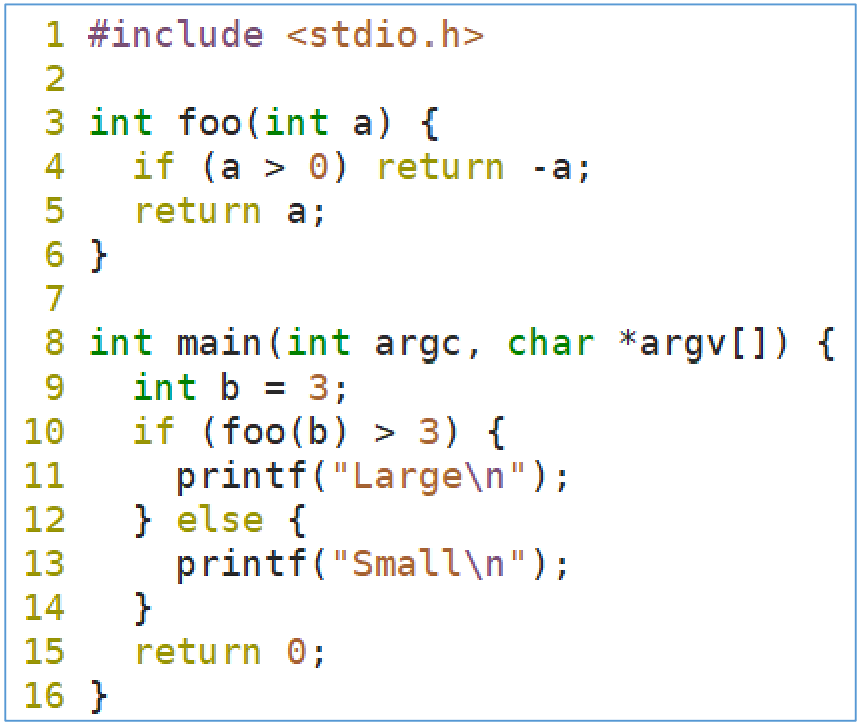
Generating Control-Flow Graph using Open-Source S/W

- GCC: version 4.8+ (recommend 5.x+)
- Graphviz (for processing .dot file)

The original slides were made by Hyunsu Lim bookman01@kaist.ac.kr

Get the target .c file

- Sample .c file that will be used: sample.c



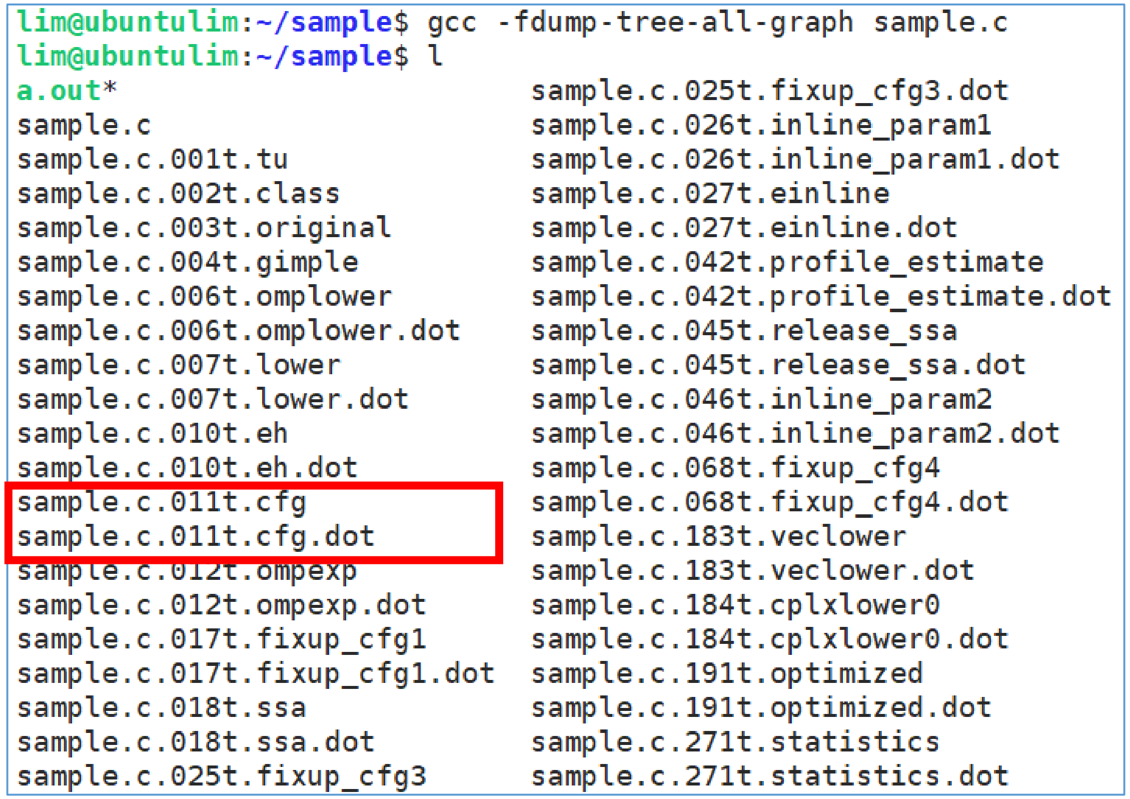
```c
#include <stdio.h>

int foo(int a) {
  if (a > 0) return -a;
  return a;
}

int main(int argc, char *argv[]) {
  int b = 3;
  if (foo(b) > 3) {
    printf("Large\n");
  } else {
    printf("Small\n");
  }
  return 0;
}
```

Generate .dot file using gcc

- $ gcc -fdump-tree-all-graph <target.c>
  - Or $ gcc -fdump-tree-all-graph-lineno <target.c>
  - For more detailed options, https://gcc.gnu.org/onlinedocs/gcc/Developer-Options.html

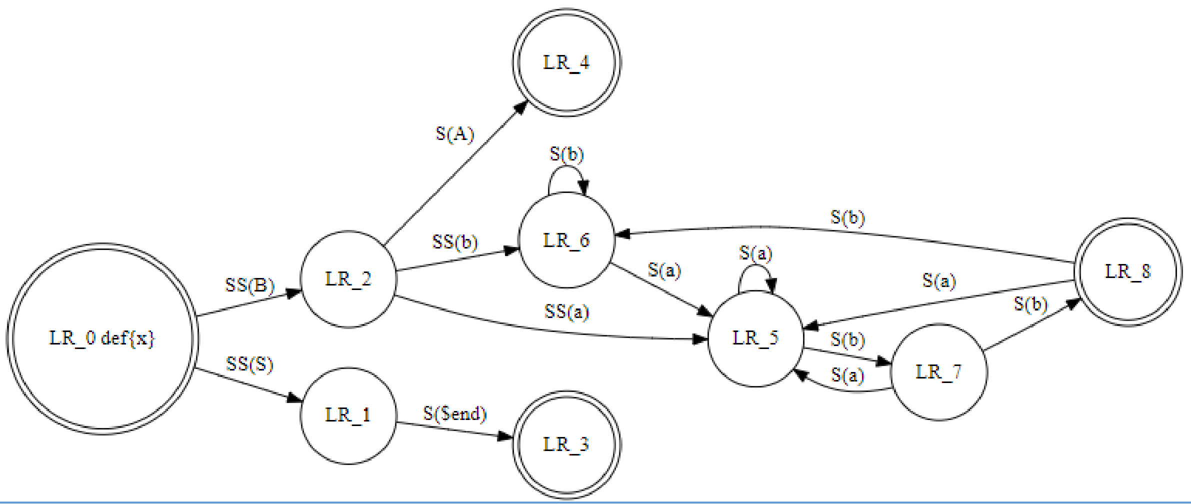


```
lim@ubuntulim:~/sample$ gcc -fdump-tree-all-graph sample.c
lim@ubuntulim:~/sample$ l
a.out*                         sample.c.025t.fixup_cfg3.dot
sample.c                       sample.c.026t.inline_param1
sample.c.001t.tu               sample.c.026t.inline_param1.dot
sample.c.002t.class            sample.c.027t.einline
sample.c.003t.original         sample.c.027t.einline.dot
sample.c.004t.gimple           sample.c.042t.profile_estimate
sample.c.006t.omplower         sample.c.042t.profile_estimate.dot
sample.c.006t.omplower.dot     sample.c.045t.release_ssa
sample.c.007t.lower            sample.c.045t.release_ssa.dot
sample.c.007t.lower.dot        sample.c.046t.inline_param2
sample.c.010t.eh               sample.c.046t.inline_param2.dot
sample.c.010t.eh.dot           sample.c.068t.fixup_cfg4
sample.c.011t.cfg              sample.c.068t.fixup_cfg4.dot
sample.c.011t.cfg.dot          sample.c.183t.veclower
sample.c.012t.ompexp           sample.c.183t.veclower.dot
sample.c.012t.ompexp.dot       sample.c.184t.cplxlower0
sample.c.017t.fixup_cfg1       sample.c.184t.cplxlower0.dot
sample.c.017t.fixup_cfg1.dot   sample.c.191t.optimized
sample.c.018t.ssa              sample.c.191t.optimized.dot
sample.c.018t.ssa.dot          sample.c.271t.statistics
sample.c.025t.fixup_cfg3       sample.c.271t.statistics.dot
```

DOT (graph description language)

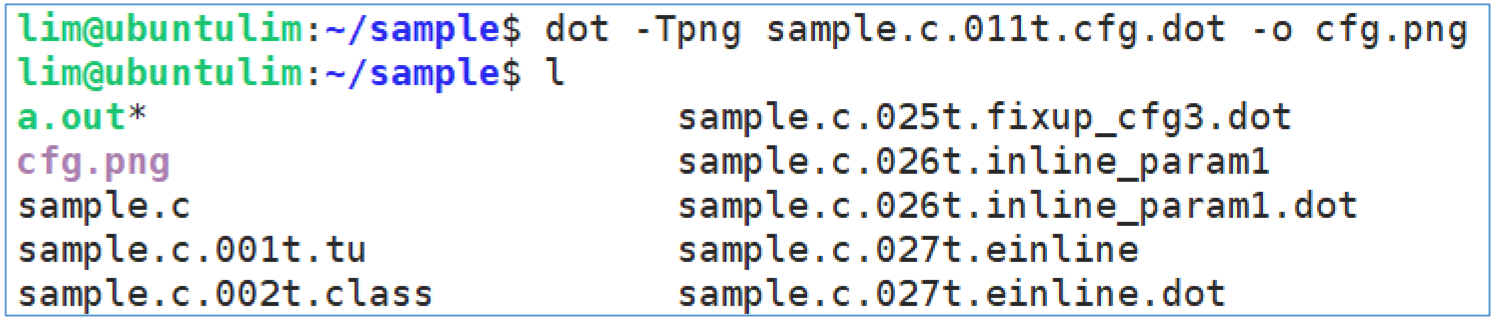
- DOT is a plain text graph description language (*.gv or `*.dot`)
- The DOT language defines a graph, but not layout of the graph.
  - Graphviz –libraries and utilities to manipulate graphs
  - http://www.webgraphviz.com/
  - https://commons.wikimedia.org/wiki/Category:Images_with_Dot_source_code

```
digraph finite_state_machine {
  rankdir=LR;
  size="8,5"
  node [shape = doublecircle];
  “LR_0 def{x}” LR_3 LR_4 LR_8;
  node [shape = circle];
 "LR_0 def{x}" -> LR_2 [ label ="SS(B)" ];
 "LR_0 def{x}" -> LR_1 [ label = "SS(S)" ];
  LR_1 -> LR_3 [ label = "S($end)" ];
  LR_2 -> LR_6 [ label = "SS(b)" ];
  LR_2 -> LR_5 [ label = "SS(a)" ];
  LR_2 -> LR_4 [ label = "S(A)" ];
  LR_5 -> LR_7 [ label = "S(b)" ];
  LR_5 -> LR_5 [ label = "S(a)" ];
  LR_6 -> LR_6 [ label = "S(b)" ];
  LR_6 -> LR_5 [ label = "S(a)" ];
  LR_7 -> LR_8 [ label = "S(b)" ];
  LR_7 -> LR_5 [ label = "S(a)" ];
  LR_8 -> LR_6 [ label = "S(b)" ];
  LR_8 -> LR_5 [ label = "S(a)" ];
}
```



Process .dot file using Graphviz

- You can use http://www.webgraphviz.com/ to generate visual graph from .dot file.
- Or
  - $ dot -Tpng <target.dot> -o <output.png>
  - <target.dot> file is the file that ends with .cfg.dot
  - In sample case, it is `sample.c.011t.cfg.dot`



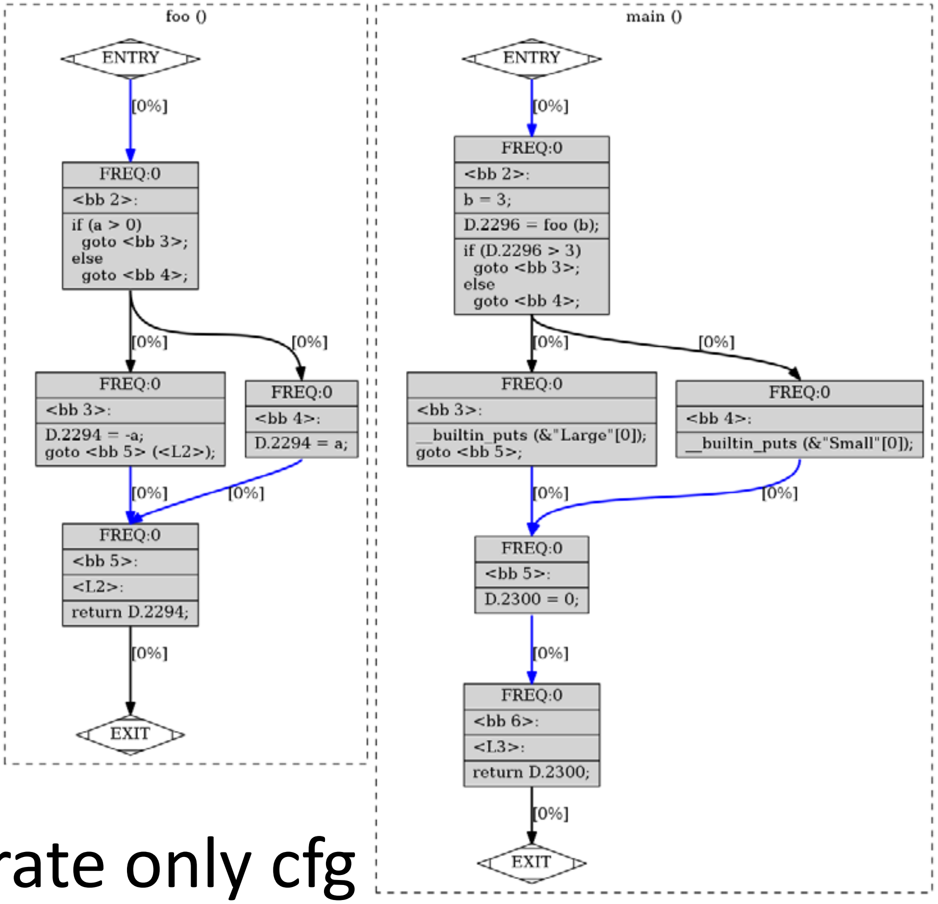
```
lim@ubuntulim:~/sample$ dot -Tpng sample.c.011t.cfg.dot -o cfg.png
lim@ubuntulim:~/sample$ l
a.out*                        sample.c.025t.fixup_cfg3.dot
cfg.png                       sample.c.026t.inline_param1
sample.c                      sample.c.026t.inline_param1.dot
sample.c.001t.tu              sample.c.027t.einline
sample.c.002t.class           sample.c.027t.einline.dot
```

Result graph image

```c
#include <stdio.h>

int foo(int a) {
  if (a > 0) return -a;
  return a;
}

int main(int argc, char *argv[]) {
  int b = 3;
  if (foo(b) > 3) {
    printf("Large\n");
  } else {
    printf("Small\n");
  }
  return 0;
}
```



- Warning: Gcc 4.x may generate only cfg of the last function in a taraget C file