

## II. Programming Utilities

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**NAME**

Introduction - the programming utilities

**FUNCTION**

The utilities described in this section are provided with the Idris operating system, or with a cross-compiler on any other operating system, to build and debug programs written in assembler, C, or Pascal. Since modules may be separately translated to object code, then combined (by link) in one or more stages to make an executable entity, each module can be written in the most appropriate of the languages supported.

Libraries may be constructed (by lib) from modules that are included only as needed (by link) in building a program. Thus, the library routines provided impose no space penalty for programs that don't use them; and each user is at liberty to add to this set or alter any of its members.

Unless explicitly labelled as machine dependent, every utility in this section can be used to develop programs for any of the machines supported by Whitesmiths, Ltd. compilers. This enhances uniformity of language implementation and simplifies programming for more than one target machine.

**BUGS**

On systems where the code generator (p2) talks to an existing, non-Idris, assembler, many of these utilities are not provided; hence, much of this section may be irrelevant.

**NAME**

Conventions - using the utilities

**FUNCTION**

Each of the utilities described in this section is a separate "program" that may be run, or "invoked", by typing a "command line", usually in response to a "prompt" such as the Idris "% ". This document provides a systematic guide to the conventions that govern how command lines are specified. It also summarizes the layout of the individual utility descriptions that follow, so that you know what information appears where, and in what format.

Command Lines

In general, a command line has three major parts: a program name, an optional series of flags, and a series of non-flag arguments, usually given in that order. Each element of a command line is usually a string separated by whitespace from all the others. Most often, of course, the program name is just the (file) name of the utility you want to run. Flags, if given, change some aspect of what a utility does, and generally precede all other arguments, because a utility must interpret them before it can safely interpret the remainder of the command line.

The meaning of the non-flag arguments strongly depends on the utility being run, but there are five general classes of command lines, presented here (where possible) with examples taken from the portable software tools, since they run much the same way on many different systems:

- 1) program name and flags followed by a series of filenames. These programs (called filters) process each file named in the order specified. An example is sort.
- 2) program name and flags followed by a series of arguments that are not filenames, but strings to which the program gives some other interpretation. echo is one such utility.
- 3) program name and a mandatory argument, which precedes the rest of the command line, followed by flags and other arguments. grep and tr belong to this class.
- 4) program name and flags followed by a series of "source" filenames, and a single "destination" filename. A filename to be paired with each source name is created by applying "pathname completion" to the destination name; for instance, the destination filename might be a directory of files whose names match the source filenames. These programs (called directed utilities) then perform some operation using each pair of files. diff is one example.
- 5) program name and flags followed by a command line that the utility executes after changing some condition under which it will run. These tend to be more sophisticated tools, like error, which redirects error messages under Idris.

A summary of the command line classes looks like this:

<u>Class</u>	<u>Example</u>	<u>Syntax</u>
filter	sort	<progrname> <flags> <files>
string		
arguments	echo	<progrname> <flags> <args>
mandatory		
argument	grep	<progrname> <arg> <flags> <files>
directed	diff	<progrname> <flags> <files> <dest>
prefix	error	<progrname> <flags> <command>

Note that, in general, <flags> are optional in any command line.

### Flags

Flags are used to select options or specify parameters when running a program. They are command line arguments recognized by their first character, which is always a '-' or a '+'. The name of the flag (usually a single letter) immediately follows the leading '-' or '+'. Some flags are simply YES/NO indicators -- either they're named, or they're not -- but others must be followed by some additional information, or "value". This value, if required, may be an integer, a string of characters, or just one character. String or integer values are specified as the remainder of the argument that names the flag; they may also be preceded by whitespace, and hence be given as the next argument.

The flags given to a utility may appear in any order, and two or more may be combined in the same argument, so long as the second flag can't be mistaken for a value that goes with the first one. Some flags have only a value, and no name. These are given as a '-' or '+' immediately followed by the value.

Thus all of the following command lines are equivalent, and would pass to `uniq` the flags `-c` and `-f`:

```
% uniq -c -f
% uniq -f -c
% uniq -fc
```

And each of the following command lines would pass the three flags `-c3`, `-n`, and `-4` to `pr`:

```
% pr -c3 -4 -n file1
% pr -4 -nc 3 file1
% pr -n4 -c 3 file1
```

In short, if you specify flags so that you can understand them, a utility should have no trouble, either.

Usually, if you give the same flag more than once, only the last occurrence of the flag is remembered, and the repetition is accepted without comment. Sometimes, however, a flag is explicitly permitted to occur multiple times, and every occurrence is remembered. Such flags are said to

be "stacked," and are used to specify a set of program parameters, instead of just one.

Another special flag is the string "--", which is taken as a flag terminator. Once it is encountered, no further arguments are interpreted as flags. Thus a string that would normally be read as a flag, because it begins with a '-' or a '+', may be passed to a utility as an ordinary argument by preceding it with the argument "--". The string "--" also causes flag processing to terminate wherever it is encountered, but, unlike "--", is passed to the utility instead of being "used up", for reasons explained below.

If you give an unknown flag to a utility, it will usually display a hint to remind you of what the proper flags are. This message summarizes the format of the command line the utility expects, and is explained below in the synopsis section of the psuedo-manual page. Should you forget what flags a utility accepts, you can force it to output this "usage summary" by giving it the flag "-help", which is never a valid flag argument. (If a utility expects a mandatory argument, you'll have to say "-help -help" to get past the argument.)

Finally, be warned that some combinations of flags to a given utility may be invalid. If a utility doesn't like the set you've given, it will output a message to remind you of what the legal combinations are.

#### Files

Any utility that accepts a series of input filenames on its command line will also read its standard input, STDIN, when no input filenames are given, or when the special filename "-" is encountered. Hence sort can be made to read STDIN just by typing:

```
% sort
```

while the following would concatenate file1, then STDIN, then file2, and write them to STDOUT:

```
% cat file1 - file2
```

Naturally, whenever STDIN is read, it is read until end-of-file, and so should not be given twice to the same program.

#### Manual Pages

The remainder of this document deals with the format of the manual pages describing each of the utilities. Manual pages are terse, but complete and very tightly organized. Because of their general sparseness, getting information out of them hinges on knowing where to find what you're after, and what form it's likely to take when you find it. Manual pages are divided into several standard sections, each of which covers one aspect of using the documented utility. So, for clarity, the rest of this document is presented as a psuedo-manual page, with the remarks on each section of a real page appearing under the normal heading for that section.

**NAME**

name - the name and a short description of the utility

**SYNOPSIS**

This section gives a one-line synopsis of the command line that the utility expects. The synopsis is taken from the message that the flag -help will cause most utilities to output, and indicates the main components of the command line: the utility name itself, the flags the utility accepts, and any other arguments that may (or must) appear.

Flags are listed by name inside the delimiters "[" and "]". They generally appear in alphabetic order; flags consisting only of a value (see above) are listed after all the others. If a flag includes a value, then the kind of value it includes is also indicated by one of the following codes, given immediately after the flag name:

<u>Code</u>	<u>Kind of Value</u>
*	string of characters
#	integer (word-sized)
##	integer (long)
?	single character

A '#' designates an integer representable in the word size of the host computer, which may limit it to a maximum as small as 32,767 on some machines. A "##" always designates a long (four-byte) integer, which can represent numbers over two billion. An integer is interpreted as hexadecimal if it begins with "0x" or "0X", otherwise as octal if it begins with '0', otherwise as decimal. A leading '+' or '-' sign is always permitted.

If a flag may meaningfully be given more than once (and stacks its values), then the value code is followed by a '^'.

Thus the synopsis of pr:

```
pr -[c# e# h l# m n s? t# w# +## ##] <files>
```

indicates that pr accepts eleven distinct flags, of which -c, -e, -l, and -w include word-sized integer values, -h, -m, and -n include no values at all, -t includes a string of characters, -s includes a single character, and the two flags +## and -## are nameless, consisting of a long integer alone.

Note that flags introduced by a '-' are shown without the '-'. Roughly the same notation is used in the other sections of a manual page to refer to flags. In the pr manual page, for example, -c# would refer to the flag listed above as c#, while -[c# e# w#] would refer to the flags "c# e# w#".

The position and meaning of non-flag arguments are indicated by "metanotions", that is, words enclosed by '<' and '>' (like <files> in the example above). Each metanotion represents zero or more argu-

ments actually to be given on the command line. When entering a command line, you type whatever the metanotation represents, and type it at that point in the line. In the example, you would enter zero or more filenames at the point indicated by <files>.

No attempt is made in this section to explain the semantics of the command line -- for example, combinations of arguments that are illegal. The next section serves that purpose.

#### FUNCTION

This section generally contains three parts: an overview of the operation of the utility, a description of each of its flags, then (if necessary) additional information on how various flags or other arguments interact, or on details of the utility's operation that affect how it is used.

Usually, the opening overview is brief, summarizing just what the utility does and how it uses its non-flag arguments. The flag descriptions following consist of a separate sentence or more of information on each flag, introduced by the same flag name and value code given under SYNOPSIS. Each description states the effect the flag has if given, and the use of its value, if it includes one. The parameters specified by flag values generally have default settings that are used when the flag is not given; such default values appear at the end of the description. Flags are listed in the same order as in the synopsis line.

Finally, one or more paragraphs may follow the flag descriptions, in order to explain what combinations of flags are not permitted, or how certain flags influence others. Any further information on the utility of interest to the general user is also given here.

#### RETURNS

When it finishes execution, every utility returns one of two values, called success or failure. This section states under what conditions a utility will return one rather than the other. A successful return generally indicates that a utility was able to perform all necessary file processing, as well as all other utility-specific operations. In any case, the returned value is guaranteed to be predictable; this section gives the specifics for each utility.

Note that the returned value is often of no interest -- it can't even be tested on some systems. But when it can be tested, it is instrumental in controlling command scripts.

#### EXAMPLE

Here are given one or more examples of how the utility can be used. The examples seek to show the use of the utility in realistic applications, if possible in conjunction with related programs.

Generally, each example is surrounded by explanatory text, and is set off from the text by an empty line and indentation. In each example, lines preceded by a prompt (such as "% ") represent user input; other lines are the utility's response to the input shown.

**FILES**

This section lists any external files that the utility requires for correct operation. Most often, these files are system-wide tables of information or common device names.

**SEE ALSO**

Here are listed the names of related utilities or tutorials, which should be examined if the current utility doesn't do quite what you want, or if its operation remains unclear to you. Another utility may come closer, and seeing the same issues addressed in different terms may aid your understanding of what's going on.

Other documents in the same manual section as the current page are simply referred to by title; documents in a different section of the same manual are referred to by title and section number.

**BUGS**

This section documents inconsistencies or shortcomings in the behavior of the utility. Most often, these consist of deviations from the conventions described in this manual page, which will always be mentioned here. Known dangers inherent in the improper use of a utility will also be pointed out here.

**BUGS**

There is a fine line between being terse and being cryptic.



**NAME**

ROM - writing read-only code

**FUNCTION**

The C compiler never generates self modifying code. If all instructions are steered into the text section at code generation time (as is the default), then the composite text section produced by the program linker can safely be made read only. This means that a program to be run under an operating system can have its text section write protected every time it is dynamically loaded.

This also means that a free-standing program can have its text section "burned" into ROM (Read Only Memory) for any of the myriad reasons that people find to do so. A free-standing program usually has other issues to contend with as well, however.

Each program has a data section, in addition to its text section. This contains all static and extern declarations, with their initial values. C provides no way to distinguish parameters and tables, which never vary during program execution, from variables with important initial values, from variables that need not be initialized. The safest thing to do, therefore, is to assume the entire data section consists of variables with important initial values -- and, therefore, that an initial image of the data section must be copied from someplace in ROM to the expected addresses in RAM (Random Access Memory, which is writable), at program startup.

This is not a major burden. At program startup, a free-standing C program must have its stack setup -- for autos, arguments, and function call linkages. It is just a bit more work to copy the initial data image. The universal link utility is easily instructed to relocate the data section for its eventual RAM destination, while the hex utility can place it following the text section in ROM. The link utility also can be instructed to define symbols at the end of the text section and the end of the data section in its output file. Thus an initialization routine to copy data from ROM to RAM can simply step through memory from the "end of text" symbol to the "end of data" symbol.

There are ways to decrease the amount of data that must be initialized this way, sometimes to none at all. First there are literals -- character strings, switch tables, and constants -- that the compiler generates of its own accord. On a machine that supports separate instruction and data spaces, literals are steered by default into the data section. Specifying the flag -x6 to the code generator encourages it to put literals in the text section. It is rare that a ROM-based system also uses separate instruction and data spaces.

Similarly, extensive tables that are known to be read only can be collected into one C source file and compiled with the flag -x7 to the code generator, thus placing all data declarations for that file in the text section.

If the remaining variables can be contrived to require no initialization at startup, or to require only a simple initialization, such as all zeros, then the data section can be simply discarded at ROM burning time. This

approach requires, naturally, that all of the source code be available for scrutiny.

One case where this is not possible is when library functions, available only in binary, are incorporated into a ROM-based, or shareable, product. Libraries provided by Whitesmiths, Ltd. contain no gratuitous barriers to being shared. A function such as `exp`, for instance, contains only tables in its data section -- it may safely be passed through the linker to have its data merged into its text section.

Some functions, however, of necessity contain static variables with important initial values. Usually these functions interact with operating system services and hence are not found in ROM-based programs. Examples are `onexit/exit`, which remembers the head of a list of functions to be called on program exit, and `sbreak`, which may hold the current end of the dynamic data area. Still other functions with static variables may find use in free standing programs -- examples are `alloc/free` and `_when/_raise`.

The best practice, therefore, is to adopt the most general startup initialization described above. It is often too hard to determine which library functions are safe, and even harder to remember special rules for keeping new code safe.

**NAME**

as.68k - assembler for MC68000

**SYNOPSIS**

as.68k -[a o\* s x] <files>

**FUNCTION**

as.68k translates MC68000 assembly language to Whitesmiths format relocatable object images. Since the output of the C code generator p2.68k is assembly code, as.68k is required to produce relocatable images suitable for binding with link.

The flags are:

- a when assembling absolute memory references, use absolute short (16-bit) address mode, rather than absolute long. This amounts to a promise that the eventual executable image, in its entirety, will be less than 64k bytes in length.
- o\* write the output to the file \*. Default is xeq. Under some circumstances, an input filename can take the place of this option, as explained below.
- s emit 16-bit, program counter relative references to memory, wherever permitted by the hardware, including for external and forward references. Elsewhere, either absolute short or absolute long references are used, depending on whether -a was given. This option may be safely specified only if every symbol is defined within 32K bytes of all references to it.
- x place all symbols in the object image. Default is to place there only those symbols that are undefined or that are to be made globally known.

If <files> are present, they are concatenated in order and used as the input file instead of the default STDIN.

If -o is absent, and one or more <files> are present, and the first filename ends with ".s", then as.68k behaves as if -o were specified using the first filename, only with the trailing 's' changed to 'o'. Thus,

as.68k file.s

is the same as

as.68k -o file.o file.s

A relocatable object image consists of a 28-byte header followed by a text segment, a data segment, the symbol table, and relocation information. The header consists of the short int 0x992d, an unsigned short int containing the number of symbol table bytes, and six unsigned long ints, giving: the number of bytes of object code defined by the text segment, the number of bytes defined by the data segment, the number of bytes defined by the bss segment, two zeros, and the data segment offset (always

equal to the text segment size). All ints in the object image are written most significant byte first, in pure descending order of byte significance.

Text and data segments each consist of an integral number of short ints. The text segment is relocated relative to location zero, the data segment is relocated relative to the end of the text segment, and the bss segment is relocated relative to the end of the data segment.

Relocation information consists of two byte streams, one for the text segment and one for the data segment, each terminated by a zero control byte. Control bytes in the range [1, 31] cause that many bytes in the corresponding segment to be skipped; bytes in the range [32, 63] skip 32 bytes, plus 256 times the control byte minus 32, plus the number of bytes specified by the relocation byte following.

All other control bytes control relocation of the next short or long int in the corresponding segment. If the 1-weighted bit is set in the control byte, then a change in load bias must be subtracted from the int. The 2-weighted bit is set if a long is being relocated instead of a short; the symbol code is the control byte right shifted two places minus 16.

A symbol code of 47 is replaced by a code obtained from the byte or bytes following in the relocation stream. If the next byte is less than 128, then the symbol code is its value plus 47. Otherwise the code is that byte minus 128, times 256, plus 175 plus the value of the next relocation byte after that one.

A symbol code of zero calls for no further relocation; 1 means that a change in text bias must be added to the item (word or longword); 2 means that a change in data bias must be added; 3 means that a change in bss bias must be added. Other symbol codes call for the value of the symbol table entry indexed by the symbol code minus 4 to be added to the item.

Each symbol table entry consists of a value longword, a flag byte, and an eleven-byte name padded with trailing NULs. Meaningful flag values are 0 for undefined, 4 for defined absolute, 5 for defined text relative, 6 for defined data relative, and 7 for defined bss relative. To this is added 010 if the symbol is to be globally known. The value of an undefined symbol is the minimum number of bytes that must be reserved, should there be no explicit defining reference.

#### SEE ALSO

link, p2.68k, rel

#### BUGS

Due to limitations in the MC68000 itself, neither form of 16-bit memory reference is as useful as one might wish. The hardware disallows storing into a location accessed by a PC-relative address mode, obliging the assembler not to use one where it would be unpalatable. Sixteen-bit absolute references are sign-extended, which can lead to surprises in accessing the upper half of the address space; as.68k, of course, can do nothing to alleviate them.

**NAME**

c - multi-pass command driver

**SYNOPSIS**

c -[f\* o\* p\* v +\*] <files>

**FUNCTION**

c is designed to facilitate multi-pass operations such as compiling, assembling, and linking source files, by expanding commands from a prototype script for each of its file arguments. It is best described by example. A script for Pascal compilation on the PDP-11 might look like:

```
p:/etc/bin/ptc      ptc
c:/etc/bin/pp       pp -x -i/lib/
:/odd/p1            p1 -cem
:/odd/p2.11         p2
s:/etc/bin/as       as
o:/etc/bin/link     link -lp.11 -lc.11 /lib/Crts.o
```

c is intended for installation under multiple aliases. Each alias normally implies the name of a ".proto" file containing a corresponding script, to be searched for in the same way that the shell looks for the file named by a command. That is, if the alias contains a '/', then only the directory named is searched; otherwise, the search is of each directory in the current execution path. If the script above were named pc.proto, it could be implicitly invoked by running c under the alias pc. The -f flag may be used to override this lookup procedure.

By convention, the alias c is a synonym for the host machine native C compiler driver, and pc for the host Pascal driver.

Given the script above, c would produce a ".o" file for any argument files ending in ".p" by executing the following command list:

COMMAND	ARGUMENTS
/etc/bin/ptc	ptc -o T1 file.p
/etc/bin/pp	pp -o T2 -x -i/lib/ T1
/odd/p1	p1 -o T1 -cem T2
/odd/p2.11	p2 -o T2 T1
/etc/bin/as	as -o file.o T2

where file.p is the argument file, and T1 and T2 are temporary intermediates.

Files whose names end in ".c" would be processed beginning at the script line labelled "c:"; similarly, ".s" files would be processed starting at the line labelled "s:". In general, all ".o" files produced, plus any files whose suffix matches no line prefix, are collected and passed to the link program for final binding. A file is passed to the link program only if its name is not already in the argument vector of the link line. Any error reported by any of the processing programs terminates processing of the current file; if any files are terminated the link program is not run.

The flags are:

- f\* take prototype input from file \* instead of from the ".proto" file implied by the command line alias. If \* is "-", STDIN is read.
- o\* place the output of the link line program in file \* (by prepending -o\* to its argument list). The prepending occurs only if this flag is given; naturally, it should be given only if the program will accept a -o specification.
- p\* prefix the names of all permanent output files with the pathname \*. If the -o flag is given, then the link line output filename will also be prefixed with \*, if it doesn't already contain a '/'. All other output files will be stripped of any pre-existent pathname before being prefixed.
- v before executing each command, output its arguments to STDOUT. The default is to output only the name of each processed file and the name of the linker when (and if) it is run, each name followed by a colon and a newline.
- +\* stop production at prototype line whose prefix is \*. The string given is matched against the prefix fields of each prototype line, and execution of prototype commands halts after the line preceding the matching one. In the example above, +c would cause ".p" files to be converted to ".c" files, with no subsequent processing, +s would process ".p" or ".c" files to ".s", and +o would inhibit linking. Any file that results in no processing causes an error message.

Each line in the prototype file has up to four parts: a prefix string (perhaps null) terminated with a colon, a pathname specifying a program to be run, and one or two groups of up to 16 strings, the groups separated by a colon. An argument vector is constructed for each program from the first string in the first group, a -o specification, the remaining strings in the first group, and one of the argument files. The second group of strings, if present, is appended to the vector after the argument file. Each entry on the command line is delimited by arbitrary whitespace. The final line in the file may have a prefix field (and colon) alone, in which case it specifies only the output file suffix for the preceding line. The final line may also have a prefix field terminated with a double colon, defining it as a "link line" with the special characteristics noted above.

Note that a prototype line with a null prefix field cannot be specified by the user as an entry or exit point.

If the last line of a prototype is not a prefix only and not a link line, then its output is written to a temporary file, which is discarded.

#### RETURNS

c returns success if it succeeded in passing all of its command line files to at least one of the prototype programs (the link line program included), and if all of the executions it supervised returned success.

**EXAMPLE**

A prototype file to do C syntax checking only, with no code generation, might be:

```
c:/etc/bin/pp  pp -x -i/lib/  
:/odd/p1      p1
```

This prototype would produce no output files, since the output of p1 would go to a temporary file.

**BUGS**

Needs some way to specify flags to the prototype programs.

This utility is currently provided for use only on Idris/UNIX host systems.

**NAME**

cpm - maintain CP/M diskettes

**SYNOPSIS**

cpm -[+cpm dec b c d p r t v x f\*] <files>

**FUNCTION**

cpm reads and writes CP/M compatible filesystems written on standard eight-inch, soft-sectored, IBM compatible diskettes. Such filesystems administer a diskette by dividing it into 243 clusters of 1024 bytes; up to 16 clusters may be allocated to an extent; up to 64 extents may be entered into the directory. A file consists of one or more extents, numbered consecutively from zero. All extents belonging to the same file have the same eight-character name and three-character type; names and types are best limited to letters of one case and digits, for maximum portability.

The flags are:

**+cpm** Convolve the sectors on each track by the recipe:

$$\text{sec} = (\text{sec} * 6 + (13 \leq \text{sec})) \% 26;$$

where sec is in the interval [0,26), i.e. one less than the hardware sector number. This option is necessary on those machines that write diskette sectors without convolving, i.e. starting with track 0 sector 1 for seek address 0L and taking subsequent sectors sequentially.

**-dec** Deconvolve the sectors to correct for DEC convolution. The DEC recipe is:

$$\begin{aligned} \text{sec} &= ((\text{sec} \ll 1) + (13 \leq \text{sec}) + \text{trk} * 6) \% 26; \\ \text{trk} &+= 1; \end{aligned}$$

where sec is as above, and trk is in the interval [0,77). This option is necessary on DEC systems such as RT-11 and RSX-11M; the CP/M reconvolving also takes place as above.

- b** Treat all files to be copied as binary images. Default is text mode, with possible processing of carriage returns, nulls, control-Z codes, etc.
- c** Create new diskette with empty directory, then copy named files to diskette.
- d** Delete named files from diskette.
- f\*** Diskette is accessed as filename \*. Default is "dx0:" if -dec flag is present, else "/dev/rx0".
- p** Print files, i.e. copy them from diskette to STDOUT. If no files are specified, all files are printed.



- r Replace named files on diskette.
- t Tabulate the diskette directory, showing all allocated extents in alphabetical order.
- v Be verbose about operations, naming files deleted "d:", added "a:", or extracted "x:". List number of free extents and clusters if -t is specified. Default is reasonably silent operation, save for errors.
- x Extract files, i.e. copy them from diskette to files with the same name. If no files are specified, all files are extracted.

At most one of the flags -c, -d, -p, -r, -t, -x may appear; default is -t.

#### RETURNS

cpm returns success if the directory structure of the diskette is intact and no file transfers failed, else failure.

#### EXAMPLE

To create a diskette and check it, under a DEC operating system:

```
>cpm -dec -c cscrip.cmd lscrip.cmd
>cpm -dec -rb prog.com
>cpm -dec
>cpm -dec -p cscrip.cmd
```

**NAME**

db - binary file editor/debugger

**SYNOPSIS**

db -[a c n p u] <file>

**FUNCTION**

db is an interactive editor designed to work with binary files. It operates in one of three modes: 1) as a binary file editor, for inspecting and patching arbitrary direct access files, such as disk images or encoded data files; 2) as a "prepartum" debugger, for inspecting and patching executable or relocatable files; and 3) as a "postmortem" debugger, for inspecting core images produced by the system, possibly using information from the original executable file. In the latter two cases, db recognizes the structure of object, executable, and core files, and does special interpretation of addresses to simulate the runtime placement of code and data.

db contains a disassembler enabled by specifying the mode 'm' in the o, p, or l commands (also used by the d and s commands, and in context searching). The disassembler interprets the file as machine instructions and translates them into conventional symbolic notation, using a symbol table and relocation information, when available, to output addresses. This "machine mode" is the initial default used for files not flagged as absolute.

A different disassembler is incorporated into db for each target machine to be supported. Thus, there may be variations with names like db11, db80, etc. By convention, the debugger for the host machine is called db.

The flags are:

- a treat <file> as an absolute binary file.
- c use the file core along with <file> and operate in debug mode. core will be the initial current file.
- n suppress the output of the current byte number normally preceding each item displayed.
- p write a prompt character '>' to STDOUT before reading command input. By default, no prompt is output.
- u open <file> in update mode. By default, <file> is opened for reading only.

At most one of -a and -c may be specified. Any core image file must always be named core. If <file> is not specified, xeq is assumed.

db has a great deal in common with the text editor e. It operates on the current binary file, a corresponding core image, or both, by reading from STDIN a series of single-character commands, and writing any output to STDOUT. Just as commands in e may be preceded by line addresses, db commands may be preceded by byte addresses, the syntax of which is a superset

of e address syntax. Analogous commands in the two editors have the same name; default behavior is also similar.

db imposes no structure on the data contained in its input files, except that implied by the current input/output mode, which defines the length of the "items" on which many commands operate. Outside machine mode, an item is one, two, or four bytes of the file. In machine mode, an item is the instruction disassembled starting at the current location, and is of varying length. Byte ordering of multiple-byte items is determined by the target machine, as are other machine-dependent characteristics such as symbol table structure and the size of an int. Thus, examining a file created for some machine other than the target is inadvisable. If <file> cannot be interpreted as an object file in standard format for the target machine, it is treated as absolute. If a core file does not begin with control bytes appropriate for the target, db aborts.

#### Address Interpretation and Syntax

In an absolute file, a byte address is simply the location of a byte relative to the start of the file (the first byte having address zero). In object or core files, an address consists of two components: the memory location a byte would occupy if the current file were actually loaded, and a flag indicating whether the location is within the text segment or within the data/bss segment of the program. (The program's bss segment immediately follows its data segment.) The ranges of addresses in the two segments may overlap; an address that could refer to either space is disambiguated as explained below.

A byte address is a series of one or more of the following terms:

The character '.' addresses the "current byte" (or "dot"). Typically, dot is the first byte of the last item affected by the most recent command (but see the command descriptions below for specifics). Dot also refers to the same segment as that item.

The character '\$' addresses the last byte of the segment to which dot currently refers. For an absolute file, '\$' has no meaning. A request to examine or change a given address will result in a seek to that byte of the file; the request succeeds if the subsequent I/O call does.

In an object file, the characters 'T', 'D', and 'B' are constants that have the value of the first address in the text, data, and bss segments, respectively, and also have the appropriate segment component. In a core file, 'T' and 'D' have the same meaning, while 'B' is set to the address of the top of stack at the time of the dump, as recorded in the core file panel. All three have the value zero if the current file is absolute.

An integer n addresses the nth byte of an absolute file, where bytes are numbered from zero. In an object or core file, an integer n addresses the nth byte of "memory", and the segment specified by the most recent term with an explicit segment component (or that of dot, if no such term exists). The easiest way to address the nth byte of

one of the two segments is to add an integer *n* to one of the constants 'T', 'D' or 'B'. An integer is interpreted as octal if it begins with '0', as hexadecimal if it starts with "0x" or "0X", and as decimal otherwise.

"x", a single-quote followed by any lower-case letter, addresses the byte that has been previously assigned that letter, as described in the *k* command below.

A regular expression, enclosed in '/', causes a context search of the current segment (or of the whole file, if it is absolute), starting with the item after the current byte and proceeding toward the end of the current segment (or file). Syntax for regular expressions is the same as that for *e*, i.e., as implemented by the portable C library routines *amatch*, *match*, and *pat*. Each item in the region searched is converted to the current output format, and compared with the search string given. The search stops at the first matching item, the value of the term being the address of that item. An error is signaled if the search fails.

A regular expression enclosed in '%' or '?' causes a backward search. The context search starts with the item before the current byte, and proceeds toward the start of the current segment (or of the file, if it is absolute), as described above. A backward search is impossible if the current output mode is machine mode.

A string beginning with a '\_' or a '"' is taken to be a symbol name, terminated by whitespace or by one of the operators given below. A leading '\_' is taken as part of the name; a leading '"' introduces names not starting with a '\_', and is discarded. The value of the term is the address of the symbol; the segment referenced by the term is the one in which the symbol is defined.

A term may be followed by an arbitrary number of '\*', each of which causes the value calculated to its left to be treated as a pointer into the data segment. The contents of the int-sized location pointed at then become the value of the term. Postfixing a term with '>' causes it to be analogously treated as a pointer into the text segment.

An address is resolved by scanning terms from left to right. Two terms separated by a plus '+' (or a minus '-'), resolve to a term that is the sum (or difference) of the values of the two original terms. Two successive terms not separated by an operator are summed. If a term explicitly refers to one of the two segments, then that segment becomes the segment to which the entire address refers.

If an address begins with a '+' or '-', then dot is assumed to be a term at the left of the '+' or '-'. The symbol '^' is equivalent to '-' in this context. Thus, "^3" standing alone is taken to be the same as "-3".

A '+' ('-' or '^') not followed by a term is taken to mean +1 (-1). Thus '-' alone stands for "-1", "++" stands for "+2", "6---" stands for "3" and so on.

An address may be arbitrarily complex, so long as it yields a value within the bounds of the segment it refers to. (Again, for an absolute file, any address will be accepted.) There can be any number of addresses preceding a command so long as the last one or two are legal for that command. For a command requiring two addresses, it is an error for the second address to be less than the first, or for the addresses to refer to different segments. In debug mode, when pointing at the core file, stack addresses are accepted.

In machine instruction mode, addresses should be specified with care. db will disassemble starting at the address specified, but if the address is not the beginning of a valid instruction, the output is meaningless. To insure valid disassembly, start at the beginning of the text section or at the address of a text-relative symbol.

#### Command Syntax

Each db command consists of a single character, which may optionally be preceded by one or more addresses typically specifying the inclusive range of bytes in the file that the command is to affect. Addresses are separated by a comma ',' or by a colon ':'. If a colon is used, then dot is set to the location and segment specified by the address to the left of the colon before the rest of the command is interpreted. The command character may be followed by additional parameters. Multiple commands may be entered on a line by separating them with semicolons. Every command needing addresses has default values, so addresses can often be omitted; db complains if an address is referred to that doesn't exist.

In the command descriptions below, addresses in parentheses are the default byte addresses that will be used for the command if none are entered. The parentheses are not to be entered with the command, but are present as a syntactical notation. If a command is described without parentheses, no addresses are required. For a two-address command, supplying only one address will default the second to be identical with the one supplied. It is an error to precede with addresses commands that do not require any. The commands are:

- (fp)a - display auto stack frame. Valid only if core is the current file. db keeps a pointer fp to the current stack frame, initialized to the one specified by the panel dumped to the core file. "a" may be preceded by an address which will be interpreted (and memorized) as the address of an auto stack frame.
- b(1) - backup one or more stack frames. Valid only if core is the current file. "b" may be followed by a zero, which reinitializes the current stack frame pointer fp to the one in the panel, or by a count of the number of frames to be backed over. "b" and this count may also be followed by "a", which will backup one stack frame and display the auto stack frame values.
- c - display the panel, which consists of the saved registers and cause of death. The registers are displayed in hexadecimal and symbolically, if meaningful. Valid only if core is the current file.

- (.,.)d - print items that differ between executable and core files.
- e file - enter a new modifiable data file, in same mode as before, then memorize filename. This works with -a flag only.
- f - display name of modifiable data file.
- (.)kx - mark address by memorizing it in x, where x is any lower case letter, suitable for later recall as a pointer with 'x'.
- (.,.)l<mode> - look at address specified, i.e., display item in output text representation, but don't change '.' to the address given. If <mode> is present, it changes the mode that was specified in the last 'o' command.
- (.)n - display address as symbol plus offset.
- o<mode> - change output text representation to <mode>, where <mode> is 'm', indicating disassembly of machine instructions, or any of the combinations [a|h|o|u] [c|s|i|l], for ASCII, hexadecimal, octal, or unsigned display of char, short, int, or long integers. If <mode> is not specified, the mode is set to the default used at db invocation: 'm' if the -a flag was not given, and unsigned short otherwise.
- (.,.)p<mode> - print item in output text representation, then change '.' to point at last address specified. If <mode> is present, it changes the mode that was specified in the last 'o' command.
- q - quit.
- (.)r file - read binary contents of specified file and replace target file from current byte, extending the file as necessary. This is valid only with -a flag. file must not be the <file> being db'ed.
- (.,.)s/pattern/new/[g] - for all items in range, expand to output text representation, edit text by changing instances of pattern to new, then update item using edited text pattern. If g suffix is specified, all matches in an item are altered, otherwise only the leftmost is altered.
- (.)u - enter update mode, i.e., treat each subsequent line of input as the output text representation of an item and replace the addressed item. Successive items are replaced, extending the file as necessary, until an input line containing only a '.' is encountered. This does not work in 'm' mode. The input must be entered in the current mode, one item per line; otherwise db will complain.
- (0,\$)w file - write the specified range of the file being db'ed to file. file must not be the same as <file> being db'ed. This command is valid only with -a flag.
- z file - point db at file. If file is omitted, z reports which file, core or executable, is currently pointed at.

(.)<newline> - equivalent to entering ". + size", where size is the number of bytes being displayed in the current mode. This form can be used to view one instruction or item at a time. If a byte address precedes the <newline>, the addressed item will be displayed. Dot will be set to the displayed byte.

!~~command~~> - send all characters on the line to the right of the '!' to the system, to be interpreted as a system command. "!cd" is handled by db directly. Occurrences of the sequence "\f" will each be replaced by the currently remembered file before the transfer to system level is made. Dot is not changed by this command. Available only in Idris/UNIX systems.

= - display the byte number of dot.

On Idris/UNIX systems, if an ASCII DEL is typed, db interrupts its current task, if any, and displays '?'. It then will be ready to accept db commands again. Dot is generally ill-defined at this point.

#### SEE ALSO

link, rel

#### BUGS

This utility is currently provided for use only on Idris/UNIX host systems.

**NAME**

hex - translate object file to ASCII formats

**SYNOPSIS**

hex -[db## dr h m\* r## s tb## +# #] <ifile>

**FUNCTION**

hex translates executable images produced by link to Intel standard hex format or to Motorola S-record object file format. The executable image is read from <ifile>. If no <ifile> is given, or if the filename given is "-", the file xeq is read.

The flags are:

- db## when processing a standard object file as input, override the object module data bias with ##.
- dr output text records as record type 0x81, data records as record type 0x82, for use with the Digital Research gencmd utility under CP/M-86.
- h don't produce start record for Intel hex files.
- m\* insert the string \*, instead of <ifile>, into the Motorola S0 record generated when -s is given.
- r## interpret the input file as "raw" binary and not as an object file. Output is produced as described below, in either format, except that the starting address of the module is specified by the long integer ##.
- s produce S-records rather than the default hex format.
- tb## when processing a standard object file as input, override the object module text bias with ##.
- +# start output with the #th byte. # should be between 0 and one less than the value specified by the -# flag. -4 +3 produces bytes 3, 7, 11, 15, ...; -2 +0 produces all even bytes; -2 +1 outputs all odd bytes; 0 is the default, which outputs all bytes.
- # output every #th byte. -2 outputs every other byte, -4 every fourth; 1 is the default, which outputs all bytes.

Output is written to STDOUT. When the input file is a standard object file, the load offset of the first record output for its text or data segment is determined as follows. If an offset is explicitly given for that segment (with "-db##" or "-tb##"), it is used. Otherwise, if all bytes of the input file are being output, the appropriate bias is used from the object file header. Otherwise, a load offset of zero is used. Then, the value given with "+#" is added to the chosen offset to obtain the first offset actually output.



Hex Files

A file in Intel hex format consists of the following records, in the order listed:

- 1) a '\$' alone on a line to indicate the end of the (non-existent) symbol table. If -h is specified, this line is omitted.
- 2) data records for the text segment, if any. These represent 32 image bytes per line, possibly terminated by a shorter line.
- 3) data records for the data segment, if any, in the same format as the text segment records.
- 4) an end record specifying the start address.

Data records each begin with a ':' and consist of pairs of hexadecimal digits, each pair representing the numerical value of a byte. The last pair is a checksum such that the numerical sum of all the bytes represented on the line, modulo 256, is zero. The bytes on a data record line are:

- a) the number of image bytes on the line.
- b) two bytes for the load offset of the first image byte. The offset is written more significant byte first so that it reads correctly as a four-digit hexadecimal number.
- c) a zero byte "00".
- d) the image bytes in increasing order of address.
- e) the checksum byte.

An end record also begins with a ':' and is written as digit pairs with a trailing checksum. Its format is:

- a) a zero byte "00".
- b) two bytes for the start address, in the same format as the load offset in a data record. The start address used is the first load offset output for the file.
- c) a one byte "01".
- d) the checksum byte.

S-Record Files

A file in Motorola S-record format is a series of records each containing the following fields:

<S field><count><addr><data bytes><checksum>

All information is represented as pairs of hexadecimal digits, each pair representing the numerical value of a byte.

<S field> determines the interpretation of the remainder of the line; valid S fields are "S0", "S1", "S2", "S8", "S9". <count> indicates the number of bytes represented in the rest of the line, so the total number of characters in the line is <count> \* 2 + 4.

<addr> indicates the byte address of the first data byte in the data field. S0 records have two zero bytes as their address field; S1 and S2 records have <addr> fields of two and three bytes in length, respectively; S9 and S8 records have <addr> fields of two and three bytes in length, respectively, and contain no data bytes. <addr> is represented most significant byte first.

The S0 record contains the name of the input file, formatted as data bytes. If input was from xeq, XEQ is used as the name. S1 and S2 records represent text or data segment bytes to be loaded. They normally contain 32 image bytes, output in increasing order of address; the last record of each segment may be shorter. The text segment is output first, followed by the data segment. S9 records contain only a two-byte start address in their <addr> field; S8 records contain a three-byte address. The start address used is the first load offset output for the file.

<checksum> is a single byte value such that the numerical sum of all the bytes represented on the line (except the S field), taken modulo 256, is 255 (0xFF).

#### RETURNS

hex returns success if no error messages are printed, that is, if all records make sense and all reads and writes succeed; otherwise it reports failure.

#### EXAMPLE

The file hello.c, consisting of:

```
char *p {"hello world"};
```

when compiled produces the following Intel hex file:

```
% hex hello.o
$
:0E000000020068656C6C6F20776F726C640094
:00000001FF
```

and the following Motorola S-records:

```
% hex -s hello.o
S00A000068656C6C6F2E6F44
S1110000020068656C6C6F20776F726C640090
S9030000FC
```

#### SEE ALSO

link, rel

**NAME**

lib - maintain libraries

**SYNOPSIS**

lib <lfile> [-c d i p r t v3 v6 v7 v x] <files>

**FUNCTION**

lib provides all the functions necessary to build and maintain object module libraries in either standard library format or those used by UNIX/System III, UNIX/V6, or UNIX/V7. lib can also be used to collect arbitrary files into one bucket. <lfile> is the name of an existing library file or, in the case of replace or create operations, the name of the library to be constructed.

The flags are:

- c create a library containing <files>, in the order specified. Any existing <lfile> is removed before the new one is created.
- d delete from the library the zero or more files in <files>.
- i take <files> from STDIN instead of the command line. Any <files> on the command line are ignored.
- p print named files (do a -x to STDOUT). If no files are named, all files are extracted.
- r in an existing library, replace the zero or more files in <files>; if no library <lfile> exists, create a library containing <files>, in the order specified. The files in <files> not present in the library are appended to it, in the order specified.
- t list the files in the library in the order they occur. If <files> are given, then only the files named and present are listed.
- v3 create the output library in UNIX/System III format, VAX-11 byte-order. This flag is meaningful with -c or -r; it is mandatory for -t and -x (UNIX/V7 format is assumed if this flag is not specified).
- v6 create the output library in UNIX/V6 format. Meaningful only with -c or -r.
- v7 create the output library in UNIX/V7 format, PDP-11 byte-order. Meaningful only with -c or -r.
- v be verbose. The name of each object file operated on is output, preceded by a code indicating its status: "c" for files retained unmodified, "d" for those deleted, "r" for those replaced, and "a" for those appended to <lfile>. If -v is used in conjunction with -t, each object file is listed followed by its length in bytes.

**-x** extract the files in <files> that are present in the library into discrete files with the same names. If no <files> are given, all files in the library are extracted.

At most one of the flags **-[c d p r t x]** may be given; if none is given, **-t** is assumed. Similarly, at most one of the flags **-[v3 v6 v7]** should be present; if none is present, standard library file format is assumed when a new library is created by **-r** or **-c**. An existing library is processed in its proper mode, except for UNIX/III libraries, for which the flag **-v3** must be specified.

The standard library format consists of a two-byte header having the value 0177565, written less significant byte first, followed by zero or more entries. Each entry consists of a fourteen-byte name, NUL padded, followed by a two-byte unsigned file length, also stored less significant byte first, followed by the file contents proper. If a name begins with a NUL byte, it is taken as the end of the library file.

Note that this differs in several small ways from UNIX/V6 format, which has a header of 0177555, an eight-byte name, six bytes of miscellaneous UNIX-specific file attributes, and a two-byte file length. Moreover, a file whose length is odd is followed by a NUL padding byte in the UNIX format, while no padding is used in standard library format.

UNIX/III and UNIX/V7 formats are characterized by a header of 0177545, a fourteen-byte name, eight bytes of UNIX-specific file attributes, and a four-byte length. The length is in VAX-11 native byte order for UNIX/III or in PDP-11 native byte order for UNIX/V7. Odd length files are also padded to even.

#### RETURNS

lib returns success if no problems are encountered, else failure. After most failures, an error message is printed to STDERR and the library file is not modified. Output from the **-t** flag, and verbose remarks, are written to STDOUT.

#### EXAMPLE

To build a library and check its contents:

```
% lib clib -r one.o two.o three.o
% lib clib -tv
```

#### SEE ALSO

link, lord, rel

#### BUGS

If all modules are deleted from a library, a vestigial file remains.

Modifying UNIX/III, UNIX/V6, or UNIX/V7 format files causes all attributes of all file entries to be zeroed.

- 3 -

lib doesn't check for files too large to be properly represented in a library (> 65,534 bytes).

**NAME**

link - combine object files

**SYNOPSIS**

```
link -[a bb## b## c db## dr# d eb* ed* et* h i l*^ o* r sb* sd* st*  
      tb## tf# t u*^ x#] <files>
```

**FUNCTION**

link combines relocatable object files in standard format for any target machine, selectively loading from libraries of such files made with lib, to create an executable image for operation under Idris, or for stand alone execution, or for input to other binary reformatters.

The flags are:

- a make all relocation items and all symbols absolute. Used to prerelocate code that will be linked in elsewhere, and is not to be re-relocated.
- bb## relocate the bss (block started by symbol) segment to start at ##. By default, the bss segment is relocated relative to the end of the data segment. Once -bb## has been specified, the resulting output file is unsuitable for input to another invocation of link.
- b## set the stack plus heap size in the output module header to ##. Idris takes this value, if non-zero, as the minimum number of bytes to reserve at execution time for stack and data area growth. If the value is odd, Idris will execute the program with a smaller heap plus stack size, so long as some irreducible minimum space can still be provided by using all of available memory.
- c suppress code output (.text and .data), and make all symbols absolute. Used to make a module that only defines symbol values, for specifying addresses in shared libraries, etc.
- db## set data bias to the long integer ##. Default is end of text section, rounded up to required storage boundary for the target machine.
- dr# round data bias up to ensure that there are at least # low-order binary zeros in its value. Ignored if -db## is specified.
- d do not define bss symbols, and do not complain about undefined symbols. Used for partial links, i.e., if the output module is to be input to link.
- eb\* if the symbol \* is referenced, make it equal to the first unused location past the bss area.
- ed\* if the symbol \* is referenced, make it equal to the first unused location past the initialized data area.
- et\* if the symbol \* is referenced, make it equal to the first unused location past the text area.

- h suppress header in output file. This should be specified only for stand alone modules such as bootstraps.
- i take <files> from STDIN instead of the command line. Any <files> on the command line are ignored.
- l# append library name to the end of the list of files to be linked, where the library name is formed by appending # to "/lib/lib". Thus "-lc.11" produces "/lib/libc.11". Up to ten such names may be specified as flags; they are appended in the order specified.
- o# write output module to file #. Default is xeq.
- r suppress relocation bits. This should not be specified if the output module is to be input to link or executed under a version of Idris that relocates commands on startup.
- sb# if the symbol # is referenced, make it equal to the size of the bss area.
- sd# if the symbol # is referenced, make it equal to the size of the data area.
- st# if the symbol # is referenced, make it equal to the size of the text area.
- tb## set text bias to the long integer ##. Default is location zero.
- tf# round text size up by appending NUL bytes to the text section, to ensure that there are at least # low-order binary zeroes in the resulting value. Default is zero, i.e. no padding.
- t suppress symbol table. This should not be specified if the output module is to be input to link.
- u# enter the symbol # into the symbol table as an undefined public reference, usually to force loading of selected modules from a library.
- x# specify placement in the output module of the input .text and .data sections. The 2-weighted bit of # routes .text input, the 1-weighted bit, .data. If either bit is set, the corresponding sections are put in the text segment output; otherwise, they go in the data segment. The default value used, predictably, is 2.

The bss section is always assumed to follow the data section in all input files. Unless -bb## is given, the bss section will be made to follow the data section in the output file, as well. It is perfectly permissible for text and data sections to overlap, as far as link is concerned; the target machine may or may not make sense of this situation (as with separate instruction and data spaces).

The specified <files> are linked in order; if a file is in library format, it is searched once from start to end. Only those library modules

are included which define public symbols for which there are currently outstanding unsatisfied references. Hence, libraries must be carefully ordered, or rescanned, to ensure that all references are resolved. By special dispensation, flags of the form "-l#" may be interspersed among <files>. These call for the corresponding libraries to be searched at the points specified in the list of files. No space may occur after the "-l", in this usage.

#### File Format

A relocatable object image consists of a header followed by a text segment, a data segment, the symbol table, and relocation information.

The header consists of an identification byte 0x99, a configuration byte, a short unsigned int containing the number of symbol table bytes, and six unsigned ints giving: the number of bytes of object code defined by the text segment, the number of bytes of object code defined by the data segment, the number of bytes needed by the bss segment, the number of bytes needed for stack plus heap, the text segment offset, and the data segment offset.

Byte order and size of all ints in the header are determined by the configuration byte.

The configuration byte contains all information needed to fully represent the header and remaining information in the file. Its value val defines the following fields:  $((val \& 07) \ll 1) + 1$  is the number of characters in the symbol table name field, so that values [0, 8) provide for odd lengths in the range [1, 15]. If  $(val \& 010)$  then ints are four bytes; otherwise they are two bytes. If  $(val \& 020)$  then ints in the data segment are represented least significant byte first, otherwise, most significant byte first; byte order is assumed to be purely ascending or purely descending. If  $(val \& 040)$  then even byte boundaries are enforced by the hardware. If  $(val \& 0100)$  then the text segment byte order is reversed from that of the data segment; otherwise text segment byte order is the same. If  $(val \& 0200)$  no relocation information is present in this file.

The text segment is relocated relative to the text segment offset given in the header (usually zero), while the data segment is relocated relative to the data segment offset (usually the end of the text segment). Unless -bb# is given, the bss segment is relocated relative to the end of the data segment.

Relocation information consists of two successive byte streams, one for the text segment and one for the data segment, each terminated by a zero control byte. Control bytes in the range [1, 31] cause that many bytes in the corresponding segment to be skipped; bytes in the range [32, 63] skip 32 bytes, plus 256 times the control byte minus 32, plus the number of bytes specified by the relocation byte following.

All other control bytes control relocation of the next short or long int in the corresponding segment. If the 1-weighted bit is set in such a control byte, then a change in load bias must be subtracted from the int.



The 2-weighted bit is set if a long int is being relocated instead of a short int. The value of the control byte right-shifted two places, minus 16, constitutes a "symbol code".

A symbol code of 47 is replaced by a code obtained from the byte or bytes following in the relocation stream. If the next byte is less than 128, then the symbol code is its value plus 47. Otherwise, the code is that byte minus 128, times 256, plus 175 plus the value of the next relocation byte after that one.

A symbol code of zero calls for no further relocation; 1 means that a change in text bias must be added to the item (short or long int); 2 means that a change in data bias must be added; 3 means that a change in bss bias must be added. Other symbol codes call for the value of the symbol table entry indexed by the symbol code minus 4 to be added to the item.

Each symbol table entry consists of a value int, a flag byte, and a name padded with trailing NULs. Meaningful flag values are 0 for undefined, 4 for defined absolute, 5 for defined text relative, 6 for defined data relative, and 7 for defined bss relative. To this is added 010 if the symbol is to be globally known. If a symbol still undefined after linking has a non-zero value, link assigns the symbol a unique area, in the bss segment, whose length is specified by the value, and considers the symbol defined. This occurs only if -d has not been given.

#### RETURNS

link returns success if no error messages are printed to STDOUT, that is, if no undefined symbols remain and if all reads and writes succeed; otherwise it returns failure.

#### EXAMPLE

To load the C program echo.o under Idris/S11:

```
% link -lc.11 -t /lib/Crts.o echo.o
```

with separate I/D spaces, for UNIX:

```
% link -lc.11 -rt -db0 /lib/Crts.o echo.o; taout
```

or with read only text section for UNIX:

```
% link -lc.11 -rt -dr13 /lib/Crts.o echo.o; taout
```

And to load the 8080 version of echo under CP/M:

```
A:link -hrt -tb0x0100 a:chdr.o echo.o a:clib.a a:mplib.a
```

#### SEE ALSO

hex, lib, lord, rel

**NAME**

lord - order libraries

**SYNOPSIS**

lord -[c\* d\*^ i r\*^ s]

**FUNCTION**

lord reads in a list of module names, with associated interdependencies, from STDIN, and outputs to STDOUT a topologically sorted list of module names such that, if at all possible, no module depends on an earlier module in the list. Each module is introduced by a line containing its name followed by a colon. Subsequent lines are interpreted as either:

**defs** - things defined by the module,

**refs** - things referred to by the module, or

**other stuff** - other stuff.

Refs and defs have the syntax given by one or more formats entered as flags on the command line. Each character of the format must match the corresponding character at the beginning of an input line; a ? will match any character except newline. If all the characters of the format match, then the rest of the input line is taken as a ref or def name. Thus, the format flag "-d0x????D " would identify as a valid def any line beginning with "0x", four arbitrary characters and a "D ", so that the input line "0x3ff0D \_inbuf" would be taken as a def named "\_inbuf".

The flags are:

**-c\*** prepend the string \* to the output stream. Implies -s. Each module name is output preceded by a space; the output stream is terminated with a newline. Hence, lord can be used to build a command line.

**-d\*** use the string \* as a format for defs.

**-i** ignore other stuff. Default is to complain about any line not recognizable as a def or ref.

**-r\*** use the string \* as a format for refs.

**-s** suppress output of defs and refs; output only module names in order.

Up to ten formats may be input for defs, and up to ten for refs.

If no -d flags are given, lord uses the default def formats: "0x????????B ", "0x????????D ", "0x????????T ", "0x?????B ", "0x?????D ", "0x?????T ". If no -r flags are given, lord uses the default ref formats: "0x????????U " and "0x?????U ". These are compatible with the default output of rel.

If there are circular dependencies among the modules, lord writes the name of the file that begins the unsorted list to STDERR, followed by the message "not completely sorted". In general, rearrangements are made only

when necessary, so an ordered set of modules should pass through lord unchanged.

**RETURNS**

lord returns success if no error messages are printed, otherwise failure.

**EXAMPLE**

To create an ordered library of object modules under Idris:

```
% rel *.o | lord -c"lib libx.a -c" | sh
```

To order a set of objects using UNIX nm:

```
% nm *.o > nmlist
% lord < nmlist -c"ar r libx.a" | \
-d"??????T " -d"??????D " -d"??????B " -r"??????U " | sh
```

**SEE ALSO**

lib, rel

**NAME**

p1 - parse C programs

**SYNOPSIS**

p1 -[a b# c e l m n# o\* r# u] <file>

**FUNCTION**

p1 is the parsing pass of the C compiler. It accepts a sequential file of lexemes from the preprocessor pp and writes a sequential file of flow graphs and parse trees, suitable for input to a machine-dependent code generator p2. The operation of p1 is largely independent of any target machine. The flag options are:

- a compile code for machines with separate address and data registers. This flag implies -r6 (because currently used only in conjunction with the MC68000 code generator).
- b# enforce storage boundaries according to #, which is reduced modulo 4. A bound of 0 leaves no holes in structures or auto allocations; a bound of 1 (default) requires short, int and longer data to begin on an even bound; a bound of 2 is the same as 1, except that 4-8 byte data are forced to a multiple of four byte boundary; a bound of 3 is the same as 2, except that 8 byte data (doubles) are forced to a multiple of eight byte boundary.
- c ignore case distinctions in testing external identifiers for equality, and map all names to lowercase on output. By default, case distinctions matter.
- e don't force loading of extern references that are declared but never defined or used in an expression. Default is to load all externs declared.
- l take integers and pointers to be 4 bytes long. Default is 2 bytes.
- m treat each struct/union as a separate name space, and require x.m to have x a structure with m one of its members.
- n# ignore characters after the first # in testing external identifiers for equality. Default is 7; maximum is 8, except that values up to 32 are permitted for the VAX-11 code generator only.
- o\* write the output to the file \* and write error messages to STDOUT. Default is STDOUT for output and STDERR for error messages.
- r# assign no more than # variables to registers at any one time, where # is reduced modulo 7. Default is 3 register variables; values above 3 are currently acceptable only for the MC68000 code generator (3 data registers + 3 address registers maximum), and the VAX-11 code generator (6 registers maximum).
- u take "string" as array of unsigned char, not array of char.

If <file> is present, it is used as the input file instead of the default STDIN. On many systems (other than Idris/UNIX), the -o option and <file> are mandatory because STDIN and STDOUT are interpreted as text files, and hence become corrupted.

**EXAMPLE**

p1 is usually sandwiched between pp and some version of p2, as in:

```
pp -x -o temp1 file.c
p1 -o temp2 temp1
p2.11 -o file.s temp2
```

**SEE ALSO**

pp

**BUGS**

p1 can be rather cavalier about semicolons.

**NAME**

p2.68k - generate code for MC68000 C programs

**SYNOPSIS**

p2.68k -[ck dx n# o# p x#] <file>

**FUNCTION**

p2.68k is the code generating pass of the C compiler. It accepts a sequential file of flow graphs and parse trees from p1 and writes a sequential file of assembly language statements, suitable for input to an MC68000 assembler. Two versions of p2.68k are available for the MC68000; one that generates code compatible with the Motorola VERSAdos assembler, and one that is compatible with the Idris assembler as.68k.

As much as possible, the compiler generates free-standing code; but for those operations which cannot be done compactly, it generates inline calls to a set of machine-dependent runtime library routines. The MC68000 runtime library is documented in Section IV of this manual.

The flags are:

- ck enable stack overflow checking.
- dx disable double indexing.
- n# use the name # as the module name in the assembler output. Default is to use the first defined external encountered.
- o# write the output to the file # and write error messages to STDOUT. Default is STDOUT for output and STDERR for error messages.
- p emit profiler calls on entry to each function.
- x# map the three virtual sections, for Functions (04), Literals (02), and Variables (01), to the two physical sections Code (bit is a one) and Data (bit is a zero). Thus, "-x4" is for separate I/D space, "-x6" is for ROM/RAM code, and "-x7" is for compiling tables into ROM. Default is 6.

If <file> is present, it is used as the input file instead of the default STDIN. On many systems (other than Idris/UNIX), <file> is mandatory, because STDIN is interpreted as a text file, and hence becomes corrupted.

Files output from p1 for use with the MC68000 code generator should be generated with: -a signifying separate Address and Data registers; -l since pointers are long; and no -b# flag, since only the default value of "-b1" is acceptable. For use with the VERSAdos assembler, p1 should be run with the flags "-cn7" to check externals properly; "-n8" is preferred for the Idris assembler.

Wherever possible, labels in the emitted code are each followed by a comment which gives the source line from which the code immediately following obtains, along with a running count of the number of words of code produced for a given function body.

**EXAMPLE**

p2.68k usually follows pp and p1, as follows:

```
pp -x -o temp1 file.c
p1 -aln8 -o temp2 temp1
p2.68k -o file.s temp2
```

**SEE ALSO**

as.68k, p1

**BUGS**

Stack overflow checking is only approximate, since a calculation of the exact stack high water mark is not attempted.

Complex expressions involving the ternary operator (?:) may generate branch range errors. The only solution is to simplify the expression.

**NAME**

pp - preprocess defines and includes

**SYNOPSIS**

pp -[c d\* i\* o\* p? s? x 6] <files>

**FUNCTION**

pp is the preprocessor used by the C compiler, to perform #define, #include, and other functions signalled by a #, before actual compilation begins. It can be used to advantage, however, with most language processors. The flag options are:

- c don't strip out /\* comments \*/ nor continue lines that end with \.
- d\* where \* has the form name=def, define name with the definition string def before reading the input; if =def is omitted, the definition is taken as "1". The name and def must be in the same argument, i.e., no blanks are permitted unless the argument is quoted. Up to ten definitions may be entered in this fashion.
- i\* change the prefix used with #include <filename> from the default "" to the string \*. Multiple prefixes to be tried in order may be specified, separated by the character '|'.  
-o\* write the output to the file \* and write error messages to STDOUT. Default is STDOUT for output and STDERR for error messages. On many systems (other than Idris/UNIX), the -o option is mandatory with -x because STDOUT is interpreted as a text file, and hence becomes corrupted.
- p? change the preprocessor control character from '#' to the character ?.
- s? change the secondary preprocessor control character from '@' to the character ?.
- x put out lexemes for input to the C compiler p1, not lines of text.
- 6 put out extra newlines and/or SOH ('\01') codes to keep source line numbers correct for UNIX/V6 compiler or ptc.

pp processes the named files, or STDIN if none are given, in the order specified, writing the resultant text to STDOUT. Preprocessor actions are described in detail in Section I of the C Programmers' Manual.

The presence of a secondary preprocessor control character permits two levels of parameterization. For instance, the invocation

pp -c -p@

will expand define and ifdef conditionals, leaving all # commands and comments intact; invoking pp with no arguments would expand both @ and # commands. The flag -s# would effectively disable the secondary control character.



**EXAMPLE**

The standard style for writing C programs is:

```
/* name of program
 */
#include <std.h>

#define MAXN    100

COUNT things[MAXN];
etc.
```

The use of uppercase only identifiers is not required by pp, but is strongly recommended to distinguish parameters from normal program identifiers and keywords.

**SEE ALSO**

p1, ptc

**BUGS**

Unbalanced quotes ' or " may not occur in a line, even in the absence of the -x flag. Floating constants longer than 38 digits may compile incorrectly, on some host machines.

**NAME**

prof - produce execution profile

**SYNOPSIS**

prof -[a f +l n r s t +z] [<ofile>] [<pfiles>]

**FUNCTION**

prof correlates one or more files of statistics recorded during the execution of a program with the symbol table of the corresponding executable file, and produces a report profiling the run. The statistics are contained in "profile" files of standard format. The <ofile> given on the command line is the program whose execution produced the statistics.

Flags are:

- a sort output in increasing order of address.
- f sort output in decreasing order of frequency of calls to each function.
- +l include local symbols in output. By default, only global symbols are included.
- n sort output in increasing order of symbol name.
- r reverse the default sense of the output sort.
- s suppress the default heading.
- t sort output in decreasing order of time spent in each function. This is the default sort key.
- +z include symbols in output for which no entries or execution time were recorded. By default, these are excluded.

If no <ofile> is given, "xex" is used as the object filename. If no <pfiles> are given, prof expects profiling data to come from the file "profil". However, if any filenames appear after <ofile> on the command line, they will be read for profiling data instead. If more than one file is given, prof will accumulate data from each in turn, and output a single report giving the totals from all data files read. Thus the results of several instrumented runs of a given program may be merged to reduce statistical error. Naturally, if <pfiles> are given <ofile> must be given as well.

Profiling involves two statistics: counting the calls made to each function in a program, and recording what portion of execution time is spent inside each function. In its report, prof outputs one line for each text-relative symbol in <file> (subject to +l and +z), showing the symbol name, the percentage of total execution time spent in the region between this symbol and the next higher one, time in this region in milliseconds, the number of calls made directly to this symbol's address, and the average amount of time recorded per call. Also, prof treats the final location available for function entry counts as an overflow location, in which

calls are counted to all functions that could not be given a location of their own. If this count is non-zero, prof outputs it, with the name "other syms".

Idris records execution time by periodically examining the PC of the executing program, using its value to index an array whose elements correspond to the permissible range of the PC. The selected array element is then incremented. Function entry counts are maintained by calls to a counting routine, which every Whitesmiths C compiler can be made to output by specifying the flag -p to the code generator. A function must be thus instrumented for an entry count to be maintained for it. The counting routine itself is specified at link time, as part of the runtime startup code.

#### RETURNS

prof returns success if all input files are readable and consistent with their expected format.

#### SEE ALSO

The profile file format description is in Section III of the Idris Programmers' Manual, while the runtime initialization code used to profile under Idris is documented along with the Idris system interface, in Section III.a of this manual. The portable profiling setup functions are described in Section IV of the Idris Programmers' Manual, and the machine-dependent function entry counting routine is described in Section IV of the current manual.

#### BUGS

Sampling errors may occur unless the scaling factor used to record the PC location is no larger than the smallest boundary on which an instruction may begin; that is, a given array element may overlap function bodies, and a PC caught in one function may be treated as if it were caught in another. prof does what it can to compensate, by dividing the value of an overlapping array element between the functions involved.

This utility is currently provided for use only on Idris host systems.

**NAME**

ptc - Pascal to C translator

**SYNOPSIS**

ptc -[c f k m# n# o\* r s#] <ifile>

**FUNCTION**

ptc is a program that accepts as input lines of Pascal text and produces as output a corresponding C program which is acceptable to the Whitesmiths, Ltd. C compiler. If <ifile> is present, it is taken as the Pascal program to translate; otherwise input is taken from STDIN.

The flags are:

- c pass comments through to the C program.
- f set the precision for reals to single precision (float). Default is double.
- k permit pointer types to be defined using type identifiers from outer blocks. Default is ISO standard, i.e., the type pointed to must be defined in the same type declaration as the pointer type definition.
- m# make # the number of bits in MAXINT excluding the sign bit, e.g., MAXINT becomes 32767 for -m15, 1 for -m1, etc. Default for MAXINT is 32766 [sic]. Acceptable values for # are in the range [0 , 32). Declaring MAXINT greater than the size of a pointer (16 or 32) will give unpredictable results. On a target machine with 16-bit pointers, # should be less than 16.
- n# Make # the number of significant characters in external names. Default is 8 character external names.
- o\* write the C program to the file \* and diagnostics to STDOUT. Default is STDOUT for the C program and STDERR for diagnostics.
- r turn off runtime array bounds checks.
- s# make # the number of bits in the maximum allowable set size, i.e., the size of all sets whose basetype is integer becomes the specified power of two. Acceptable values are in the range [0 , 32). Default is 8 (256 elements).

The CP/M operating system implementation, on the Intel 8080 and Zilog Z/80, restricts the acceptable value for # to the range [0,16]; for maximum portability, this restriction should be honored.

Identifiers are mapped to uppercase to keep from conflicting with those declared as reserved words in C. Moreover, structure declarations may be produced that contain conflicting field declarations; and declarations are present for library functions that may not be needed. All of these peccadillos are forgiven by the use of appropriate C compiler options.

**RETURNS**

ptc returns success if it produces no diagnostics.

**BUGS**

Complex set expressions can produce very long lines that are truncated by pp.

**NAME**

rel - examine object files

**SYNOPSIS**

rel -[d g i o s t u v] <files>

**FUNCTION**

rel permits inspection of relocatable object files, in standard format, for any target machine. Such files may have been output by an assembler, combined by link, or archived by lib. rel can be used either to check their size and configuration, or to output information from their symbol tables.

The flags are:

- d output all defined symbols in each file, one per line. Each line contains the value of the symbol, a code indicating to what the value is relative, and the symbol name. Values are output as the number of digits needed to represent an integer on the target machine. Relocation codes are: 'T' for text relative, 'D' for data relative, 'B' for bss relative, 'A' for absolute, or '?' for anything rel doesn't recognize. Lowercase letters are used for local symbols, uppercase for globals.
- g print global symbols only.
- i print all global symbols, with the interval in bytes between successive symbols shown in each value field. Implies the flags -[d u v].
- o output symbol values in octal. Default is hexadecimal.
- s display the sizes, in decimal, of the text segment, the data segment, the bss segment, and the space reserved for the runtime stack plus heap, followed by the sum of all the sizes.
- t list type information for this file. For each object file the data output is: the size of an integer on the target machine, the target machine byte order, whether even byte boundaries are enforced by the hardware, whether the text segment byte order is reversed from that of the data segment, and the maximum number of characters permitted in an external name. If the file is a library, then the type of library is output and the information above is output for each module in the library.
- u list all undefined symbols in each file. If -d is also specified, each undefined symbol is listed with the code 'U'. The value of each symbol, if non-zero, is the space to be reserved for it at load time if it is not explicitly defined.
- v sort by value; implies the -d flag above. Symbols of equal value are sorted alphabetically.

If no flags are given, the default is -[d u]; that is, all symbols are listed, sorted in alphabetical order on symbol name. If more than one of

the flags `-[d s t u]` is selected, then type information is output first, followed by segment sizes, followed by the symbol list specified with `-d` or `-u`.

`<files>` specifies zero or more files, which must be in relocatable format, or standard library format, or UNIX/V6 library format, or UNIX/V7 library format. If more than one file, or a library, is specified, then the name of each separate file or module precedes any information output for it, each name followed by a colon and a newline; if `-s` is given, a line of totals is also output. If no `<files>` are specified, or if `"-"` is encountered on the command line, `xeq` is used.

#### RETURNS

`rel` returns success if no diagnostics are produced, that is, if all reads are successful and all file formats are valid.

#### EXAMPLE

To obtain a list of all symbols in a module:

```
% rel alloc.o
0x00000074T _alloc
0x00000000U _exit
0x000001feT _free
0x000000beT _nalloc
0x00000000U _sbreak
0x00000000U _write
```

#### SEE ALSO

`lib`, `link`, `ld`