LILO
Generic boot loader for Linux
Version 0.10

User's guide

Werner Almesberger
almesber@bernina.ethz.ch

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LILO is a versatile boot loader for Linux. It does not depend on a specific file system, can boot Linux boot images and unstripped Linux kernels from floppy disks and from hard disks and can even boot other operating systems[1].

One of up to sixteen different boot images can be selected at boot time. Various parameters, such as the root device, can be set independently for each of them. LILO can even be used as the master boot record.

This document introduces the basics of disk organization and booting, continues with an overview of common boot techniques and finally describes installation and use of LILO in greater detail. The troubleshooting section at the end describes diagnostic messages and contains suggestions for most problems that have been observed in the past.

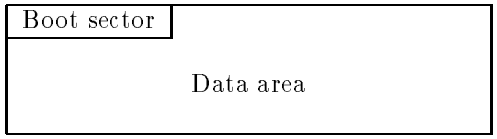
Please read the sections about installation and configuration if you're already using an older version of LILO. This distribution is accompanied by a file named `INCOMPAT` that describes further incompatibilities to older versions.

For the impatient: there is a quick-installation script that creates a simple but quite usable installation. See section 6.2 for details.

[1] PC/MS-DOS, DR DOS, OS/2, 386BSD, SCO UNIX, ...

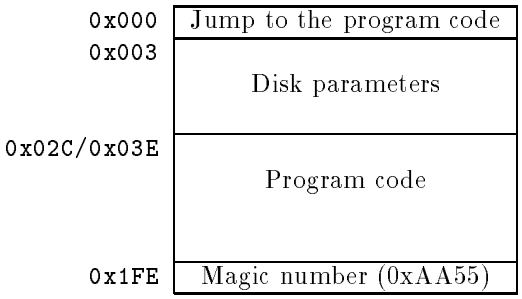
1 Disk organization

When designing a boot concept, it is important to understand all the subtleties of how MS-DOS organizes disks. The most simple case are floppy disks. They consist of a boot sector, some administrative data (FAT or super block, etc.) and the data area. Because that administrative data is irrelevant as far as booting is concerned, it is regarded as part of the data area for simplicity.



The entire disk appears as one device (i.e. `/dev/fd0`) on Linux.

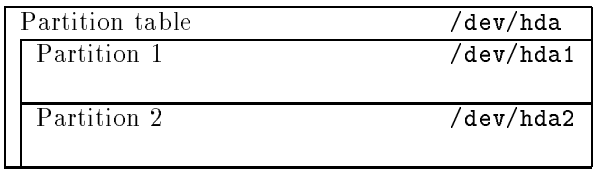
The MS-DOS boot sector has the following structure:



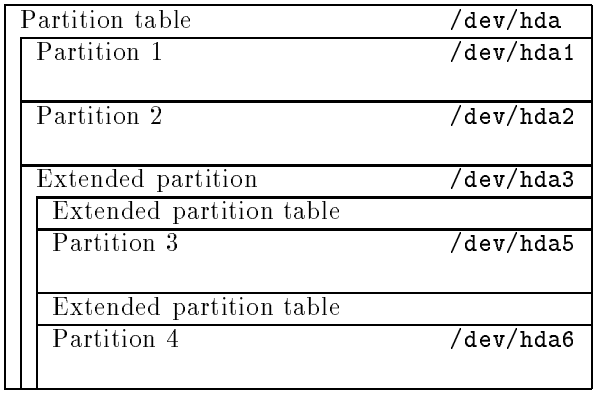
LILO uses a similar boot sector, but it does not contain the disk parameters part. This is no problem for Minix, EXT or similar file systems, because they don't look at the boot sector, but putting a LILO boot sector on an MS-DOS file system would make it inaccessible for MS-DOS.

Hard disks are organized in a more complex way than floppy disks. They contain several data areas called partitions. Up to four so-called primary partitions can exist on an MS-DOS hard disk. If more partitions are needed, a primary partition is used as an extended partition that contains several logical partitions.

The first sector of each hard disk contains a partition table and an extended partition and **each** logical partition contains a partition table too.



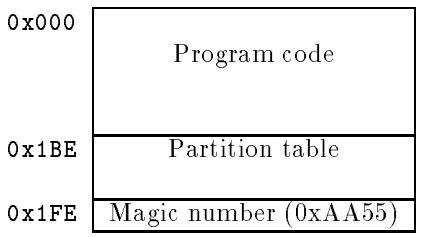
The entire disk can be accessed as `/dev/hda`, `/dev/hdb`, `/dev/sda`, etc. The primary partitions are `/dev/hda1` ... `/dev/hda4`.



This hard disk has two primary partitions and an extended partition that contains two logical partitions. They are accessed as `/dev/hda5` ...

Note that the partition tables of logical partitions are not accessible as the first blocks of some devices, while the main partition table, all boot sectors and the partition tables of extended partitions are.

Partition tables are stored in partition boot sectors. Normally, only the partition boot sector of the entire disk is used as a boot sector. It is also frequently called the master boot record (MBR).



The LILO boot sector is designed to be usable as a partition boot sector. (I.e. there is room for the partiton table.) Therefore, the LILO boot sector can be stored at the following locations:

- boot sector of a Linux floppy disk. (`/dev/fd0`, ...)
- MBR of the first hard disk. (`/dev/hda`, ...)
- boot sector of a primary Linux file system partition on the first hard disk. (`/dev/hda1`, ...)
- partition boot sector of an extended partition on the first hard disk. (`/dev/hda1`, ...)[2]

It **can't** be stored at any of the following locations:

- boot sector of a non-Linux floppy disk or primary partition.
- a Linux swap partition.
- boot sector of a logical partition in an extended partition.[3]
- on the second hard disk. (Unless for backup installations, if the current first disk will be removed or disabled, or if some other boot loader is used, that is capable of loading boot sectors from other drives.)

LILO typically doesn't detect attempts to put its boot sector at an invalid location.

[2] Most FDISK-type programs don't believe in booting from an extended partition and refuse to activate it. LILO is accompanied by a simple program (`activate`) that doesn't have this restriction.

[3] LILO can be forced to put the boot sector on such a partition by using the `-b` option or the `boot` variable. However, hardly any programs that operate as master boot records support booting from a logical partition.

2 Booting basics

When booting from a floppy disk, the first sector of the disk, the so-called boot sector, is loaded. That boot sector contains a small program that loads the respective operating system. MS-DOS boot sectors also contain a data area, where disk and file system parameters (cluster size, number of sectors, number of heads, etc.) are stored.

When booting from a hard disk, the very first sector of that disk, the so-called master boot record (MBR) is loaded. This sector contains a loader program and the partition table of the disk. The loader program usually loads the boot sector, as if the system was booting from a floppy.

Note that there is no functional difference between the MBR and the boot sector other than that the MBR contains the partition information but doesn't contain any (MS-DOS) disk parameter information.

The first 446 (0x1BE) bytes of the MBR are used by the loader program. They are followed by the partition table, with a length of 64 (0x40) bytes. The last two bytes contain a magic number that is sometimes used to verify that a given sector really is a boot sector.

There is a large number of possible boot configurations. The most common ones are described in the following sections.

2.1 MS-DOS alone

Master Boot Record	Boot sector	Operating system
DOS-MBR ⟶	**MS-DOS** ⟶	**COMMAND.COM**

This is what usually happens when MS-DOS boots from a hard disk: the DOS-MBR determines the active partition and loads the MS-DOS boot sector. This boot sector loads MS-DOS and finally passes control to `COMMAND.COM`. (This is greatly simplified.)

2.2 BOOTLIN

Master Boot Record	Boot sector	Operating systems	
DOS-MBR ⟶	**MS-DOS** ⟶	**COMMAND.COM**	
	⟶	**BOOTLIN** ⟶	**Linux**

A typical BOOTLIN setup: everything happens like when booting MS-DOS, but in `CONFIG.SYS` or `AUTOEXEC.BAT`, BOOTLIN is invoked. Typically, a program like `BOOT.SYS` is used to choose among configuration sections in `CONFIG.SYS` and `AUTOEXEC.BAT`. This approach has the pleasant property that no boot sectors have to be altered.

Installation:

- boot Linux.
- copy a bootable kernel image to your MS-DOS partition.[4]
- install `BOOT.SYS` and `BOOTLIN.SYS` on your MS-DOS partition and add them to your `CONFIG.SYS`. (The READMEs describe how this is done.)
- reboot.

Deinstallation:

- remove `BOOT.SYS` and `BOOTLIN.SYS` from your `CONFIG.SYS`.

[4] With Mtools or the MS-DOS FS.

2.3 LILO started by DOS-MBR

Master Boot Record	Boot sector	Operating system
DOS-MBR ⟶	**LILO** ⟶	**Linux**
⟶	other OS	

This is a "safe" LILO setup: LILO is booted by the DOS-MBR. No other boot sectors have to be touched. If the other OS (or one of them, if there are several other operating systems being used) should be booted without using LILO, the other partition has to be marked "active" with fdisk or activate.

Installation:

- install LILO with its boot sector on the Linux partition.
- use fdisk or activate to make that partition active.
- reboot.

Deinstallation:

- make a different partition active.
- install whatever should replace LILO or Linux.

2.4 Several alternate branches

Master Boot Record	Boot sector	Operating systems	
DOS-MBR ⟶	**MS-DOS** ⟶	**COMMAND.COM**	
	⟶	**BOOTLIN** ⟶	**Linux**
⟶	**LILO** ⟶	**Linux**	
	⟶	**MS-DOS** ⟶ ···	

An extended form of the above setup: the MBR is not changed and both branches can either boot Linux or MS-DOS. (LILO could also boot any other operating system.)

2.5 LILO started by BOOTACTV

Master Boot Record	Boot sector	Operating system
BOOTACTV ⟶	**LILO** ⟶	**Linux**
⟶	other OS	

Here, the MBR is replaced by BOOTACTV (or any other interactive boot partition selector) and the choice between Linux and the other operating system(s) can be made at boot time. This approach should be used if LILO fails to boot the other operating system(s).[5]

Installation:

- boot Linux.
- make a backup copy of your MBR on a floppy disk, e.g.
  `dd if=/dev/hda of=/fd/MBR bs=512 count=1`
- install LILO with the boot sector on the Linux partition.

[5] And the author would like to be notified if booting the other operating system(s) doesn't work with LILO, but if it works with an other boot partition selector.

- install BOOTACTV as the MBR, e.g.
  `dd if=bootactv.bin of=/dev/hda bs=446 count=1`
- reboot.

Deinstallation:

- boot Linux.
- restore the old MBR, e.g.
  `dd if=/MBR of=/dev/hda bs=446 count=1`

If replacing the MBR appears undesirable and if a second Linux partition exists (e.g. `/usr`, **not** a swap partition), BOOTACTV can be merged with the partition table and stored as the "boot sector" of that partition. Then, the partition can be marked active to be booted by the DOS-MBR.

Example:

```
# dd if=/dev/hda of=/dev/hda3 bs=512 count=1
# dd if=bootactv.bin of=/dev/hda3 bs=446 count=1
```

Warning: whenever the disk is re-partitioned, the merged boot sector on that "spare" Linux partition has to be updated too.

2.6 LILO alone

Master Boot Record	Operating system
LILO ——————→	**Linux**
——→	other OS

LILO can also take over the entire boot procedure. If installed as the MBR, LILO is responsible for either booting Linux or any other OS. This approach has the disadvantage, that the old MBR is overwritten and has to be restored (either from a backup copy, with `FDISK /MBR` on MS-DOS 5.0 or by overwriting it with BOOTACTV) if Linux should ever be removed from the system.

You should verify that LILO is able to boot your other operating system(s) before relying on this method.

Installation:

- boot Linux.
- make a backup copy of your MBR on a floppy disk, e.g.
  `dd if=/dev/hda of=/fd/MBR bs=512 count=1`
- install LILO with its boot sector as the MBR.
- reboot.

Deinstallation:

- boot Linux.
- restore the old MBR, e.g.
  `dd if=/fd/MBR of=/dev/hda bs=446 count=1`

If you've installed LILO to be the master boot record, you have to explicitly specify the boot sector (configuration variable `boot=...`) when updating the map. Otherwise, it will try to use the boot sector of your current root partition, which may even work, but will leave your system unbootable.

2.7 Names

The following names have been used to describe boot sectors or parts of operating systems:

DOS-MBR is the original MS-DOS MBR. It scans the partition table for a partition that is marked "active" and loads the boot sector of that partition. Programs like MS-DOS' FDISK, Linux fdisk or activate (accompanies LILO) can change the active marker in the partition table.

MS-DOS denotes the MS-DOS boot sector that loads the other parts of the system (`IO.SYS`, etc.).

COMMAND.COM is the standard command interpreter of MS-DOS.

BOOTLIN is a program that loads a Linux boot image from an MS-DOS partition into memory and executes it. It is usually invoked from `CONFIG.SYS` and used in combination with a `CONFIG.SYS` configuration switcher, like BOOT.SYS.[6]

LILO can either load a Linux kernel or the boot sector of any other operating system. It has a first stage boot sector that loads the remaining parts of LILO from various locations.

BOOTACTV permits interactive selection of the partition from which the boot sector should be read. If no key is pressed within a given interval, the partition marked active is booted. BOOTACTV is included in the pfdisk package. There are also several similar programs, like PBOOT and OS-BS.[7]

[6] BOOTLIN is available for anonymous FTP from
`tsx-11.mit.edu:/pub/linux/INSTALL/dos_utils/bootlin4.zip` or
`nic.funet.fi:/pub/OS/Linux/tools/bootlin.zip`,
BOOT.SYS is available for anonymous FTP from
`sunsite.unc.edu:/pub/Linux/system/Linux-boot/boot142.zip`,
`nic.funet.fi:/pub/OS/Linux/tools/boot142.zip` or
`wuarchive.wustl.edu:/mirrors/msdos/sysutl/boot142.zip`.

[7] pfdisk is available for anonymous FTP from
`sunsite.unc.edu:/pub/Linux/utils/disk-management/pfdisk.tar.Z` or
`nic.funet.fi:/pub/OS/Linux/tools/pfdisk.tar.Z`.
PBOOT can be found at the same sites in
`tsx-11.mit.edu:/pub/linux/INSTALL/dos_utils/pboot.zip` and
`nic.funet.fi:/pub/OS/Linux/tools/pboot.zip`.

3 Choosing the "right" boot concept

Although LILO can be installed in many different ways, the choice is usually limited by the present setup and therefore, typically only a small number of configurations which fit naturally into an existing system remains.

The configuration file `/etc/lilo/config` for the examples could look like this:

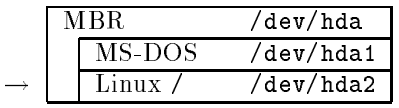
```
compact
boot = /dev/hda2
install = /etc/lilo/boot.b
image = /linux
image = /linux.backup
other = /dev/hda1
  table = /dev/hda
  label = msdos
```

It installs a traditional Linux boot image (`/linux`), an alternate traditional Linux boot image (`/linux.backup`) and a chain loader to boot MS-DOS from `/dev/hda1`.

In all examples, the names of the AT-type hard disk devices (`/dev/hda...`) are used. Everything applies to SCSI disks (`/dev/sda...`) too.

3.1 One disk, Linux on a primary partition

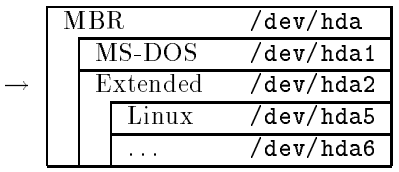
If at least one primary partition of the first hard disk is used as a Linux file system (`/`, `/usr`, etc. but **not** as a swap partition), the LILO boot sector should be stored on that partition and it should be booted by the original master boot record or by a program like BOOTACTV.



In this example, the `boot` variable could be omitted, because the boot sector is on the root partition.

3.2 One disk, Linux on a logical partition

If no primary partition is available for Linux, but at least one logical partition of an extended partition on the first hard disk contains a Linux file system, the LILO boot sector should be stored in the partition sector of the extended partition and it should be booted by the original master boot record or by a program like BOOTACTV.



Because many disk partitioning programs refuse to make an extended partition (in our example `/dev/hda2`) active, you might have to use `activate`, which comes with the LILO distribution.

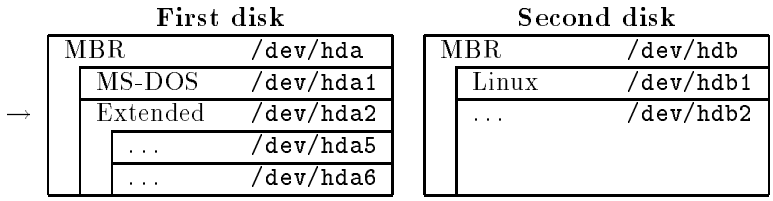
3.3 Two disks, Linux (at least partially) on the first disk

This case is equivalent to the configurations where only one disk is in the system. The Linux boot sector resides on the first hard disk and the second disk is used later.

Only the location of the boot sector matters – everything else (`/etc/lilo/boot.b`, `/etc/lilo/map`, the root file system, a swap partition, other Linux file systems, etc.) can be located anywhere on the second disk.

3.4 Two disks, Linux on the second disk, the first disk has an extended partition

If there is no Linux partition on the first disk, but there is an extended partition, the LILO boot sector can be stored in the partition sector of the extended partition and it should be booted by the original master boot record or by a program like BOOTACTV.

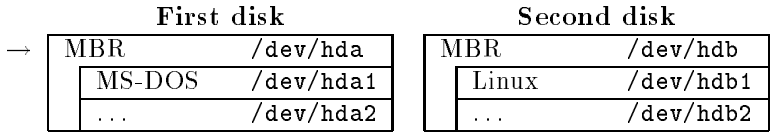


The program activate, that accompanies LILO, has to be used to set the active marker on an extended partition, because MS-DOS' FDISK and fdisk refuse to do that. (Which is generally a good idea.)

3.5 Two disks, Linux on the second disk, the first disk has no extended partition

If there is neither a Linux partition nor an extended partition on the first disk, where a LILO boot sector could be stored, then there's only one place left: the master boot record.

In this configuration, LILO is responsible for booting all other operating systems too.



You should back up your old MBR before installing LILO and verify that LILO is able to boot your other operating system(s) before relying on this approach.

The line `boot = /dev/hda2` in `/etc/lilo/config` would have to be changed to `boot = /dev/hda` in this example.

4 The boot prompt

Immediately after it's loaded, LILO checks, whether one of the following is happening:

- any of the [Shift], [Control] or [Alt] keys is being pressed.
- [CapsLock] or [ScrollLock] is set.

If this is the case, LILO displays the `boot:` prompt and waits for the name of a boot image. Otherwise, it boots the default boot image[8] or – if a delay has been specified – waits for one of the listed activities until that amount of time has passed.

At the boot prompt, the name of the image to boot can be entered. Typing errors can be corrected with [BackSpace], [Delete], [Ctrl U] and [Ctrl X]. A list of known images can be obtained by pressing [?] (on the US keyboard) or [Tab].

If [Enter] is pressed and no file name has been entered, the default image is booted.

LILO is also able to pass command-line options to the kernel. Command-line options are words that follow the name of the boot image and that are separated by spaces. Currently, the kernel recognizes the options `root=`*device*, `ro` and `rw`, and all current init programs also recognize the option `single`. The option `vga` is processed by the boot loader itself.

`single` boots the system in single-user mode. This bypasses all system initialization procedures and directly starts a root shell on the console. Multi-user mode can be entered by exiting the single-user shell or by rebooting.

`root=`*device* changes the root device. This overrides settings that may have been made in the boot image and on the LILO command line. *device* is the hexadecimal device number.[9]

`ro` instructs the kernel to mount the root file system read-only. `rw` mounts it read-write. If neither `ro` nor `rw` is specified, the setting from the boot image is used.

`vga=`*mode* alters the VGA mode set at startup. The values `normal`, `extended`, `ask` or a decimal number are recognized. (See also page 15.)

Other options of the type *variable*`=`*value* than `root` and `vga` cause the respective variables to be set in the environment passed to init. The case of the variable name is preserved. (I.e. it's not automatically converted to upper case.)

Example:

```
boot: linux single root=200
```

LILO always passes the string "`BOOT_IMAGE=`*name*" to the kernel, where *name* is the name by which the kernel is identified (e.g. the label). This variable can be used in `/etc/rc` to select different behaviour, depending on the kernel.

When booting automatically, the word "`auto`" is also passed on the command line. This can be used by init to suppress interactive prompts in the boot phase.

The details of selecting the boot image are somewhat complicated. The following tables illustrate them. First, if neither `prompt` is set nor a shift key is being pressed:

[8] The default boot image is either the first boot image or the image that has been selected at the boot prompt.

[9] This is a list of device numbers of some frequently used devices:

/dev/fd0	200	/dev/hda1	301	/dev/sda1	801
/dev/fd1	201	/dev/hda2	302	/dev/sda2	802
...		...		...	
		/dev/hdb1	341	/dev/sdb1	811
		/dev/hdb2	342	/dev/sdb2	812
		...		...	

Externally provided cmd. line	Command line in map file	Auto-matic boot	Booted image
No	No	Yes	Default image
Yes	—	Yes	Specified by external command line
No	Yes	Yes	Specified by command line in map file

If `prompt` is not set and a shift key is being pressed:

Input timeout	Empty cmd.l.	Extern. cmd.l.	Cmd.l. in map file	Auto-matic boot	Booted image
No	No	—	—	No	Specified by the user
No	Yes	—	—	No	Default image
Yes	n/a	—	—	Yes	Default image

Finally, if the configuration variable `prompt` is set:

Input timeout	Empty cmd.l.	Extern. cmd.l.	Cmd.l. in map file	Auto-matic boot	Booted image
No	No	No	No	No	Specified by the user
No	Yes	No	No	No	Default image
Yes	n/a	No	No	Yes	Default image
n/a	n/a	Yes	—	Yes	Specified by external command line
n/a	n/a	No	Yes	Yes	Specified by command line in map file

The default image is typically the first image in the map file. However, after an unsuccessful boot attempt, the respective image becomes the default image.

5 Map installer

The map installer program `/etc/lilo/lilo` updates the boot sector and creates the map file. It is usually run by `/etc/lilo/install`, which is typically a link to `lilo` or a shell script. If the map installer detects an error, it terminates immediately and does not touch the boot sector and the map file.

Whenever the map installer updates a boot sector, the original boot sector is copied to `/etc/lilo/boot.`*number*, where *number* is the hexadecimal device number. If such a file already exists, no backup copy is made. Similarly, a file `/etc/lilo/part.`*number* is created if LILO modifies the partition table. (See page 15.)

5.1 Command-line arguments

The LILO map installer accepts the following command-line options:

`-C` *config_file*
: Specifies the configuration file that is used by the map installer (see section 5.2). If `-C` is omitted, `/etc/lilo/config` is used.

`-I` *name* [*options*]
: Translates the specified label name to the path of the corresponding kernel image and prints that path on standard output. This can be used to rebuild files that depend on the kernel (e.g. the `ps` database). The image name can be obtained from the environment variable `BOOT_IMAGE`. An error message is issued and a non-zero exit code is returned if no matching label name can be found. If an options argument is present, the following characters specify additional filtering:

  `i` only traditional boot images are found.

  `c` only compound unstripped kernels are found.

  The existence of the image file is verified if the character `v` is added.

`-q`
: Lists the currently mapped files.

`-r` *root_directory*
: Chroots to the specified directory before doing anything else. This is useful when running the map installer while the normal root file system is mounted somewhere else, e.g. when recovering from an installation failure with a bootimage/rootimage. The `-r` option is implied if the environment variable `ROOT` is set.[10] The current directory is changed to the new root directory, so using relative paths may not work.

`-R` *word* ...
: Stores the specified words in the map file. The boot loader uses those words as the default command line when booting the next time. That command line is removed from the map file by the boot loader by overwriting the sector immediately after reading it. The first word has to be the name of a boot image. If `-R` is not followed by any words, the current default command line in the map file is erased.[11] An error message is issued and a non-zero exit code is returned if the command line is not accepted.

`-t`
: Test only. This performs the entire installation procedure except replacing the map file and writing

[10] I.e. if your root partition is mounted on `/mnt`, you can update the map by simply running `ROOT=/mnt /mnt/etc/lilo/install`.

[11] `-R` is typically used in reboot scripts, e.g.

```
#!/bin/sh
if /etc/lilo/install -R "$*"; then
    echo | shutdown -r now
fi
```

the modified boot sector. This can be used in conjunction with the `-v` option to verify that LILO will use sane values.

There are also many command-line options that correspond to configuration variables. See section 5.2 for a description.

Command-line option	Configuration variable
`-b` *boot_device*	`boot=`*boot_device*
`-c`	`compact`
`-d` *tsecs*	`delay=`*tsecs*
`-i` *boot_sector*	`install=`*boot_sector*
`-f` *disktab_file*	`disktab=`*disktab_file*
`-l`	`linear`
`-m` *map_file*	`map=`*map_file*
`-P fix`	`fix-table`
`-P ignore`	`ignore-table`
`-s` *backup_file*	`backup=`*backup_file*
`-S` *backup_file*	`force-backup=`*backup_file*
`-v` ...	`verbose=`*level*

The image files can reside on any media that is accessible at boot time. There's no need to put them on the root device, although this certainly doesn't hurt.

5.2 Configuration

`/etc/lilo/install` is invoked to install or update the boot sector and LILO's map file. It is typically a symbolic link to `lilo`, but if special actions are necessary, a shell script like
`$ROOT/etc/lilo/lilo $*`
can be used too.

The configuration information is stored in the file `/etc/lilo/config` and consists of variable assignments. The following syntax rules apply:

- flag variables consist of a single word and are followed by whitespace or the end of the file.
- string variables consist of the variable name, optional whitespace, an equal sign, optional whitespace, the value and required whitespace or the end of the file.
- a non-empty sequence of blanks, tabs, newlines and comments counts as whitespace.
- variable names are case-insensitive. Values are usually case-sensitive, but there are a few exceptions. (See below.)
- tabs and newlines are special characters and may not be part of a variable name or a value. The use of other control characters and non-ASCII characters is discouraged.
- blanks and equal signs may only be part of a variable name or a value if they are escaped by a backslash. An equal sign may not be the only character in a name or value.
- an escaped tab is converted to an escaped blank. An escaped newline is removed from the input stream. An escaped backslash (i.e. two backslashes) is converted to a backslash.
- comments begin with a number sign and end with the next newline. All characters (including backslashes) until the newline are ignored.

`/etc/lilo/config` begins with a possibly empty options section. Most options can also be set from the command line, but storing permanent options in the configuration file is more convenient. The following options are recognized:

`boot=`*boot_device* Sets the name of the device that contains the boot sector. If `boot` is omitted, the boot sector is read from (and possibly written to) the device that is currently mounted as root.

`compact` Tries to merge read requests for adjacent sectors into a single read request. This drastically reduces load time and keeps the map smaller. Using `compact` is especially recommended when booting from a floppy disk.

`delay=`*tsecs* Specifies the number of tenths of a second LILO should wait before booting the first image. This is useful on systems that immediately boot from the hard disk after enabling the keyboard. LILO doesn't wait if `delay` is omitted.

`linear` Generate linear sector addresses instead of sector/head/cylinder addresses. Linear addresses are translated at run time and do not depend on disk geometry. Note that boot disks, where `linear` is used, may not be portable.

`install=`*boot_sector* Install the specified file as the new boot sector. If `install` is omitted, the old boot sector is modified. `install` is usually a permanent part of the configuration.

`disktab=`*disktab_file* Specifies the name of the disk parameter table (see section 5.4). The map installer looks for `/etc/lilo/disktab` if `disktab` is omitted.

`map=`*map_file* Specifies the location of the map file. If `map` is omitted, a file `/etc/lilo/map` is used.

`message=`*message_file* specifies a file containing a message that is displayed before the boot prompt. No message is displayed when waiting for a shifting key after printing "LILO ". The **FF** character ([Ctrl L]) clears the local screen. The size of the message file is limited to 65535 bytes. The map file has to be rebuilt if the message file is changed or moved.

`verbose=`*level* Turns on lots of progress reporting. Higher numbers give more verbose output. If `-v` is additionally specified on the command line, *level* is increased accordingly.

`backup=`*backup_file* Copy the original boot sector to *backup_file* (which may also be a device, e.g. `/dev/null`) instead of `/etc/lilo/boot.`*number*

`force-backup=`*backup_file* Like `backup`, but overwrite an old backup copy if it exists. `backup=`*backup_file* is ignored if `force-backup` appears in the same configuration file.

`prompt` forces entering the boot prompt without expecting any prior key-presses. Unattended reboots are impossible if `prompt` is set and `timeout` isn't.

`timeout=`*tsecs* sets a timeout (in tenths of a second) for keyboard input. If no key is pressed for the specified time, the first image is automatically booted. Similarly, password input is aborted if the user is idle for too long. The default timeout is infinite.

`serial=`*parameters* enables control from a serial line. The specified serial port is initialized and LILO is accepting input from it and from the PC's keyboard. Sending a break on the serial line corresponds to pressing a shift key on the console in order to get LILO's attention. All boot images should be password-protected if the serial access is less secure than access to the console, e.g. if the line is connected to a modem. The parameter string has the following syntax:
port`,`*bps parity bits*
The components *bps*, *parity* and *bits* can be omitted. If a component is omitted, all following components have to be omitted too. Additionally, the comma has to be omitted if only the port number is specified.

port the number of the serial port, zero-based. 0 corresponds to `COM1` alias `/dev/ttyS0`, etc. All four ports can be used (if present).

bps the baud rate of the serial port. The following baud rates are supported: 110, 150, 300, 600, 1200, 2400, 4800 and 9600 bps. Default is 2400 bps.

parity the parity used on the serial line. LILO ignores input parity and strips the 8th bit. The following (upper or lower case) characters are used to describe the parity: `n` for no parity, `e` for even parity and `o` for odd parity.

bits the number of bits in a character. Only 7 and 8 bits are supported. Default is 8 if parity is "none", 7 if parity is "even" or "odd".

If `serial` is set, the value of `delay` is automatically raised to 20. Example: `serial=0,2400n8` initializes `COM1` with the default parameters.

`ignore-table` tells LILO to ignore corrupt partition tables.

`fix-table` allows LILO to adjust 3D addresses in partition tables. Each partition entry contains a 3D (sector/head/cylinder) and a linear address of the first and the last sector of the partition. If a partition is not track-aligned and if certain other operating systems (e.g. PC/MS-DOS or OS/2) are using the same disk, they may change the 3D address. LILO can store its boot sector only on partitions where both address types correspond. LILO re-adjusts incorrect 3D start addresses if `fix-table` is set.

WARNING: This does not guarantee that other operating systems may not attempt to reset the address later. It is also possible that this change has other, unexpected side-effects. The correct fix is to re-partition the drive with a program that does align partitions to tracks.

`password` sets a password for all images. (See below.)

`restricted` relaxes the password protection. (See below.)

`optional` makes all images optional. (See below.)

Additionally, the kernel configuration parameters `ramdisk`, `read-only`, `read-write`, `root` and `vga` can be set in the options section. They are used as defaults if they aren't specified in the configuration sections of the respective kernel images. See below for a description.

If the option `-q` is specified on the command line, the currently mapped files are listed. Otherwise, a new map is created for the images described in the configuration file `/etc/lilo/config` and they are registered in the boot sector.

Each image description begins with a special variable and is followed by optional variables. The following variables can be used for all image descriptions that describe a Linux kernel:

`ramdisk=`*size* specifies the size of the optional RAM disk. A value of zero indicates that no RAM disk should be created. If this variable is omitted, the RAM disk size that is configured into the boot image is used.

`read-only` specifies that the root file system should be mounted read-only. Typically, the system startup procedure re-mounts the root file system read-write later (e.g. after fsck'ing it).

`read-write` specifies that the root file system should be mounted read-write.

`root=`*root_device* specifies the device that should be mounted as root. If the special name `current` is used, the root device is set to the device on which the root file system is currently mounted. If the root has been changed with `-r`, the respective device is used. If the variable `root` is omitted, the root device setting that is contained in the boot image is used. It can be changed with the `rdev` program.

`vga=`*mode* specifies the VGA text mode that should be selected when booting. The following values are recognized (case is ignored):

`normal` select normal 80x25 text mode.

`extended` select 80x50 text mode. The word `extended` can be abbreviated to `ext`.

`ask` stop and ask for user input (at boot time). A system where this option is being used is unable to reboot automatically.

number use the corresponding text mode. A list of available modes can be obtained by booting with `vga=ask` and pressing [Enter].

If this variable is omitted, the VGA mode setting that is contained in the boot image is used. `rdev` supports manipulation of the VGA text mode setting in the boot image.

If one of `ramdisk`, `read-only`, `read-write`, `root`, or `vga` is omitted in the configuration file and the corresponding value in the boot image is changed, LILO will use the new value.

It is perfectly valid to use different settings for the same image, because LILO stores them in the image descriptors and not in the images themselves.

Example:

```
image = /linux
  label = lin-hd
  root = /dev/hda2
image = /linux
  label = lin-fd
  root = /dev/fd0
```

LILO uses the main file name (without its path) of each image specification to identify that image. A different name can be used by setting the variable `label` (see the example above). A different name for the same entry can be used by specifying the `alias=`*name* option.

Images are protected by a password if the variable `password` is set. If the variable `restricted` is set in addition to `password`, a password is only required to boot the respective image if parameters are specified on the command line (e.g. `single`). `password` and `restricted` can also be set in the options section to be the default password and password protection mode for all images.

If an image section contains the variable `optional` (or if that variable is set in the options section), the respective image is omitted if its main file is not available at map creation time. This is useful to specify test kernels that are not always present.

5.3 Boot image types

LILO can boot the following types of images:

- "traditional" boot images from a file.
- "traditional" boot images from a block device. (I.e. a floppy disk.)
- compound unstripped kernels.
- the boot sector of some other operating system.

The image type is determined by the name of the initial variable of the configuration section.

In the configuration sections of all boot images, the following variables are recognized: `alias`, `label` and `optional`.

In the configuration sections of all kernels (i.e. every boot image type except "other operating system"), the following variables are recognized: `password`, `ramdisk`, `read-only`, `read-write`, `restricted`, `root` and `vga`.

5.3.1 Booting "traditional" boot images from a file

The image is specified as follows: `image=`*name*

Example:

```
image = /linux
```

Compressed kernels are also booted like "traditional" boot images.

5.3.2 Booting "traditional" boot images from a device

The root device setting in the image is ignored.[12] The range of sectors that should be mapped, has to be specified. Either a range (*start*-*end*) or a start and a distance (*start*+*number*) have to be specified. *start* and *end* are zero based. If only the start if specified, only that sector is mapped.

The image is specified as follows: `image=`*device_name* Additionally, the `range` variable must be set.

Example:

```
image = /dev/fd0
  range = 1+512
```

5.3.3 Booting compound unstripped kernels

Compound unstripped kernels are similar to traditional boot images, but they still contain their symbol information. The order of the kernel proper, the setup code and the floppy boot sector is also different. This is described in more detail in the technical overview.

Compound kernels are generated with the `mkck` program. `mkck` is run in the top-level directory of the kernel source and writes the kernel to the file that has been specified on the command line. If no file has been specified, the file name `/linux` is used. `mkck` should be run by the kernel `Makefile`, e.g.

```
linux: $(CONFIGURE) Image
        if [ -f /linux ]; then mv /linux /linux.old; fi
        /etc/lilo/mkck
        /etc/lilo/install
```

The image is specified as follows: `compound=`*name*

Example:

```
compound = /linux
```

5.3.4 Booting a foreign operating system

LILO can even boot other operating systems, i.e. MS-DOS. To boot an other operating system, the name of a loader program, the device that contains the boot sector and the device that contains the partition table have to be specified.

The boot sector is merged with the partition table and stored in the map file.

Currently, the loaders `chain.b`, `os2_d.b` and `any_d.b` exist. `chain.b` simply starts the specified boot sector.[13] `os2_d.b` can boot OS/2 from the second hard disk. `any_d.b` installs a resident driver that swaps the first

[12] That device may not be available at the time LILO is installed and it is therefore impossible to read the settings from the image file.

[13] The boot sector is loaded by LILO's secondary boot loader before control is passed to the code of `chain.b`.

and the second hard disk drive. It can boot any operating system from the second hard disk, if it uses only the BIOS. This is known to work for PC/MS-DOS.

The image is specified as follows: `other=`*device_name*

The following additional variables are recognized: `loader`, `table` and `unsafe`.

`loader=`*chain_loader* specifies the chain loader that should be used. If it is omitted, `/etc/lilo/chain.b` is used.

`table=`*device* specifies the device that contains the partition table. LILO does not pass partition information to the booted operating system if this variable is omitted. (Some operating systems have other means to determine from which partition they have been booted. E.g. MS-DOS usually stores the geometry of the boot disk or partition in its boot sector.)

`unsafe` do not access the boot sector at map creation time. This disables some sanity checks. If the boot sector is on a fixed-format floppy disk device, using `unsafe` avoids the need to put a readable disk into the drive when running the map installer. `unsafe` and `table` are mutually incompatible.

Example:

```
other = /dev/hda2
  label = os2
  table = /dev/hda
```

5.4 Disk parameter table

For floppies, IDE disks (or MFM, RLL, ESDI, etc.) and most SCSI disks, LILO can obtain the disk geometry information from the kernel. Unfortunately, this is not possible with all SCSI adapters.[14] In such cases, LILO reports either the error
`geo_query_dev HDIO_GETGEO (dev 0x`*number*`)`
or
`Device 0x`*number*`: Got bad geometry` *sec/hd/cyl*

The file `/etc/lilo/disktab` is used to describe such disks. For each device (`/dev/sda` → 0x800, `/dev/sda1` → 0x801, etc.), the BIOS code and the disk geometry have to be specified, e.g.

```
# /etc/lilo/disktab  -  LILO disk parameter table
#
# This table contains disk parameters for SCSI disks and non-
# standard parameters of IDE disks. Parameters in disktab
# _always_ override auto-detected disk parameters.

# Dev.  BIOS    Secs/   Heads/  Cylin-  Part.
# num.  code    track   cylin.  ders    offset
#                                      (optional)

0x800   0x80    32      64      631     0       # /dev/sda
0x801   0x80    32      64      631     32      # /dev/sda1
0x802   0x80    32      64      631     204800  # /dev/sda2
```

Those parameters are just a random example from my system. However, many SCSI controllers re-map the drives to 32 sectors and 64 heads. The number of cylinders does not have to be exact, but it shouldn't be lower than the number of effectively available cylinders.

[14] The 0.99pl7 kernel provides geometry information for Adaptec AHA-1542 and AHA-1740, Future Domain TMC-1660, TMC-1670 and TMC-1680, UltraStor 14F and WD-7000 adapters.

Note that the device number and the BIOS code have to be specified as hexadecimal numbers with the "0x" prefix.

The disk geometry parameters can be obtained by booting MS-DOS and running the program `DPARAM.COM` with the hexadecimal BIOS code of the drive as its argument, e.g. `dparam 0x80` for the first hard disk. It displays the number of sectors per track, the number of heads per cylinder and the number of cylinders. All three numbers are one-based.

The partition offset is only necessary when using devices for which the kernel does not provide that information, e.g. CD-ROMs. The partition offset is counted in sectors and is zero-based.

Because many SCSI controllers don't support more than 1 GB when using the BIOS interface, LILO can't access files that are located beyond the 1 GB limit of large SCSI disks on such controllers and reports errors in these cases.

6 Installation and updates

6.1 Compatibility

The kernel header files have to be in `/usr/include/linux` and the kernel usually has to be configured by running `make config` before LILO can be compiled.

`/bin/sh` has to be a real bourne shell. `bash` is sufficiently compatible, but some `ksh` clones may cause problems.

Using command-line options that are handled by `init` usually requires a comparably new version of `init`. All currently available `init` packages typically support new features of LILO in the respective next release.

A file named `INCOMPAT` is included in the distribution. It describes incompatibilities to older versions of LILO and may also contain further compatibility notes.

6.2 Quick installation

If you want to install LILO on your hard disk and if you don't want to use all its features, you can use the quick installation script. Read `QuickInst` for details.

`QuickInst` can only be used for first-time installations or to entirely replace an existing installation, **not** to update or modify an existing installation of LILO. Be sure you've extracted LILO into a directory that doesn't contain any files of other LILO installations.

6.3 Normal first-time installation

First, you have to install the LILO files:

- extract all files from `lilo.`*version*`.tar.z` in a new directory.[15]
- configure the `Makefile` (see section 6.6)
- run `make` to compile and assemble all parts.
- run `make install` to copy all LILO files to `/etc/lilo`. `/etc/lilo` should now contain the following files: `any_d.b`, `boot.b`, `chain.b`, `disktab`, `lilo`, `mkck` and `os2_d.b`.

If you want to use LILO on a SCSI disk, you might have to determine the parameters of your SCSI disk(s) and put them into the file `/etc/lilo/disktab`. See section 5.4 for details. If you're using a disktab file, the next step is to test LILO with the boot sector on a floppy disk:

- insert a blank (but low-level formatted) floppy disk into `/dev/fd0`.
- cd to `/etc/lilo`
- run `echo image=`*kernel_image* `|`
  `./lilo -C - -b /dev/fd0 -i boot.b -v -v -v`[16]
- reboot. LILO should now load its boot loaders from the floppy disk and then continue loading the kernel from the hard disk.

[15] Don't use `/etc/lilo` for the LILO source. Standard installation procedures fail if the source is in the same directory as the production binaries.

[16] If you've already installed LILO on your system, you might not want to overwrite your old map file. Use the `-m` option to specify an alternate map file name.

Now, your have to decide, which boot concept you want to use. Let's assume you have a Linux partition on `/dev/hda2` and you want to install your LILO boot sector there. The DOS-MBR loads the LILO boot sector.

- get a working bootable rootimage. Verify that you can boot with this setup and that you can mount your Linux partition(s) with it.
- if the boot sector you want to overwrite with LILO is of any value (e.g. it's the MBR or if it contains a boot loader, you might want to use if you encounter problems with LILO), you should mount your rootimage and make a backup copy of your boot sector to a file on that floppy, e.g. `dd if=/dev/hda of=/fd/boot_sector bs=512 count=1`
- link `/etc/lilo/install` to `lilo`,[17], e.g.
  `cd /etc/lilo; ln -s lilo install`
  Then create the configuration file `/etc/lilo/config`, e.g.
  `install = /etc/lilo/boot.b`
  image specifications
  ...
  Be sure to use absolute paths for all files. Relative paths may cause unexpected behaviour when using the `-r` option.
- Now, you can check what LILO would do if you were about to install it on your hard disk:
  `/etc/lilo/install -v -v -v -t`
- If you need some additional boot utility (i.e. BOOTACTV), you should install that now.
- Run `/etc/lilo/install` to install LILO on your hard disk.
- If you have to change the active partition, use fdisk or activate to do that.
- Reboot.

6.4 LILO update

When updating to a new version of LILO, the initial steps are the same as for a first time installation: extract all files, configure the `Makefile`, run `make` to build the executables and run `make install` to move the files to `/etc/lilo`.

The old versions of `boot.b`, `chain.b`, etc. are automatically renamed to `boot.old`, `chain.old`, etc.. This is done to ensure that you can boot even if the installation procedure did not finish. `boot.old`, `chain.old`, etc. can be deleted after the map file is rebuilt.

Because the locations of `boot.b`, `chain.b`, etc. have changed and because the map file format may be different too, you have to update the boot sector and the map file. Run `/etc/lilo/install` to do this.

6.5 Kernel update

Whenever any of the kernel files that are accessed by LILO is moved or overwritten, the map has to be re-built.[18] Run `/etc/lilo/install` to do this.

The kernel has make targets "lilo" and "zlilo" that copy the kernel to `/vmlinux` or `/vmlinuz` and run `/etc/lilo/install`.

[17] If special actions are necessary at map creation time, a shell script can be used for `/etc/lilo/install`.

[18] It is advisable to keep a second, stable, boot image that can be booted if you forget to update the map after a change to your usual boot image.

6.6 Build-time configuration

Certain build-time parameters can be configured. They can either be edited in the top-level `Makefile` or they can be stored in a file `/etc/lilo/config.defines`. Settings in the `Makefile` are ignored if that file exists.

The following items can be configured:

`IGNORECASE` Makes image name matching case-insensitive, i.e. "linux" and "Linux" are identical. This option is enabled by default. Note that password matching is always case-sensitive.

`ONE_SHOT` Disables the command-line timeout (configuration variable `TIMEOUT`) if any key is pressed. This way, very short timeouts can be used if `PROMPT` is set. `ONE_SHOT` is disabled by default.

`READONLY` Disallows overwriting the default command line sector of the map file. This way, command lines set with `-R` stay in effect until they are explicitly removed. This option is disabled by default.

`/etc/lilo/config.defines` should be used if one wishes to make permanent configuration changes. The usual installation procedures don't touch that file. Example:

```
-DIGNORECASE -DONE_SHOT
```

7 Troubleshooting

All parts of LILO display some messages that can be used to diagnose problems.

7.1 Map installer errors

Most messages of the map installer (`/etc/lilo/lilo`) should be self-explanatory. Some messages that indicate common errors are listed below:

`Can't put the boot sector on logical partition` *number*
: An attempt has been made to put LILO's boot sector on the current root file system partition which is on a logical partition. This usually doesn't have the desired effect, because common MBRs can only boot primary partitions. This check can be bypassed by explicitly specifying the boot partition with the `-b` option or by setting the configuration variable `boot`.

`Device 0x`*number*`: Got bad geometry` *sec/hd/cyl*
: The device driver for your SCSI controller does not support geometry detection. You have to use an `/etc/lilo/disktab` file.

`Device 0x`*number*`: Invalid partition table, entry` *number*
: The 3D and linear addresses of the first sector of the specified partition don't correspond. This is typically caused by partitioning a disk with a program that doesn't align partitions to tracks and using PC/MS-DOS or OS/2 later on that disk. LILO can attempt to correct the problem, see page 15.

`First sector of` *device* `doesn't have a valid boot signature`
: The first sector of the specified device does not appear to be a valid boot sector. You might have confused the device name.[19]

`geo_comp_addr: Cylinder number is too big (`*number* $>$ `1023)`
: A file is located beyond the 1024th cylinder of a hard disk. LILO can't access such files, because the BIOS limits cylinder numbers to the range 0...1023. Try moving the file to a different place, preferably a partition that is entirely within the first 1024 cylinders of the disk.

`Hole found in map file (`*location*`)`
: The map installer is confused about the disk organization. Please report this error.

item `doesn't have a valid LILO signature`
: The specified item has been located, but is not part of LILO. If *item* is the first boot sector, you've probably forgotten to specify the `-i` option or the `install` variable to install the LILO boot sector.

item `has an invalid stage code (`*number*`)`
: The specified item has probably been corrupted. Try re-building LILO.

item `is version` *number*`. Expecting version` *number*`.`
: The specified entity is either too old or too new. Make sure all parts of LILO (map installer, boot loaders and chain loaders) are from the same distribution. If *item* is the first boot sector, you have to run the map installer with the `-i` option to update it.[20]

`Kernel` *name* `is too big`
: The kernel image (without the setup code) is bigger than 512 kbytes. LILO would overwrite itself when trying to load such a kernel. Try removing some unused drivers and compiling the kernel again.

[19] Because different partition programs may display the partitions in a different order, it is possible that what you think is your first partition isn't `/dev/hda1`, etc. A good method to verify the content of a partition is to try to mount it.

[20] The expected version number may be different from the version number of the LILO package.

`Partition entry not found`
: The partition from which an other operating system should be booted isn't listed in the specified partition table. This either means that an incorrect partition table has been specified or that you're trying to boot from a logical partition. The latter usually doesn't work. You can bypass this check by omitting the partition table specification (e.g. omitting the variable `table`).

`Sorry, don't know how to handle device` *number*
: LILO uses files that are located on a device for which there is no easy way to determine the disk geometry. Such devices have to be described in the file `/etc/lilo/disktab`.

7.2 LILO start message

When LILO loads itself, it displays the word "LILO". Each letter is printed before or after performing some specific action. If LILO fails at some point, the letters printed so far can be used to identify the problem. This is described in more detail in the technical overview.

(*nothing*) No part of LILO has been loaded. LILO either isn't installed or the partition on which its boot sector is located isn't active.

`L` The first stage boot loader has been loaded and started, but it can't load the second stage boot loader. This usually indicates a media failure or a geometry mismatch (e.g. bad parameters in `/etc/lilo/disktab`).

`LI` The first stage boot loader was able to load the second stage boot loader, but has failed to execute it. This can either be caused by a geometry mismatch or by moving `/etc/lilo/boot.b` without running the map installer.

`LIL` The second stage boot loader has been started, but it can't load the descriptor table from the map file. This is typically caused by a media failure or by a geometry mismatch.

`LIL?` The second stage boot loader has been loaded at an incorrect address. This is typically caused by a subtle geometry mismatch or by moving `/etc/lilo/boot.b` without running the map installer.

`LIL-` The descriptor table is corrupt. This can either be caused by a geometry mismatch or by moving `/etc/lilo/map` without running the map installer.

`LILO` All parts of LILO have been successfully loaded.

7.3 Disk error codes

If the BIOS signals an error when LILO is trying to load a boot image, the respective error code is displayed. The following BIOS error codes are known:

`0x00` *Internal error.* This code is generated by the sector read routine of the LILO boot loader whenever an internal inconsistency is detected. This might be caused by corrupt files, try re-building the map file.

`0x01` *Illegal command.* This shouldn't happen.

`0x02` *Address mark not found.* This usually indicates a media problem. Try again several times.

`0x03` *Write-protected disk.* This shouldn't happen.

`0x04` *Sector not found.* This typically indicates a geometry mismatch. If you're booting a raw-written disk image, verify whether it was created for disks with the same geometry as the one you're using. If you're booting from a SCSI disk, you should check, whether LILO has obtained correct geometry data from the kernel or whether the contents of your `/etc/lilo/disktab` file corresponds to the real disk geometry. (See section 5.4.)

`0x06` *Change line active.* This should be a transient error. Try booting a second time.

`0x08` *DMA overrun.* This shouldn't happen. Try booting again.

`0x09` *DMA attempt across 64k boundary.* This shouldn't happen. Try omitting the `-c` option and report this problem to the author.

`0x0C` *Invalid media.* This shouldn't happen and might be caused by a media error. Try booting again.

`0x10` *CRC error.* A media error has been detected. Try booting several times, running the map installer a second time (to put the map file at some other physical location or to write "good data" over the bad spot), mapping out the bad sectors/tracks and, if all else fails, replacing the media.

`0x20` *Controller error.* This shouldn't happen.

`0x40` *Seek failure.* This might be a media problem. Try booting again.

`0x80` *Disk timeout.* The disk or the drive isn't ready. Either the media is bad or the disk isn't spinning. If you're booting from a floppy, you might not have closed the drive door. Otherwise, trying to boot again might help.