GCC Translation Sequence and Gimple IR

Uday Khedker

GCC Resource Center,
Department of Computer Science and Engineering,
Indian Institute of Technology, Bombay

January 2010

Outline

- GCC Translation Sequence
- An External View of Gimple
- An Internal View of Gimple
- Adding a Pass to GCC
- Working with Gimple API

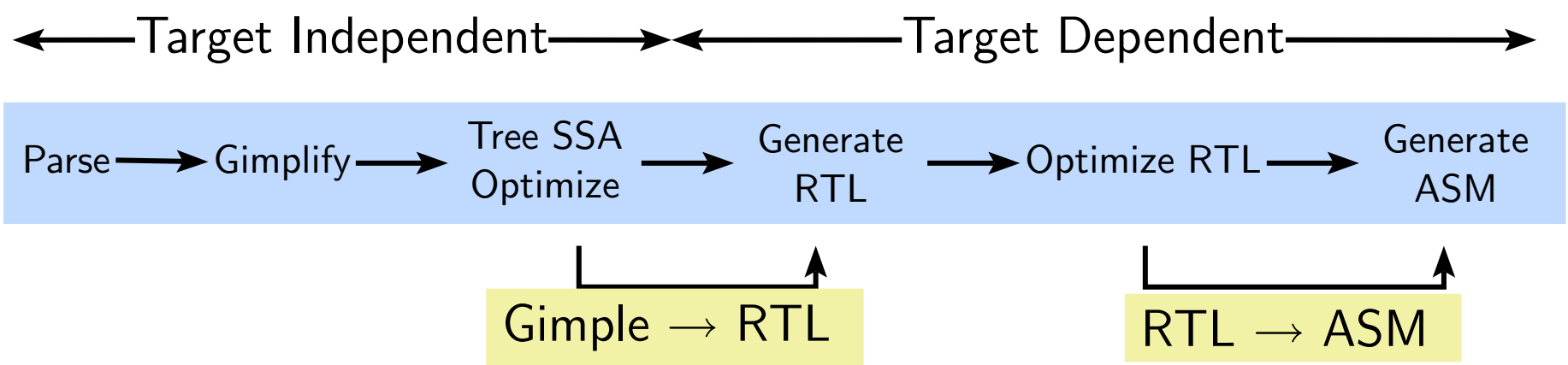
Part 1

GCC Translation Sequence

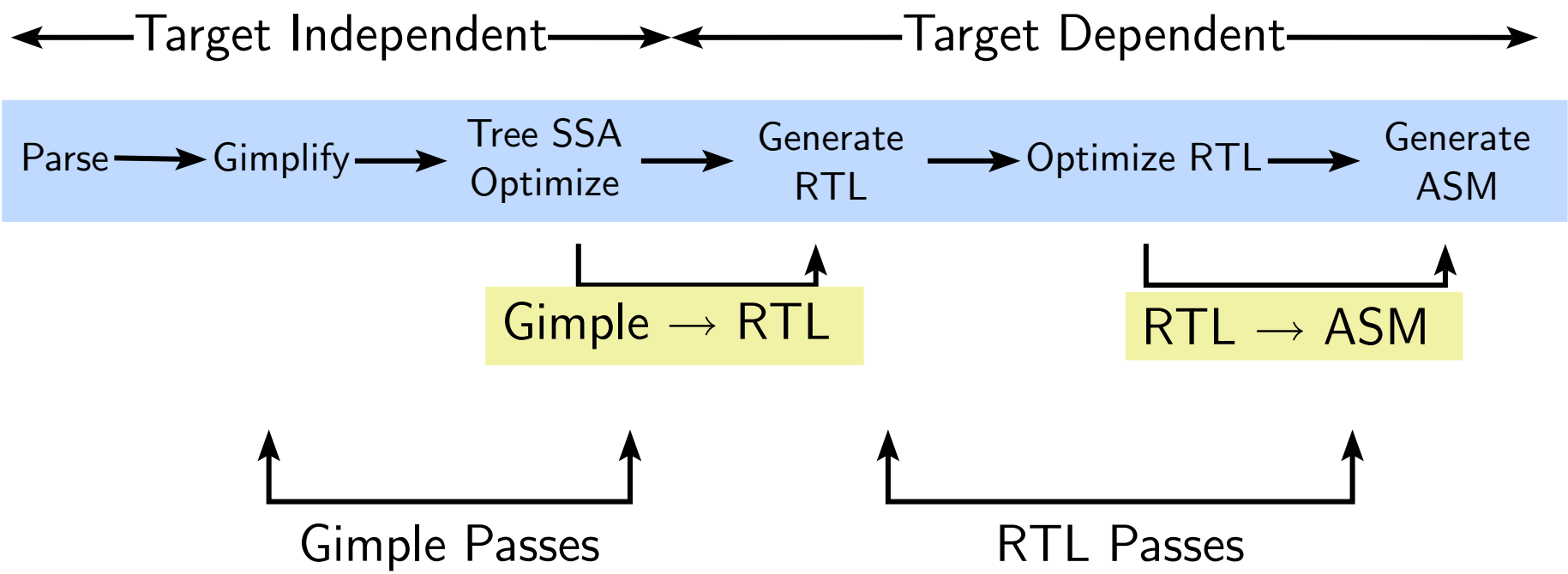
Transformation Passes in GCC

- 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

Finding Out List of Optimizations

Along with the associated flags

- A complete list of optimizations with a brief description

  ```
  gcc -c --help=optimizers
  ```

- Optimizations enabled at level 2 (other levels are 0, 1, and 3)

  ```
  gcc -c -O2 --help=optimizers -Q
  ```

Dumps Produced by GCC

To see the output after each pass use the option

`-fdump-<ir>-<pass>`

where `<ir>` is

- `tree`
  `<pass>` could be: `gimple` , `cfg` etc.
  Use `-all` to see all dumps
- `rtl`
  `<pass>` could be: `expand`, `greg`, `vreg` etc.
  Use `-all` to see all dumps
  We can also use `-da` option

Example:

```
gcc -fdump-tree-all -fdump-rtl-all test.c
```

Example Program

```
int main()
{
    int a=2, b=3, c=4;
    while (a<=7)
    {
        a = a+1;
    }
    if (a<=12)
        a = a+b+c;
}
```

Command used to compile the program

```
gcc -fdump-tree-all -da test.c
```

GCC 4.4.2 Dumps for Our Example Program

```
test.c.001t.tu
test.c.003t.original
test.c.004t.gimple
test.c.006t.vcg
test.c.007t.useless
test.c.010t.lower
test.c.011t.ehopt
test.c.012t.eh
test.c.013t.cfg
test.c.014t.cplxlower0
test.c.015t.veclower
test.c.021t.cleanup_cfg1
test.c.051t.apply_inline
test.c.131r.expand
test.c.132r.sibling
test.c.134r.initvals
test.c.135r.unshare
test.c.136r.vregs
test.c.137r.into_cfglayout
test.c.138r.jump
test.c.157r.regclass
test.c.160r.outof_cfglayout
test.c.166r.split1
test.c.168r.dfinit
test.c.169r.mode-sw
test.c.171r.asmcons
test.c.174r.subregs_of_mode_init
test.c.175r.lreg
test.c.176r.greg
test.c.177r.subregs_of_mode_finish
test.c.180r.split2
test.c.182r.pro_and_epilogue
test.c.196r.stack
test.c.197r.alignments
test.c.200r.mach
test.c.201r.barriers
test.c.204r.eh-ranges
test.c.205r.shorten
test.c.206r.dfinish
test.s
```

Examples of Gimple and RTL Dumps

Gimple (or Tree-SSA) dumps	RTL dumps
Dump file number ending in t	Dump file number ending in r
test.c.003t.original	test.c.166r.split1
test.c.004t.gimple	test.c.168r.dfinit
test.c.006t.vcg	test.c.169r.mode-sw
test.c.007t.useless	test.c.171r.asmcons
test.c.010t.lower	test.c.175r.lreg
test.c.013t.cfg	test.c.176r.greg

Dumping Detailed Information of a Pass

- For Gimple passes (dump file numbers ending in `t`)

  `gcc -fdump-tree-<name>-all`

- For RTL passes (dump file numbers ending in `r`)

  `gcc -fdump-rtl-<name>-all`

- In each case, `<name>` is the dump file name extension of the pass

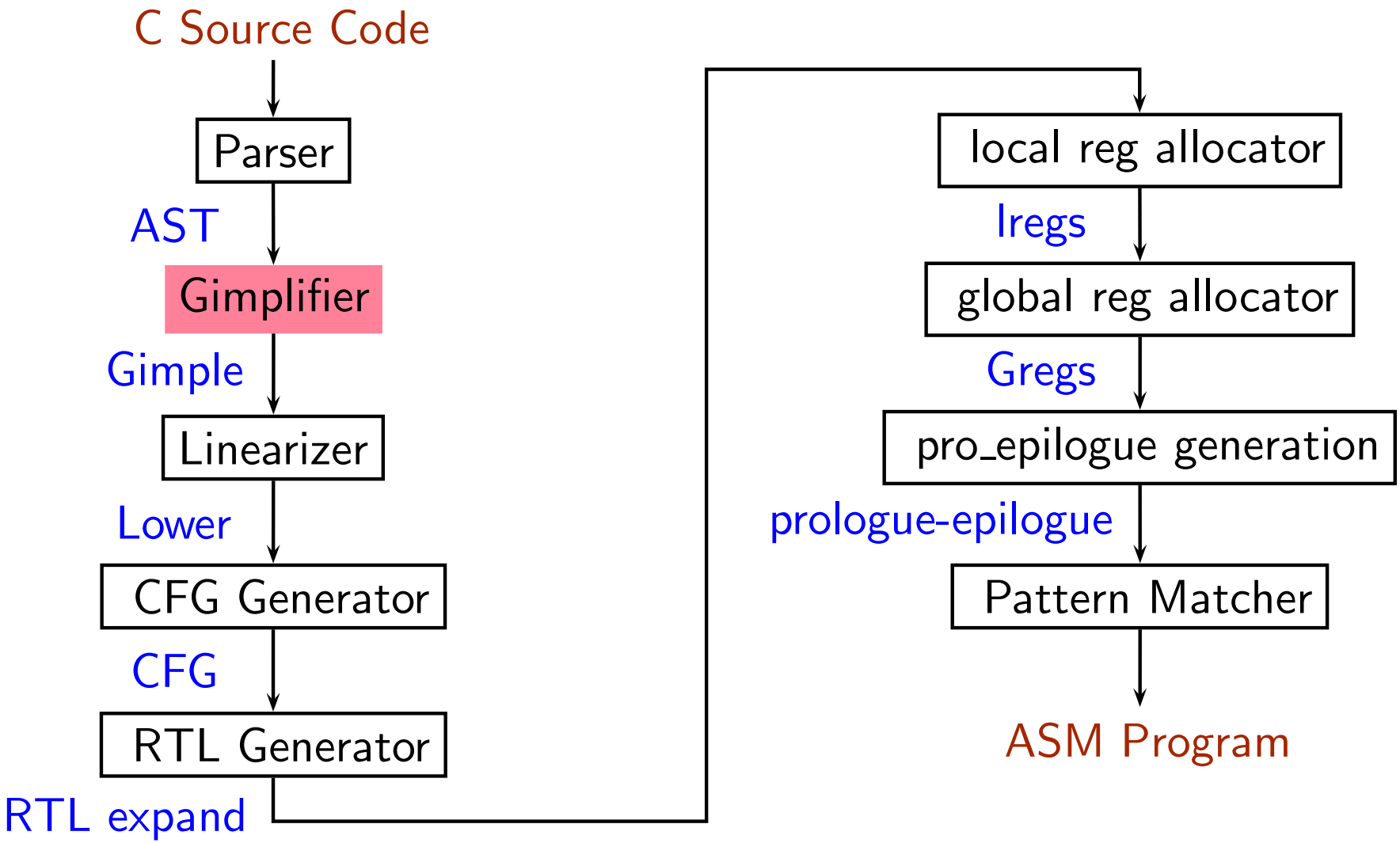
Selected Dumps for Our Example Program

```
test.c.001t.tu
test.c.003t.original
test.c.004t.gimple
test.c.006t.vcg
test.c.007t.useless
test.c.010t.lower
test.c.011t.ehopt
test.c.012t.eh
test.c.013t.cfg
test.c.014t.cplxlower0
test.c.015t.veclower
test.c.021t.cleanup_cfg1
test.c.051t.apply_inline
test.c.131r.expand
test.c.132r.sibling
test.c.134r.initvals
test.c.135r.unshare
test.c.136r.vregs
test.c.137r.into_cfglayout
test.c.138r.jump
test.c.157r.regclass
test.c.160r.outof_cfglayout
test.c.166r.split1
test.c.168r.dfinit
test.c.169r.mode-sw
test.c.171r.asmcons
test.c.174r.subregs_of_mode_init
test.c.175r.lreg
test.c.176r.greg
test.c.177r.subregs_of_mode_finish
test.c.180r.split2
test.c.182r.pro_and_epilogue
test.c.196r.stack
test.c.197r.alignments
test.c.200r.mach
test.c.201r.barriers
test.c.204r.eh-ranges
test.c.205r.shorten
test.c.206r.dfinish
test.s
```

Part 2

An External View of Gimple

Important Phases of GCC



Gimplifier

- Three-address language independent representation derived from Generic
  - Computation represented as a sequence of basic operations
  - Temporaries introduced to hold intermediate values
- Control construct are explicated into conditional jumps

Motivation behind Gimple

- Previously, the only common IR was RTL (Register Transfer Language)
- Drawbacks of RTL for performing high-level optimizations :
  - RTL is a low-level IR, works well for optimizations close to machine (e.g., register allocation)
  - Some high level information is difficult to extract from RTL (e.g. array references, data types etc.)
  - Optimizations involving such higher level information are difficult to do using RTL.
  - Introduces stack too soon, even if later optimizations dont demand it.

Notice

Inlining at tree level could partially address the the last limitation of RTL.

Why not ASTs for optimization ?

- ASTs contain detailed function information but are not suitable for optimization because
  - Lack of a common representation
    - No single AST shared by all front-ends
    - So each language would have to have a different implementation of the same optimizations
    - Difficult to maintain and upgrade so many optimization frameworks
  - Structural Complexity
    - Lots of complexity due to the syntactic constructs of each language

Need for a new IR

- In the past, compiler would only build up trees for a single statement,and then lower them to RTL before moving on to the next statement.
- For higher level optimizations, entire function needs to be represented in trees in a language-independent way.
- Result of this effort - Generic and Gimple

What is Generic ?

What?

- Language independent IR for a complete function in the form of trees
- Obtained by removing language specific constructs from ASTs
- All tree codes defined in `$(SOURCE)/gcc/tree.def`

Why?

- Each language frontend can have its own AST
- Once parsing is complete they must emit Generic

What is Gimple ?

- Gimple is influenced by SIMPLE IR of McCat compiler
- But Gimple is not same as SIMPLE (Gimple supports GOTO)
- It is a simplified subset of Generic
  - 3 address representation
  - Control flow lowering
  - Cleanups and simplification, restricted grammar
- Benefit : Optimizations become easier

Gimple Phase Sequence in cc1 and GCC-4.3.1

```
c_genericize()                                  c-gimplify.c
   gimplify_function_tree()                       gimplify.c
      gimplify_body()                             gimplify.c
         gimplify_stmt()                          gimplify.c
            gimplify_expr()                       gimplify.c
lang_hooks.callgraph.expand_function()
 tree_rest_of_compilation()                 tree-optimize.c
  tree_register_cfg_hooks()                      cfghooks.c
   execute_pass_list()                             passes.c
 /* TO: Gimple Optimisations passes */
                  ...
            NEXT_PASS(pass_lower_cf)
```

May have changed in GCC-4.4.2

Gimple Goals

The Goals of Gimple are

- Lower control flow
  Program = sequenced statements + unrestricted jump
- Simplify expressions
  Typically: two operand assignments!
- Simplify scope
  move local scope to block begin, including temporaries

Notice

Lowered control flow $\rightarrow$ nearer to register machines + Easier SSA!

Gimple: Translation of Composite Expressions

Dump file: `test.c.004t.gimple`

```
int main()
{
    int a=2, b=3, c=4;
    while (a<=7)
    {
        a = a+1;
    }
     if (a<=12)
          a = a+b+c;

}
```

```
if (a <= 12)
{
     D.1199 = a + b;
     a = D.1199 + c;
}
else
{
}
```


Gimple: Translation of Higher Level Control Constructs

Dump file: `test.c.004t.gimple`

```
int main()
{
    int a=2, b=3, c=4;
     while (a<=7)
     {
         a = a+1;
     }
    if (a<=12)
        a = a+b+c;
}
```

```
goto <D.1197>;
<D.1196>:;
a = a + 1;
<D.1197>:;
if (a <= 7)
{
      goto <D.1196>;
}
else
{
      goto <D.1198>;
}
<D.1198>:;
```

Gimple: Translation of Higher Level Control Constructs

Dump file: `test.c.004t.gimple`

```
int main()
{
    int a=2, b=3, c=4;
     while (a<=7)
     {
         a = a+1;
     }
    if (a<=12)
        a = a+b+c;
}
```

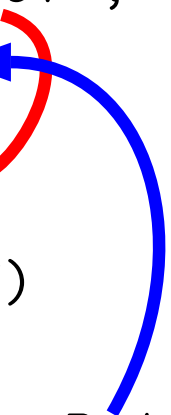
```
goto <D.1197>;
<D.1196>:;
a = a + 1;
<D.1197>:;
if (a <= 7)
{
      goto <D.1196>;
}
else
{
      goto <D.1198>;
}
<D.1198>:;
```

Gimple: Translation of Higher Level Control Constructs

Dump file: `test.c.004t.gimple`

```
int main()
{
    int a=2, b=3, c=4;
     while (a<=7)
     {
         a = a+1;
     }
    if (a<=12)
        a = a+b+c;
}
```

```
goto <D.1197>;
<D.1196>:;
a = a + 1;
<D.1197>:;
if (a <= 7)
{
    goto <D.1196>;
}
else
{
    goto <D.1198>;
}
<D.1198>:;
```



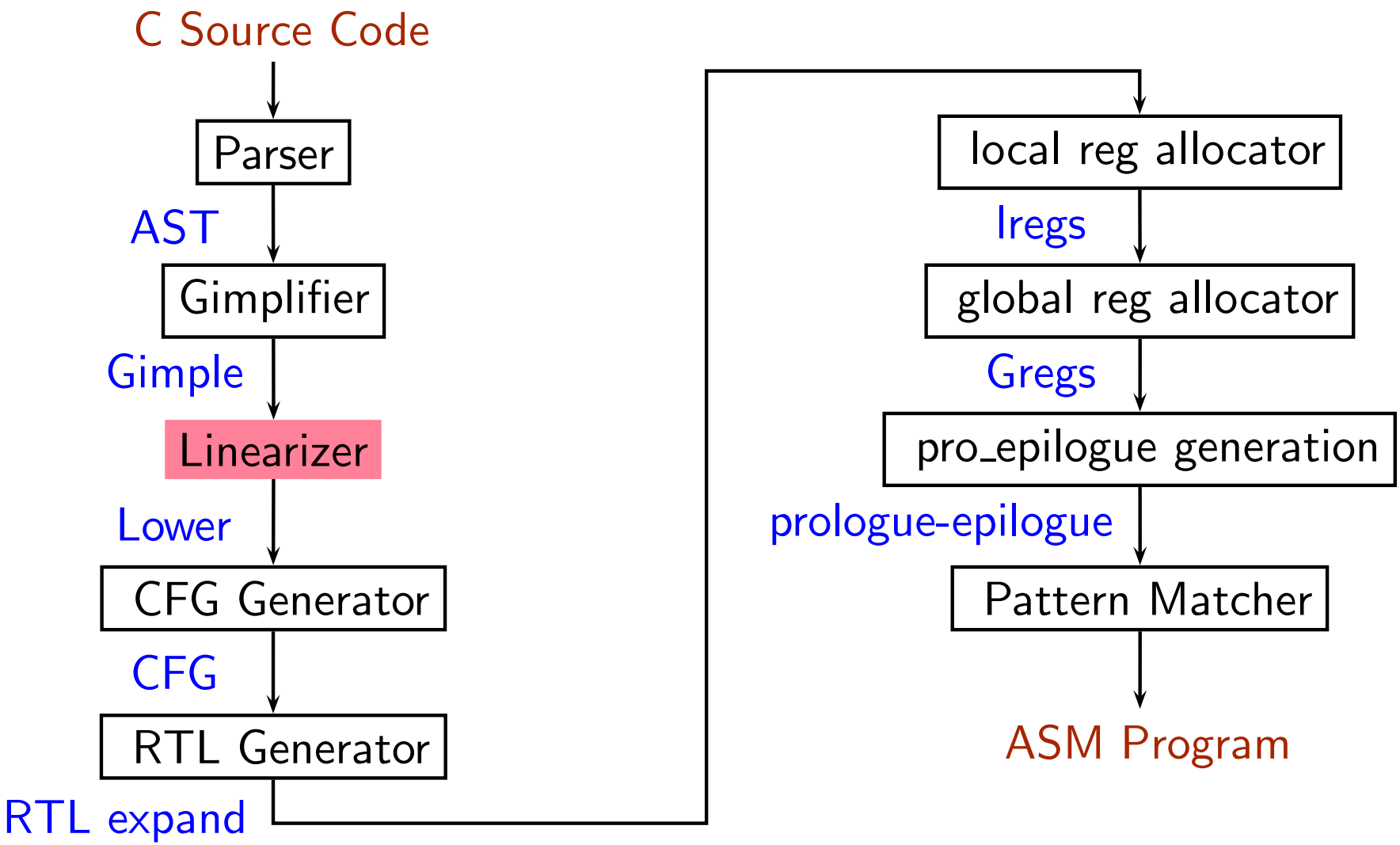
Gimple: Translation of Higher Level Control Constructs

Dump file: `test.c.004t.gimple`

```
int main()
{
    int a=2, b=3, c=4;
     while (a<=7)
     {
         a = a+1;
     }
    if (a<=12)
        a = a+b+c;
}
```

```
goto <D.1197>;
<D.1196>:;
a = a + 1;
<D.1197>:;
if (a <= 7)
{
    goto <D.1196>;
}
else
{
    goto <D.1198>;
}
<D.1198>:;
```

Important Phases of GCC



Lowering Gimple

Dump file: `test.c.010t.lower`

```
if (a <= 12)
{
      D.1199 = a + b;
      a = D.1199 + c;
}
```

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

Lowering Gimple

Dump file: `test.c.010t.lower`

```
if (a <= 12)
{
      D.1199 = a + b;
      a = D.1199 + c;
}
```

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

`if-then` translated in terms of conditional and unconditional gotos

Lowering Gimple

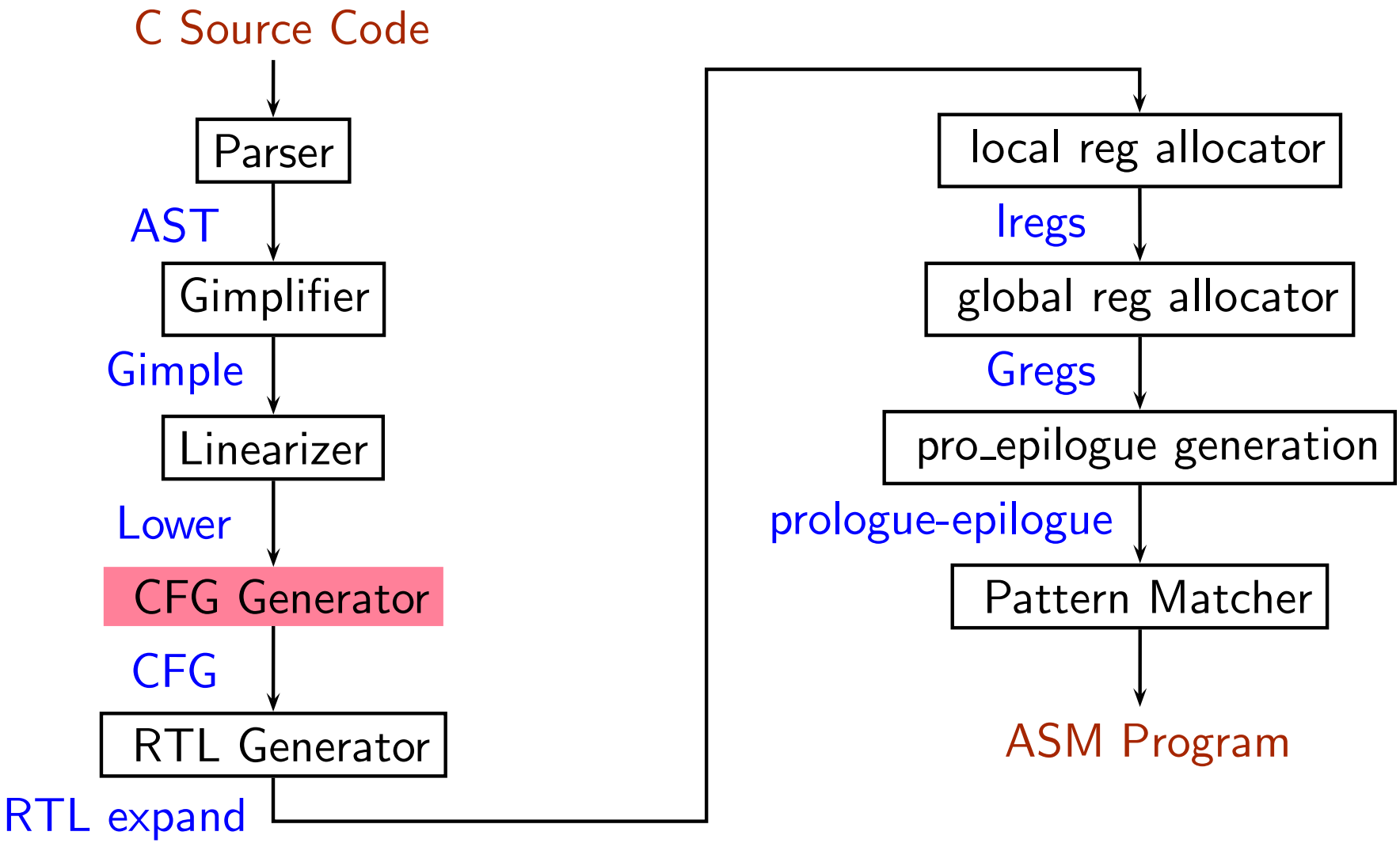
Dump file: `test.c.010t.lower`

```
if (a <= 12)
{
      D.1199 = a + b;
      a = D.1199 + c;
}
```

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

`if-then` translated in terms of conditional and unconditional gotos

Important Phases of GCC



Constructing the Control Flow Graph

Dump file: `test.c.013t.cfg`

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

```
# BLOCK 5
# PRED: 4 (false)
if (a <= 12)
  goto <bb 6>;
else
  goto <bb 7>;
# SUCC: 6 (true) 7 (false)
# BLOCK 6
# PRED: 5 (true)
D.1199 = a + b;
a = D.1199 + c;
# SUCC: 7 (fallthru)
# BLOCK 7
# PRED: 5 (false) 6 (fallthru)
return;
# SUCC: EXIT
```


Constructing the Control Flow Graph

Dump file: `test.c.013t.cfg`

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

```
# BLOCK 5
# PRED: 4 (false)
if (a <= 12)
  goto <bb 6>;
else
  goto <bb 7>;
# SUCC: 6 (true) 7 (false)
# BLOCK 6
# PRED: 5 (true)
D.1199 = a + b;
a = D.1199 + c;
# SUCC: 7 (fallthru)
# BLOCK 7
# PRED: 5 (false) 6 (fallthru)
return;
# SUCC: EXIT
```

Constructing the Control Flow Graph

Dump file: `test.c.013t.cfg`

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

```
# BLOCK 5
# PRED: 4 (false)
if (a <= 12)
  goto <bb 6>;
else
  goto <bb 7>;
# SUCC: 6 (true) 7 (false)
# BLOCK 6
# PRED: 5 (true)
D.1199 = a + b;
a = D.1199 + c;
# SUCC: 7 (fallthru)
# BLOCK 7
# PRED: 5 (false) 6 (fallthru)
return;
# SUCC: EXIT
```

Constructing the Control Flow Graph

Dump file: `test.c.013t.cfg`

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

```
# BLOCK 5
# PRED: 4 (false)
if (a <= 12)
  goto <bb 6>;
else
  goto <bb 7>;
# SUCC: 6 (true) 7 (false)
# BLOCK 6
# PRED: 5 (true)
D.1199 = a + b;
a = D.1199 + c;
# SUCC: 7 (fallthru)
# BLOCK 7
# PRED: 5 (false) 6 (fallthru)
return;
# SUCC: EXIT
```

Constructing the Control Flow Graph

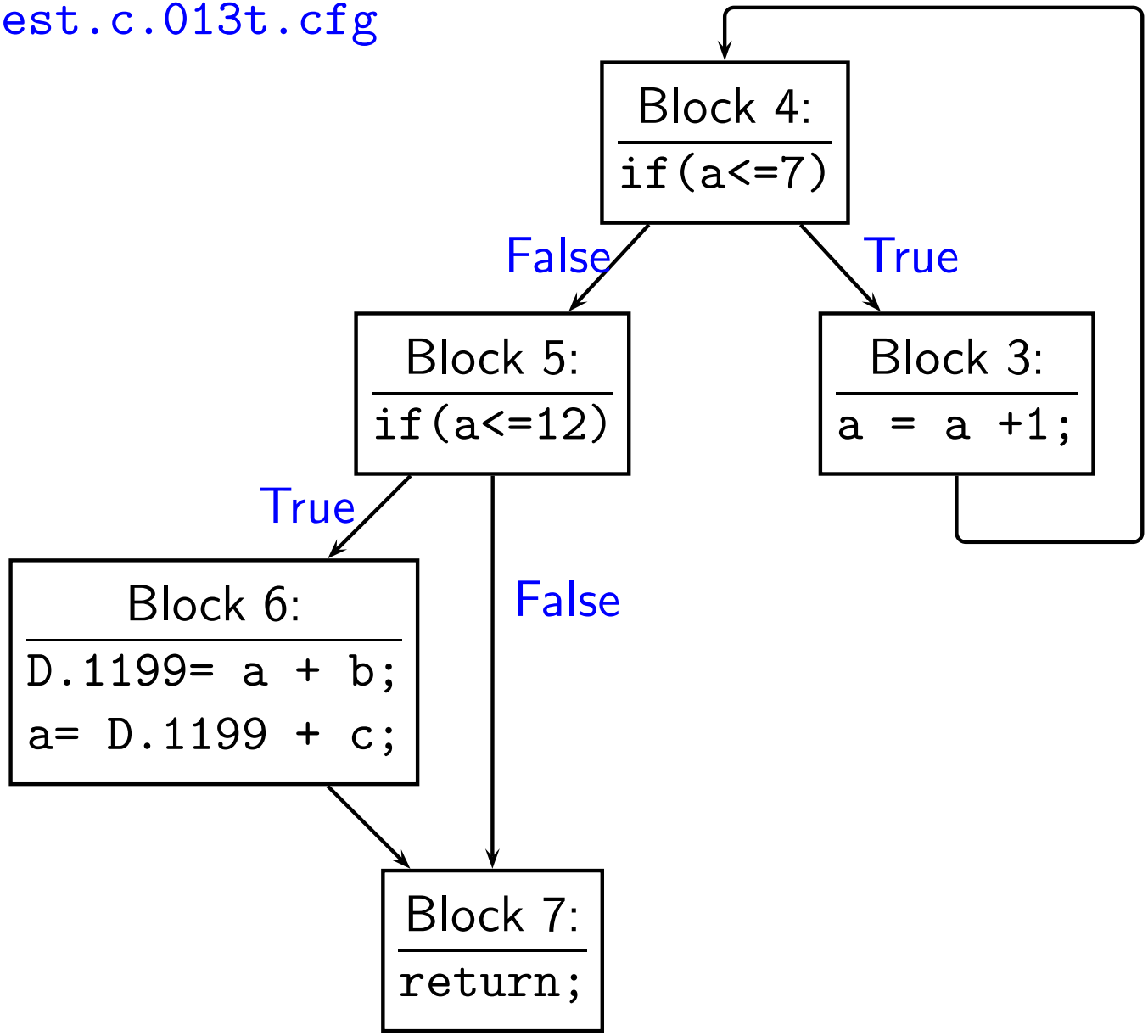
Dump file: `test.c.013t.cfg`

```
if (a <= 12) goto <D.1200>;
else  goto <D.1201>;
<D.1200>:;
D.1199 = a + b;
a = D.1199 + c;
<D.1201>:;
return;
```

```
# BLOCK 5
# PRED: 4 (false)
if (a <= 12)
  goto <bb 6>;
else
  goto <bb 7>;
# SUCC: 6 (true) 7 (false)
# BLOCK 6
# PRED: 5 (true)
D.1199 = a + b;
a = D.1199 + c;
# SUCC: 7 (fallthru)
# BLOCK 7
# PRED: 5 (false) 6 (fallthru)
return;
# SUCC: EXIT
```


Control Flow Graph

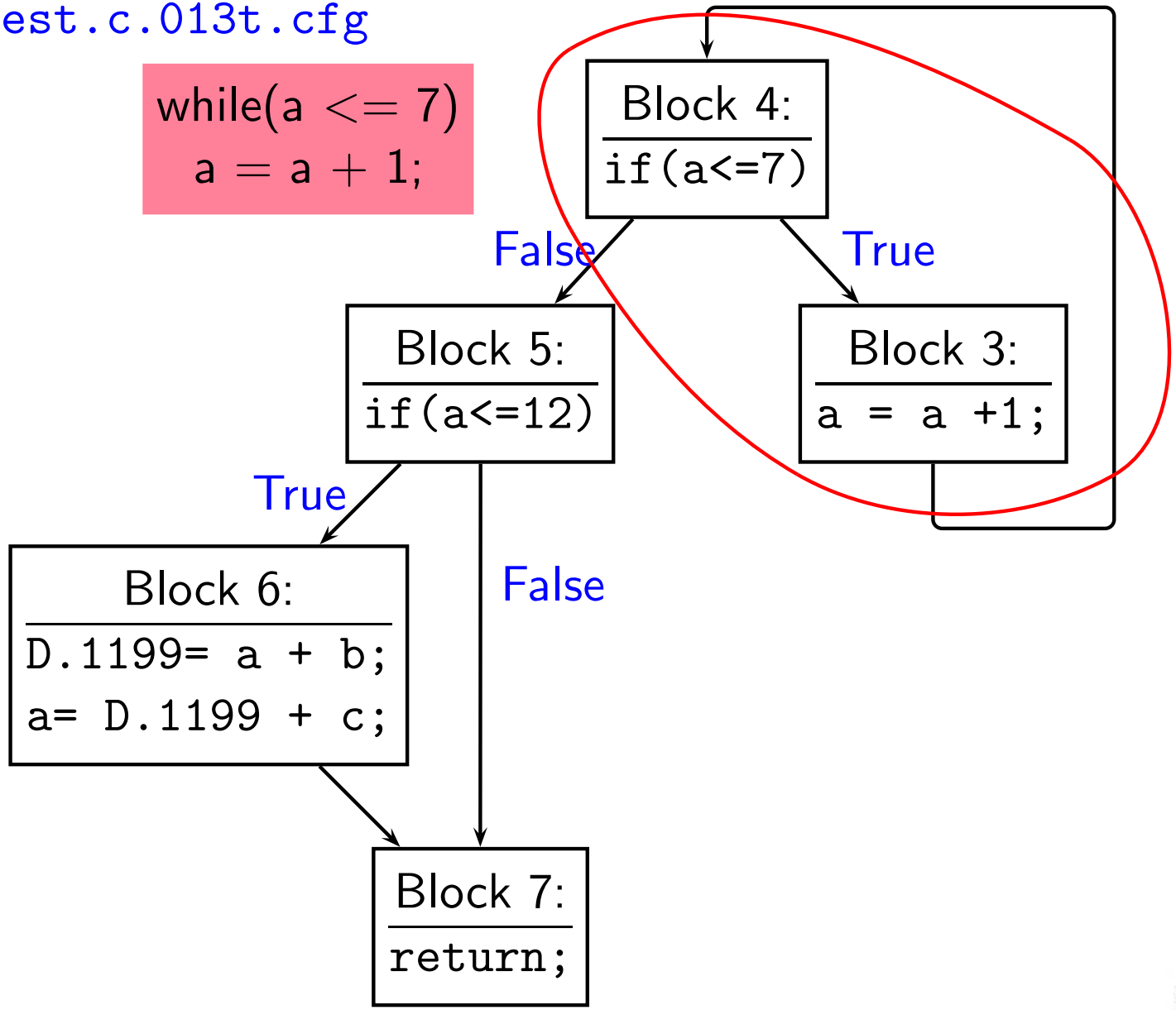
Dump file: `test.c.013t.cfg`



Control Flow Graph

Dump file: `test.c.013t.cfg`

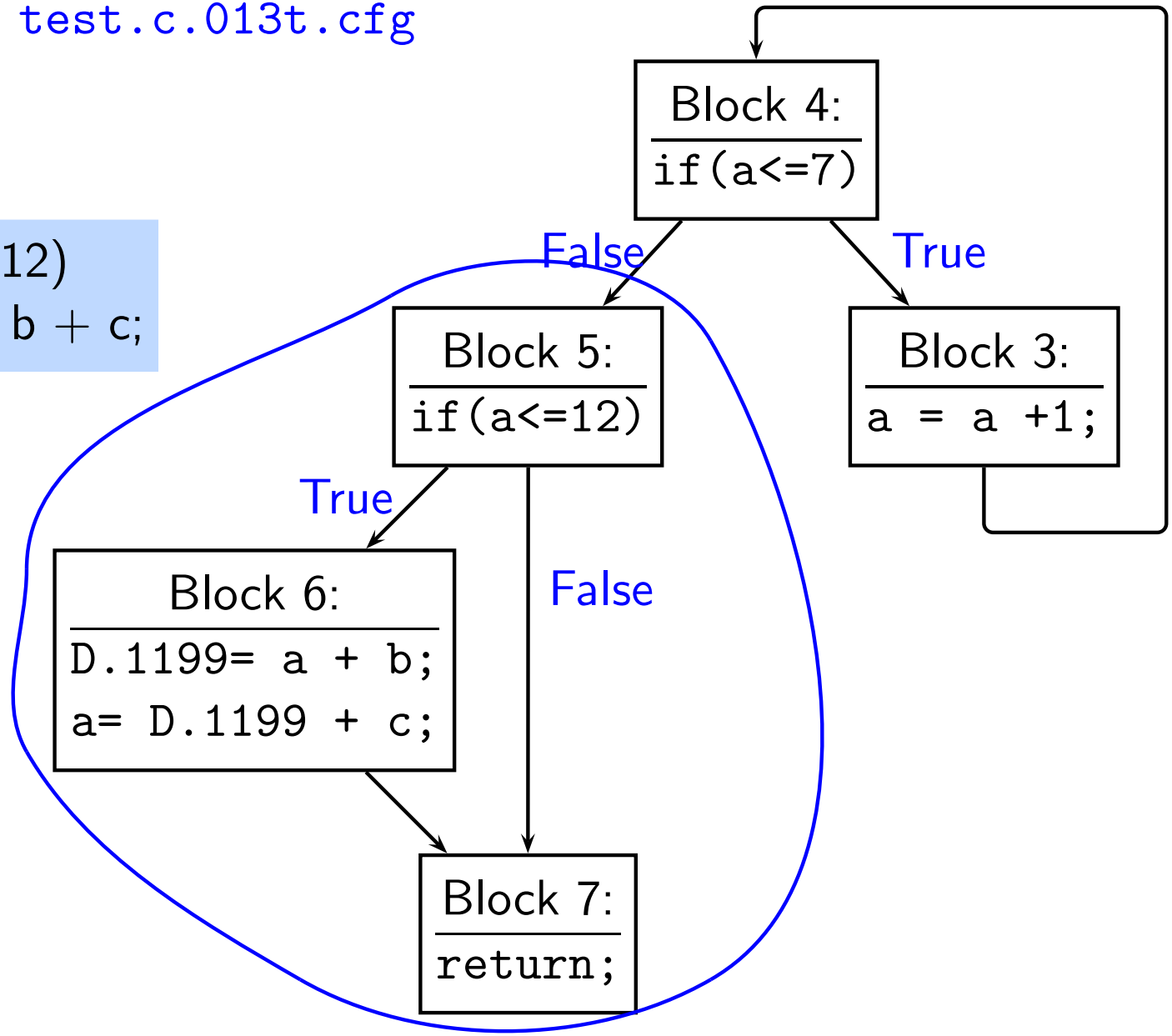
```
while(a <= 7)
  a = a + 1;
```



Control Flow Graph

Dump file: `test.c.013t.cfg`

```
if(a <= 12)
a = a + b + c;
```



Resolving doubts by inspecting Gimple

Inspect Gimple when in doubt

```
int main(void)
{
  int x=2,y=3;
  x= y++ + ++x + ++y ;
  printf("\nx = %d", x);
  printf("\ny = %d", y);
  return 0;
}
```


Resolving doubts by inspecting Gimple

Inspect Gimple when in doubt

```
int main(void)
{
  int x=2,y=3;
  x= y++ + ++x + ++y ;
  printf("\nx = %d", x);
  printf("\ny = %d", y);
  return 0;
}
```

```
x = 2;
y = 3;
x = x + 1;
D.1572 = y + x;
y = y + 1;
x = D.1572 + y;
y = y + 1;
printf (&"\nx = %d"[0], x);
printf (&"\y = %d"[0], y);
```


Resolving doubts by inspecting Gimple

Inspect Gimple when in doubt

```
int main(void)
{
  int x=2,y=3;
  x= y++ + ++x + ++y ;
  printf("\nx = %d", x);
  printf("\ny = %d", y);
  return 0;
}
```

```
x = 2;
y = 3;
x = x + 1;
D.1572 = y + x;
y = y + 1;
x = D.1572 + y;
y = y + 1;
printf (&"\nx = %d"[0], x);
printf (&"\y = %d"[0], y);
```

x = 10 , y =5

Decisions that have been taken

- Three-address representation is generated
- All high level control flow structures are made explicit.
- Source code divided into interconnected blocks of sequential statements.
- This is a convenient structure for later analysis.

Part 3

An Internal View of Gimple in GCC-4.3.1

High Gimple in GCC-4.3.1

Gimple is based on *tree* data structure.

- Gimple that is not fully lowered.
- Consists of Intermediate Language before the pass *pass_lower_cf*.
- Contains some container statements like lexical scopes and nested expressions.

- High Gimple Instruction Set : GIMPLE_BIND, GIMPLE_CALL, GIMPLE_CATCH, GIMPLE_GOTO, GIMPLE_EH_FILTER, GIMPLE_RETURN, GIMPLE_SWITCH, GIMPLE_TRY, GIMPLE_ASSIGN

Low Gimple in GCC-4.3.1

Gimple is based on *tree* data structure.

- Gimple that is fully lowered after the pass *pass_lower_cf*.
- Exposes all of the implicit jumps for control and exception expressions.

- Low Gimple Instruction Set : GIMPLE_CALL, GIMPLE_GOTO, GIMPLE_RETURN, GIMPLE_SWITCH, GIMPLE_ASSIGN
- Lowered Instruction Set : GIMPLE_BIND, GIMPLE_CATCH, GIMPLE_EH_FILTER, GIMPLE_TRY

Some Gimple Node types in GCC-4.3.1

Binary Operator	MAX_EXPR
Comparison	EQ_EXPR, LT_EXPR
Constants	INTEGER_CST, STRING_CST
Declaration	FUNCTION_DECL, LABEL_DECL , VAR_DECL
Expression	PLUS_EXPR, ADDR_EXPR
Reference	COMPONENT_REF, ARRAY_RANGE_REF
Statement	GIMPLE_MODIFY_STMT, RETURN_EXPR, COND_EXPR, INIT_EXPR
Type	BOOLEAN_TYPE, INTEGER_TYPE
Unary	ABS_EXPR, NEGATE_EXPR

Tip :

All tree nodes ($\sim$ 152) in GCC are listed in: `$(SOURCE)/gcc/tree.def`
(In GCC-4.4.2, the file is `$(SOURCE)/gcc/gimple.def`)

Part 4

Adding a Pass to GCC

Adding a Pass on Gimple IR in GCC-4.3.1

- Step 0. Write function gccwk09_main() in file gccwk09.c.
- Step 1. Create the following data structure in file gccwk09.c.

```
struct tree_opt_pass pass_gccwk09 =
{
   "gccwk09",  /* name */
   NULL,       /* gate, for conditional entry to this pass */
   gccwk09_main, /* execute, main entry point */
   NULL,       /* sub-passes, depending on the gate predicate */
   NULL,       /* next sub-passes, independ of the gate predicate */
   0,          /* static_pass_number , used for dump file name*/
   0,          /* tv_id */
   0,          /* properties_required, indicated by bit position */
   0,          /* properties_provided , indicated by bit position*/
   0,          /* properties_destroyed , indicated by bit position*/
   0,          /* todo_flags_start */
   0,          /* todo_flags_finish */
   0,          /* character for RTL dump */
};
```

Adding a Pass on Gimple IR in GCC-4.4.2

- Step 0. Write function gccwk09_main() in file gccwk09.c.
- Step 1. Create the following data structure in file gccwk09.c.

```
struct gimple_opt_pass pass_gccwk09 =
{
  {
   GIMPLE_PASS,
   "gccwk09",  /* name */
   NULL,       /* gate, for conditional entry to this pass */
   gccwk09_main, /* execute, main entry point */
   NULL,       /* sub-passes, depending on the gate predicate */
   NULL,       /* next sub-passes, independ of the gate predicate */
   0,          /* static_pass_number , used for dump file name*/
   0,          /* tv_id */
   0,          /* properties_required, indicated by bit position */
   0,          /* properties_provided , indicated by bit position*/
   0,          /* properties_destroyed , indicated by bit position*/
   0,          /* todo_flags_start */
   0,          /* todo_flags_finish */
  }
};
```


Adding a Pass on Gimple IR

- Step 2. Add the following line to `tree-pass.h`

```
extern struct gimple_opt_pass pass_gccwk09;
```

Adding a Pass on Gimple IR

- Step 2. Add the following line to `tree-pass.h`

```
extern struct gimple_opt_pass pass_gccwk09;
```

- Step 3. Include the following call at an appropriate place in the function `init_optimization_passes()` in the file `passes.c`

```
NEXT_PASS (pass_gccwk09);
```

Adding a Pass on Gimple IR

- Step 2. Add the following line to `tree-pass.h`
  `extern struct gimple_opt_pass pass_gccwk09;`
- Step 3. Include the following call at an appropriate place in the function `init_optimization_passes()` in the file `passes.c`
  `NEXT_PASS (pass_gccwk09);`
- Step 4. Add the file name in the Makefile
  - Either in `$SOURCE/gcc/Makefile.in`
    Reconfigure and remake
  - Or in `$BUILD/gcc/Makefile`
    Remake

Adding a Pass on Gimple IR

- Step 2. Add the following line to `tree-pass.h`
  `extern struct gimple_opt_pass pass_gccwk09;`
- Step 3. Include the following call at an appropriate place in the function `init_optimization_passes()` in the file `passes.c`
  `NEXT_PASS (pass_gccwk09);`
- Step 4. Add the file name in the Makefile
  - Either in `$SOURCE/gcc/Makefile.in`
    Reconfigure and remake
  - Or in `$BUILD/gcc/Makefile`
    Remake
- Step 5. Build the compiler

Adding a Pass on Gimple IR

- Step 2. Add the following line to `tree-pass.h`
  `extern struct gimple_opt_pass pass_gccwk09;`
- Step 3. Include the following call at an appropriate place in the function `init_optimization_passes()` in the file `passes.c`
  `NEXT_PASS (pass_gccwk09);`
- Step 4. Add the file name in the Makefile
  - Either in `$SOURCE/gcc/Makefile.in`
    Reconfigure and remake
  - Or in `$BUILD/gcc/Makefile`
    Remake
- Step 5. Build the compiler
- Step 6. Debug using gdb if need arises

Part 5

Working with the Gimple API in GCC-4.3.1

Gimple Statements

- Gimple Statements are nodes of type tree
- Every basic block contains a doubly linked-list of statements
- Processing of statements can be done through iterators

Gimple Statements

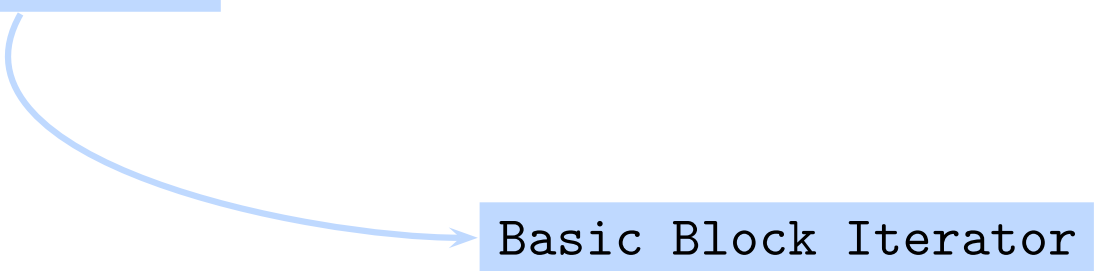
- Gimple Statements are nodes of type tree
- Every basic block contains a doubly linked-list of statements
- Processing of statements can be done through iterators

```
block_statement_iterator bsi;
basic_block bb;
```

Gimple Statements

- Gimple Statements are nodes of type tree
- Every basic block contains a doubly linked-list of statements
- Processing of statements can be done through iterators

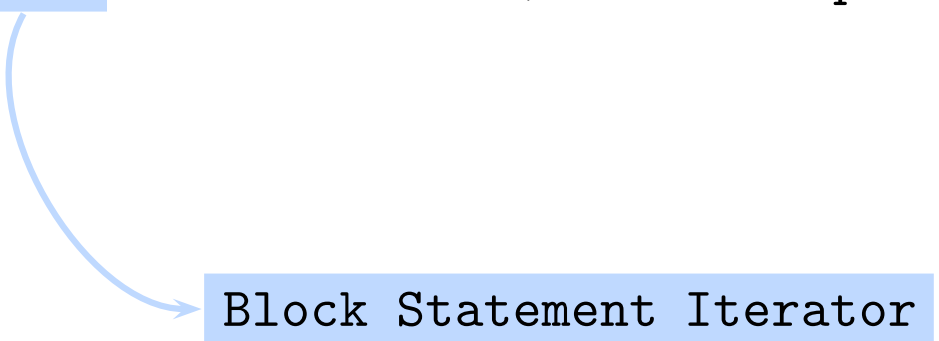
```
block_statement_iterator bsi;
basic_block bb;
FOR_EACH_BB (bb)
```



Gimple Statements

- Gimple Statements are nodes of type tree
- Every basic block contains a doubly linked-list of statements
- Processing of statements can be done through iterators

```
block_statement_iterator bsi;
basic_block bb;
FOR_EACH_BB (bb)
   for ( bsi =bsi_start(bb); !bsi_end_p(bsi); bsi_next(&bsi))
```



Gimple Statements

- Gimple Statements are nodes of type tree
- Every basic block contains a doubly linked-list of statements
- Processing of statements can be done through iterators

```
block_statement_iterator bsi;
basic_block bb;
FOR_EACH_BB (bb)
   for ( bsi =bsi_start(bb); !bsi_end_p(bsi); bsi_next(&bsi))
      print_generic_stmt (stderr, bsi_stmt(bsi), 0);
```


A simple application

Counting the number of assignment statements in Gimple

```
#include <stdio.h>
int m,q,p;
int main(void)
{
  int x,y,z,w;
  x = y + 5;
  z = x * m;
  p = m + q + w ;
  return 0;
}
```

```
x = y + 5;
m.0 = m;
z = x * m.0;
m.1 = m;
q.2 = q;
D.1580 = m.1 + q.2;
p.3 = D.1580 + w;
p = p.3;
D.1582 = 0;
return  D.1582;
```

The statements in blue are the assignments corresponding to the source.

A simple application

Counting the number of assignment statements in Gimple

```
struct tree_opt_pass pass_gccwk09 =
{
    "gccwk09",
     NULL,
     gccwk09_main,
     NULL,
     NULL,
     0,
     0,
     0,
     0,
     0,
     0,
     0,
     0
};
```


A simple application

Counting the number of assignment statements in Gimple

```
static unsigned int gccwk09_main(void)
{  basic_block bb;
   block_stmt_iterator si;

   initialize_stats();

   FOR_EACH_BB (bb)
   {
       for (si=bsi_start(bb); !bsi_end_p(si); bsi_next(&si))
           {
             tree stmt = bsi_stmt(si);
             process_statement(stmt);
           }
   }
   return 0;
}
```

A simple application

Counting the number of assignment statements in Gimple

```
void process_statement(tree stmt)
{  tree lval,rval;
    switch (TREE_CODE(stmt))
    {    case GIMPLE_MODIFY_STMT:
              lval=GIMPLE_STMT_OPERAND(stmt,0);
              rval=GIMPLE_STMT_OPERAND(stmt,1);
              if(TREE_CODE(lval) == VAR_DECL)
              {   if(!DECL_ARTIFICIAL(lval))
                   {  print_generic_stmt(stderr,stmt,0);
                      numassigns++;
                   }
                  totalassigns++;
              }
              break;
        default :
              break;
    }
}
```


A simple application

Counting the number of assignment statements in Gimple

- Add the following in `$(SOURCE)/gcc/common.opt` :
- `fpass_gccwk09`
- Common Report Var (`flag_pass_gccwk09`)
- Enable pass named `pass_gccwk09`

Compile using `./gcc -fdump-tree-all -fpass_gccwk09 test.c`