

NAME

clang - the Clang C, C++, and Objective-C compiler

SYNOPSIS

clang [*options*] *filename* ...

DESCRIPTION

clang is a C, C++, and Objective-C compiler which encompasses preprocessing, parsing, optimization, code generation, assembly, and linking. Depending on which high-level mode setting is passed, Clang will stop before doing a full link. While Clang is highly integrated, it is important to understand the stages of compilation, to understand how to invoke it. These stages are:

Driver

The clang executable is actually a small driver which controls the overall execution of other tools such as the compiler, assembler and linker. Typically you do not need to interact with the driver, but you transparently use it to run the other tools.

Preprocessing

This stage handles tokenization of the input source file, macro expansion, #include expansion and handling of other preprocessor directives. The output of this stage is typically called a ".i" (for C), ".ii" (for C++), ".mi" (for Objective-C), or ".mii" (for Objective-C++) file.

Parsing and Semantic Analysis

This stage parses the input file, translating preprocessor tokens into a parse tree. Once in the form of a parse tree, it applies semantic analysis to compute types for expressions as well and determine whether the code is well formed. This stage is responsible for generating most of the compiler warnings as well as parse errors. The output of this stage is an "Abstract Syntax Tree" (AST).

Code Generation and Optimization

This stage translates an AST into low-level intermediate code (known as "LLVM IR") and ultimately to machine code. This phase is responsible for optimizing the generated code and handling target-specific code generation. The output of this stage is typically called a ".s" file or "assembly" file.

Clang also supports the use of an integrated assembler, in which the code generator produces object files directly. This avoids the overhead of generating the ".s" file and of calling the target assembler.

Assembler

This stage runs the target assembler to translate the output of the compiler into a target object file.

The output of this stage is typically called a ".o" file or "object" file.

Linker

This stage runs the target linker to merge multiple object files into an executable or dynamic library. The output of this stage is typically called an "a.out", ".dylib" or ".so" file.

Clang Static Analyzer

The Clang Static Analyzer is a tool that scans source code to try to find bugs through code analysis. This tool uses many parts of Clang and is built into the same driver. Please see <https://clang-analyzer.llvm.org> for more details on how to use the static analyzer.

OPTIONS

Stage Selection Options

-E Run the preprocessor stage.

-fsyntax-only

Run the preprocessor, parser and semantic analysis stages.

-S Run the previous stages as well as LLVM generation and optimization stages and target-specific code generation, producing an assembly file.

-c Run all of the above, plus the assembler, generating a target ".o" object file.

no stage selection option

If no stage selection option is specified, all stages above are run, and the linker is run to combine the results into an executable or shared library.

Language Selection and Mode Options

-x <language>

Treat subsequent input files as having type language.

-std=<standard>

Specify the language standard to compile for.

Supported values for the C language are:

c89

c90

iso9899:1990

ISO C 1990

iso9899:199409

ISO C 1990 with amendment 1

gnu89**gnu90**

ISO C 1990 with GNU extensions

c99**iso9899:1999**

ISO C 1999

gnu99

ISO C 1999 with GNU extensions

c11**iso9899:2011**

ISO C 2011

gnu11

ISO C 2011 with GNU extensions

c17**iso9899:2017**

ISO C 2017

gnu17

ISO C 2017 with GNU extensions

The default C language standard is **gnu17**, except on PS4, where it is **gnu99**.

Supported values for the C++ language are:

c++98**c++03**

ISO C++ 1998 with amendments

gnu++98

gnu++03

ISO C++ 1998 with amendments and GNU extensions
c++11

ISO C++ 2011 with amendments
gnu++11

ISO C++ 2011 with amendments and GNU extensions
c++14

ISO C++ 2014 with amendments
gnu++14

ISO C++ 2014 with amendments and GNU extensions
c++17

ISO C++ 2017 with amendments
gnu++17

ISO C++ 2017 with amendments and GNU extensions
c++20

ISO C++ 2020 with amendments
gnu++20

ISO C++ 2020 with amendments and GNU extensions
c++2b

Working draft for ISO C++ 2023
gnu++2b

Working draft for ISO C++ 2023 with GNU extensions

The default C++ language standard is **gnu++17**.

Supported values for the OpenCL language are:

cl1.0

OpenCL 1.0

cl1.1

OpenCL 1.1

cl1.2

OpenCL 1.2

cl2.0

OpenCL 2.0

The default OpenCL language standard is **cl1.0**.

Supported values for the CUDA language are:

cuda

NVIDIA CUDA(tm)

-stdlib=<library>

Specify the C++ standard library to use; supported options are libstdc++ and libc++. If not specified, platform default will be used.

-rtlib=<library>

Specify the compiler runtime library to use; supported options are libgcc and compiler-rt. If not specified, platform default will be used.

-ansi

Same as -std=c89.

-ObjC, -ObjC++

Treat source input files as Objective-C and Object-C++ inputs respectively.

-trigraphs

Enable trigraphs.

-ffreestanding

Indicate that the file should be compiled for a freestanding, not a hosted, environment. Note that it is assumed that a freestanding environment will additionally provide *memcpy*, *memmove*, *memset* and *memcmp* implementations, as these are needed for efficient codegen for many programs.

-fno-builtin

Disable special handling and optimizations of well-known library functions, like **strlen()** and **malloc()**.

-fno-builtin-*<function>*

Disable special handling and optimizations for the specific library function. For example, **-fno-builtin-strlen** removes any special handling for the **strlen()** library function.

-fno-builtin-std-*<function>*

Disable special handling and optimizations for the specific C++ standard library function in namespace **std**. For example, **-fno-builtin-std-move_if_noexcept** removes any special handling for the **std::move_if_noexcept()** library function.

For C standard library functions that the C++ standard library also provides in namespace **std**, use *-fno-builtin-*<function>** instead.

-fmath-errno

Indicate that math functions should be treated as updating **errno**.

-fpascal-strings

Enable support for Pascal-style strings with "\pfoo".

-fms-extensions

Enable support for Microsoft extensions.

-fmsc-version=

Set `_MSC_VER`. Defaults to 1300 on Windows. Not set otherwise.

-fborland-extensions

Enable support for Borland extensions.

-fwritable-strings

Make all string literals default to writable. This disables uniquing of strings and other optimizations.

-flax-vector-conversions, -flax-vector-conversions=<kind>, -fno-lax-vector-conversions

Allow loose type checking rules for implicit vector conversions. Possible values of *<kind>*:

- ⊕ **none**: allow no implicit conversions between vectors

- ⊕ **integer**: allow implicit bitcasts between integer vectors of the same overall bit-width

⊕ **all**: allow implicit bitcasts between any vectors of the same overall bit-width

<kind> defaults to **integer** if unspecified.

-fblocks

Enable the "Blocks" language feature.

-fobjc-abi-version=version

Select the Objective-C ABI version to use. Available versions are 1 (legacy "fragile" ABI), 2 (non-fragile ABI 1), and 3 (non-fragile ABI 2).

-fobjc-nonfragile-abi-version=<version>

Select the Objective-C non-fragile ABI version to use by default. This will only be used as the Objective-C ABI when the non-fragile ABI is enabled (either via *-fobjc-nonfragile-abi*, or because it is the platform default).

-fobjc-nonfragile-abi, -fno-objc-nonfragile-abi

Enable use of the Objective-C non-fragile ABI. On platforms for which this is the default ABI, it can be disabled with *-fno-objc-nonfragile-abi*.

Target Selection Options

Clang fully supports cross compilation as an inherent part of its design. Depending on how your version of Clang is configured, it may have support for a number of cross compilers, or may only support a native target.

-arch <architecture>

Specify the architecture to build for (Mac OS X specific).

-target <architecture>

Specify the architecture to build for (all platforms).

-mmacosx-version-min=<version>

When building for macOS, specify the minimum version supported by your application.

-miphoneos-version-min

When building for iPhone OS, specify the minimum version supported by your application.

--print-supported-cpus

Print out a list of supported processors for the given target (specified through

--target=<architecture> or *-arch <architecture>*). If no target is specified, the system default target

will be used.

-mcpu=?, -mtune=?

Acts as an alias for *--print-supported-cpus*.

-march=<cpu>

Specify that Clang should generate code for a specific processor family member and later. For example, if you specify *-march=i486*, the compiler is allowed to generate instructions that are valid on i486 and later processors, but which may not exist on earlier ones.

Code Generation Options**-O0, -O1, -O2, -O3, -Ofast, -Os, -Oz, -Og, -O, -O4**

Specify which optimization level to use:

-O0 Means "no optimization": this level compiles the fastest and generates the most debuggable code.

-O1 Somewhere between *-O0* and *-O2*.

-O2 Moderate level of optimization which enables most optimizations.

-O3 Like *-O2*, except that it enables optimizations that take longer to perform or that may generate larger code (in an attempt to make the program run faster).

-Ofast Enables all the optimizations from *-O3* along with other aggressive optimizations that may violate strict compliance with language standards.

-Os Like *-O2* with extra optimizations to reduce code size.

-Oz Like *-Os* (and thus *-O2*), but reduces code size further.

-Og Like *-O1*. In future versions, this option might disable different optimizations in order to improve debuggability.

-O Equivalent to *-O1*.

-O4 and higher

Currently equivalent to *-O3*

-g, -gline-tables-only, -gmodules

Control debug information output. Note that Clang debug information works best at *-O0*. When more than one option starting with *-g* is specified, the last one wins:

-g Generate debug information.

-gline-tables-only Generate only line table debug information. This allows for symbolicated backtraces with inlining information, but does not include any information about variables, their locations or types.

-gmodules Generate debug information that contains external references to types defined in Clang modules or precompiled headers instead of emitting redundant debug type information into every object file. This option transparently switches the Clang module format to object file containers that hold the Clang module together with the debug information. When compiling a program that uses Clang modules or precompiled headers, this option produces complete debug information with faster compile times and much smaller object files.

This option should not be used when building static libraries for distribution to other machines because the debug info will contain references to the module cache on the machine the object files in the library were built on.

-fstandalone-debug -fno-standalone-debug

Clang supports a number of optimizations to reduce the size of debug information in the binary. They work based on the assumption that the debug type information can be spread out over multiple compilation units. For instance, Clang will not emit type definitions for types that are not needed by a module and could be replaced with a forward declaration. Further, Clang will only emit type info for a dynamic C++ class in the module that contains the vtable for the class.

The *-fstandalone-debug* option turns off these optimizations. This is useful when working with 3rd-party libraries that don't come with debug information. This is the default on Darwin. Note that Clang will never emit type information for types that are not referenced at all by the program.

-feliminate-unused-debug-types

By default, Clang does not emit type information for types that are defined but not used in a program. To retain the debug info for these unused types, the negation

-fno-eliminate-unused-debug-types can be used.

-fexceptions

Enable generation of unwind information. This allows exceptions to be thrown through Clang compiled stack frames. This is on by default in x86-64.

-ftrapv

Generate code to catch integer overflow errors. Signed integer overflow is undefined in C. With this flag, extra code is generated to detect this and abort when it happens.

-fvisibility

This flag sets the default visibility level.

-fcommon, -fno-common

This flag specifies that variables without initializers get common linkage. It can be disabled with *-fno-common*.

-ftls-model=<model>

Set the default thread-local storage (TLS) model to use for thread-local variables. Valid values are: "global-dynamic", "local-dynamic", "initial-exec" and "local-exec". The default is "global-dynamic". The default model can be overridden with the `tls_model` attribute. The compiler will try to choose a more efficient model if possible.

-flto, -flto=full, -flto=thin, -emit-llvm

Generate output files in LLVM formats, suitable for link time optimization. When used with *-S* this generates LLVM intermediate language assembly files, otherwise this generates LLVM bitcode format object files (which may be passed to the linker depending on the stage selection options).

The default for *-flto* is "full", in which the LLVM bitcode is suitable for monolithic Link Time Optimization (LTO), where the linker merges all such modules into a single combined module for optimization. With "thin", *ThinLTO* compilation is invoked instead.

NOTE:

On Darwin, when using *-flto* along with *-g* and compiling and linking in separate steps, you also need to pass **-Wl,-object_path_lto,<lto-filename>.o** at the linking step to instruct the ld64 linker not to delete the temporary object file generated during Link Time Optimization (this flag is automatically passed to the linker by Clang if compilation and linking are done in a single step). This allows debugging the executable as well as generating the **.dSYM** bundle using **dsymutil(1)**.

Driver Options**-###**

Print (but do not run) the commands to run for this compilation.

--help

Display available options.

-Qunused-arguments

Do not emit any warnings for unused driver arguments.

-Wa,<args>

Pass the comma separated arguments in args to the assembler.

-Wl,<args>

Pass the comma separated arguments in args to the linker.

-Wp,<args>

Pass the comma separated arguments in args to the preprocessor.

-Xanalyzer <arg>

Pass arg to the static analyzer.

-Xassembler <arg>

Pass arg to the assembler.

-Xlinker <arg>

Pass arg to the linker.

-Xpreprocessor <arg>

Pass arg to the preprocessor.

-o <file>

Write output to file.

-print-file-name=<file>

Print the full library path of file.

-print-libgcc-file-name

Print the library path for the currently used compiler runtime library ("libgcc.a" or "libclang_rt.builtins.*.a").

-print-prog-name=<name>

Print the full program path of name.

-print-search-dirs

Print the paths used for finding libraries and programs.

-save-temps

Save intermediate compilation results.

-save-stats, -save-stats=cwd, -save-stats=obj

Save internal code generation (LLVM) statistics to a file in the current directory (*-save-stats/"-save-stats=cwd"*) or the directory of the output file (*"-save-state=obj"*).

-integrated-as, -no-integrated-as

Used to enable and disable, respectively, the use of the integrated assembler. Whether the integrated assembler is on by default is target dependent.

-time

Time individual commands.

-ftime-report

Print timing summary of each stage of compilation.

-v Show commands to run and use verbose output.

Diagnostics Options

-fshow-column, -fshow-source-location, -fcaret-diagnostics, -fdiagnostics-fixit-info, -fdiagnostics-parseable-fixits, -fdiagnostics-print-source-range-info, -fprint-source-range-info, -fdiagnostics-show-option, -fmessage-length

These options control how Clang prints out information about diagnostics (errors and warnings). Please see the Clang User's Manual for more information.

Preprocessor Options**-D<macroname>=<value>**

Adds an implicit #define into the predefines buffer which is read before the source file is preprocessed.

-U<macroname>

Adds an implicit #undef into the predefines buffer which is read before the source file is preprocessed.

-include <filename>

Adds an implicit `#include` into the predefines buffer which is read before the source file is preprocessed.

-I<directory>

Add the specified directory to the search path for include files.

-F<directory>

Add the specified directory to the search path for framework include files.

-nostdinc

Do not search the standard system directories or compiler builtin directories for include files.

-nostdlibinc

Do not search the standard system directories for include files, but do search compiler builtin include directories.

-nobuiltininc

Do not search clang's builtin directory for include files.

ENVIRONMENT**TMPDIR, TEMP, TMP**

These environment variables are checked, in order, for the location to write temporary files used during the compilation process.

CPATH

If this environment variable is present, it is treated as a delimited list of paths to be added to the default system include path list. The delimiter is the platform dependent delimiter, as used in the `PATH` environment variable.

Empty components in the environment variable are ignored.

**C_INCLUDE_PATH, OBJC_INCLUDE_PATH, CPLUS_INCLUDE_PATH,
OBJCPLUS_INCLUDE_PATH**

These environment variables specify additional paths, as for `CPATH`, which are only used when processing the appropriate language.

MACOSX_DEPLOYMENT_TARGET

If `-mmacosx-version-min` is unspecified, the default deployment target is read from this

environment variable. This option only affects Darwin targets.

BUGS

To report bugs, please visit [<https://github.com/llvm/llvm-project/issues/>](https://github.com/llvm/llvm-project/issues/). Most bug reports should include preprocessed source files (use the `-E` option) and the full output of the compiler, along with information to reproduce.

SEE ALSO

as(1), **ld(1)**

AUTHOR

Maintained by the Clang / LLVM Team ([<http://clang.llvm.org>](http://clang.llvm.org/))

COPYRIGHT

2007-2023, The Clang Team