

Linux/MIPS HOWTO

Table of Contents

Linux/MIPS HOWTO.....	1
Ralf Bächle, ralf@gnu.org.....	1
1.What is Linux/MIPS?.....	1
2.Getting this FAQ.....	1
3.What hardware does Linux/MIPS support?.....	1
4.Linux distributions.....	1
5.Linux/MIPS net resources.....	1
6.Installation of Linux/MIPS and common problems.....	2
7.Milo.....	2
8.Loadable Modules.....	2
9.How do I set up a cross-compiler?.....	2
10.Related Literature.....	2
1.What is Linux/MIPS?.....	3
2.Getting this FAQ.....	3
3.What hardware does Linux/MIPS support?.....	3
3.1 Hardware platforms.....	4
 Acer PICA.....	4
 Baget/MIPS series.....	4
 Cobalt Oube and Raq.....	4
 NEC machines.....	4
 NEC VR41xx-based platforms.....	5
 Toshiba TMPR39xx/Philips PR31700 platforms.....	5
 Netpower 100.....	5
 Nintendo 64.....	5
 Silicon Graphics Challenge S.....	5
 Silicon Graphics Indigo.....	5
 Silicon Graphics Indigo2.....	5
 Silicon Graphics Indy.....	6
 Strange numbers of available memory.....	6
 Indy PROM related problems.....	6
 ELF support in old PROM versions.....	6
 Why is so much memory reserved on my Indy?.....	7
 Silicon Graphics Origin 200 and 2000.....	7
 Silicon Graphics Onyx 2.....	7
 Silicon Graphics Power Series.....	7
 Serial console on SGI machines.....	7
 Other Silicon Graphics machines.....	8
 Sony Playstation.....	8
 SNI RM200C.....	8
 SNI RM200.....	8
 SNI RM300C.....	8
 SNI RM400.....	8
 SNI RW320.....	9
 Algorithmics P4032.....	9
 Algorithmics P5064.....	9
 DECstation series.....	9
 Mips Magnum 4000 / Olivetti M700-10.....	10

Table of Contents

MIPS Magnum 4000SC	10
3.2 Processor types	10
R2000, R3000 family	10
R6000	11
R4000 and R5000 family	11
R8000	11
R10000	11
Processors without TLB	12
Processors with partial or no FPU	12
3.3 Hardware we're never going to support	12
IBM RS6000	12
VaxStation	12
SGI VisPC	12
Motorola 68k based machines like the Iris 3000	13
4.Linux distributions	13
4.1 RedHat	13
4.2 Debian	13
4.3 Simple	13
5.Linux/MIPS net resources	14
5.1 Anonymous FTP servers	14
5.2 Anonymous CVS servers	14
5.3 Web servers	15
5.4 Web CVS server	15
5.5 Mailing lists	15
5.6 IRC channel	16
6.Installation of Linux/MIPS and common problems	16
6.1 NFS booting fails	16
6.2 Self compiled kernels crash when booting	16
6.3 Booting the kernel on the Indy fails with PROM error messages	17
6.4 Where can I get the little endian firmware for my SNI?	17
6.5 ld dies with signal 6	17
6.6 My machine doesn't download the kernel when I try to netboot	18
6.7 Bug in DHCP version 2	18
7.Milo	18
7.1 Building Milo	18
7.2 Pandora	18
8.Loadable Modules	19
9.How do I set up a cross-compiler?	19
9.1 Available binaries	19
9.2 Building your own cross-compiler	19
9.3 Disk space requirements	20
9.4 Byte order	20
9.5 Configuration names	20
9.6 Installation of GNU Binutils	21
9.7 Assert.h	21
9.8 Installing the kernel sources	21
9.9 First installation of egcs	21

Table of Contents

9.10 Test what you've done so far	22
9.11 Installing GNU libc	22
9.12 Building egcs again	23
9.13 Should I build the C++, Objective C or F77 compilers?	23
9.14 Known problem when cross-compiling	23
IRIX crashes	24
Resource limits on System V based hosts	24
9.15 GDB	24
10.Related Literature	24
10.1 See MIPS Run	24
10.2 The MIPS Programmer's Handbook	25
10.3 Computer Architecture – A Quantitative Approach	25
10.4 UNIX System V ABI MIPS Processor Supplement	25

Linux/MIPS HOWTO

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This FAQ describes the MIPS port of the Linux operating system, common problems and their solutions, availability and more. It also tries to be a little helpful to other people who might read this FAQ in an attempt to find information that actually should be covered elsewhere.

[1. What is Linux/MIPS?](#)

[2. Getting this FAQ](#)

[3. What hardware does Linux/MIPS support?](#)

- [3.1 Hardware platforms](#)
- [3.2 Processor types](#)
- [3.3 Hardware we're never going to support](#)

[4. Linux distributions.](#)

- [4.1 RedHat](#)
- [4.2 Debian](#)
- [4.3 Simple](#)

[5. Linux/MIPS net resources.](#)

- [5.1 Anonymous FTP servers.](#)
- [5.2 Anonymous CVS servers.](#)
- [5.3 Web servers.](#)
- [5.4 Web CVS server.](#)
- [5.5 Mailing lists.](#)
- [5.6 IRC channel.](#)

6. Installation of Linux/MIPS and common problems.

- [6.1 NFS booting fails.](#)
- [6.2 Self compiled kernels crash when booting.](#)
- [6.3 Booting the kernel on the Indy fails with PROM error messages](#)
- [6.4 Where can I get the little endian firmware for my SNI?](#)
- [6.5 ld dies with signal 6](#)
- [6.6 My machine doesn't download the kernel when I try to netboot](#)
- [6.7 Bug in DHCP version 2](#)

7. Milo

- [7.1 Building Milo](#)
- [7.2 Pandora](#)

8. Loadable Modules

9. How do I set up a cross-compiler?

- [9.1 Available binaries](#)
- [9.2 Building your own cross-compiler](#)
- [9.3 Disk space requirements](#)
- [9.4 Byte order](#)
- [9.5 Configuration names](#)
- [9.6 Installation of GNU Binutils.](#)
- [9.7 Assert.h](#)
- [9.8 Installing the kernel sources](#)
- [9.9 First installation of egcs](#)
- [9.10 Test what you've done so far](#)
- [9.11 Installing GNU libc](#)
- [9.12 Building egcs again](#)
- [9.13 Should I build the C++, Objective C or F77 compilers?](#)
- [9.14 Known problem when cross-compiling](#)
- [9.15 GDB](#)

10. Related Literature

- [10.1 See MIPS Run](#)
 - [10.2 The MIPS Programmer's Handbook](#)
 - [10.3 Computer Architecture – A Quantitative Approach](#)
 - [10.4 UNIX System V ABI MIPS Processor Supplement](#)
-

1. What is Linux/MIPS?

Linux/MIPS is a port of the widespread UNIX clone Linux to the MIPS architecture. Linux/MIPS is running on a large number of technically very different systems ranging from little embedded systems and servers to large desktop machines and servers that, at least at the time when they were introduced into the market, were the best of their class.

Linux/MIPS advantages over other operating systems at this time are

- The entire Linux system consists only of Free Software.
- Excellent Price/Performance ratio.
- Availability of large amounts of software of which a large part again is Free Software.
- Binary compatibility across a growing number of platforms.
- Small footprint making Linux/MIPS suitable for many embedded systems.

In short, Linux has been designed and ships with Fahrvergnügen. However as usual your mileage may vary and you should examine Linux's suitability for your purpose which purpose this document tries to serve.

2. Getting this FAQ

You can download this document in various formats:

- The HTML version <http://oss.sgi.com/mips/mips-howto.html>
- The text version <http://oss.sgi.com/mips/mips-howto.txt>
- The Postscript version <http://oss.sgi.com/mips/mips-howto.ps>
- The Linux-Doc SGML version. <http://oss.sgi.com/mips/mips-howto.sgml>

This FAQ is also available as SGML source code via anonymous CVS from oss.sgi.com. The archive also has a Makefile which will translate it into various formats. An ASCII version is regularly being posted via *comp.os.linux.answers* and the other Linux HOWTO channels.

3. What hardware does Linux/MIPS support?

3.1 Hardware platforms

Many machines are available with a number of different CPU options of which not all are currently supported. Please check section [Processor Types](#) to make sure your CPU type is supported. This is a listing of machines that are running Linux/MIPS, systems to which Linux/MIPS could be ported or systems that people have an interest in running Linux/MIPS.

Acer PICA

The *Acer PICA* is derived from the *Mips Magnum 4000* design. It has a R4400PC CPU running at 133Mhz or optionally 150Mhz plus a 512kb (optionally 2mb) second level cache; the Magnum's G364 gfx card was replaced with a S3 968 based one. The system is supported with the exception of the X server.

Baget/MIPS series

The Baget series includes several boxes which have R3000 processors: Baget 23, Baget 63, and Baget 83. Baget 23 and 63 have BT23–201 or BT23–202 motherboards with R3500A (which is basically a R3000A chip) at 25 MHz and R3081E at 50 MHz respectively. The BT23–201 board has VME bus and VIC068, VAC068 chips as system controllers. The BT23–202 board has PCI as internal bus and VME as internal. Support for BT23–201 board has been done by [Gleb Raiko \(rajko@mech.math.msu.su\)](mailto:rajko@mech.math.msu.su) and [Vladimir Roganov \(vroganov@msiu.ru\)](mailto:vroganov@msiu.ru) with a bit help from [Serguei Zimin \(zimin@msiu.ru\)](mailto:zimin@msiu.ru). Support for BT23–202 is under development along with Baget 23B which consists of 3 BT23–201 boards with shared VME bus.

Baget 83 is mentioned here for completeness only. It has only 2mb RAM and it's too small to run Linux. The Baget/MIPS code has been merged with the DECstation port; source for both is available at <http://decstation.unix-ag.org/>.

Cobalt Qube and Raq

The Cobalt Qube product series are low cost headless server systems based on a IDT R5230. Cobalt has developed its own Linux/MIPS variant to fit the special requirements of the Qube as well as possible. Basically the Qube kernel has been derived from Linux/MIPS 2.1.56, then backported to 2.0.30 for stability's sake, then optimized. Cobalt kernels are available from Cobalt's ftp site <http://www.cobaltnet.com>. The Cobalt Qube support has never been integrated into the official Linux/MIPS 2.1.x kernels.

NEC machines

The NEC uniprocessor machines are OEM *Acer PICA* systems, see that section for details. The SMP systems are different from that. The Linux/MIPS developers have no technical documentation as necessary to write an OS. As long as this does not change this will pretty much stay a show stopper preventing a port to NEC's SMP systems.

NEC VR41xx-based platforms

The Linux VR project is porting Linux to devices based on the NEC VR41xx microprocessors. Many of these devices were originally designed to run Windows CE. The project has produced working kernels with basic drivers for the Vadem Clio, Casio E-105, Everex Freestyle, and more. For more information please see <http://linux-vr.org/>.

Toshiba TMPR39xx/Philips PR31700 platforms

Similar to the VR41xx, devices with these processors were originally intended for running Windows CE. However, there are working kernels with basic drivers for *Sharp Mobilon* and the *Compaq C-Series*. Support for more devices is under construction. The code is part of the Linux VR project and as such more information can be found at <http://linux-vr.org/>.

Netpower 100

The *Netpower 100* is apparently an *Acer PICA* in disguise. It should therefore be supported but this is untested. If there is a problem then it is probably the machine detection.

Nintendo 64

The *Nintendo 64* is R4300 based game console with 4mb RAM. Its graphics chips were developed by Silicon Graphics for Nintendo. Right now this port has pipe dream status and will continue to be in that state until Nintendo decides to publish the necessary technical information. The question remains as to whether this is a good idea.

Silicon Graphics Challenge S

This machine is very similar to the Indy; the difference is that it doesn't have a keyboard and a GFX card but has an additional SCSI WD33C95 based adapter. This WD33C95 hostadapter is currently not supported.

Silicon Graphics Indigo

This machine is only being mentioned here because occasionally people have confused it with Indys or the Indigo 2. The Indigo is a different, R3000 based architecture however and not yet unsupported.

Silicon Graphics Indigo2

This machine is the successor to the Indigo and is very similar to the Indy. It is now supported, however it is lacking in several areas. You will have to use serial console. If you have a Indigo2 and still want to run Linux on it, contact either [Florian Lohoff \(flo@rfc822.org\)](mailto:flor@rfc822.org) or [Klaus Naumann \(spock@mgnet.de\)](mailto:Klaus.Naumann@spock@mgnet.de).

Silicon Graphics Indy

The Indy is currently the only (mostly) supported Silicon Graphics machine. The only supported graphics card is the Newport card aka ``XL" graphics. The Indy is available with a large number of CPU options at various clock rates all of which are supported. There's also a X server available now written by [Guido Guenther \(guido.guenther@gmx.net\)](mailto:guido.guenther@gmx.net). If you're able to use the Newport console on your Indy it should be possible to also use this X server. It's based on XFree86 4.0 and currently running at snail speed but seems to work quite ok. If you want to try it take a look at <http://honk.physik.uni-konstanz.de/~agx/mipslinux/x/>.

Strange numbers of available memory

On bootup the kernel on the Indy will report available memory with a message like

```
Memory: 27976k/163372k available (1220k kernel code, 2324k data)
```

The large difference between the first pair of numbers is caused by a 128mb area in the Indy's memory address space which mirrors up to the first 128mb of memory. The difference between the two numbers will always be about 128mb and does not indicate a problem of any kind. Kernels since 2.3.23 don't count this 128mb gap any longer.

Indy PROM related problems

Several people have reported these problems with their machines after upgrading them typically from surplus parts. There are several PROM versions for the Indy available. Machines with old PROM versions which have been upgraded to newer CPU variants like a R4600SC or R5000SC module can crash during the self test with an error message like

```
Exception: <vector=Normal>
Status register: 0x30004803<CU1,CU0,IM7,IM4,IPL=???,MODE=KERNEL,EXL,IE>
Cause register: 0x4000<CE=0,IP7,EXC=INT>
Exception PC: 0xbf0b598
Interrupt exception
CPU Parity Error Interrupt
Local I/O interrupt register 1: 0x80 <VR/GIO2>
CPU parity error register: 0x80b<B0,B1,B3,SYSAD_PAR>
CPU parity error: address: 0x1fc0b598
NESTED EXCEPTION #1 at EPC: 9fc3df00; first exception at PC: bfc0b598
```

In that case you'll have to upgrade your machine's PROMs to a newer version or go back to an older CPU version. Usually R4000SC or R4400SC modules should work in that case. Just to be clear, this is a problem which is unrelated to Linux. It's only mentioned here because several Linux users have asked about it.

ELF support in old PROM versions

Old PROM versions don't know about the ELF binary format which the Linux kernel uses, that is can't boot Linux directly. The preferable solution for this is of course a PROM upgrade. Alternatively you can use Sash of IRIX 5 or newer to boot the kernel. Sash knows how to load ELF binaries and doesn't care if it's an IRIX or Linux kernel. Simply type ``Sash" to the prom monitor. You should get another shell prompt, this time

from Sash. Now launch Linux as usual.

Sash can read EFS or XFS filesystems or read the kernel from bootp / tftp. That means if you intend to use Sash for booting the kernel from local disk you'll still have to have a minimal IRIX installation on your system.

Why is so much memory reserved on my Indy?

On bootup the `Memory: ...' message on an Indy says that there is 128mb of RAM reserved. That is ok; just like the PC architecture has a gap in its memory address space between 640kb and 1024kb, the Indy has a 128mb-sized area in its memory map where the first 128mb of its memory is mirrored. Linux knows about it and just ignores that memory, thus this message.

Silicon Graphics Origin 200 and 2000

[Ralf Bächle \(ralf@gnu.org\)](mailto:ralf@gnu.org) and a team of SGI employees are currently working on a port to the Origin 200. While still in it's early stages it's running in uniprocessor and multiprocessor mode and has drivers for the builtin IOC3 Ethernet and SCSI hostadapters. The code is available in the Linux/MIPS CVS tree.

Silicon Graphics Onyx 2

The Onyx 2 is basically an Origin 2000 with additional graphics hardware. As of now about Linux support for the graphics hardware has not yet been decided. Aside of that Linux should run just as well as on a normal headless Origin 2000 configuration.

Silicon Graphics Power Series

This is a very old series of R3000 SMP systems. There is no hardware documentation for these machines, few of them exist anymore, the hardware is weird. In short, chances that Linux will ever run on them are approximating zero. Not that we want to discourage takers ...

Serial console on SGI machines

Make sure the kernel you're using includes the appropriate driver for a serial interface and serial console. Set the *console* ARC environment variable to either the value *d1* or *d2* for Indy and Challenge S depending on which serial interface you're going to use as console.

If you have the problem that all kernel messages appear on the serial console on bootup but everything is missing from the point when init starts, then you probably have the wrong setup for your */dev/console*. You

can find more information about this in the Linux kernel source documentation; it's in `/usr/src/linux/Documentation/serial-console.txt` if you have the kernel source installed.

Other Silicon Graphics machines

At this time no other Silicon Graphics machine is supported. This also applies to the *very* old Motorola 68k based systems.

Sony Playstation

The Sony Playstation is based on an R3000 derivative and uses a set of graphics chips developed by Sony themselves. While the machine in theory would be capable of running Linux, a port is difficult, since Sony so far hasn't provided the necessary technical information. This still leaves the question of whether the port would be worthwhile. So in short, nothing has happened yet even though many people have shown their interest in trying Linux on a Playstation so far.

SNI RM200C

In contrast to the RM200 (see below) this machine has EISA and PCI slots. The RM200 is supported with the exception of the availability of the onboard NCR53c810A SCSI controller.

SNI RM200

If your machine has both EISA and PCI slots, then it is an RM200C; please see above. Due to the slight architectural differences of the RM200 and the RM200C this machine isn't currently supported in the official sources. [Michael Engel \(engel@numerik.math.uni-siegen.de\)](mailto:engel@numerik.math.uni-siegen.de) has managed to get his RM200 working partially but the patches haven't yet been included in the official Linux/MIPS sources.

SNI RM300C

The RM300 is technically very similar to the RM200C. It should be supported by the current Linux kernel, but we haven't yet received any reports.

SNI RM400

The RM400 isn't supported.

SNI RW320

This machine is a OEM variant of the SGI Indigo and therefore also still unsupported.

Algorithmics P4032

The Algorithmics P4032 port is at the time of this writing still running Linux 2.1.36.

Algorithmics P5064

The P5064 is basically an R5000-based 64bit variant of the P4032. A port is ongoing.

DECstation series

During the late 80's and the early 90's Digital (now Compaq) built MIPS based Workstations named DECstation resp. DECsystem. Other x86 and Alpha based machines were sold under the name DECstation, but these are obviously not subject of this FAQ. Support for DECstations is still under development, started by Paul M. Antoine. These days most of the work is done by [Harald Koerfgen](mailto:Harald.Koerfgen@home.ivm.de) (Harald.Koerfgen@home.ivm.de) and others. On the Internet, DECstation-related information can be found at <http://decstation.unix-ag.org/>.

The DECstation family ranges from the DECstation 2100 with an R2000/R2010 chipset at 12 Mhz to the DECstation 5000/260 with a 60 MHz R4400SC.

The following DECstation models are actively supported:

- 2100, codename PMAX
- 5000/xx (Personal DECstation), codename MAXine
- 5000/1xx, codename 3MIN
- 5000/200, codename 3MAX
- 5000/2x0, codename 3MAX+
- 5900/2x0 (identical to the 3MAX+).

These DECstation models are orphaned because nobody is working on them, but support for these should be relatively easy to achieve.

- 3100, identical to the 2100 except the R2000A/R2010A @ 16 MHz
- 5100, codename MIPS MATE, almost identical to the 2100 but with an R3000/R3010 chipset.

The other members of the DECstation family, besides the x86 based ones, should be considered as VAXen with the CPU replaced by a MIPS CPU. There is absolutely no information available about these machines and support for them is unlikely to happen ever unless the VAXLinux port comes to a new life. These are:

- 5400, codename MIPSFAIR
- 5500, codename MIPSFAIR2
- 5800, codename ISIS

Mips Magnum 4000 / Olivetti M700-10

These two machines are almost completely identical. Back during the ACE initiative Olivetti licensed the Jazz design and marketed the machine with Windows NT as OS. MIPS Computer Systems, Inc. itself bought the Jazz design and marketed it as the MIPS Magnum 4000 series of machines. Magnum 4000 systems were marketed with Windows NT and RISC/os as operating systems.

The firmware on the machine depended on the operating system which was installed. Linux/MIPS supports only the little endian firmware on these two types of machines. Since the M700-10 was only marketed as an NT machine all M700-10 machines have this firmware installed. The MIPS Magnum case is somewhat more complex. If your machine has been configured big endian for RISC/os then you need to reload the little endian firmware. This firmware was originally included on a floppy with the delivery of every Magnum. If you don't have the floppy anymore you can download it via anonymous ftp from <ftp://ftp.fnet.fr>.

It is possible to reconfigure the M700 for headless operation by setting the firmware environment variables ConsoleIn and ConsoleOut to multi()serial(0)term(). Also try the command *listdev* which will show the available ARC devices.

In some cases, like where the G364 graphics card is missing but the console is still configured to use normal graphics it will be necessary to set the configuration jumper JP2 on the board. After the next reset the machine will reboot with the console on COM2.

MIPS Magnum 4000SC

The Mips Magnum 4000SC is the same as a Magnum 4000 (see above) with the exception that it uses an R4000SC CPU.

3.2 Processor types

R2000, R3000 family

The R2000 is the original MIPS processor. It's a 32 bit processor which was clocked at 8MHz back in '85 when the first MIPS processors came to the market. Later versions were clocked faster: for instance, the R3000 is a 100% compatible redesign of the R2000, just clocked faster. Because of their high compatibility, where this document mentions the R3000, in most cases the same facts also apply to the R2000. The R3000A is basically an R2000 plus an R3010 FPU and 64k cache running at up to 40Mhz and integrated into the same chip.

[Harald Koerfgen \(Harald.Koerfgen@home.ivm.de\)](mailto:Harald.Koerfgen@home.ivm.de) and [Gleb O. Raiko \(raiko@niisi.msk.ru\)](mailto:raiko@niisi.msk.ru) have both independently worked on patches for R3000 processors. The work has been merged and is integrated into the official Linux/MIPS sources since July 1999. Actually Linux supports R3000 processors including some derivatives like the R3081 and the TMPR3912/PR31700

R6000

Sometimes people confuse the R6000, a MIPS processor, with RS6000, a series of workstations made by IBM. So if you're reading this in hope of finding out more about Linux on IBM machines you're reading the wrong document.

The R6000 is currently not supported. It is a 32-bit MIPS ISA 2 processor and a pretty interesting and weird piece of silicon. It was developed and produced by a company named *BIT Technology*. Later NEC took over the semiconductor production. It was built in ECL technology, the same technology that was and still is being used to build extremely fast chips like those used in some Cray computers. The processor had its TLB implemented as part of the last couple of lines of the external primary cache, a technology called *TLB slice*. That means its MMU is substantially different from those of the R3000 or R4000 series, which is also one of the reasons why the processor isn't supported.

R4000 and R5000 family

Linux supports many of the members of the R4000 family. Currently these are R4000PC, R4400PC, R4300, R4600, R4700, R5000, R5230, R5260. Many others are probably working as well.

Not supported are R4000MC and R4400MC CPUs (that is multiprocessor systems) as well as R5000 systems with a CPU controlled second level cache. This means where the cache is controlled by the R5000 itself in contrast to some external external cache controller. The difference is important because, unlike other systems, especially PCs, on MIPS the cache is architecturally visible and needs to be controlled by software.

Special credit goes to [Ulf Carlsson \(ulfc@engr.sgi.com\)](mailto:ulfc@engr.sgi.com) who provided the CPU module for debugging the R4000SC / R4400SC support.

R8000

The R8000 is currently unsupported partly because this processor is relatively rare and has only been used in a few SGI machines, partly because the Linux/MIPS developers don't have such a machine.

The R8000 is a pretty interesting piece of silicon. Unlike the other members of the MIPS family it is a set of seven chips. Its cache and TLB architecture are pretty different from the other members of the MIPS family. It was born as a quick hack to get the floating point crown back to Silicon Graphics before the R10000 is finished.

R10000

The R10000 is supported as part of the mips64 kernel which currently is supported on the IP22 (SGI Indy, Challenge S and Indigo 2) and Origin.

Due to the very hard to handle way this processor works in non-cache coherent systems it's probably still taking some time until we support this processor in such systems. As of today these systems are the SGI O2 and Indigo

Processors without TLB

For embedded purposes there are special derivatives of above CPU available which often lack a full TLB. We don't support those types nor should you ever expect such support to be added.

Hackers may want to take a look at a Linux subset named Microcontroller Linux or short ucLinux. This would be supportable on TLB-less processors. Given the little difference between CPU types with and without TLB we still recommend to choose a processor with TLB. It's going to save you a lot of engineering.

Processors with partial or no FPU

In theory these processors are supportable, especially when applications don't rely on the presence of a FPU. We however don't support that yet.

3.3 Hardware we're never going to support

IBM RS6000

As the name says these are IBM machines which are based on the RS6000 processor series and as such they're not subject of the Linux/MIPS project. People frequently confuse the IBM RS6000 with the MIPS R6000 architecture. However the Linux/PPC project might do so. Check out <http://www.linuxppc.org/> for further information.

VaxStation

As the name already implies this machine is a member of Digital Equipment's VAX family. It's mentioned here because people often confuse it with Digital's MIPS based DECstation family due to the similar type numbers. These two families of architectures share little technical similarities. Unfortunately the VaxStation, like the entire VAX family, is currently unsupported.

SGI VisPC

This is actually an x86 based system, therefore not covered by this FAQ. There is some limited Linux support available for the older Visual Workstations. The current series of Visual Workstations is an officially supported SGI product, please see <http://oss.sgi.com> and <http://www.sgi.com> for information.

Motorola 68k based machines like the Iris 3000

These are *very* old machines, probably more than ten years old by now. As these machines are not based on MIPS processors this document is the wrong place to search for information. However, in order to make things easy, these machines are currently not supported.

4. [Linux distributions.](#)

4.1 RedHat

For MIPSel, there's Rough Cuts Linux, previously known as Hard Hat Linux, which is most of Red Hat Linux 5.1 ported for MIPSel. You can get this at <ftp://oss.sgi.com/pub/hardhat>.

It is also bundled along with M68k, UltraSparc and PowerPC in a package called "Rough Cuts" pressed by Red Hat, and available wherever Red Hat products are sold. This is a very convenient way to get it without having to download 280MB. You can order Rough Cuts directly from Red Hat at <http://www.redhat.com/product.phtml/RC1000>.

As well, there's a distribution based on Red Hat 5.2 that's targeting the Cobalt Qubes; those binaries will work perfectly on other MIPSel architectures available at <ftp://intel.cleveland.lug.net/pub/Mipsel>. <ftp://bolug.uni-bonn.de/mips> has various rpm packages from Redhat 6.0 and 6.1.

4.2 Debian

A Debian port is underway. Current efforts are being bootstrapped using SGI/Linux as a base, and dpkg compiles natively with few changes. In addition to the SGI version, some interest has been shown in little endian platforms. Keep an eye on the Debian-MIPS Port page, <http://www.debian.org/ports/mips/> for developments.

4.3 Simple

This distribution is for big-endian systems only so far. It's highly experimental, intended for developers' use in testing the latest versions of gcc, binutils, glibc, and the kernel. This is the only glibc 2.2 based distribution available for MIPS. You can always get the latest version of this distribution and accompanying release notes at <ftp://oss.sgi.com/pub/linux/mips/mips-linux/simple>. Also available is a cross-compiler system to aid in development.

5.Linux/MIPS net resources.

5.1 Anonymous FTP servers.

The two primary anonymous FTP servers for Linux/MIPS are

oss.sgi.com

This server should satisfy almost all your Linux/MIPS related ftp desires. Really.

ftp.fnet.fr

This server is currently pretty outdated; it's included here mostly for completeness and for people with interest in prehistoric software.

On all these ftp servers there is a list of mirror sites you may want to use for faster access.

Another source for little endian MIPS binaries is ftp://intel.cleveland.lug.net/pub/Mipsel which carries mostly newer versions of binaries for the Redhat flavour shipping with the Cobalt's.

5.2 Anonymous CVS servers.

For those who always want to stay on the bleeding edge and want to avoid having to download patch files or full tarballs we also have an anonymous CVS server. Using CVS you can checkout the Linux/MIPS source tree with the following commands:

```
cvs -d :pserver:cvs@oss.sgi.com:/cvs login
(Only needed the first time you use anonymous CVS, the password is "cvs")
cvs -d :pserver:cvs@oss.sgi.com:/cvs co <repository>
```

where you insert linux, libc, gdb or faq for <repository>.

The other important CVS archive of the Linux community is vger.kernel.org where a lot of code is being collected before being sent to Linus for distribution. Although vger itself no longer offers anonymous access, there are mirror sites which do provide anonymous access. For details how to access them see <http://cvs.on.openprojects.net/>. The modules which are of interest are ``linux'', ``modutils'', ``pciutils'', ``netutils''.

5.3 Web servers.

The two primary web servers for Linux/MIPS are

<http://oss.sgi.com/mips>

This server covers most of Linux/MIPS; it's somewhat SGI centric but since Linux/MIPS tries to be the same on every platform most of its information is of interest to all users.

<http://lena.fnet.fr>

This server is currently pretty outdated; it's included here mostly for completeness.

All these servers have mirrors scattered all over the world; you may want to use one for best performance.

5.4 Web CVS server.

Via <http://oss.sgi.com/mips/cvsweb> you have direct access the new Linux/MIPS kernel sources and a few other projects hosted in the same CVS archive. The intuitive interface allows you to follow the development at the click of your mouse.

5.5 Mailing lists.

There are three Linux/MIPS oriented mailing lists:

linux-mips@fnet.fr

This mailing list is used for most non-SGI related communication of all kinds. Subscription is handled by a human; send your subscription requests to linux-mips-request@fnet.fr. You can unsubscribe from this mailing list by sending *unsubscribe* <*your-email-address*> to the same address.

linux-mips@oss.sgi.com

This mailing list currently has the most traffic. It's somewhat SGI-centric but is nevertheless of interest especially to developers as a good number of SGI engineers are subscribed to this list. Subscription to this list is handled via [Majordomo \(majordomo@oss.sgi.com\)](mailto:Majordomo(majordomo@oss.sgi.com)); just send an email with the words *subscribe linux*. In order to unsubscribe send *unsubscribe linux*. Note that you have to be subscribed if you want to post; the growth of spam forced us into that policy. For more information see also <http://oss.sgi.com/mips/email.html>.

5.6 IRC channel.

There is a IRC channel named #mipslinux for Linux/MIPS which may be found on irc.openprojects.net.

6. Installation of Linux/MIPS and common problems.

6.1 NFS booting fails.

Usually the reason for this is that people have unpacked the tar archive under IRIX, not Linux. Since the representation of device files over NFS is not standardized between various Unices, this fails. The symptom is that the system dies with the error message ``Warning: unable to open an initial console." right after mounting the NFS filesystem.

For now the workaround is to use a Linux system (doesn't need to be MIPS) to unpack the installation archive onto the NFS server. The NFS server itself may be any type of UNIX.

6.2 Self compiled kernels crash when booting.

When I build my own kernel, it crashes. On an Indy the crash message looks like the following; the same problem hits other machines as well but may look completely different.

```
Exception: <vector=UTLB Miss>
Status register: 0x300004803<CU1,CU0,IM4,IPL=???,MODE=KERNEL,EXL,IE>
Cause register: 0x8008<CE=0,IP8,EXC=RMISS>
Exception PC: 0x881385cc, Exception RA: 0x88002614
exception, bad address: 0x47c4
Local I/O interrupt register 1: 0x80 <VR/GIO2>
Saved user regs in hex (&gpda 0xa8740e48, &_regs 0xa8741048):
  arg: 7 8bfff938 8bffc4d 880025dc
  tmp: 8818c14c 8818c14c 10 881510c4 14 8bfad9e0 0 48
  sve: 8bdfd3e8 8bffc40 8bfb2720 8bfff938 a8747420 9fc56394 0 9fc56394
  t8 48 t9 8bfffef66 at 1 v0 0 v1 8bfff890 k1 bad11bad
  gp 881dfd90 fp 9fc4be88 sp 8bfff8b8 ra 88002614

PANIC: Unexpected exception
```

This problem is caused by a still unfixed bug in Binutils newer than version 2.7. As a workaround, change the following line in arch/mips/Makefile from:

```
LINKFLAGS      = -static -N
```

to:

```
LINKFLAGS      = -static
```

6.3 Booting the kernel on the Indy fails with PROM error messages

```
>> boot bootp()/vmlinux
73264+592+11520+331680+27848d+3628+5792 entry: 0x8df9a960
Setting $netaddres to 192.168.1.5 (from server deadmoon)
Obtaining /vmlinux from server deadmoon

Cannot load bootp()/vmlinux
Illegal f_magic number 0x7f45, expected MIPSELMAGIC or MIPSEBMAGIC.
```

This problem only happens for Indys with very old PROM versions which cannot handle the ELF binary format which Linux uses. A solution for this problem is in the works.

6.4 Where can I get the little endian firmware for my SNI?

SNI's system can be operated in both big and little endian modes. At this time Linux/MIPS only supports the little endian firmware. This is somewhat unlucky since SNI hasn't shipped that firmware for quite some time, since they dropped NT.

When running in big endian mode the firmware looks similar to an SGI Indy which is already supported, therefore fixing the SNI support will be relatively easy. Interested hackers should contact [Ralf Bächle](mailto:ralf@gnu.org) (ralf@gnu.org).

6.5 ld dies with signal 6

```
collect2: ld terminated with signal 6 [Aborted]
```

This is a known bug in older binutils versions. You will have to upgrade to binutils 2.8.1 plus very current patches.

6.6 My machine doesn't download the kernel when I try to netboot

Your machine is replying to the BOOTP packets (you may verify this using a packet sniffer like tcpdump or ethereal) but doesn't download the kernel from your BOOTP server. This happens if your boot server is running a kernel of the 2.3 series or higher. The problem may be circumvented by doing a "echo 1 > /proc/sys/net/ipv4/ip_no_pmtu_disc" as root on your boot server.

6.7 Bug in DHCP version 2

When using DHCP version 2 you might see the following problem: Your machine receives its BOOTP reply 3 times but refuses to start TFTP. You can fix this by doing a "unsetenv netaddr" in the PROM command monitor before you boot your system. DHCP version 3 fixes that problem.

7. [Milo](#)

Milo is the boot loader used to boot the little endian MIPS systems with ARC firmware, currently the Jazz family and the SNI RM 200. While Milo uses the same name and has a similar purpose to the Alpha version of Milo, these two Milos have nothing else in common. They were developed by different people, don't share any code, and work on different hardware platforms. The fact that both have the same name is just a kind of historic ``accident".

Plans are to remove the need for Milo in the near future.

7.1 Building Milo

The building procedure of Milo is described in detail in the README files in the Milo package. Since Milo has some dependencies to kernel header files which have changed over time Milo often cannot be built easily; however the Milo distribution includes binaries for both Milo and Pandora.

7.2 Pandora

Pandora is a simple debugger. It has been primarily developed in order to analyze undocumented systems. Pandora includes a disassembler, memory dump functions and more. If you only want to use Linux there is no need to install Pandora. It's small though.

8. [Loadable Modules](#)

Using modules on Linux/MIPS is quite easy; it should work as expected for people who have used it on other Linux systems. If you want to run a module-based system then you should have at least kernel version 980919 and modutils newer than version 2.1.121 installed. Older versions won't work.

9. [How do I set up a cross-compiler?](#)

9.1 Available binaries

The easiest thing to setup a cross-compiler is to just download the binaries. For Linux/i386 hosts and big endian targets this are the packages:

```
binutils-mips-linux-2.8.1-1.i386.rpm
egcs-c++-mips-linux-1.0.3a-1.i386.rpm
egcs-g77-mips-linux-1.0.3a-1.i386.rpm
egcs-libstdc++-mips-linux-2.8.0-1.i386.rpm
egcs-mips-linux-1.0.3a-1.i386.rpm
egcs-objc-mips-linux-1.0.3a-1.i386.rpm
```

And this is the list of packages for little endian targets:

```
binutils-mipsel-linux-2.8.1-1.i386.rpm
egcs-c++-mipsel-linux-1.0.3a-1.i386.rpm
egcs-g77-mipsel-linux-1.0.3a-1.i386.rpm
egcs-libstdc++-mipsel-linux-2.8.0-1.i386.rpm
egcs-mipsel-linux-1.0.3a-1.i386.rpm
egcs-objc-mipsel-linux-1.0.3a-1.i386.rpm
```

It's not necessary that you install all these packages; most people can just omit the C++, Objective C and Fortran 77 compilers. The Intel binaries have been linked against GNU libc 2.1, so you may have to install that as well when upgrading.

9.2 Building your own cross-compiler

First of all go and download the following source packages and patches:

- binutils-2.8.1.tar.gz
- binutils-2.8.1-2.diff.gz
- egcs-1.0.3a.tar.gz
- egcs-1.0.3a-1.diff.gz
- glibc-2.0.6.tar.gz
- glibc-crypt-2.0.6.tar.gz
- glibc-localedata-2.0.6.tar.gz

- glibc–linuxthreads–2.0.6.tar.gz

These are the currently recommended versions. Older versions may or may not be working. If you're trying to use older versions please don't send bug reports; we don't care. When installing please install things in the order binutils, egcs, then glibc. Unless you have older versions already installed, changing the order *will* fail. The installation description below mentions a number of patches which you can get from the respective SRPM packages on oss.sgi.com. However since these SRPM packages are intended to be compiled natively it's not possible to just rebuild them.

9.3 Disk space requirements

For the installation you'll have to choose a directory for installation. I'll refer to that directory below with <prefix>. To avoid a certain problem it's best to use the same value for <prefix> as your native gcc. For example if your gcc is installed in /usr/bin/gcc then choose /usr for <prefix>. You must use the same <prefix> value for all the packages that you're going to install.

During compilation you'll need about 31mb disk space for binutils; for installation you'll need 7mb disk space for on <prefix>'s partition. Building egcs requires 71mb and installation 14mb. GNU libc requires 149mb disk space during compilation and 33mb for installation. Note these numbers are just a guideline and may differ significantly for different processor and operating system architectures.

9.4 Byte order

One of the special features of the MIPS architecture is that all processors except the R8000 can be configured to run either in big or in little endian mode. Byte order means the way the processor stores multibyte numbers in memory. Big endian machines store the byte with the highest value digits at the lowest address while little endian machines store it at the highest address. Think of it as writing multi-digit numbers from left to right or vice versa.

In order to setup your cross-compiler correctly you have to know the byte order of the cross-compiler target. If you don't already know, check the section [Hardware Platforms](#) for your machine's byte order.

9.5 Configuration names

Many of the packages based on autoconf support many different architectures and operating systems. In order to differentiate between these many configurations, names are constructed with <cpu>–<company>–<os> or even <cpu>–<company>–<kernel>–<os>. Expressed this way the configuration names of Linux/MIPS are mips–unknown–linux–gnu for big endian targets or mipsel–unknown–linux–gnu for little endian targets. These names are a bit long and are allowed to be abbreviated to mips–linux or mipsel–linux. You *must* use the same configuration name for all packages that comprise your cross-compilation environment. Also, while other names like mips–sni–linux or mipsel–sni–linux are legal configuration names, use mips–linux or mipsel–linux instead; these are the configuration names known to other packages like the Linux kernel sources and they'd otherwise have to be changed for cross-compilation.

I'll refer to the target configuration name below with <target>.

9.6 Installation of GNU Binutils.

This is the first and simplest part – at least as long as you're trying to install on any halfway–sane UNIX flavour. Just cd into a directory with enough free space and do the following:

```
gzip -cd binutils-<version>.tar.gz | tar xf -
cd binutils-<version>
patch -p1 < ../binutils-<version>-mips.patch
./configure --prefix=<prefix> --target=<target>
make CFLAGS=-O2
make install
```

This usually works very easily. On certain machines using GCC 2.7.x as compiler is known to dump core. This is a known bug in GCC and can be fixed by upgrading to GCC 2.8.1 or egcs.

9.7 Assert.h

Some people have an old assert.h header file installed, probably a leftover from an old cross–compiler installation. This file may cause autoconf scripts to fail silently; it was never necessary and was only installed because of a bug in older GCC versions. Check to see if the file <prefix>/<target>/include/assert.h exists in your installation. If so, just delete it: it should never have been installed for any version of the cross–compiler and will cause trouble.

9.8 Installing the kernel sources

Installing the kernel sources is simple. Just place them into some directory of your choice and configure them. Configuring them is necessary such that files which are generated by the procedure will be installed. Make sure you enable CONFIG_CROSSCOMPILE near the end of the configuration process. The only problem you may run into is that you may need to install some required GNU programs like bash or have to override the manufacturer–provided versions of programs by placing the GNU versions earlier in the PATH variable. Now go to the directory <prefix>/<target>/include and create two symbolic links named asm and linux pointing to include/asm resp. include/linux within your just installed and configured kernel sources. These are necessary such that necessary header files will be found during the next step.

9.9 First installation of egcs

Now the not–so–funny part begins: there is a so–called bootstrap problem. In our case that means the installation process of egcs needs an already– installed glibc, but we cannot compile glibc because we don't have a working cross–compiler yet. Luckily you'll only have to go through this once when you install a cross–compiler for the first time. Later when you already have glibc installed things will be much smoother. So now do:

```
gzip -cd egcs-1.0.3a.tar.gz | tar xf -
cd egcs-<version>
patch -p1 < ../egcs-1.0.3a-mips.patch
./configure --prefix=<prefix> --with-newlib --target=<target>
make SUBDIRS="libiberty texinfo gcc" ALL_TARGET_MODULES= \
    CONFIGURE_TARGET_MODULES= INSTALL_TARGET_MODULES= LANGUAGES="c"
```

Note that we deliberately don't build gcov, protoize, unprotoize and the libraries. Gcov doesn't make sense in a cross-compiler environment and protoize and unprotoize might even overwrite your native programs – this is a bug in the gcc makefiles. Finally we cannot build the libraries because we don't have glibc installed yet. If everything went successfully, install with:

```
make SUBDIRS="libiberty texinfo gcc" INSTALL_TARGET_MODULES= \
    LANGUAGES="c" install
```

If you only want the cross-compiler for building the kernel, you're done. Cross-compiling libc is only required to be able to compile user applications.

9.10 Test what you've done so far

Just to make sure that what you've done so far is actually working you may now try to compile the kernel. Cd to the MIPS kernel's sources and type ``make clean; make dep; make''. If everything went ok do ``make clean'' once more to clean the sources.

9.11 Installing GNU libc

Do:

```
gzip -cd glibc-2.0.6.tar.gz | tar xf -
cd glibc-2.0.6
gzip -cd glibc-crypt-2.0.6.tar.gz | tar xf -
gzip -cd glibc-localedata-2.0.6.tar.gz | tar xf -
gzip -cd glibc-linuxthreads-2.0.6.tar.gz | tar xf -
patch -p1 < ../glibc-2.0.6-mips.patch
mkdir build
cd build
CC=<target>-gcc BUILD_CC=gcc AR=<target>-ar RANLIB=<target>-ranlib \
    ../configure --prefix=/usr --host=<target> \
    --enable-add-ons=crypt,linuxthreads,localedata --enable-profile
make
```

You now have a compiled GNU libc which still needs to be installed. Do *not* just type make install. That would overwrite your host system's files with Linux/MIPS-specific files with disastrous effects. Instead install GNU libc into some other arbitrary directory <somedir> from which we'll move the parts we need for cross-compilation into the actual target directory:

```
make install_root=<somedir> install
```

Now cd into <somedir> and finally install GNU libc manually:

```
cd usr/include
```

```
find . -print | cpio -pumd <prefix>/<target>/include
cd ../../lib
find . -print | cpio -pumd <prefix>/<target>/lib
cd ../usr/lib
find . -print | cpio -pumd <prefix>/<target>/lib
```

GNU libc also contains extensive online documentation. Your systems might already have a version of this documentation installed, so if you don't want to install the info pages, which will save you a less than a megabyte, or already have them installed, skip the next step:

```
cd ../info
gzip -9 *.info*
find . -name \*.info\* -print | cpio -pumd <prefix>/info
```

If you're not bootstrapping your installation is now finished.

9.12 Building egcs again

The first attempt of building egcs was stopped by lack of a GNU libc. Since we now have libc installed we can rebuild egcs but this time as complete as a cross-compiler installation can be:

```
gzip -cd egcs-<version>.tar.gz | tar xf -
cd egcs-<version>
patch -p1 < ../egcs-1.0.3a-mips.patch
./configure --prefix=<prefix> --target=<target>
make LANGUAGES="c c++ objective-c f77"
```

As you can see the procedure is the same as the first time with the exception that we dropped the `--with-newlib` option. This option was necessary to avoid the libgcc build breaking due to the lack of libc. Now install with:

```
make LANGUAGES="c c++ objective-c f77" install
```

You're almost finished. If you think you don't need the Objective C or F77 compilers you can omit them from above commands; each will save you about 3mb. Do not build gcov, protoize or unprotoize.

9.13 Should I build the C++, Objective C or F77 compilers?

The answer to this question largely depends on your use of your cross-compiler environment. If you only intend to rebuild the Linux kernel then you have no need for the full blown setup and can safely omit the Objective C and F77 compilers. You must, however, build the C++ compiler, because building the libraries included with the egcs distribution requires C++.

9.14 Known problem when cross-compiling

IRIX crashes

Origin 200 running IRIX 6.5.1 may crash when running ``make depend'' on the Linux kernel sources. IRIX 6.5 on Indy and IRIX 6.5.4 on Origin 200 are known to work. Further reports on that help isolating the problematic configuration are welcome.

Resource limits on System V based hosts

Typical System V based Unices like IRIX or Solaris have limits for the maximum number of arguments to be passed to a child process which may be exceeded when cross-compiling some software like the Linux kernel or GNU libc. For IRIX systems the maximum length of the argument list defaults to 20kb while Linux defaults to at least 128kb. This size can be modified by the command ``systemctl ncargs 131072'' as root.

9.15 GDB

Building GDB as cross-debugger is only of interest to kernel developers; for them GDB may be a life saver. Such a remote debugging setup always consists of two parts: the remote debugger GDB running on one machine and the target machine running the Linux/MIPS kernel being debugged. The machines are typically interconnected with a serial line. The target machine's kernel needs to be equipped with a ``debugging stub'' which communicates with the GDB host machine using the remote serial protocol.

Depending on the target's architecture you may have to implement the debugging stub yourself. In general you'll only have to write very simple routines for serial. The task is further simplified by the fact that most machines are using similar serial hardware typically based on the 8250, 16450 or derivatives.

10. [Related Literature](#)

10.1 See MIPS Run

author Dominic Sweetman, published Morgan Kaufmann, ISBN 1-55860-410-3.

This is intended as a pretty comprehensive guide to programming MIPS, wherever it's different from programming any other 32-bit CPU. It's the first time anyone tried to write a readable and comprehensive explanation and account of the wide range of MIPS CPUs available, and should be very helpful for anyone programming MIPS who isn't insulated by someone else's operating system. And the author is a free-unix enthusiast who subscribes to the Linux/MIPS mailing list!

John Hennessey, father of the MIPS architecture, was kind enough to write in the foreword: ``... this book is

the best combination of completeness and readability of any book on the MIPS architecture ...";

It includes some context about RISC CPUs, a description of the architecture and instruction set including the "co-processor 0" instructions used for CPU control; sections on caches, exceptions, memory management and floating point. There's a detailed assembly language guide, some stuff about porting, and some fairly heavy-duty software examples.

Available from:

- <http://www.algor.co.uk/algor/info/seemipsrun.html> (europe)
- http://www.mkp.com/books_catalog/1-55860-410-3.asp (US)

and from good bookshops anywhere. It's 512 pages and costs around \$50 in the US, £39.95 in the UK.

I'd be inclined to list two other books too, both from Morgan Kaufmann and available from www.mkp.com or any good bookshop:

10.2 The MIPS Programmer's Handbook

authors Farquhar and Bunce, published by Morgan Kaufmann, ISBN 1-55860-297-6.

A readable introduction to the practice of programming MIPS at the low level, by the author of PMON. Strengths: lots of examples; weakness: leaves out some big pieces of the architecture (such as memory management, floating point and advanced caches) because they didn't feature in the LSI ``embedded"; products this book was meant to partner.

10.3 Computer Architecture – A Quantitative Approach

authors Hennessy & Patterson, published Morgan Kaufmann, ISBN 1-55860-329-8.

The bible of modern computer architecture and a must-read if you want to understand what makes programs run slow or fast. Is it about MIPS? Well, it's mostly about something very *like* MIPS... Its sole defect is its size and weight – but unlike most big books it's worth every page.

10.4 UNIX System V ABI MIPS Processor Supplement

by Prentice Hall, published 05/1991, ISBN 0-13880-170-3. This book defines many of the MIPS specific technical standards like calling conventions, ELF properties and much more that are being used by Linux/MIPS. Unfortunately it's out of print. Similarly the site "<http://www.mipsabi.org/>" is offline.
