LILO
Generic boot loader for Linux
Version 0.16

User's guide

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Contents

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

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

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

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 to create a simple but quite usable installation. See section 4.1.2 for details.

But wait ... here are a few easy rules that will help you avoiding most problems people experience with LILO:

- **Don't panic.** If something doesn't work, try to find out what is wrong, try to verify your assumption and only then attempt to fix it.
- Read the documentation. Especially if what the system does doesn't correspond to what you think it should do.
- Make sure you have an emergency boot disk, that you know how to use it, and that it is always kept up to date.
- Run `/sbin/lilo` **whenever** the kernel or any part of LILO, including its configuration file, has changed.
- If using LILO as the MBR, de-install it **before** performing a destructive upgrade and/or erasing your Linux partitions.
- Don't trust setup scripts. Always verify the `/etc/lilo.conf` they create before booting.
- If using a big disk, be prepared for inconveniences: you may have to use the `linear` option.

1 Introduction

The following sections describe how PCs boot in general and what has to be known when booting Linux and using LILO in particular.

1.1 Disk organization

When designing a boot concept, it is important to understand some of the subtleties of how PCs typically organize 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 (e.g. `/dev/fd0`) on Linux.

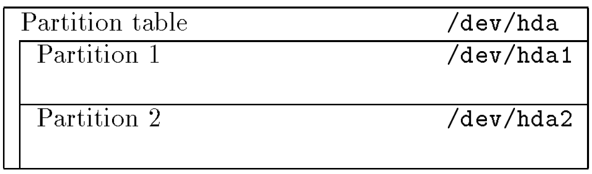
The MS-DOS boot sector has the following structure:

`0x000`	Jump to the program code
`0x003`	Disk parameters
`0x02C/0x03E`	Program code
`0x1FE`	Magic number (0xAA55)

LILO uses a similar boot sector, but it does not contain the disk parameters part. This is no problem for Minix, Ext2 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, one 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`.

Partition table	`/dev/hda`
Partition 1	`/dev/hda1`
Partition 2	`/dev/hda2`
Extended partition	`/dev/hda3`
Extended partition table	
Partition 3	`/dev/hda5`
Extended partition table	
Partition 4	`/dev/hda6`

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).

`0x000`	Program code
`0x1BE`	Partition table
`0x1FE`	Magic number (0xAA55)

The LILO boot sector is designed to be usable as a partition boot sector. (I.e. there is room for the partition 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. Linux `fdisk` also supports activating extended partitions.

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

1.2 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 file system-specific information (e.g. MS-DOS disk parameters).

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.

1.2.1 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.)

1.2.2 BOOTLIN[4]

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.

Please refer to the documentation accompanying the package for installation instructions and further details.

1.2.3 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:

[4] A more recent program called LOADLIN uses the same approach. Those who wish to use this method of booting are advised to use LOADLIN instead of BOOTLIN.

- 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.

1.2.4 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.)

1.2.5 LILO started by BOOTACTV[5]

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).[6]

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.
- 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`
  or `FDISK /MBR` under MS-DOS.

[5] Other, possibly better known boot switchers, e.g. OS/2 Bootmanager operate in a similar way. The installation procedures typically vary.

[6] 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.

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.

1.2.6 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 recent versions of MS-DOS or by overwriting it with something like 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 as 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 probably leave your system unbootable.

1.2.7 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" and "LOADLIN" are programs that load a Linux kernel image from an MS-DOS partition into memory and execute it. They are usually invoked from `CONFIG.SYS` and used in combination with a `CONFIG.SYS` configuration switcher, like BOOT.SYS.[7]

"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.[8]

"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.[9]

1.3 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.conf` for the examples could look like this:

```
boot = /dev/hda2
compact
image = /vmlinuz
image = /vmlinuz.old
other = /dev/hda1
  table = /dev/hda
  label = msdos
```

It installs a Linux kernel image (`/vmlinuz`), an alternate Linux kernel image (`/vmlinuz.old`) and a chain loader to boot MS-DOS from `/dev/hda1`. The option `compact` on the second line instructs the map installer to optimize loading.

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

1.3.1 BIOS restrictions

Nowadays, an increasing number of systems is equipped with comparably large disks or even with multiple disks. At the time the disk interface of the standard PC BIOS has been designed (about 15 years ago), such configurations were apparently considered to be too unlikely to be worth supporting.

The most common BIOS restrictions that affect LILO are the limitation to two hard disks and the inability to access more than 1024 cylinders per disk. LILO can detect both conditions, but in order to solve the underlying problems, manual intervention is necessary.

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[7] BOOTLIN is available for anonymous FTP from
`nic.funet.fi:/pub/OS/Linux/tools/bootlin.zip`
LOADLIN is available for anonymous FTP from
`sunsite.unc.edu:/pub/Linux/system/Linux-boot/lodlin15.tgz`
BOOT.SYS is available for anonymous FTP from
`sunsite.unc.edu:/pub/Linux/system/Linux-boot/boot142.zip` or
`nic.funet.fi:/pub/OS/Linux/tools/boot142.zip`

[8] LILO can be found in
`tsx-11.mit.edu:/pub/linux/packages/lilo/lilo.`*n*`.tar.gz`
`sunsite.unc.edu:/pub/Linux/system/Linux-boot/lilo/lilo.`*n*`.tar.gz`
`nic.funet.fi:/pub/OS/Linux/tools/lilo.`*n*`.tar.gz`

[9] 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 in
`nic.funet.fi:/pub/OS/Linux/tools/pboot.zip`

The drive limit does not exist in every BIOS. Some modern motherboards and disk controllers are equipped with a BIOS that supports more (typically four) disk drives. When attempting to access the third, fourth, etc. drive, LILO prints a warning message but continues. Unless the BIOS really supports more than two drives, the system will **not** be able to boot in that case.[10]

The cylinder limit is a very common problem with IDE disks. There, the number of cylinders typically exceeds 1024 if the drive has a capacity of more than 504 MB. Many SCSI driver BIOSes present the disk geometry in a way that makes the limit occur near 1 GB. Modern disk controllers may even push the limit up to about 8 GB. All cylinders beyond the 1024th are inaccessible for the BIOS. LILO detects this problem and aborts the installation (unless the `linear` option is used, see section 3.2.2).

Note that large partitions that only partially extend into the "forbidden zone" are still in jeopardy even if they appear to work at first, because the file system does not know about the restrictions and may allocate disk space from the area beyond the 1024th cylinder when installing new kernels. LILO therefore prints a warning message but continues as long as no imminent danger exists.

There are four approaches of how such problems can be solved:

- use of a different partition which is on an accessible disk and which does not exceed the 1024 cylinder limit. If there is only a DOS partition which fulfills all the criteria, that partition can be used to store the relevant files. (See section 1.3.8.)
- rearranging partitions and disks. This is typically a destructive operation, so care should be taken to make good backups.
- if the system is running DOS, LOADLIN can be used instead of LILO.
- if all else fails, installation of a more capable BIOS, a different controller or a different disk configuration.

LILO depends on the BIOS to load the following items:

- `/boot/boot.b`
- `/boot/map` (created when running `/sbin/lilo`)
- all kernels
- the boot sectors of all other operating systems it boots
- the startup message, if one has been defined

Normally, this implies that the Linux root file system should be in the "safe" area. However, it is already sufficient to put all kernels into `/boot` and to either mount a "good" partition on `/boot` or to let `/boot` be a symbolic link pointing to or into such a partition.

See also `/usr/src/linux/drivers/block/README.ide` for a detailed description of problems with large disks.

1.3.2 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.

	MBR		`/dev/hda`
		MS-DOS	`/dev/hda1`
→		Linux /	`/dev/hda2`

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

[10] If only "unimportant" parts of the system are located on the "high" drives, some functionality may be available.

1.3.3 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.

	MBR	`/dev/hda`
	MS-DOS	`/dev/hda1`
→	Extended	`/dev/hda2`
	Linux	`/dev/hda5`
	...	`/dev/hda6`

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.

OS/2 BootManager should be able to boot LILO boot sectors from logical partitions. The installation on the extended partition itself is not necessary in this case.

1.3.4 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 in the boot process.

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

1.3.5 Two disks, Linux on second disk, 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.

	First disk		**Second disk**	
	MBR	`/dev/hda`	MBR	`/dev/hdb`
	MS-DOS	`/dev/hda1`	Linux	`/dev/hdb1`
→	Extended	`/dev/hda2`	...	`/dev/hdb2`
	...	`/dev/hda5`		
	...	`/dev/hda6`		

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

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

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

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

	First disk		**Second disk**	
→	MBR	`/dev/hda`	MBR	`/dev/hdb`
	MS-DOS	`/dev/hda1`	Linux	`/dev/hdb1`
	...	`/dev/hda2`	...	`/dev/hdb2`

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.conf` would have to be changed to `boot = /dev/hda` in this example.

1.3.7 More than two disks

On systems with more than two disks, typically only the first two can be accessed. The configuration choices are therefore the same as with two disks.

When attempting to access one of the extra disks, LILO displays a warning message (`Warning: BIOS drive 0x`*number* `may not be accessible`) but does not abort. This is done in order to allow the lucky few whose BIOS (or controller-BIOS) does support more than two drives to make use of this feature. By all others, this warning should be considered a fatal error.

Note that the two disks restriction is only imposed by the BIOS. Linux normally has no problems using all disks once it is booted.

1.3.8 `/boot` on a DOS partition

Recent kernels support all the functions LILO needs to map files also on MS-DOS (or UMSDOS) file systems. Since DOS partitions tend to occupy exactly the places where BIOS restrictions (see section 1.3.1) are invisible, they're an ideal location for `/boot` if the native Linux file systems can't be used because of BIOS problems.

In order to accomplish this, the DOS partition is mounted read-write, a directory (e.g. `/dos/linux`) is created, all files from `/boot` are moved to that directory, `/boot` is replaced by a symbolic link to it, the kernels are also moved to the new directory, their new location is recorded in `/etc/lilo.conf`, and finally `/sbin/lilo` is run.

From then on, new kernels must always be copied into that directory on the DOS partition before running `/sbin/lilo`, e.g. when recompiling a kernel, the standard procedure changes from

```
# make zlilo
```

to

```
# make zImage
# mv /dos/linux/vmlinuz /dos/linux/vmlinuz.old
# mv arch/i386/boot/zImage /dos/linux/vmlinuz
# /sbin/lilo
```

WARNING: De-fragmenting such a DOS partition is likely to make Linux or even the whole system unbootable. Therefore, the DOS partition should either not be de-fragmented, or a Linux boot disk should be prepared (and tested) to bring up Linux and to run `/sbin/lilo` after the de-fragmentation.[11]

[11] Setting the "system" attribute from DOS on the critical files (e.g. everything in `C:\LINUX`) may help to protect them from being rearranged. However, the boot floppy should still be ready, just in case.

2 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 (i.e. Linux kernel or other operating system). Otherwise, it boots the default boot image[12] 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.

2.1 Boot command-line options

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.

Example:

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

2.1.1 Standard options

The 1.1.90 kernel recognizes the options `debug`, `no387`, `no-hlt`, `ramdisk=`*size*, `reserve=`*base*`,`*size*`,`..., `root=`*device*, `ro`, and `rw`, and all current `init` programs also recognize the option `single`. The options `lock` and `vga` are processed by the boot loader itself. Boot command-line options are always case-sensitive.

`single` boots the system in single-user mode. This bypasses most system initialization procedures and directly starts a root shell on the console. Multi-user mode can typically 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 either the hexadecimal device number [13] or the full path name of the device, e.g. `/dev/hda3`.[14]

`reserve=`*base*`,`*size*`,`... reserves IO port regions. This can be used to prevent device drivers from auto-probing addresses where other devices are located, which get confused by the probing.

`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.

[12] The default boot image is either the first boot image, the image specified with the `default` variable, or the image that has been selected at the boot prompt.

[13] 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
		...		...	

[14] The device names are hard-coded in the kernel. Therefore, only the "standard" names are supported and some less common devices may not be recognized. In those cases, only numbers can be used.

no-hlt avoids executing a HLT instructions whenever the system is idle. HLT normally significantly reduces power consumption and therefore also heat dissipation of the CPU, but may not work properly with some clone CPUs. no387 disables using the hardware FPU even if one is present.

debug enables more verbose console logging.

vga=*mode* alters the VGA mode set at startup. The values normal, extended, ask or a decimal number are recognized. (See also page 22.)

Finally, lock stores the current command-line as the default command-line, so that LILO boots the same image with the same options (including lock) when invoked the next time.

2.1.2 Device-specific options

There is also a large number of options to specify certain characteristics (e.g. IO and memory addresses) of devices. The 1.1.90 kernel understands the following device options (if the corresponding devices are included): ether, max_scsi_luns, hd, hda, hdb,hdc, hdd, st, bmouse, st0x, tmc8xx, t128, pas16, ncr5380, aha152x, aha1542, aha274x, buslogic, xd, mcd, aztcd, sound, sbpcd, and cdu31a. The usage of these options is *option*=*number*,.... Please consult the corresponding FAQs and HOWTOs for details.

2.1.3 Other options

Options of the type *variable*=*value* which are neither standard options nor device-specific options, 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.)

Note that environment variables passed to init are typically available in system initialization scripts (e.g. /etc/rc.local), but they're not visible from ordinary login sessions, because the login program removes them from the user's environment.

2.1.4 Repeating options

The effect of repeating boot command-line options depends on the options.[15] There are three possible behaviours:

Options that only enable or disable a certain functionality can be repeated any number of times. debug, lock, no-hlt, and no387 fall into this category.

Other options change a global setting whenever they appear, so only the value or presence of the last option matters. The antagonists ro and rw are such options. Also, ramdisk, root, and vga work this way. Example: ro rw would mount the root file system read-write.

Finally, when reserve and many device-specific options are repeated, each occurrence has its own meaning, e.g. hd=... hd=... would configure two hard disks, and reserve=0x300,8 reserve=0x5f0,16 would reserve the ranges 0x300 to 0x307 and 0x5f0 to 0x5ff (which is equivalent to writing reserve=0x300,8,0x5f0,16).

2.1.5 Implicit options

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 a 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.

[15] Options are frequently repeated when a string defined with append or literal is prepended to the parameters typed in by the user. Also, LILO implicitly prepends the options ramdisk, ro, root, or rw when ramdisk, read-only, read-write, or root, respectively, are set in the configuration file. (lock and vga are handled by a different internal mechanism.)

2.2 Boot image selection

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:

Externally provided cmd. line[16]	Command line in map file[17]	Automatic boot[18]	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	Automatic 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	Automatic 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

Note that LILO pauses for the amount of time specified in `delay` when at the end of a default command line. The automatic boot can then be interrupted by pressing a shifting key.

The default image is the first image in the map file or the image specified with the `default` variable. However, after an unsuccessful boot attempt, the respective image becomes the default image.

[16] Externally provided command lines could be used to add front-ends to LILO. They would pass the respective command string to LILO, which would then interpret it like keyboard input. This feature is currently not used.
[17] This command line is set by invoking the map installer with the `-R` option or by using the boot command-line option `lock`.
[18] I.e. the keyword `auto` is added.

3 Map installer

The map installer program `/sbin/lilo` updates the boot sector and creates the map file. 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 `/boot/boot.`*number*, where *number* is the hexadecimal device number. If such a file already exists, no backup copy is made. Similarly, a file `/boot/part.`*number* is created if LILO modifies the partition table. (See page 19.)

3.1 Command-line options

The LILO map installer can be invoked in the following ways:

3.1.1 Show current installation

The currently mapped files are listed. With `-v`, also many parameters are shown.

`/sbin/lilo` [`-C` *config_file*] [`-q`] [`-m` *map_file*] [`-v` ...]

`-C` *config_file*
: Specifies the configuration file that is used by the map installer (see section 3.2). If `-C` is omitted, `/etc/lilo.conf` is used.

`-m` *map_file*
: Specifies an alternate map file. See also sections 3.1.7 and 3.2.2.

`-q`
: Lists the currently mapped files.

`-v` ...
: Increase verbosity. See also sections 3.1.7 and 3.2.2.

3.1.2 Create or update map

A new map is created for the images described in the configuration file `/etc/lilo.conf` and they are registered in the boot sector.

`/sbin/lilo` [`-C` *config_file*] [`-b` *boot_device*] [`-c`] [`-l`] [`-i` *boot_sector*] [`-f` *disk_tab*] [`-m` *map_file*]
[`-d` *delay*] [`-v` ...] [`-t`] [`-s` *save_file* | `-S` *save_file*] [`-P fix` | `-P ignore`] [`-r` *root_dir*]

`-b` *boot_device*
: Specifies the boot device. See also sections 3.1.7 and 3.2.2.

`-c`
: Enables map compaction. See also sections 3.1.7 and 3.2.2.

`-C` *config_file*
: Specifies an alternate configuration file. See also section 3.1.1.

`-d` *delay*
: Sets the delay before LILO boots the default image. Note that the delay is specified in **tenths** of a second. See also sections 3.1.7 and 3.2.2.

`-f` *disk_tab*
Specifies a disk parameter table file. See also sections 3.1.7 and 3.2.2.

`-i` *boot_sector*
Specifies an alternate boot file. See also sections 3.1.7 and 3.2.2.

`-l`
Enables linear sector addresses. See also sections 3.1.7 and 3.2.2.

`-m` *map_file*
Specifies an alternate map file. See also sections 3.1.7 and 3.2.2.

`-P` *mode*
Specifies how invalid partition table entries should be handled. See also sections 3.1.7 and 3.2.2.

`-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 recovery disk. The `-r` option is implied if the environment variable `ROOT` is set.[19] The current directory is changed to the new root directory, so using relative paths may not work.

`-s` *save_file*
Specifies an alternate boot sector save file. See also sections 3.1.7 and 3.2.2.

`-S` *save_file*
Like `-s`, but overwrites old save file.

`-t`
Test only. This performs the entire installation procedure except replacing the map file, writing the modified boot sector and fixing partition tables. This can be used in conjunction with the `-v` option to verify that LILO will use sane values.

`-v` ...
Increase verbosity. See also sections 3.1.7 and 3.2.2.

3.1.3 Change default command line

Changes LILO's default command line. See also section 2.2.

`/sbin/lilo` [`-C` *config_file*] [`-m` *map_file*] [`-R` [*word* ...]]

`-C` *config_file*
Specifies an alternate configuration file. See also section 3.1.1.

`-m` *map_file*
Specifies an alternate map file. See also sections 3.1.7 and 3.2.2.

`-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

[19] E.g. if your root partition is mounted on `/mnt`, you can update the map by simply running `ROOT=/mnt /mnt/sbin/lilo`

image. If `-R` is not followed by any words, the current default command line in the map file is erased.[20] An error message is issued and a non-zero exit code is returned if the command line is not accepted.

3.1.4 Kernel name translation

Determines the path of the kernel.

`/sbin/lilo` [`-C` *config_file*] `-I` *name* [*options*]

`-C` *config_file*
: Specifies an alternate configuration file. See also section 3.1.1.

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

3.1.5 De-installation

Restores the boot sector that was used before the installation of LILO. Note that this option only works properly if LILO's directories (e.g. `/boot`) have not been touched since the first installation. See also section 4.4.

`/sbin/lilo` [`-C` *config_file*] [`-s` *save_file*] `-u` | `-U` [*boot_device*]

`-C` *config_file*
: Specifies an alternate configuration file. See also section 3.1.1.

`-s` *save_file*
: Specifies an alternate boot sector save file. See also sections 3.1.7 and 3.2.2.

`-u` [*device_name*]
: Restores the backup copy of the specified boot sector. If no device is specified, the value of the `boot` variable is used. If this one is also unavailable, LILO uses the current root device. The name of the backup copy is derived from the device name. The `-s` option or the `backup` variable can be used to override this. LILO validates the backup copy by checking a time stamp.

`-U` [*device_name*]
: Like `-u`, but does not check the time stamp.

3.1.6 Print version number

`/sbin/lilo -V`

`-V`
: Print the version number and exit.

---

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

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

3.1.7 Options corresponding to configuration variables

There are also many command-line options that correspond to configuration variables. See section 3.2.2 for a description.

Command-line option	Configuration variable
`-b` *boot_device*	`boot=`*boot_device*
`-c`	`compact`
`-d` *tsecs*	`delay=`*tsecs*
`-D` *name*	`default=`*name*
`-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*

3.2 Configuration

The configuration information is stored in the file `/etc/lilo.conf` and consists of variable assignments.

3.2.1 Syntax

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 or if the value is embedded in double quotes. 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. Inside quoted strings, only double quotes and backslashes can be escaped.
- comments begin with a number sign and end with the next newline. All characters (including backslashes) until the newline are ignored.

3.2.2 Global options

`/etc/lilo.conf` begins with a possibly empty global options section. Many global options can also be set from the command line, but storing permanent options in the configuration file is more convenient.

The following global options are recognized:

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

`boot=`*boot_device* Sets the name of the device (e.g. a hard disk partition) 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.

`default=`*name* Uses the specified image as the default boot image. If `default` is omitted, the image appearing first in the configuration file is used.

`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 or if `delay` is set to zero.

`disk=`*device_name* Defines non-standard parameters for the specified disk. See section 3.4 for details.

`disktab=`*disktab_file* Specifies the name of the disk parameter table (see section 3.4.3). The map installer looks for `/etc/disktab` if `disktab` is omitted. The use of disktabs is discouraged; see section 3.4 for a vastly superior approach.

`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. Also, with some disks (e.g. some large EIDE disks with address translation enabled), under some circumstances, it may even be unavoidable to have conflicting partition table entries.

`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.

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

`install=`*boot_sector* Install the specified file as the new boot sector. If `install` is omitted, `/boot/boot.b` is used as the default.

`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 may not be portable if `linear` is used, because the BIOS service to determine the disk geometry does not work reliably for floppy disks. When using `linear` with large disks, `/sbin/lilo` may generate references to inaccessible disk areas (see section 1.3.1), because 3D sector addresses are not known before boot time.

`lock` Enables automatic recording of boot command lines as the defaults for the following boots. This way, LILO "locks" on a choice until it is manually overridden.

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

`message=`*message_file* specifies a file containing a message that is displayed before the boot prompt. No message is displayed while waiting for a shifting key after printing "LILO ". In the message, 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.

`nowarn` Disables warnings about possible future dangers.

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

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

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

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

`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.

`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.

`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. The following verbosity levels exist:

<0 only warnings and errors are shown

0 prints one line for each added or skipped image

1 mentions names of important files and devices and why they are accessed. Also displays informational messages for exceptional but harmless conditions and prints the version number.

2 displays statistics and processing of temporary files and devices

3 displays disk geometry information

4 lists sector mappings as they are written into the map file (i.e. after compaction, in a format suitable to pass it to the BIOS)

5 lists the mapping of each sector (i.e. before compaction, raw)

When using the `-q` option, the levels have a slightly different meaning:

0 displays only image names

1 also displays all global and per-image settings

2 displays the address of the first map sector

Additionally, the kernel configuration parameters `append`, `ramdisk`, `read-only`, `read-write`, `root` and `vga` can be set in the global 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.

The plethora of options may be intimidating at first, but in "normal" configurations, hardly any options but `boot`, `compact`, `delay`, `root`, and `vga` are used.

3.2.3 General per-image options

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 second 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. Because the configuration file contains unencrypted passwords when using `password`, it should only be readable for the super-user.

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.

3.2.4 Per-image options for kernels

Each (kernel or non-kernel) image description begins with a special variable (see section 3.3) which is followed by optional variables. The following variables can be used for all image descriptions that describe a Linux kernel:

`append=`*string* Appends the options specified in *string* to the parameter line passed to the kernel. This is typically used to specify parameters of hardware that can't be entirely auto-detected, e.g.
`append = "hd=64,32,202"`

`literal=`*string* Like `append`, but removes all other options (e.g. setting of the root device). Because vital options can be removed unintentionally with `literal`, this option cannot be set in the global options section.

`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 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 contained in the kernel 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).

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 contained in the kernel image is used. `rdev` supports manipulation of the VGA text mode setting in the kernel image.

If one of `ramdisk`, `read-only`, `read-write`, `root`, or `vga` is omitted in the configuration file and the corresponding value in the kernel image is changed, LILO or the kernel 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 = /vmlinuz
  label = lin-hd
  root = /dev/hda2
image = /vmlinuz
  label = lin-fd
  root = /dev/fd0
```

3.3 Boot image types

LILO can boot the following types of images:

- kernel images from a file.
- kernel images from a block device. (E.g. a floppy disk.)
- the boot sector of some other operating system.

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

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.

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

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

3.3.1 Booting kernel images from a file

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

Example:

```
image = /linux
```

3.3.2 Booting kernel images from a device

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 is 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
```

3.3.3 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 or file 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`, `any_b.b` and `any_d.b` exist. `chain.b` simply starts the specified boot sector.[21] `os2_d.b` can boot OS/2 from the second hard disk. `any_b.b` and `any_d.b` install resident drivers that swap the first and the second floppy or hard disk drive. They 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* or `other=`*file_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, `/boot/chain.b` is used. The chain loader must be specified if booting from a device other than the first hard or floppy disk.

`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.) Note that `/sbin/lilo` must be re-run if a partition table mapped referenced with `table` is modified.

`unsafe` do not access the boot sector at map creation time. This disables some sanity checks, including a partition table check. 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
```

3.4 Disk geometry

For floppies and most hard disks, LILO can obtain the disk geometry information from the kernel. Unfortunately, there are some exotic disks or adapters which may either not supply this information or which may even return incorrect information.

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

If no geometry information is available, LILO reports either the error
`geo_query_dev HDIO_GETGEO (dev 0x`*number*`)`
or
`Device 0x`*number*`: Got bad geometry` *sec/hd/cyl*

If incorrect information is returned, booting may fail in several ways, typically with a partial "LILO" banner message. In this document, that is called a "geometry mismatch".

The next step should be to attempt setting the `linear` configuration variable or the `-l` command-line option. If this doesn't help, the entire disk geometry has to be specified explicitly. Note that `linear` doesn't always work with floppy disks.

3.4.1 Obtaining the geometry

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.

Alternatively, the geometry may also be determined by reading the information presented by the "setup" section of the ROM-BIOS or by using certain disk utilities under operating systems accessing the disk through the BIOS.

3.4.2 Specifying the geometry

Disk geometry parameters are specified in the options section of the configuration file. Each disk parameter sub-section begins with `disk=`*disk_device*, similar to the way how boot images are specified. It is suggested to group disk parameter sections together, preferably at the beginning or the end of the options section.

For each disk, the following variables can be specified:

`bios=`*bios_device_code* Is the number the BIOS uses to refer to that device. Normally, it's `0x80` for the first hard disk and `0x81` for the second hard disk. Note that hexadecimal numbers have to begin with "0x". If `bios` is omitted, LILO tries to "guess" that number.

`sectors=`*sectors* and

`heads=`*heads* specify the number of sectors per track and the number of heads, i.e. the number of tracks per cylinder. Both parameters have to be either specified together or they have to be entirely omitted. If omitted, LILO tries to obtain that geometry information from the kernel.

`cylinders=`*cylinders* Specifies the number of cylinders. This value is only used for sanity checks. If `cylinders` is omitted, LILO uses the information obtained from the kernel if geometry information had to be requested in order to determine some other parameter. Otherwise,[22] it just assumes the number of cylinders to be 1024, which is the cylinder limit imposed by the BIOS.

Additionally, partition sub-sub-sections can be added with `partition=`*partition_device*. Each partition section can contain only one variable:

`start=`*partition_offset* Specifies the zero-based number of the start sector of that partition. The whole disk always has a partition offset of zero. The partition offset is only necessary when using devices for which the kernel does not provide that information, e.g. CD-ROMs.

Example:

[22] I.e. if the BIOS device code, the number of sectors, the number of heads and the partition start are specified. Note that the number of cylinders may appear to vary if `cylinders` is absent and only some of the partition starts are specified.

```
disk = /dev/sda
  bios = 0x80
  sectors = 32
  heads = 64
  cylinders = 632
  partition = /dev/sda1
    start = 2048
  partition = /dev/sda2
    start = 204800
  partition = /dev/sda3
    start = 500000
  partition = /dev/sda4
    start = 900000
```

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.

3.4.3 Disk parameter table

The file `/etc/disktab` is the obsolete way to define the disk geometry. It is described here only for completeness. Its use with LILO 0.15 and newer is deprecated.

For each device (`/dev/hda` → 0x300, `/dev/sda` → 0x800, `/dev/sda1` → 0x801, etc.), the BIOS code and the disk geometry have to be specified, e.g.

```
# /etc/disktab  -  LILO disk parameter table
#
# This table contains disk parameters for non-standard disks.
# Parameters in disktab _always_ override auto-detected disk parameters.
# Note: this file is typically not needed for normal use of LILO.

# 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.

Note that the device number and the BIOS code have to be specified as hexadecimal numbers with the "0x" prefix. Also note that the complete information has to be repeated for each partition.

4 Installation and updates

4.1 Installation

This section describes the installation of LILO. See section 4.4 for how to uninstall LILO.

4.1.1 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 works with any current 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.

4.1.2 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.

4.1.3 Files

Some of the files contained in `lilo.16.tar.gz`:

`lilo/README`
: This documentation in plain ASCII format. Some sections containing complex tables are only included in the LaTeX version in `doc/user.tex`

`lilo/INCOMPAT`
: List of incompatibilities to previous versions of LILO.

`lilo/CHANGES`
: Change history.

`lilo/QuickInst`
: Quick installation script.

`lilo/Makefile`
: Makefile to generate everything else.

`lilo/*.c`, `lilo/*.h`
: LILO map installer C source.

`lilo/*.S`
: LILO boot loader assembler source.

`lilo/activate.c`
: C source of a simple boot partition setter.

`lilo/dparam.s`
: Assembler source of a disk parameter dumper.

`lilo/disktab`
: Sample disk parameter table. (Obsolete.)

`lilo/mkdist`
: Shell script used to create the current LILO distribution.

`lilo/doc/README`
: Description of how the documentation is generated.

`lilo/doc/Makefile`
: Makefile used to convert the LaTeX source into either DVI output or the plain ASCII README file.

`lilo/doc/user.tex`
: LaTeX source of LILO's user's guide (this document).

`lilo/doc/tech.tex`
: LaTeX source of LILO's technical overview.

`lilo/doc/*.fig`
: Various xfig pictures used in the technical overview.

`lilo/doc/fullpage.sty`
: Style file to save a few square miles of forest.

`lilo/doc/rlatex`
: Shell script that invokes LaTeX repeatedly until all references have settled.

`lilo/doc/t2a.pl`
: Perl script to convert the LaTeX source of the user's guide to plain ASCII.

Files created after `make` in `lilo/` (among others):

`lilo/any_b.b`
: Chain loader that swaps the first two floppy drives (i.e. "A:" and "B:"). `make install` puts this file into `/boot`

`lilo/any_d.b`
: Chain loader that swaps the first two hard disk devices (i.e. "C:" and "D:"). `make install` puts this file into `/boot`

`lilo/boot.b`
: Combined boot sector. `make install` puts this file into `/boot`

`lilo/chain.b`
: Generic chain loader. `make install` puts this file into `/boot`

`lilo/os2_d.b`
: Chain loader to load OS/2 from the second hard disk. `make install` puts this file into `/boot`

`lilo/lilo`
: LILO (map) installer. `make install` puts this file into `/sbin`

`lilo/activate`
: Simple boot partition setter.

`lilo/dparam.com`
: MS-DOS executable of the disk parameter dumper.

4.1.4 Normal first-time installation

First, you have to install the LILO files:

- extract all files from `lilo.`*version*`.tar.gz` in a new directory.[23]
- configure the `Makefile` (see section 4.2)
- run `make` to compile and assemble all parts.
- run `make install` to copy all LILO files to the directories where they're installed. `/sbin` should now contain the file `lilo`, `/etc` should contain `disktab`[24] and `/boot` should contain the following files: `any_b.b`, `any_d.b`, `boot.b`, `chain.b` and `os2_d.b`.

If you want to use LILO on a non-standard disk, you might have to determine the parameters of your disk(s) and specify them in the configuration file. See section 3.4 for details. If you're using such a non-standard system, 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`.
- run `echo image=`*kernel_image* `|`
  `/sbin/lilo -C - -b /dev/fd0 -v -v -v`[25]
- reboot. LILO should now load its boot loaders from the floppy disk and then continue loading the kernel from the hard disk.

Now, you 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 boot disk, e.g. an install or recovery disk. 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 boot disk 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`
- create the configuration file `/etc/lilo.conf`, e.g.
  global settings
    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:
  `/sbin/lilo -v -v -v -t`
- if you need some additional boot utility (i.e. BOOTACTV), you should install that now
- run `/sbin/lilo` to install LILO on your hard disk
- if you have to change the active partition, use fdisk or activate to do that
- reboot

[23] E.g. `/usr/src/lilo`

[24] Actually, it shouldn't, because `disktab` is now obsolete.

[25] 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.

4.2 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.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.

`NO1STDIAG` Do not generate diagnostics on read errors in the first stage boot loader. This avoids possibly irritating error codes if the disk controller has transient read problems. This option is disabled by default.

`NOINSTDEF` If the option `install` is omitted, don't install a new boot sector, but try to modify the old boot sector instead. This option is disabled by default.

`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.

`VARSETUP` Enables the use of variable-size setup segments. This option is enabled by default and is only provided to fall back to fixed-size setup segments in the unlikely case of problems when using old kernels.

`/etc/lilo.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
```

4.3 Updates

LILO is affected by updates of kernels, the whole system and (trivially) of LILO itself. Typically, only `/sbin/lilo` has to be run after any of those updates and everything will be well again (at least as far as LILO is concerned).

4.3.1 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 install the files.

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 does 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 `/sbin/lilo` to do this.

4.3.2 Kernel update

Whenever any of the kernel files that are accessed by LILO is moved or overwritten, the map has to be re-built.[26] Run `/sbin/lilo` to do this.

The kernel has a make target "zlilo" that copies the kernel to `/vmlinuz` and runs `/sbin/lilo`.

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

4.3.3 System upgrade

Normally, system upgrades (i.e. installation or removal of packages, possibly replacement of large a part of the installed binaries) do not affect LILO. Of course, if a new kernel is installed in the process, the normal kernel update procedure has to be followed (see section 4.3.2). Also, if kernels are removed or added, it may be necessary to update the configuration file.

If LILO is updated by this system upgrade, `/sbin/lilo` should be run before booting the upgraded system. It is generally a good idea not to rely on the upgrade procedure to perform this essential step automatically.

However, system upgrades which involve removal and re-creation of entire partitions (e.g. `/`, `/usr`, etc.) are different. First, they should be avoided, because they bear a high risk of losing other critical files, e.g. the `/etc/Xconfig` you've spent the last week fiddling with. If an upgrade really has to be performed in such a brute-force way, this is equal with total removal of LILO, followed by a new installation. Therefore, the procedures described in the sections 4.4 and 4.3.1 have to be performed. If you've forgotten to make a backup copy of `/etc/lilo.conf` (and possibly also of `/etc/disktab`) before the destructive upgrade, you might also have to go through section 4.1.4 again.

4.4 LILO de-installation

In order to stop LILO from being invoked when the system boots, its boot sector has to be either removed or disabled. All other files belonging to LILO can be deleted **after** removing the boot sector, if desired.[27]

Again, **when removing Linux, LILO must be de-installed before (!) its files (`/boot`, etc.) are deleted.** This is especially important if LILO is operating as the MBR.

LILO 0.14 (and newer) can be de-installed with `lilo -u`. If LILO 0.14 or newer is currently installed, but the first version of LILO installed was older than 0.14, `lilo -U` may work. When using `-U`, the warning at the end of this section applies.

If LILO's boot sector has been installed on a primary partition and is booted by the "standard" MBR or some partition switcher program, it can be disabled by making a different partition active. MS-DOS' FDISK, Linux fdisk or LILO's activate can do that.

If LILO's boot sector is the master boot record (MBR) of a disk, it has to be replaced with a different MBR, typically MS-DOS' "standard" MBR. When using MS-DOS 5.0 or above, the MS-DOS MBR can be restored with `FDISK /MBR`. This only alters the boot loader code, not the partition table.

LILO automatically makes backup copies when it overwrites boot sectors. They are named `/boot/boot.`*nnnn*, with *nnnn* corresponding to the device number, e.g. `0300` is `/dev/hda`, `0800` is `/dev/sda`, etc. Those backups can be used to restore the old MBR if no easier method is available. The commands are
`dd if=/boot/boot.0300 of=/dev/hda bs=446 count=1` or
`dd if=/boot/boot.0800 of=/dev/sda bs=446 count=1`
respectively.

WARNING: Some Linux distributions install `boot.`*nnnn* files from the system where the distribution was created. Using those files may yield unpredictable results. Therefore, the file creation date should be carefully checked.

4.5 Installation of other operating systems

Some other operating systems (e.g. MS-DOS 6.0) appear to modify the MBR in their install procedures. It is therefore possible that LILO will stop to work after such an installation and Linux has to be booted from floppy disk. The original state can be restored by either re-running `/sbin/lilo` (if LILO is installed as the MBR) or by making LILO's partition active (if it's installed on a primary partition).

It is generally a good idea to install LILO after the other operating systems have been installed. E.g. OS/2 is

[27] Backup copies of old boot sectors may be needed when removing the boot sector. They are stored in `/boot`.

said to cause trouble when attempting to add it to an existing Linux system. (However, booting from floppy and running `/sbin/lilo` should get around most interferences.)

Typically, the new operating system then has to be added to LILO's configuration (and `/sbin/lilo` has to be re-run) in order to boot it.

See also section 5.4 for a list of known problems with some other operating systems.

5 Troubleshooting

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

5.1 Map installer warnings and errors

Most messages of the map installer (`/sbin/lilo`) should be self-explanatory. Some messages that indicate common errors are listed below. They are grouped into fatal errors and warnings (non-fatal errors).

5.1.1 Fatal errors

`Boot sector of` *device_name* `doesn't have a boot signature`

`Boot sector of` *device_name* `doesn't have a LILO signature`
: The sector from which LILO should be uninstalled doesn't appear to be a LILO boot sector.

`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`.

`Checksum error`
: The descriptor table of the map file has an invalid checksum. Refresh the map file **immediately** !

`Device 0x`*number*`: Got bad geometry` *sec/hd/cyl*
: The device driver for your SCSI controller does not support geometry detection. You have to specify the geometry explicitly (see section 3.4).

`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 later using PC/MS-DOS or OS/2 on that disk. LILO can attempt to correct the problem, see page 19.

device_name `is not a valid partition device`
: The specified device is either not a device at all, a whole disk, or a partition on a different disk than the one in whose section its entry appears.

device_name `is not a whole disk device`
: Only the geometry of whole disks (e.g. `/dev/hda`, `/dev/sdb`, etc.) can be redefined when using `disk` sections.[28]

`DISKTAB and DISK are mutually exclusive`
: You cannot use a `disktab` file and disk geometry definitions in the configuration file at the same time. Maybe `/etc/disktab` was accidentally used, because that's the default for backward-compatibility. You should delete `/etc/disktab` after completing the transition to `disk` sections.

`Duplicate entry in partition table`
: A partition table entry appears twice. The partition table has to be fixed with `fdisk`.

`Duplicate geometry definition for` *device_name*
: A disk or partition geometry definition entry for the same device appears twice in the configuration file. Note that you mustn't write a partition section for the whole disk — its start sector is always the first sector of the disk.

[28] When using a `disktab` file, you don't have this restriction. The additional flexibility offered by this is, however, useless and dangerous.

`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.[29]

`geo_comp_addr: Cylinder` *number* `beyond end of media (`*number*`)`
: A file block appears to be located beyond the last cylinder of the disk. This probably indicates an error in the disk geometry specification (see sections 3.4 and 3.4.3) or a file system corruption.

`geo_comp_addr: Cylinder number is too big (`*number* `> 1023)`
: Blocks of a file are 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.

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. [30]

`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. With recent (compressed) kernels, the reason for this error is most likely that the kernel image is damaged or that it contains trailing "junk", e.g. as the result of copying an entire boot floppy to the hard disk.

`Map` *path* `is not a regular file.`
: This is probably the result of an attempt to omit writing a map file, e.g. with `-m /dev/null`. The `-t` option should be used to accomplish this.

`Must specify LOADER for BIOS device` *number*
: When booting an operating system from any device than the first hard or floppy disk, specifying the chain loader (option `loader` in the image section) is now mandatory.

`Must specify SECTORS and HEADS together`
: It is assumed that disks with a "strange" number of sectors will also have a "strange" number of heads. Therefore, it's all or nothing.

`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 explicitly described, see section 3.4.

---

[29] 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.

[30] The expected version number may be different from the version number of the LILO package, because file version numbers are only increased when the file formats change.

`Timestamp in boot sector of` *device* `differs from date of` *file*
: The backup copy of the boot sector does not appear to be an ancestor of the current boot sector. If you are absolutely sure that the boot sector is indeed correct, you can bypass this check by using `-U` instead of `-u`.

`Trying to map files from your RAM disk. Please check -r option or ROOT environment variable.`
: Most likely, you or some installation script is trying to invoke LILO in a way that some of the files is has to access reside on the RAM disk. Normally, the `ROOT` environment variable should be set to the mount point of the effective root device if installing LILO with a different root directory. See also sections 3.1.2 and 4.1.4.

`write` *item*`:` *error_reason*
: The disk is probably full or mounted read-only.

5.1.2 Warnings

Warnings labeled with "Warning" can be turned off with the `nowarn` option.

`FIGETBSZ` *file_name*`:` *error_reason*
: The map installer is unable to determine the block size of a file system. It assumes a block size of two sectors (1kB).

`Ignoring entry '`*variable_name*`'`
: The command-line option corresponding to the specified variable is set. Therefore, the configuration file entry is ignored.

`Setting DELAY to 20 (2 seconds)`
: Because accidentally booting the wrong kernel or operating system may be very inconvenient on systems that are not run from a local display, the minimum delay is two seconds if the `serial` variable is set.

`(temp)` *item*`:` *error_reason*
: Deleting a temporary file has failed for the specified reason.

`Warning: BIOS drive 0x`*number* `may not be accessible`
: Because most BIOS versions only support two floppies and two hard disks, files located on additional disks may be inaccessible. This warning indicates that some kernels or even the whole system may be unbootable.

`Warning:` *config_file* `should be owned by root`
: In order to prevent users from compromising system integrity, the configuration file should be owned by root and write access for all other users should be disabled.

`Warning:` *config_file* `should be readable only for root if using PASSWORD`
: Users should not be allowed to read the configuration file when using the `password` option, because then, it contains unencrypted passwords.

`Warning:` *config_file* `should be writable only for root`
: See "`Warning:` *config_file* `should be owned by root`".

`Warning: device 0x`*number* `exceeds 1024 cylinder limit`
: A disk or partition exceeds the 1024 cylinder limit imposed by the BIOS. This may result in a fatal error in the current installation run or in later installation runs. See "`geo_comp_addr: Cylinder number is too big (`*number* `> 1023)`" for details.

`Warning:` *device* `is not on the first disk`
: The specified partition is probably not on the first disk. LILO's boot sector can only be booted from the first disk unless some special boot manager is used.

`WARNING: The system is unbootable !`
: One of the last installation steps has failed. This warning is typically followed by a fatal error describing the problem.

5.2 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.

Note that some hex digits may be inserted after the first "L" if a transient disk problem occurs. Unless LILO stops at that point, generating an endless stream of error codes, such hex digits do not indicate a severe problem.

(*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`*error*... The first stage boot loader has been loaded and started, but it can't load the second stage boot loader. The two-digit error codes indicate the type of problem. (See also section 5.3.) This condition usually indicates a media failure or a geometry mismatch (e.g. bad disk parameters, see section 3.4).

`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 `/boot/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 `/boot/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 `/boot/map` without running the map installer.

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

5.3 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, but if it does, it may indicate an attempt to access a disk which is not supported by the BIOS. See also "Warning: BIOS drive 0x*number* may not be accessible" in section 5.1.2.

`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 or a large IDE disk, you should check, whether LILO has obtained correct geometry data from the kernel or whether the geometry definition corresponds to the real disk geometry. (See section 3.4.) Removing `compact` may help too. So may adding `linear`.

`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 `compact` 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.

Generally, invalid geometry and attempts to use more than two disks without a very modern BIOS may yield misleading error codes. Please check carefully if `/sbin/lilo` doesn't emit any warnings. Then try using the `linear` option (see section 3.2.2).

5.4 Other problems

This section contains a collection of less common problems that have been observed. See also section 4.5 for general remarks on using LILO with other operating systems. Some of the problems are obscure and so are the work-arounds.

- If LILO doesn't go away even if you erase its files, format your Linux partition, etc., you've probably installed LILO as your MBR and you've forgotten to deinstall it before deleting its files. See section 4.4 for what you can do now.
- For yet unknown reasons, LILO may fail on some systems with AMI BIOS if the "Hard Disk Type 47 RAM area" is set to "0:300" instead of "DOS 1K".
- Some disk controller BIOSes perform disk geometry/address translations that are incompatible with the way the device's geometry is seen from Linux, i.e. without going through the BIOS. Particularly, large IDE disks and some recent PCI SCSI controllers appear to have this problem. In such cases, either the translated geometry has to be specified in a `disk` section or the sector address translation can be deferred by using the `linear` option. In a setup where floppies are not normally used for booting, the `linear` approach should be preferred, because this avoids the risk of specifying incorrect numbers.
- OS/2 is said to be bootable from a logical partition with LILO acting as the primary boot selector if LILO is installed on the MBR, the OS/2 BootManager is on an active primary partition and LILO boots BootManager. Putting LILO on an extended partition instead is said to crash the OS/2 FDISK in this scenario.

  Note that booting LILO from BootManager (so BootManager is the primary selector) or booting OS/2 directly from a primary partition (without BootManager) should generally work. See also section 4.5.
- Windows NT is reported to be bootable with LILO when LILO acts as the MBR and the Windows NT boot loader is on the DOS partition. However, NT's disk manager complains about LILO's MBR when trying to edit the partition table.

- Some PC UNIX systems (SCO and Unixware have been reported to exhibit this problem) depend on their partition being active. Such a setup can currently only be obtained by installing LILO as the MBR and making the respective partition active.[31]
- Future Domain TMC-1680 adapters with the BIOS versions 3.4 and 3.5 assign BIOS device numbers in the wrong order, e.g. on a two-disk system, `/dev/sda` becomes `0x81` and `/dev/sdb` becomes `0x80`. This can be fixed with the following disk section:
  `disk=/dev/sda bios=0x81 disk=/dev/sdb bios=0x80`
  Note that this is only valid for a two-disk system. In three-disk systems, `/dev/sdc` would become `0x80`, etc. Also, single-disk systems don't have this problem (and the "fix" would break them).

[31] Future versions of LILO may be able to change the active flag dynamically.