

vlink portable multi-format linker

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1 General

1.1 Introduction

`vlink` is a portable linker which can be configured to support multiple input and output file formats at once. It even allows to link input files with a different format in a single run and generate the output file format of your choice from it.

The linker supports linking with objects, object archives (static libraries) and shared objects or libraries. It can generate an executable file with or without additional information for dynamic linking, a shared object, or a new object suitable for another linker pass.

Empty sections and other unused data are deleted to achieve a size-optimized output.

1.2 Legal

`vlink` is freeware and part of the portable and retargetable ANSI C compiler `vbcc`, copyright (c) 1995-2008 by Volker Barthelmann.

`vlink` may be freely redistributed as long as no modifications are made and nothing is charged for it. Non-commercial usage is allowed without any restrictions.

Every product or program derived directly from my source may not be sold commercially without permission from the author.

1.3 Installation

`vlink` comes as a stand-alone program, so no further installation is necessary. To use `vlink` with `vbcc`, copy the binary to '`vbcc/bin`' after following the installation instructions for `vbcc`.

2 The Linker

2.1 Usage

`vlink` combines the object and archive files given on the command line into a new object file. The output object file is either an executable program, a shared object suitable for loading at run-time, or an object file that can once again be processed by `vlink`.

Object files and archives are processed in the order given on the command line. Unlike other linkers you usually have to specify each library to link against only once, as `vlink` is smart enough to figure out all dependencies.

The file format of an input object file is determined automatically by the linker. The default output file format is compiled in (see `'-v'`) and may be changed by `'-b'`. Optionally also the default library search path can be compiled in and is visible with `'-v'` as well.

The number of output file formats included is configurable at compile time.

2.2 Supported file formats

The following file formats are supported:

`amigahunk`

The AmigaDos hunk format for M68k. Requires AmigaOS 2.04. No shared objects. Small data offset `0x7ffe`. Linker symbols:

- `._DATA_BAS_` (PhxAss)
- `._DATA_LEN_` (PhxAss)
- `._BSS_LEN_` (PhxAss)
- `._LinkerDB`
- `__BSSBAS` (SASC/StormC)
- `__BSSLEN` (SASC/StormC)
- `__ctors` (SASC/StormC)
- `__dtors` (SASC/StormC)
- `__DATA_BAS` (DICE-C)
- `__DATA_LEN` (DICE-C)
- `__BSS_LEN` (DICE-C)
- `__RESIDENT` (DICE-C)
- `___machtype` (GNU-gcc)
- `___text_size` (GNU-gcc)
- `___data_size` (GNU-gcc)
- `___bss_size` (GNU-gcc)

Automatic constructor/destructor function tables: `__ctors` and `__dtors` (will be mapped automatically to `__CTOR_LIST__` and `__DTOR_LIST__`). Supports `'-Rstd'` and `'-Rshort'`. This format was called "amigaos" in former `vlink` versions.

- amigaehf** An extension of the AmigaDOS hunk format for the PowerPC, 32-bit, big endian, as introduced by Haage&Partner GmbH. No executables (they are in **amigahunk** format) or shared objects. The same linker symbols, constructors/destructors as under **amigaos** are supported. Additionally, **@_name** symbols will be created on demand (when referenced). Supports **'-Rstd'** and **'-Rshort'**.
- ataritos** Atari-ST TOS file format. Executables only at the moment. The internal linker script defines **_LinkerDB** for small data and supports **vbcc**-style constructor/destructor tables in the data section (**__CTOR_LIST__** and **__DTOR_LIST__**).
- elf32m68k** ELF (executable linkable format) for Motorola M68k, 32-bit, big endian. Small data offset: **0x8000**. Linker symbols: **_SDA_BASE_**. Automatic constructor/destructor function tables will be placed into the sections **.ctors** and **.dtors**. Supports **'-Rstd'** and **'-Radd'**.
- elf32i386** ELF (executable linkable format) for Intel 386 and better, 32-bit, little endian. No small data. Automatic constructor/destructor function tables will be placed into the sections **.ctors** and **.dtors**. Supports **'-Rstd'** and **'-Radd'**.
- elf32aros** ELF i386 32-bit little endian like **elf32i386**, but generates relocatable object files as executables. This format is used for the AROS (Amiga Research OS) operating system. Supports **'-Rstd'** and **'-Radd'**.
- elf32arm** ELF (executable linkable format) for the ARM architecture. 32-bit, little endian. Small data offset: **0x1000**. Linker Symbols: **_SDA_BASE_**. Automatic constructor/destructor function tables will be placed into the sections **.ctors** and **.dtors**. Supports **'-Rstd'** and **'-Radd'**.
- elf32ppcbe** ELF (executable linkable format) for PowerPC, 32-bit, big endian. Small data offset: **0x8000**. Linker symbols: **_SDA_BASE_** and **_SDA2_BASE** (EABI only). Automatic constructor/destructor function tables will be placed into the sections **.ctors** and **.dtors**.
- elf32powerup** ELF PowerPC 32-bit big endian like **elf32ppcbe**, but generates relocatable object files as executables. This format is used for the PowerUp kernel. The linker symbol **_LinkerDB** is defined for **vbccppc**-compatibility. Small data offset: **0x8000**. This format was also called **elf32amiga** in former **vlink** versions.
- elf32morphos** Nearly identical to **elf32powerup**. Only difference is that **.sdata** and **.sbss** sections will not be merged as the MorphOS loader will take care of it. This format is used for MorphOS.
- a.out** Currently supported:
- **aoutbsd68k** (NetBSD/68k)
 - **aoutbsd68k4k** (NetBSD/68k 4K page size)

- aoutsun010 (SunOS 68010 and AmigaOS/Atari 68000/010)
- aoutsun020 (SunOS 68020 and AmigaOS/Atari 68020-68060)
- aoutbsdi386 (NetBSD/i386)
- aoutpc386
- aoutmint (Embeds a.out in TOS format for Atari MiNT executables)

Small data offset: 0x8000 (unused). Linker symbols: `__GLOBAL_OFFSET_TABLE_`, `__PROCEDURE_LINKAGE_TABLE_`, `__DYNAMIC`.

<code>vobj-le</code>	
<code>vobj-be</code>	VOBJ file format, generated by the <code>vasm</code> assembler. VOBJ is a read-only object file format and is designed to support any little- or big-endian architecture with all their specific relocations.
<code>rawbin1</code>	Absolute raw binary file. The sections and base addresses have to be specified by a linker script (option ‘-T’). Gaps between sections are filled with 0-bytes. Without a linker script, the raw binary will be relocated to base address 0.
<code>rawbin2</code>	Similar to <code>rawbin1</code> . The only difference is, that a separate file will be created for every section. The file name will get the section’s base address appended.
<code>srec19</code>	
<code>srec28</code>	
<code>srec37</code>	Motorola S-Record format. No symbols. Output format only. Without a linker script, the raw binary will be relocated to base address 0.
<code>ihex</code>	Intel Hex format. No symbols. Output format only. Without a linker script, the raw binary will be relocated to base address 0.

2.3 Linker Options

`vlink` command template:

```
vlink [-dhnqrstvwxMRSX] [-B linkmode] [-b targetname]
[-baseoff offset] [-C constructor-type] [-e entrypoint] [-f flavour]
[-fixunnamed] [-F filename] [-interp path] [-L library-search-path]
[-l library-specifier] [-multibase] [-nostdlib] [-o filename]
[-sc] [-sd] [-T filename] [-Ttext addr] [-textbaserel]
[-tos-flags/fastload/fastram/private/global/super/readable]
[-u symbol] [-V version] [-y symbol] [-P symbol] input-files...
```

Usually options and input file names can be mixed. Order of options may be important (e.g. when specifying a library with ‘-l’ or a search path with ‘-L’).

The following options are supported:

‘-Bdynamic’

Specifies that linking against dynamic libraries can take place. If a library specifier of the form ‘-lx’ appears on the command line, `ld` searches for a library of the form ‘libx.so.n.m’ (see the ‘-l’ option) according to the search rules in effect. If such a file can not be found a traditional archive is looked for. This options can appear anywhere on the command line and is complementary to ‘-Bstatic’.

‘-Bstatic’

The counterpart of ‘-Bdynamic’. This option turns off dynamic linking for all library specifiers until a ‘-Bdynamic’ is once again given. Any explicitly mentioned shared object encountered on the command line while this option is in effect is flagged as an error.

‘-Bshareable’

Instructs the linker to build a shared object from the object files rather than a normal executable image.

‘-Bsymbolic’

This option causes all symbolic references in the output to be resolved in this link-edit session. The only remaining run-time relocation requirements are base-relative relocations, ie. translation with respect to the load address. Failure to resolve any symbolic reference causes an error to be reported.

‘-Bforcearchive’

Force all members of archives to be loaded, whether or not such members contribute a definition to any plain object files. Useful for making a shared library from an archive of PIC objects without having to unpack the archive.

‘-b targetname’

Specifies target file format for the output file. See also "Supported file formats".

‘-baseoff offset’

Defines section offset for base-relative relocations. The default offset is target-dependant (e.g. 0x7ffe for amigaos and 0x8000 for elf32m68k).

‘-C constructor-type’

Defines the type of constructor/destructor function names to scan for. Valid types are:

- gnu GNU style constructors
- vbcc vbcc style constructors: `__INIT[_<pri>]_<name> / __EXIT`
- vbccelf vbcc style constructors: `_INIT.. / _EXIT..`

‘-clr-adduscore’

No longer add a preceding underscore for the symbols of the following objects in the command line.

‘-clr-deluscore’

No longer delete a preceding underscore for the symbols of the following objects in the command line.

‘-d’

Force allocation of commons even when producing relocatable output (‘-r’ option).

‘-e entrypoint’

Defines the entry point of an executable and may be either a symbol or an absolute address. The linker will set the entry point by trying each of the following methods in order, stopping when the first succeeds:

1. -e option

2. `ENTRY()` command in a linker script
3. value of the symbol `_start`, if defined
4. start of the first executable code section
5. address 0

‘-f flavour’

Adds a library-flavour. All flavours are cumulatively appended to each library search-path, whenever a library was specified with ‘-l’. Example: One search path and two flavours will search in:

1. ‘<lib-path>’,
2. ‘<lib-path>/<flavour1>’ and
3. ‘<lib-path>/<flavour1>/<flavour2>’

‘-F filename’

A list of object file names is read from the specified file. Useful, if the number of objects exceeds the length of the command line.

‘-fixunnamed’

All unnamed sections will get a default name according to their section type (`.text`, `.data` and `.bss`).

‘-h’

Prints a short help text.

‘-interp interpreter-path’

Defines the name of the interpreter, which is usually the dynamic linker for dynamically linked ELF executables. Defaults to ‘`/usr/lib/ld.so.1`’.

‘-L library-search-path’

Add path to the list of directories to search for libraries specified with the ‘-l’ option. When a default search path was compiled in (see ‘-v’), then it is searched last.

‘-l library-specifier’

This option specifies a library to be considered for inclusion in the output. If the ‘-Bdynamic’ option is in effect, a shared library of the form ‘`lib<spec>.so.m.n`’ (where `m` is the major, and `n` is the minor version number, respectively) is searched for first. The library with the highest version found in the search path is selected. If no shared library is found or the ‘-Bstatic’ option is in effect, an archive of the form ‘`lib<spec>.a`’ is looked for in the library search path. For `amigaos/amigaehf` file formats, the libraries are called ‘`<spec>.lib`’.

‘-M’

Produce output about the mapping of sections of the input files and the values assigned to symbols in the output file.

‘-multibase’

The default behaviour of `vlink` is to merge all sections which are accessed base-relative. This guarantees a single small data section, which can be accessed through a base register. If this is not desired - maybe you have several base registers and small data sections - you can disable this behaviour by specifying ‘`-multibase`’.

- ‘-n’ No page alignment of sections or segments in the final executable (NMAGIC).
- ‘-nostdlib’ Ignore default library search path, if one was compiled in.
- ‘-o filename’ Specifies the name of the output file. Defaults to ‘a.out’.
- ‘-P symbol’ Protect a symbol from stripping. This doesn’t work for all targets!
- ‘-q’ Emit relocations, even for absolute executables.
- ‘-R format’ Sets the relocation table format. Usually there is no need to change the default format defined by the target (‘-b’ option). Valid format strings are:
- std : standard format with addends in the code
 - add : addends are stored in the relocation table
 - short : relocation table with short offsets (e.g. 16 bit)
- Note that most targets only support one or two of those formats.
- ‘-r’ Produce relocatable object file, suitable for another linker pass.
- ‘-rpath library-search-path’ Add a directory to the runtime library search path. This is used when linking an ELF executable with shared objects. All ‘-rpath’ arguments are concatenated and passed to the runtime linker, which uses them to locate shared objects at runtime.
- ‘-S’ Strip all debugger symbols from the output.
- ‘-s’ Strip all symbols from the output.
- ‘-sc’ Merge all code sections to a single code section.
- ‘-sd’ Merge all data and bss sections to a single data-bss section.
- ‘-set-addunderscore’ Start adding a preceding underscore for the symbols of the following objects in the command line.
- ‘-set-delunderscore’ Start deleting a preceding underscore for the symbols of the following objects in the command line.
- ‘-shared’ Instructs the linker to build a shared object from the object files rather than a normal executable image.
- ‘-soname name’ Sets the "real name" of a shared object or library. For ELF this will create the SONAME tag in the .dynamic section.
- ‘-T script’ Specifies a linker script, which defines the absolute locations for every section. The syntax is very similar to that used in GNU linker scripts. Supported commands:

- CONSTRUCTORS
- ENTRY
- EXTERN
- FILL
- INPUT
- GROUP
- OUTPUT_ARCH
- OUTPUT_FORMAT
- PROVIDE
- SEARCH_DIR
- VBCC_CONSTRUCTORS
- VBCC_CONSTRUCTORS_ELF

Supported functions:

- ADDR
- ALIGN
- KEEP
- LOADADDR
- SIZEOF
- SIZEOF_HEADERS
- SORT

‘-t’ Trace the linker’s file accesses.

‘-textbaserel’
Allow base-relative access on code sections. Otherwise the linker will display a warning.

‘-tos-flags value’
Set the 32 bit flags field of the Atari TOS header to **value**. All ‘-tos’ options are only valid for the targets ataritos and aoutmint.

‘-tos-fastload’
Sets the fastload bit (0) in the TOS header.

‘-tos-fastram’
Sets the fastload bit (1) in the TOS header.

‘-tos-fastalloc’
Sets the fastload bit (2) in the TOS header.

‘-tos-private’
Sets the flags in the TOS header to mark memory space as private.

‘-tos-global’
Sets the flags in the TOS header to mark memory space as global (read/write by any process).

- ‘-tos-super’
Sets the flags in the TOS header to mark memory space as read-writeable by processes in supervisor mode only.
- ‘-tos-readable’
Sets the flags in the TOS header to mark memory space as read-only for other processes.
- ‘-u symbol’
Marks symbol as undefined in the first section which was found on the command line. This might trigger linking of additional modules from standard libraries. This is equivalent to the linker script command EXTERN.
- ‘-V version’
Minimum major version of shared object to be linked.
- ‘-v’
Prints **vlink** version string, default library search path and implemented target file formats.
- ‘-w’
Suppress all warning messages.
- ‘-X’
Discard local symbols in the input files that start with the letters ‘L’ or ‘l’, or with a dot.
- ‘-x’
Discard all local symbols in the input files.
- ‘-y symbol’
Trace the manipulations inflicted on symbol.

2.4 Known Problems

- Neither shared objects nor dynamically linked executables can be generated for **a.out** format.
- The following options are not really supported: ‘-S’, ‘-X’, ‘-Bsymbolic’
- Source level debugging support is missing for some formats.
- Many linker script commands are still missing.
- Default linker scripts are mostly missing, so you need to provide your own script using the ‘-T’ option.
- PHDR support for ELF is not perfect.

2.5 Credits

All those who wrote parts of the **vlink** distribution, made suggestions, answered my questions, texted **vlink**, reported errors or were otherwise involved in the development of **vlink** (in ascending alphabetical order, probably not complete):

- Karoly Balogh
- Volker Barthelmann
- Mikael Kalms
- Miro Kropacek
- Gunther Nikl
- Jörg Strohmayr

2.6 Error Messages

1. Out of memory
2. Unrecognized option '%s'
3. Unknown link mode: %s
4. Unknown argument for option -d: %c
5. Option '-%c' requires an argument
6. No input files
7. File \"%s\" has a read error
8. Cannot open \"%s\": No such file or directory
9. Invalid target format \"%s\"
10. Directory \"%s\" could not be examined
11. %s: File format not recognized
12. \"%s\" is already an executable file
13. %s: File format corrupted
14. %s (%s): Illegal relocation type %d at %s+%x
15. %s: Unexpected end of section %s in %s
16. %s: %s appeared twice in %s
17. %s: Misplaced %s in %s
18. %s: Symbol definition %s in %s uses unsupported type %d
19. %s: Global symbol %s from %s is already defined in %s
20. %s: Unresolved reference to symbol %s in %s uses unsupported type %d
21. %s (%s+0x%x): Reference to undefined symbol %s
22. Attributes of section %s were changed from %s in %s to %s in %s
23. Alignment of section %s was changed from %d in %s to %d in %s
24. %s (%s+0x%x): Illegal relative reference to %s+0x%llx
25. %s (%s+0x%x): %dbit %s reference to %s+0x%llx (value to write: 0x%llx) out of range
26. %s (%s+0x%x): Referenced absolute symbol %s=0x%llx + 0x%llx (value to write: 0x%llx) doesn't fit into %d bits
27. %s (%s+0x%x): Illegal relative reference to symbol %s
28. %s (%s+0x%x): Relative reference to relocatable symbol %s=0x%llx + 0x%llx (value to write: 0x%llx) doesn't fit into %d bits
29. Can't create output file %s
30. %s (%s+0x%x): Absolute reference to relocatable symbol %s=0x%llx + 0x%llx (value to write: 0x%llx) doesn't fit into %d bits
31. Error while writing to %s
32. Target %s: Unsupported relocation type %s (offset=%d, size=%d, mask=%llx) at %s+0x%x
33. Target %s: Can't reproduce symbol %s, which is a %s%s%s
34. Option '%s' requires an argument

35. %s (%s+0x%x): Calculated value 0x%llx doesn't fit into relocation type %s (offset=%d, size=%d, mask=0x%llx)
36. UNUSED
37. %s: Malformatted archive member %s
38. %s: Empty archive ignored
39. %s: %s doesn't support shared objects in library archives
40. %s: %s doesn't support executables in library archives
41. %s (%s): Illegal format / file corrupted
42. %s: Consistency check for archive member %s failed
43. %s: Invalid ELF section header index (%d) in %s
44. %s: ELF section header #%d has illegal offset in %s
45. %s: ELF section header string table has illegal type in %s", EF_ERROR,
46. %s: ELF section header string table has illegal offset in %s
47. %s: ELF program header table in %s was ignored
48. %s: ELF section header type %d in %s is not needed in relocatable objects
49. %s: Illegal section offset for %s in %s
50. %s: ELF %s table has illegal type in %s
51. %s: ELF %s table has illegal offset in %s
52. %s: %s in %s defines relocations relative to a non-existing section with index=%d
53. %s: Symbol %s, defined in %s, has an invalid reference to a non-existing section with index=%d
54. %s: Illegal symbol type %d for %s in %s
55. %s: Symbol %s has illegal binding type %d in %s
56. %s: Symbol %s in %s is multiply defined
57. %s: Merging a code section with name \"__MERGED\"
58. Relative references between %s section \"%s\" and %s section \"%s\" (%s) force a combination of the two
59. Can't define %s as ctors/dtors label. Symbol already exists.
60. %s: ELF section header type %d in %s is not needed in shared objects
61. %s: Endianess differs from previous objects
62. Target file format doesn't support relocatable objects
63. Predefined limits of destination memory region %s for section %s were exceeded (0x%llx)
64. Section %s(%s) was not recognized by target linker script
65. %s line %d: Unknown keyword <%s> ignored
66. %s line %d: '%c' expected
67. %s line %d: Absolute number expected
68. %s line %d: Keyword <%s> expected
69. %s line %d: GNU command <%s> ignored

- 70. %s line %d: Unknown memory region <%s>
- 71. %s line %d: Multiple constructor types in output file
- 72. UNUSED %s line %d: Syntax error
- 73. UNUSED %s line %d: Can't define symbols without a section
- 74. %s line %d: SECTIONS block defined twice
- 75. %s line %d: Segment %s is closed and can't be reused
- 76. %s line %d: Address overrides specified %cMA memory region
- 77. %s line %d: Segment %s must include both, FILEHDR and PHDR
- 78. %s line %d: Missing argument
- 79. %s line %d: Undefined section: <%s>
- 80. %s line %d: Section %s was assigned to more than one PT_LOAD segment
- 81. First ELF segment (%s) doesn't contain first section (%s)
- 82. Intermediate uninitialized sections in ELF segment <%s> (first=<%s>, last=<%s>) will be turned into initialized
- 83. %s: No load segment for the file header and PHDRS found
- 84. %s: QMAGIC is deprecated and will no longer be supported
- 85. %s: a.out %s table has illegal offset or size in %s
- 86. %s: a.out %s table size in <%s> is not a multiple of %d
- 87. %s: a.out symbol name has illegal offset %ld in %s
- 88. %s: a.out symbol %s has illegal binding type %d in %s
- 89. %s: a.out relocations without an appropriate section in %s
- 90. %s: illegal a.out relocation in section %s of %s at offset 0x%08lx: <pcrel=%d len=%d ext=%d brel=%d jmptab=%d rel=%d copy=%d>
- 91. %s: illegal a.out external reference to symbol %s in %s, which is no external symbol
- 92. %s: illegal nlist type %lu in a.out relocation in section %s of %s at offset 0x%08lx
- 93. Target %s: Common symbol %s is unreferenced and will disappear
- 94. Target file format doesn't support executable files
- 95. %s: a.out relocation <pcrel=%d len=%d ext=%d brel=%d jmptab=%d rel=%d copy=%d> is treated as a normal relocation in section %s of %s at offset 0x%08lx
- 96. %s: size %d for a.out symbol %s in %s was ignored
- 97. Target %s: %s section must not be absent for a valid executable file", EF_FATAL,
- 98. Target %s: Section %s is overlapping %s
- 99. %s line %d: Illegal PHDR type: <%s>
- 100. %s line %d: <%s> behind SECTIONS ignored
- 101. %s line %d: Address symbol '.' invalid outside SECTIONS block
- 102. %s line %d: Reference to non-absolute symbol <%s> outside SECTIONS", EF_ERROR,
- 103. %s line %d: Division by zero
- 104. %s line %d: Unknown symbol or function: <%s>

- 105. %s line %d: No function-calls allowed here
- 106. %s line %d: Symbol <%s> is not yet assigned
- 107. %s line %d: Command <%s> not allowed outside SECTIONS block
- 108. %s line %d: Address symbol '.' cannot be provided
- 109. %s line %d: Symbol <%s> already defined
- 110. %s line %d: Only absolute expressions may be assigned outside SECTIONS block
- 111. %s line %d: Unknown PHDR: <%s>
- 112. %s (%s+0x%x): Cannot resolve reference to %s, because section %s was not recognized by the linker script
- 113. %s (%s): %d bits per byte are not supported
- 114. %s (%s): %d bytes per target-address are not supported
- 115. %s (%s): Relocation type %d (offset=%lld, bit-offset=%d bit-size=%d mask=0x%llx referring to symbol <%s> (type %d) is not supported
- 116. %s (%s): Symbol type %d for <%s> in section %s is not supported
- 117. %s (%s+0x%x): Cannot resolve %s reference to %s, because host section %s is invalid
- 118. %s: Malformatted ELF %s section in %s
- 119. %s: Ignoring junk at end of ELF %s section in %s
- 120. %s (%s+0x%x): Relocation based on missing %s section
- 121. %s (%s+0x%x): Base-relative reference to code section
- 122. Relocation table format not supported by selected output format - reverting to %s's standard
- 123. Unknown relocation table format '%s' ignored
- 124. Target %s: multiple small-data sections not allowed
- 125. .ctors/.dtors spread over multiple sections
- 126. Dynamic symbol reference not supported by target %s
- 127. %s: ELF symbol name has illegal offset 0x%lx in %s