GCC Source Code: An Internal View

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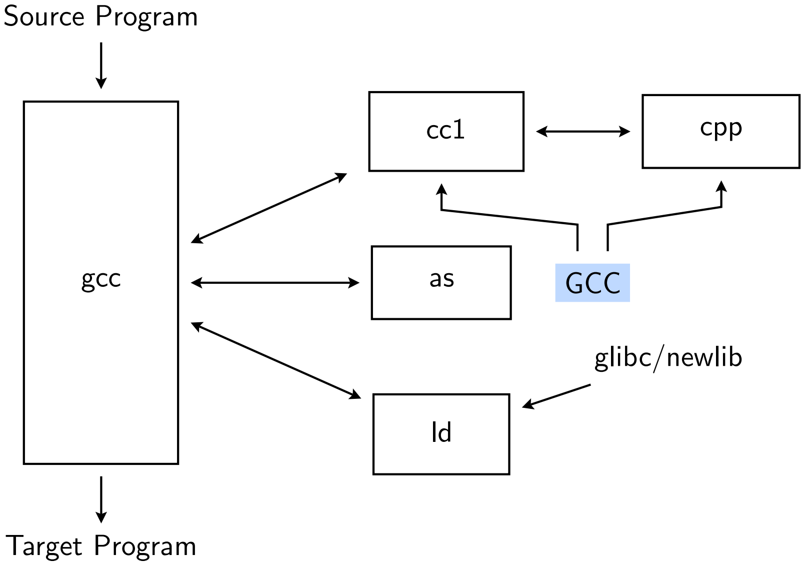
Outline

- A summary of GCC architecture
- Walking the maze of a large code base
- An Internal View of GCC code

The Gnu Tool Chain



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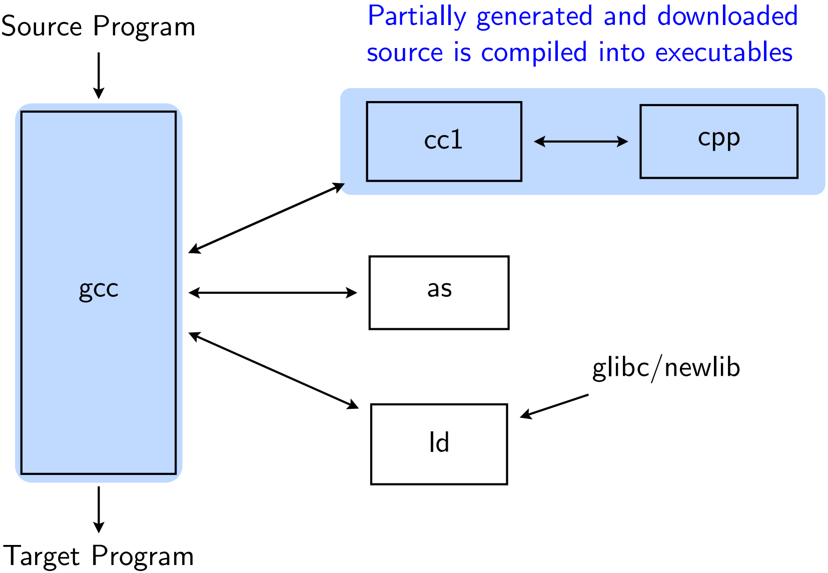
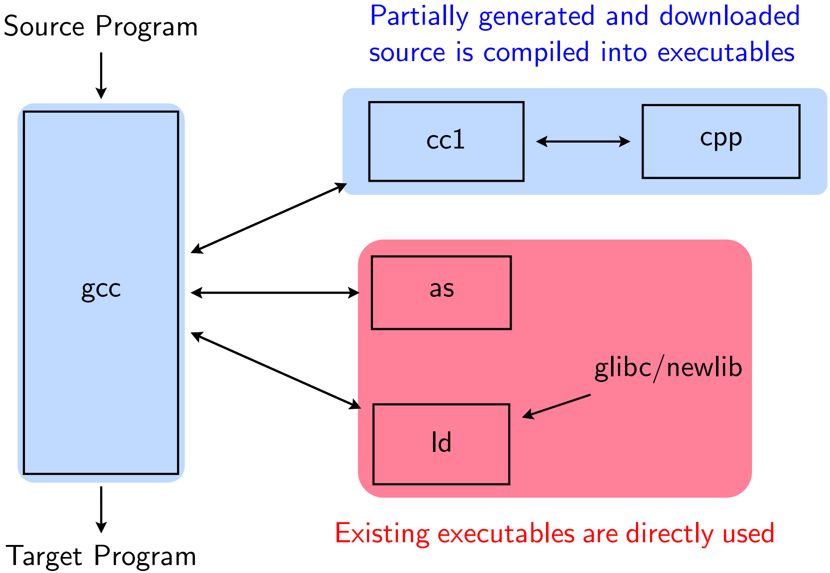

Source Program
Partially generated and downloaded source is compiled into executables
cc1
cpp
gcc
as
glibc/newlib
ld
Target Program

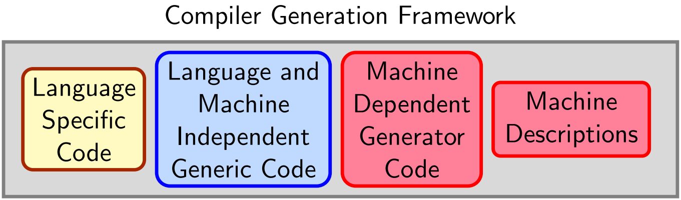
The Gnu Tool Chain



Partially generated and downloaded source is compiled into executables

Existing executables are directly used

The Architecture of GCC



Compiler Generation Framework

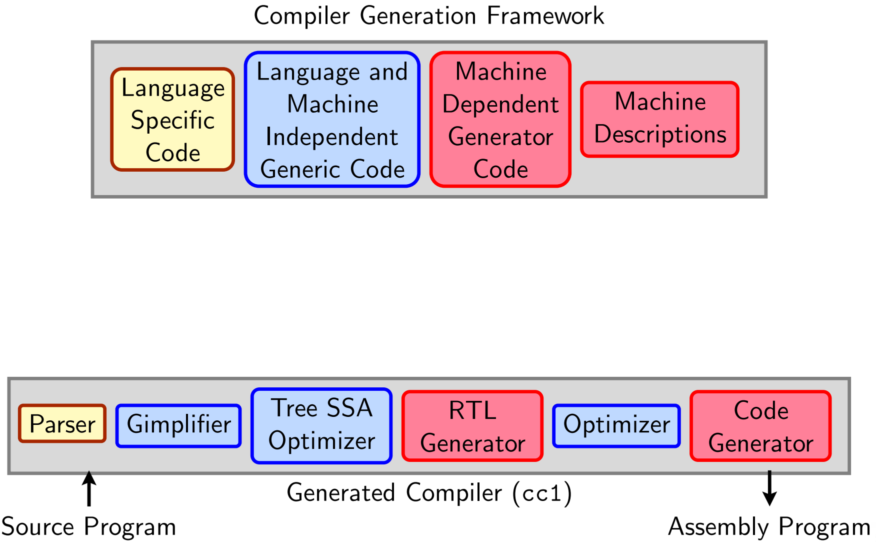
Language Specific Code

Language and Machine Independent Generic Code

Machine Dependent Generator Code

Machine Descriptions

The Architecture of GCC


Compiler Generation Framework

Language Specific Code

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Machine Descriptions

Parser

Gimplifier

Tree SSA Optimizer

RTL Generator

Optimizer

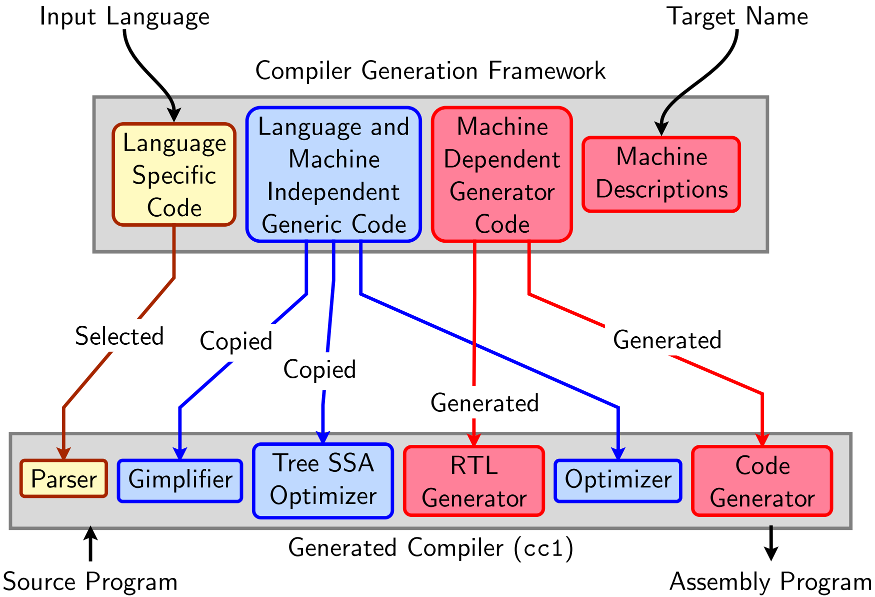
Code Generator

Generated Compiler (cc1)

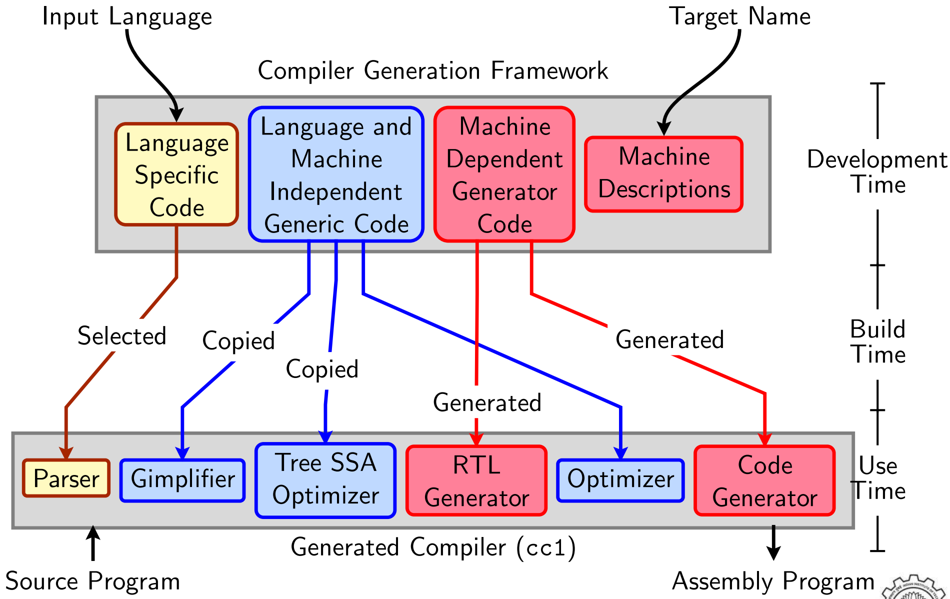
Source Program

Assembly Program

The Architecture of GCC



The Architecture of GCC



An Example of The Generation Related Gap

- Predicate function for invoking the loop distribution pass

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static bool
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- The required C statements are generated during the build

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```
  File              Line
0 collect2.c         766 main (int argc, char **argv)
1 fix-header.c      1074 main (int argc, char **argv)
2 fp-test.c           85 main (void )
3 gcc.c             6216 main (int argc, char **argv)
4 gcov-dump.c         76 main (int argc ATTRIBUTE_UNUSED, char **argv
5 gcov-iov.c          29 main (int argc, char **argv)
6 gcov.c             355 main (int argc, char **argv)
7 gen-protos.c       130 main (int argc ATTRIBUTE_UNUSED, char **argv
8 genattr.c           89 main (int argc, char **argv)
9 genattrtab.c      4438 main (int argc, char **argv)
a genautomata.c     9321 main (int argc, char **argv)
b genchecksum.c       65 main (int argc, char ** argv)
c gencodes.c          51 main (int argc, char **argv)
d genconditions.c    209 main (int argc, char **argv)
e genconfig.c        261 main (int argc, char **argv)
f genconstants.c      50 main (int argc, char **argv)
```

Another Example of The Generation Related Gap

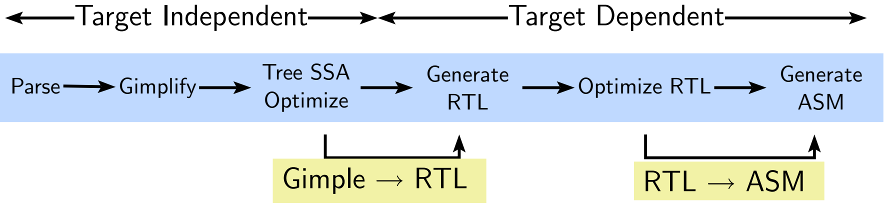
Locating the `main` function in the directory `gcc-4.4.2/gcc` using cscope

```
g genemit.c       820 main (int argc, char **argv)
h genextract.c    394 main (int argc, char **argv)
i genflags.c      231 main (int argc, char **argv)
j gengenrtl.c     350 main (int argc, char **argv)
k gengtype.c     3584 main (int argc, char **argv)
l genmddeps.c      45 main (int argc, char **argv)
m genmodes.c     1376 main (int argc, char **argv)
n genopinit.c     472 main (int argc, char **argv)
o genoutput.c    1005 main (int argc, char **argv)
p genpeep.c       353 main (int argc, char **argv)
q genpreds.c     1399 main (int argc, char **argv)
r genrecog.c     2718 main (int argc, char **argv)
s main.c           33 main (int argc, char **argv)
t mips-tdump.c   1393 main (int argc, char **argv)
u mips-tfile.c    655 main (void )
v mips-tfile.c   4690 main (int argc, char **argv)
w protoize.c     4373 main (int argc, char **const argv)
```

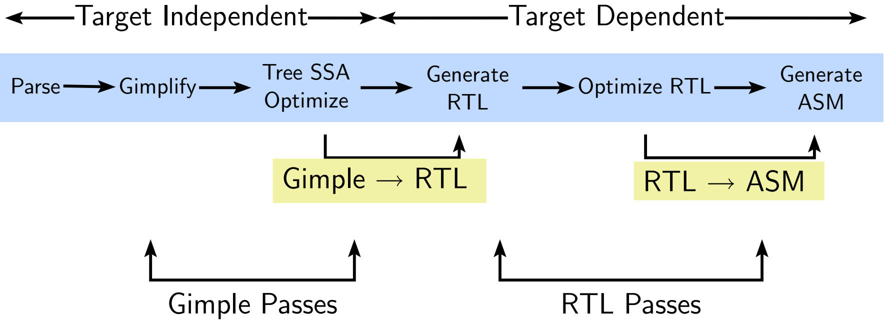
Transformation Passes in GCC

- A total of 196 unique pass names initialized in `${SOURCE}/gcc/passes.c`
    - Some passes are called multiple times in different contexts
      Conditional constant propagation and dead code elimination are called thrice
    - Some passes are only demo passes (eg. data dependence analysis)
    - Some passes have many variations (eg. special cases for loops)
      Common subexpression elimination, dead code elimination
- The pass sequence can be divided broadly in two parts
    - Passes on Gimple
    - Passes on RTL
- Some passes are organizational passes to group related passes

Basic Transformations in GCC



Basic Transformations in GCC



Passes On Gimple

Pass Group	Examples	Number of passes
Lowering	Gimple IR, CFG Construction	12
Interprocedural Optimizations	Conditional Constant Propagation, Inlining, SSA Construction	36
Intraprocedural Optimizations	Constant Propagation, Dead Code Elimination, PRE	40
Loop Optimizations	Vectorization, Parallelization	24
Remaining Intraprocedural Optimizations	Value Range Propagation, Rename SSA	23
Generating RTL		01
Total number of passes on Gimple		136

Passes On RTL

Pass Group	Examples	Number of passes
Intraprocedural Optimizations	CSE, Jump Optimization	15
Loop Optimizations	Loop Invariant Movement, Peeling, Unswitching	7
Machine Dependent Optimizations	Register Allocation, Instruction Scheduling, Peephole Optimizations	59
Assembly Emission and Finishing		03
Total number of passes on RTL		84

Comprehensiveness of GCC 4.4.2: Size

Source Lines	Number of lines in the main source	2,187,216
	Number of lines in libraries	1,633,558
Directories	Number of subdirectories	3794
Files	Total number of files	62998
	C source files	13968
	Header files	9163
	C++ files	4191
	Java files	6340
	Makefiles and Makefile templates	163
	Configuration scripts	52
	Machine description files	206

(Line counts estimated by the program `sloccount` by David A. Wheeler)

Walking the Maze of a Large Code Base

- Use cscope

```
cd $SOURCE
cscope -R
```

- Use ctags

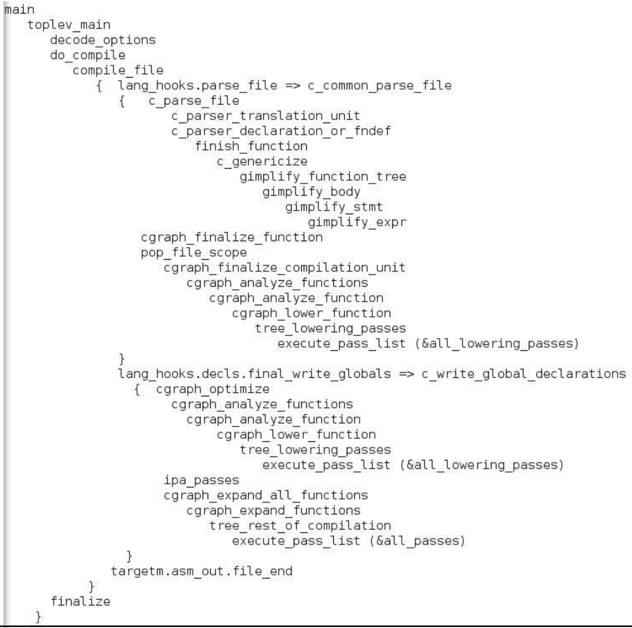
```
cd $SOURCE
ctags -R
```

  Make sure you use `exeburant-ctags`

gcc-4.4.2 Control Flow

```
main
   validate_all_switches
   lookup_compiler
   do_spec
      do_spec_2
         do_spec_1  /* Get the name of the compiler */
      execute
         pex_init
         pex_run
            pex_run_in_environment
               obj->funcs->exec_child
```

cc1-4.4.2 Control Flow



```
main
   toplev_main
      decode_options
      do_compile
         compile_file
            {  lang_hooks.parse_file => c_common_parse_file
               {   c_parse_file
                     c_parser_translation_unit
                     c_parser_declaration_or_fndef
                        finish_function
                           c_genericize
                              gimplify_function_tree
                                 gimplify_body
                                    gimplify_stmt
                                       gimplify_expr
                  cgraph_finalize_function
                  pop_file_scope
                     cgraph_finalize_compilation_unit
                        cgraph_analyze_functions
                           cgraph_analyze_function
                              cgraph_lower_function
                                 tree_lowering_passes
                                    execute_pass_list (&all_lowering_passes)
               }
               lang_hooks.decls.final_write_globals => c_write_global_declarations
                 {  cgraph_optimize
                      cgraph_analyze_functions
                        cgraph_analyze_function
                            cgraph_lower_function
                               tree_lowering_passes
                                  execute_pass_list (&all_lowering_passes)
                     ipa_passes
                     cgraph_expand_all_functions
                        cgraph_expand_functions
                           tree_rest_of_compilation
                              execute_pass_list (&all_passes)
                }
              targetm.asm_out.file_end
           }
      finalize
    }
```

cc1-4.4.2 Control Flow: Lowering Passes

```
lang_hooks.parse_file => c_common_parse_file
   c_parse_file
         c_parser_translation_unit
            c_parser_declaration_or_fndef
               finish_function
                  c_genericize
                     gimplify_function_tree
                        gimplify_body
                           gimplify_stmt
                              gimplify_expr
        cgraph_finalize_function
    pop_file_scope
       cgraph_finalize_compilation_unit
             cgraph_analyze_functions
                cgraph_analyze_function
                cgraph_lower_function
                   tree_lowering_passes
                      execute_pass_list (all_lowering_passes)
```

cc1-4.4.2 Control Flow: Optimization and Code Generation Passes

```
lang_hooks.decls.final_write_globals => c_write_global_declarations
  {  cgraph_optimize
        cgraph_analyze_functions
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             cgraph_lower_function
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                   execute_pass_list (&all_lowering_passes)
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     cgraph_expand_functions
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  }
```