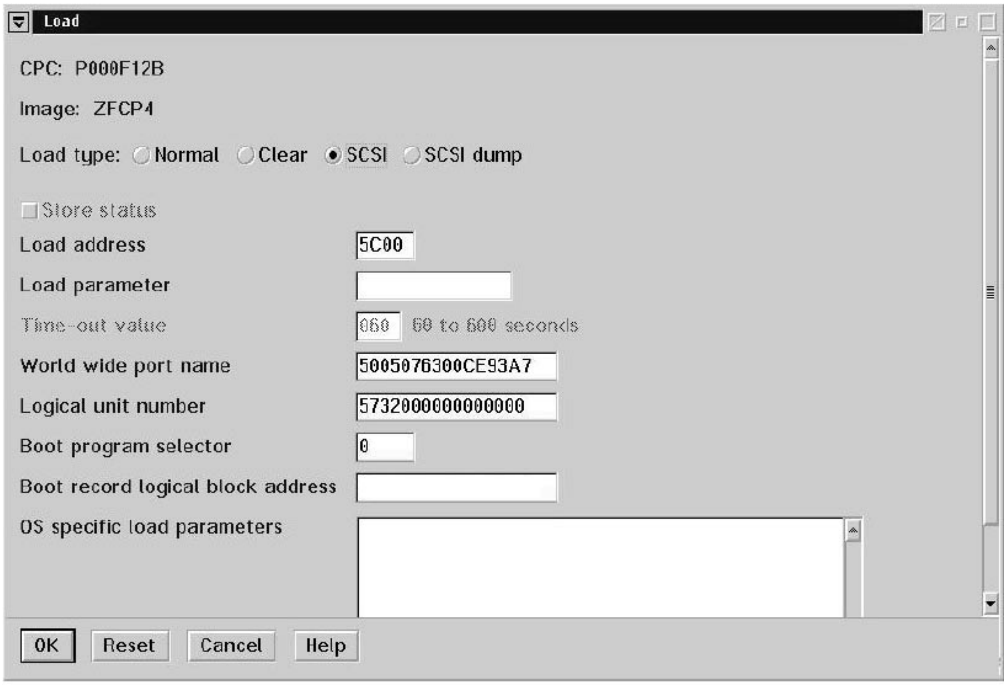
   Configuration number "0" specifies the default configuration. Depending on the menu configuration, omitting this option might display the menu or select the default configuration. Specifying "prompt" instead of a configuration number forces the menu to be displayed.

   Displaying the menu allows you to specify additional kernel parameters (see "Example for a DASD menu configuration (LPAR)" on page 355). These additional kernel parameters are appended to the parameters you might have provided in a parameter file. The combined parameter string must not exceed 895 bytes.

   See "Menu configurations" on page 325 for more details on menu configurations.

For booting from a SCSI disk:

a. Select **Load type** "SCSI".


Load

CPC: P000F12B

Image: ZFCP4

Load type: ○ Normal ○ Clear [✓ ● SCSI] ○ SCSI dump

☐ Store status

Load address 5C00

Load parameter

Time-out value 060 60 to 600 seconds

World wide port name 5005076300CE93A7

Logical unit number 5732000000000000

Boot program selector 0

Boot record logical block address

OS specific load parameters

Figure 70. Load panel with SCSI feature enabled — for booting from a SCSI disk

b. Type the device number of the FCP channel through which the SCSI disk is accessed in the **Load address** field.
c. Type the WWPN of the SCSI disk in the **World wide port name** field.
d. Type the LUN of the SCSI disk in the **Logical unit number** field.
e. If the boot configuration is part of a **zipl** created menu configuration, type the configuration number that identifies your SCSI boot configuration within the menu in the **Boot program selector** field. Configuration number "0" specifies the default configuration.

   See "Menu configurations" on page 325 for more details on menu configurations.
f. Leave the fields **Load parameter**, **Boot record logical block address**, and **OS specific load parameters** blank.

6. Click **OK** to start the boot process.

Check the output on the preferred console (see "console parameter" on page 215) to monitor the boot progress.

Example for a DASD menu configuration (LPAR)

This example illustrates how menu2 in the sample configuration file in Figure 65 on page 327 displays on the hardware console:

```
zIPL v1.3.0 interactive boot menu

0. default (boot1)

1. boot1
2. boot3

Please choose (default will boot in 30 seconds):
```

You choose a configuration by specifying the configuration number. For example, to boot configuration boot3, issue:

```
# 2
```

You can also specify additional kernel parameters by appending them to this command. For example:

```
# 2 maxcpus=1 mem=64m
```

Loading Linux from a CD-ROM or from an FTP server

You can use the SE to copy the Linux kernel image directly to your LPARs memory. This process bypasses IPL and does not require a boot loader. The SE performs the tasks that are normally done by the boot loader code. When the Linux kernel has been loaded, Linux is started using restart PSW.

As a source, you can use the SE's CD-ROM drive or any device on a remote system that you can access through FTP from your SE. If you access the SE remotely from an HMC, you can also use the CD-ROM drive of the system where your HMC runs.

Before you start: You need installation data that includes a special file with installation information (with extension "ins") either:
- On a CD-ROM that is inserted in the SE's CD-ROM drive or in the CD-ROM drive of the system where the HMC runs
- In the file system of an FTP server to which you have access

The "ins-file" contains a mapping of the location of installation data in the file system of the CD-ROM or FTP server and the memory locations where the data is to be copied.

The following description is based on accessing the SE remotely from an HMC. If you are working directly from an SE, skip step 4.

1. Click the Groups icon in the "Views" area of the HMC to display the "Groups Work Area" (Figure 71 on page 357).

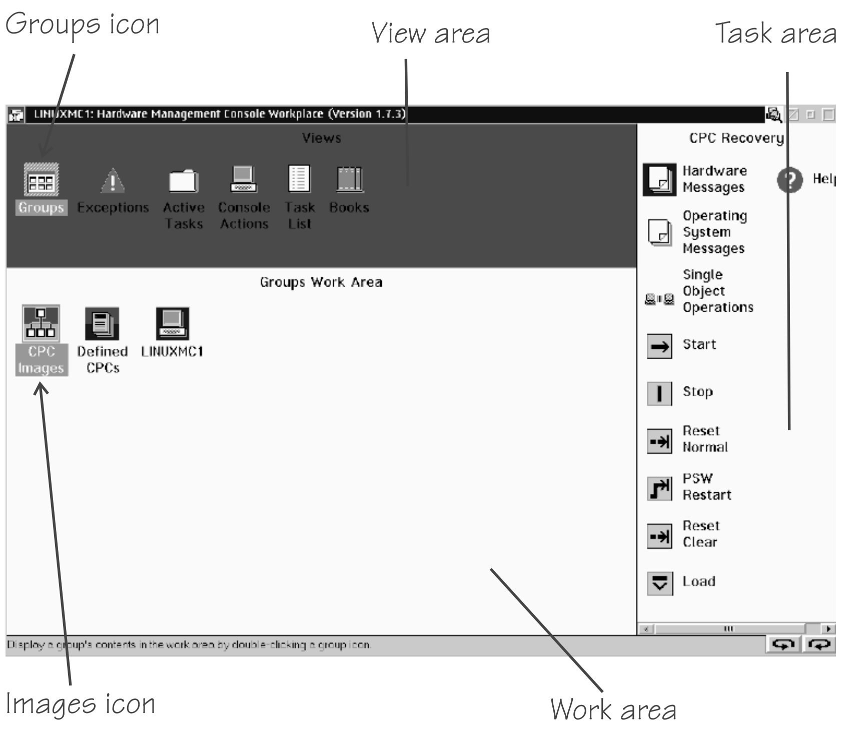


Figure 71. Groups Work Area on the HMC

2. Click the Images icon in the “Groups Work Area” to display the “Defined CPCs Work Area” with all defined images (Figure 72).

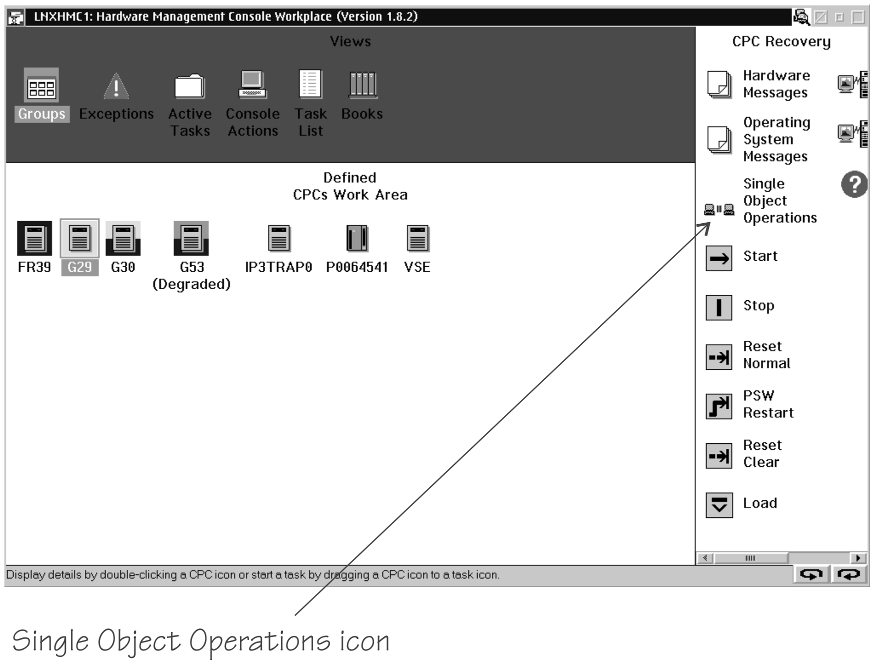
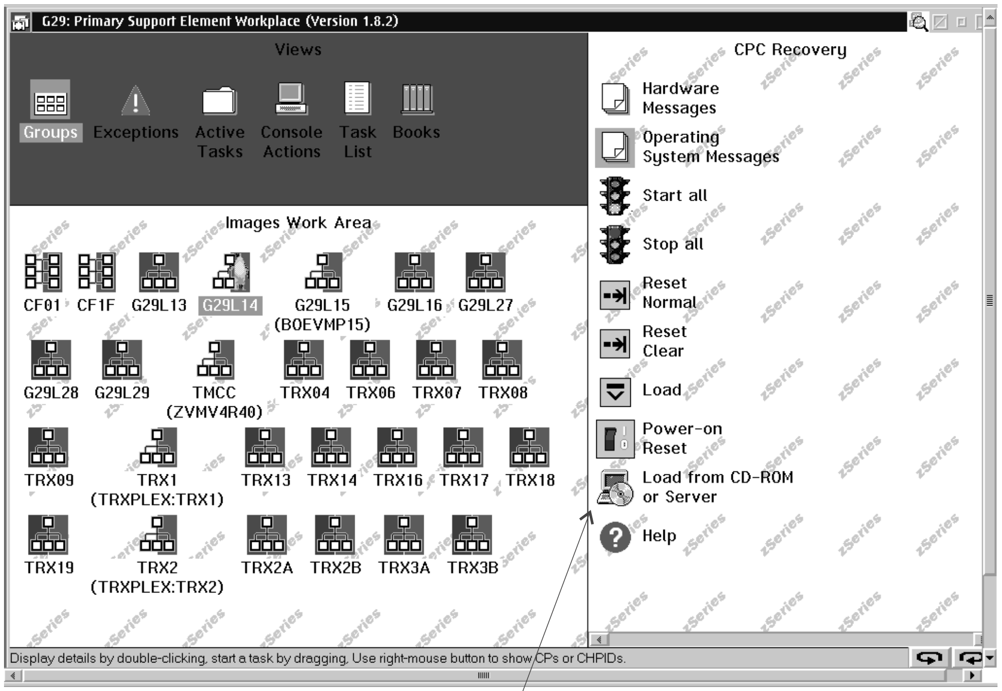


Figure 72. Defined CPCs Work Area on the HMC

3. Select the image you want to IPL.
4. If you are working from an HMC, click the “Single Object Operation” icon (Figure 72). This gives you remote access to the SE that controls the image (Figure 73 on page 358).

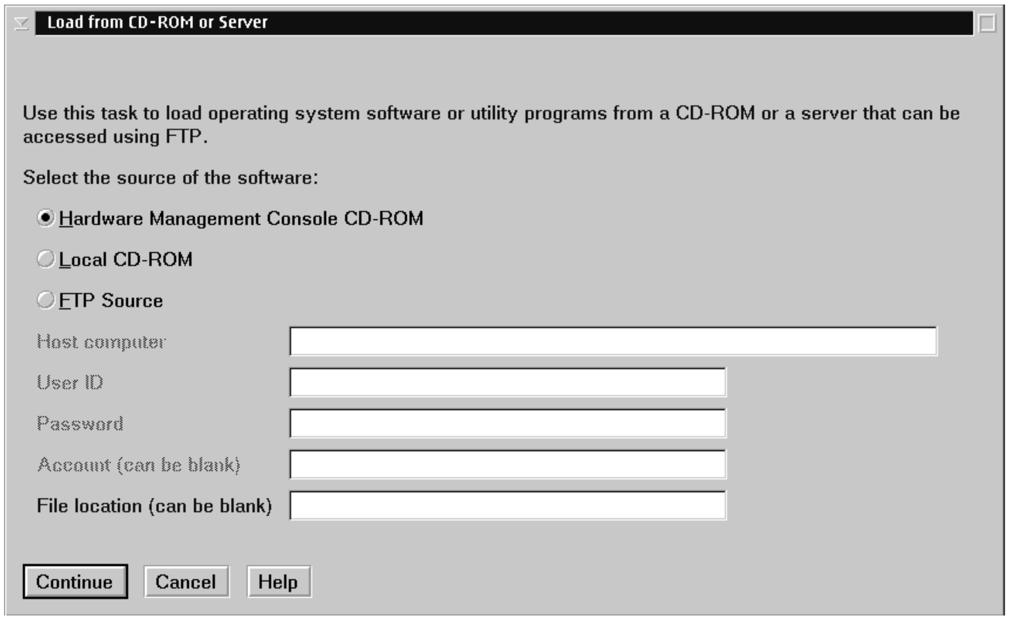
Skip this step if you are working directly form the SE.



Display details by double-clicking, start a task by dragging. Use right-mouse button to show CPs or CHPIDs.

Figure 73. Images Work Area on the SE

5. Click the “Load from CD-ROM or Server” icon in the Task Area to display the “Load from CD-ROM or Server” panel (Figure 74).



Use this task to load operating system software or utility programs from a CD-ROM or a server that can be accessed using FTP.

Select the source of the software:

● Hardware Management Console CD-ROM

○ Local CD-ROM

○ FTP Source

Host computer	
User ID	
Password	
Account (can be blank)	
File location (can be blank)	

Figure 74. Load from CD-ROM or Server panel

6. Specify the source of the code to be loaded.

   For loading from a CD-ROM drive:

a. Select the radio button for the CD-ROM you want to use. Select either of:
   - **Hardware Management Console CD-ROM** for the CD-ROM drive on the system where the HMC runs
   - **Local CD-ROM** for the SE's CD-ROM drive

   The CD-ROM drive for the HMC is not available if you are working directly from the SE.

b. Type the path for the directory where the "ins-file" resides in the **File location** field. You can leave this field blank if the "ins-file" is located in the root directory of the file system on the CD-ROM.

For loading from an FTP server:

a. Select the **FTP Source** radio button.

b. Type the IP address or host name of the FTP server where the install code resides in the **Host computer** entry field.

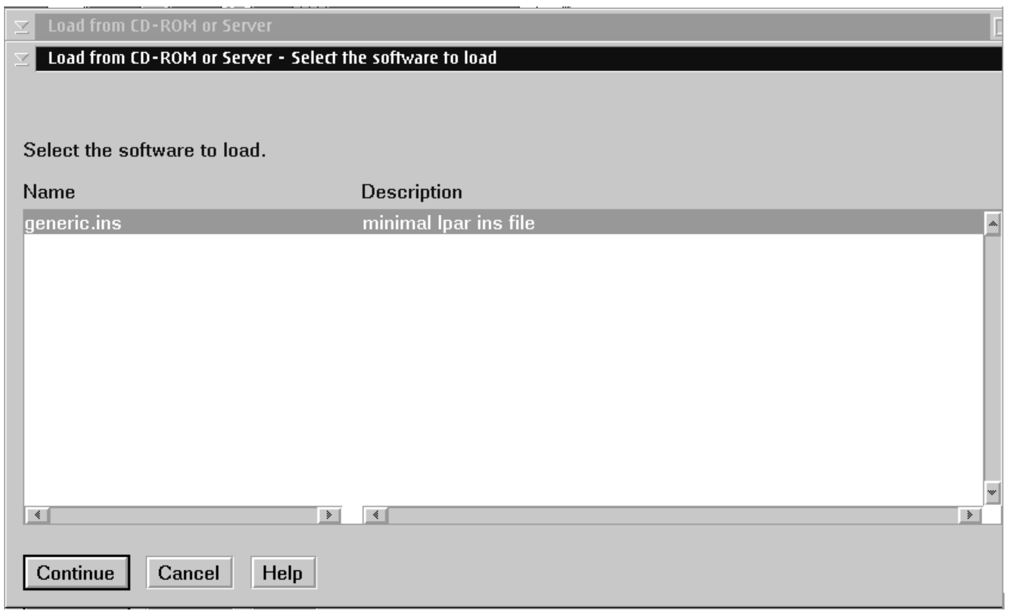
c. Type your user ID for the FTP server in the **User ID** entry field.

d. Type your password for the FTP server in the **Password** entry field.

e. If required by your FTP server, type your account information in the **Account** entry field.

f. Type the path for the directory where the "ins-file" resides in the file location entry field. You can leave this field blank if the file resides in the FTP server's root directory.

7. Click **Continue** to display the "Select the software to load" panel (Figure 75).


Load from CD-ROM or Server

Load from CD-ROM or Server - Select the software to load

Select the software to load.

Name	Description
generic.ins	minimal lpar ins file

Figure 75. Select the software to load panel

8. Select the "ins-file" to be used.
9. Click **Continue** to start loading Linux.
10. When the load process has completed click the PSW Restart icon.

At this point distribution-specific configuration scripts take over, if present.

Glossary

This glossary includes IBM product terminology as well as selected other terms and definitions. Additional information can be obtained in:

- The American National Standard Dictionary for Information Systems , ANSI X3.172-1990, copyright 1990 by the American National Standards Institute (ANSI). Copies may be purchased from the American National Standards Institute, 11 West 42nd Street, New York, New York 10036.
- The ANSI/EIA Standard–440-A, Fiber Optic Terminology. Copies may be purchased from the Electronic Industries Association, 2001 Pennsylvania Avenue, N.W., Washington, DC 20006.
- The Information Technology Vocabulary developed by Subcommittee 1, Joint Technical Committee 1, of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC1/SC1).
- The IBM Dictionary of Computing , New York: McGraw-Hill, 1994.
- Internet Request for Comments: 1208, Glossary of Networking Terms
- Internet Request for Comments: 1392, Internet Users' Glossary
- The Object-Oriented Interface Design: IBM Common User Access® Guidelines , Carmel, Indiana: Que, 1992.

Numerics

| **10 Gigabit Ethernet.** An Ethernet network with a
| bandwidth of 10000-Mbps.

3215. IBM console printer-keyboard.

3270. IBM information display system.

3370, 3380 or 3390. IBM direct access storage device (disk).

3480, 3490, 3590. IBM magnetic tape subsystem.

9336 or 9345. IBM direct access storage device (disk).

A

asynchronous transfer mode (ATM). A transfer mode in which the information is organized into cells; it is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic. ATM is specified in international standards such as ATM Forum UNI 3.1.

auto-detection. Listing the addresses of devices attached to a card by issuing a query command to the card.

C

cdl. compatible disk layout. A disk structure for Linux for zSeries and S/390 which allows access from other zSeries and S/390 operating systems. This replaces the older **ldl**.

CEC. (Central Electronics Complex). A synonym for *CPC*.

channel subsystem. The programmable input/output processors of the zSeries and S/390, which operate in parallel with the cpu.

checksum. An error detection method using a check byte appended to message data

CHPID. channel path identifier. In a channel subsystem, a value assigned to each installed channel path of the system that uniquely identifies that path to the system.

CPC. (Central Processor Complex). A physical collection of hardware that includes main storage, one or more central processors, timers, and channels. Also referred to as a *CEC*.

CRC. cyclic redundancy check. A system of error checking performed at both the sending and receiving station after a block-check character has been accumulated.

CSMA/CD. carrier sense multiple access with collision detection

CTC. channel to channel. A method of connecting two computing devices.

CUU. control unit and unit address. A form of addressing for zSeries and S/390 devices using device numbers.

D

DASD. direct access storage device. A mass storage medium on which a computer stores data.

device driver. (1) A file that contains the code needed to use an attached device. (2) A program that enables a computer to communicate with a specific peripheral device; for example, a printer, a videodisc player, or a CD-ROM drive. (3) A collection of subroutines that control the interface between I/O device adapters and the processor.

E

ECKD. extended count-key-data device. A disk storage device that has a data transfer rate faster than some processors can utilize and that is connected to the processor through use of a speed matching buffer. A specialized channel program is needed to communicate with such a device.

ESCON. enterprise systems connection. A set of IBM products and services that provide a dynamically connected environment within an enterprise.

Ethernet. A 10-Mbps baseband local area network that allows multiple stations to access the transmission medium at will without prior coordination, avoids contention by using carrier sense and deference, and resolves contention by using collision detection and delayed retransmission. Ethernet uses CSMA/CD.

F

Fast Ethernet (FENET). Ethernet network with a bandwidth of 100 Mbps

FBA. fixed block architecture. A type of DASD on Multiprise 3000 or P/390 or emulated by VM.

FDDI. fiber distributed data interface. An American National Standards Institute (ANSI) standard for a 100-Mbps LAN using optical fiber cables.

FTP. file transfer protocol. In the Internet suite of protocols, an application layer protocol that uses TCP and Telnet services to transfer bulk-data files between machines or hosts.

G

Gigabit Ethernet (GbE). An Ethernet network with a bandwidth of 1000-Mbps

G3, G4, G5 and G6. The generation names of the S/390 CMOS based product family.

H

hardware console. A service-call logical processor that is the communication feature between the main processor and the service processor.

Host Bus Adapter (HBA). An I/O controller that connects an external bus, such as a Fibre Channel, to the internal bus (channel subsystem).

HMC. hardware management console. A console used to monitor and control hardware such as the zSeries and S/390 microprocessors.

HFS. hierarchical file system. A system of arranging files into a tree structure of directories.

I

IOCS. input / output channel subsystem. See channel subsystem.

IP. internet protocol. In the Internet suite of protocols, a connectionless protocol that routes data through a network or interconnected networks and acts as an intermediary between the higher protocol layers and the physical network.

IP address. The unique 32-bit address that specifies the location of each device or workstation on the Internet. For example, 9.67.97.103 is an IP address.

IPIP. IPv4 in IPv4 tunnel, used to transport IPv4 packets in other IPv4 packets.

IPL. initial program load (or boot). (1) The initialization procedure that causes an operating system to commence operation. (2) The process by which a configuration image is loaded into storage at the beginning of a work day or after a system malfunction. (3) The process of loading system programs and preparing a system to run jobs.

IPv6. IP version 6. The next generation of the Internet Protocol.

IPX. Internetwork Packet Exchange. (1) The network protocol used to connect Novell servers, or any workstation or router that implements IPX, with other workstations. Although similar to the Internet Protocol (IP), IPX uses different packet formats and terminology.

IPX address. The 10-byte address, consisting of a 4-byte network number and a 6-byte node address, that is used to identify nodes in the IPX network. The node address is usually identical to the medium access control (MAC) address of the associated LAN adapter.

IUCV. inter-user communication vehicle. A VM facility for passing data between virtual machines and VM components.

K

kernel. The part of an operating system that performs basic functions such as allocating hardware resources.

kernel module. A dynamically loadable part of the kernel, such as a device driver or a file system.

kernel image. The kernel when loaded into memory.

L

LAN. local area network.

LCS. LAN channel station. A protocol used by OSA.

ldl. Linux disk layout. A basic disk structure for Linux for zSeries and S/390. Now replaced by `cdl`.

LDP. Linux Documentation Project. An attempt to provide a centralized location containing the source material for all open source Linux documentation. Includes user and reference guides, HOW TOs, and FAQs. The homepage of the Linux Documentation Project is **http://www.linuxdoc.org**

Linux. a variant of UNIX which runs on a wide range of machines from wristwatches through personal and small business machines to enterprise systems.

Linux for zSeries and S/390. the port of Linux to the IBM zSeries and S/390 architecture.

LPAR. logical partition of a zSeries or S/390.

LVS (Linux virtual server). Network sprayer software used to dispatch, for example, http requests to a set of Web servers to balance system load.

M

MAC. medium access control. In a LAN this is the sub-layer of the data link control layer that supports medium-dependent functions and uses the services of the physical layer to provide services to the logical link control (LLC) sub-layer. The MAC sub-layer includes the method of determining when a device has access to the transmission medium.

Mbps. million bits per second.

MIB (Management Information Base). (1) A collection of objects that can be accessed by means of a network management protocol. (2) A definition for management information that specifies the information available from a host or gateway and the operations allowed.

MTU. maximum transmission unit. The largest block which may be transmitted as a single unit.

Multicast. A protocol for the simultaneous distribution of data to a number of recipients, for example live video transmissions.

Multiprise. An enterprise server of the S/390 family.

N

NIC. network interface card. The physical interface between the zSeries or S/390 and the network.

O

OCO. Object-code only. A loadable module supplied by IBM without the associated source code.

OS. operating system. (1) Software that controls the execution of programs. An operating system may provide services such as resource allocation, scheduling, input/output control, and data management. (2) A set of programs that control how the system works. (3) The software that deals with the most basic operations that a computer performs.

OSA-2. Open Systems Adapter-2. A common zSeries and S/390 network interface feature

OSA-Express. Abbreviation for S/390 and zSeries Open Systems Adapter-Express networking features.
| These include 10 Gigabit Ethernet, Gigabit Ethernet, Fast Ethernet, Token Ring, and ATM.

OSPF. open shortest path first. A function used in route optimization in networks.

P

POR. power-on reset

POSIX. Portable Operating System Interface for Computer Environments. An IEEE operating system standard closely related to the UNIX system.

R

router. A device or process which allows messages to pass between different networks.

S

S/390. The predecessor of the zSeries.

SA/SE. stand alone support element. See SE.

SE. support element. (1) An internal control element of a processor that assists in many of the processor operational functions. (2) A hardware unit that provides communications, monitoring, and diagnostic functions to a central processor complex.

SNA. systems network architecture. The IBM architecture that defines the logical structure, formats, protocols, and operational sequences for transmitting information units through, and controlling the configuration and operation of, networks. The layered structure of SNA allows the ultimate origins and destinations of information (the users) to be independent of and unaffected by the specific SNA network services and facilities that are used for information exchange.

SNMP (Simple Network Management Protocol). In the Internet suite of protocols, a network management protocol that is used to monitor routers and attached networks. SNMP is an application layer protocol. Information on devices managed is defined and stored in the application's Management Information Base (MIB).

Sysctl. system control programming manual control (frame). A means of dynamically changing certain Linux kernel parameters during operation.

T

TCP. transmission control protocol. A communications protocol used in the Internet and in any network that follows the Internet Engineering Task Force (IETF) standards for internetwork protocol. TCP provides a reliable host-to-host protocol between hosts in packet-switched communications networks and in interconnected systems of such networks. It uses the Internet Protocol (IP) as the underlying protocol.

TCP/IP. transmission control protocol/internet protocol. (1) The Transmission Control Protocol and the Internet Protocol, which together provide reliable end-to-end connections between applications over interconnected networks of different types. (2) The suite of transport and application protocols that run over the Internet Protocol.

Telnet. A member of the Internet suite of protocols which provides a remote terminal connection service. It allows users of one host to log on to a remote host and interact as if they were using a terminal directly attached to that host.

Token Ring. (1) According to IEEE 802.5, network technology that controls media access by passing a token (special packet or frame) between media-attached stations. (2) A FDDI or IEEE 802.5 network with a ring topology that passes tokens from one attaching ring station (node) to another.

U

UNIX. An operating system developed by Bell Laboratories that features multiprogramming in a multiuser environment. The UNIX operating system was originally developed for use on minicomputers but has been adapted for mainframes and microcomputers.

V

V=R. In VM, a guest whose real memory (virtual from a VM perspective) corresponds to the real memory of VM.

V=V. In VM, a guest whose real memory (virtual from a VM perspective) corresponds to virtual memory of VM.

Virtual LAN (VLAN). A group of devices on one ore more LANs that are configured (using management software) so that they can communicate as if they were attached to the same wire, when in fact they are located on a number of different LAN segments. Because VLANs are based on logical rather than physical connections, they are extremely flexible.

volume. A data carrier that is usually mounted and demounted as a unit, for example a tape cartridge or a disk pack. If a storage unit has no demountable packs the volume is the portion available to a single read/write mechanism.

Z

zSeries and S/390. The family of IBM enterprise servers that demonstrate outstanding reliability, availability, scalability, security, and capacity in today's network computing environments.

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Information Development
Department 3248
Schoenaicher Strasse 220
71032 Boeblingen
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