# HW 5: Programming, Document, and Graphical Tools

Due: December 5

**Overview:** This is an assignment designed to give you practical experience with three sets of tools covered in class (programming, graphical, and document creation tools). The programming tools utilized are `make` , `gprof` , `diff` , and the GNU C/C++ compiler. Graphviz, Imagemagick, and LaTeX/TikZ will be used for generating graphics in a document form.

**Objective:** Complete the following tasks (in the order presented) to visualize the execution of a small calendar tool called `remind`. Each problem will have one or more outputs, taking the form of a short answer (text), code, a PNG image, or a PDF. After completing each task, clearly specify which output is matched with each problem to receive credit.

1. Download the calendar utility `remind` with the URL

   `https://www.roaringpenguin.com/files/download/remind-03.01.15.tar.gz`

   and extract the contents. After running `./configure` at the root of the directory, find the `Makefile` in the `src` folder (not at the root). The file you're looking for should have this at the top:

```
# Makefile.in for REMIND
#

SHELL= /bin/sh
BETA = 1
srcdir=.
prefix=/usr/local
exec_prefix=${prefix}
mandir=${datarootdir}/man
bindir=${exec_prefix}/bin
datadir=${datarootdir}
datarootdir=${prefix}/share

VERSION=03.01.15

INSTALL=/usr/bin/install -c
INSTALL_PROGRAM=${INSTALL}
INSTALL_DATA=${INSTALL} -m 644
```

After making a backup of this file, edit the `Makefile` so that it can be profiled with `gprof`. Explain the reasoning behind your change. Report (in this HW) the unified format (`-u` flag) output of the `diff` utility.
It is necessary to compile `remind` with the profiling flags (`-pg` ). The compiler specified by `remind` is gcc, meaning that everywhere gcc is invoked in the Makefile, those profiling flags should be added.

The diff in unified format:

```
--- Makefile 2017-12-07 14:26:27.000000000 -0500
+++ Makefile.backup 2017-12-07 14:26:22.000000000 -0500
@@ -37,20 +37,17 @@

 all: remind rem2ps

-
-PROFILING_FLAGS='-pg'
-
 test: remind
   @sh ../tests/test-rem

 .c.o:
-gcc $(PROFILING_FLAGS) -c -g -O2 -Wall -Wstrict-prototypes -DHAVE_CONFIG_H $(CEXTRA) $(LANGDEF) -I
+ gcc  -c -g -O2 -Wall -Wstrict-prototypes -DHAVE_CONFIG_H $(CEXTRA) $(LANGDEF) -I. -I$(srcdir) $<

 rem2ps: rem2ps.o dynbuf.o
-gcc  $(PROFILING_FLAGS) $(LDEXTRA) -o rem2ps rem2ps.o dynbuf.o
+ gcc   $(LDEXTRA) -o rem2ps rem2ps.o dynbuf.o

 remind: $(REMINDOBJS)
-gcc  $(PROFILING_FLAGS) $(LDEXTRA) -o remind $(REMINDOBJS) -lm
+ gcc   $(LDEXTRA) -o remind $(REMINDOBJS) -lm
```

2. Compile the code using using the `Makefile` of `remind-03.01.15` package. Report where the `remind` executable is located within the package's directory after this step.
The `remind` executable is located in the src/ directory of the package.

   Explain

   (a) How you might find `remind` if you read the Makefile, and

   One of the targets of the `Makefile` is `remind`, and the action taken creates a binary of the same name with the `-o` flag. Assuming no other flag moves this output, the remind executable should be in the same directory as the `Makefile`.

   (b) in general how you can find the (non-phony) targets of the Makefile without reading the Makefile at all (which is not always easy to read).
   There are two ways of doing this, that rely on pretty big assumptions.

      i. Assume that none of the targets exist in the unzipped package, and anything *created* after the fact is a target: Run the `find` command at the root of the package, and pipe the sorted

results to a file. Compile with `make` , and pipe the `find` and `sort` command output to a different file, and compare the two with `diff`.

ii. Assume that any file *modified* after the Make command is run is a target: Extract the package some arbitrary amount of time before compiling. Run the `find` command specifying that the only files returned should have been modified within $k$ minutes (where Make was executed fewer than $k$ minutes ago). This might look something like

```
find . -mmin -5
```

if `make` was run 4 minutes ago.

*Note:* You do not have to worry about installing any of the binaries produced (i.e. with `make install`).
*Hint:* It might help to use a utility covered in the `week_3.pdf` slides.

3. Profile the `remind` executable using `gprof`. The command you will be profiling is

```
./remind ../examples/defs.rem
```

Report the 10 functions with the *fewest* calls as recorded in `gmon.out`.

My output looks like this:

```
0.00      0.00     0.00        1     0.00     0.00  CheckSafety
0.00      0.00     0.00        1     0.00     0.00  CreateParser
0.00      0.00     0.00        1     0.00     0.00  DoRun
0.00      0.00     0.00        1     0.00     0.00  DoSubstFromString
0.00      0.00     0.00        1     0.00     0.00  FChoose
0.00      0.00     0.00        1     0.00     0.00  FEasterdate
0.00      0.00     0.00        1     0.00     0.00  FIsomitted
0.00      0.00     0.00        1     0.00     0.00  FVersion
0.00      0.00     0.00        1     0.00     0.00  GetAccessDate
0.00      0.00     0.00        1     0.00     0.00  GreaterThan
0.00      0.00     0.00        1     0.00     0.00  IncludeFile
0.00      0.00     0.00        1     0.00     0.00  OpenFile
0.00      0.00     0.00        1     0.00     0.00  PopFile
0.00      0.00     0.00        1     0.00     0.00  SystemDate
0.00      0.00     0.00        1     0.00     0.00  trig_wday_func
```

4. Use `gprof2dot` to produce a dot file. Report the contents of the dot file here, and compile it with `dot` to produce a PNG.

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*Note:* If you wish to run this from `linprog` (recommended), you will need to install both `pip` (the Python package manager) and `gprof2dot` locally (because you do not have `sudo` privileges). This can be done using the following steps:

(a) Get the pip install script:

```
wget https://bootstrap.pypa.io/get-pip.py
```

(b) Instruct the install script to install locally (in `.local/bin`):

```
python get-pip.py --user
```

(c) Within `.local/bin` you will find `pip` . Install `gprof2dot` locally

```
./pip install gprof2dot --user
```

This will put the `gprof2dot` binary in the same directory as pip. Keep this in mind when using it (either by specifying its absolute path or by changing your `PATH` environment variable).

To copy images or other files produced from `linprog` , you might use WinSCP if you are on Windows or gFTP on Ubuntu (unless you are already comfortable with `scp` or `sftp`).

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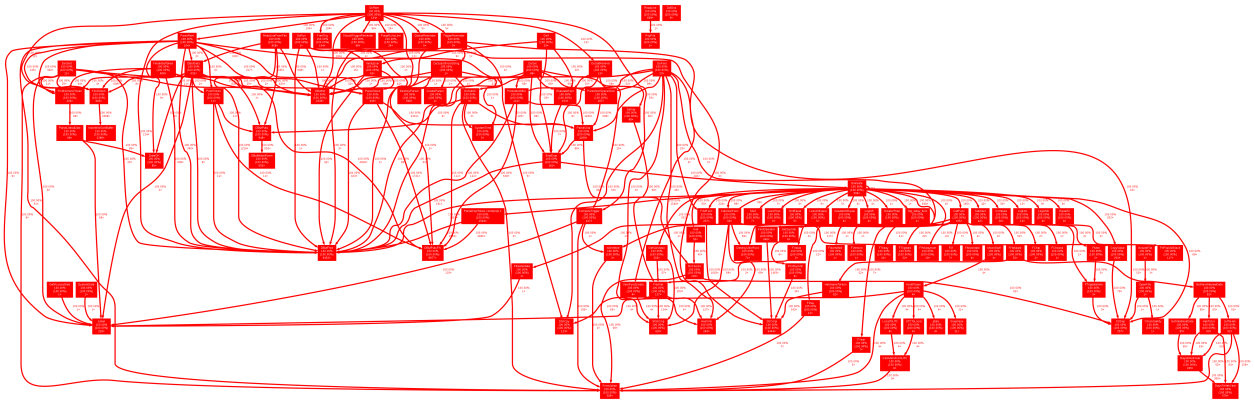
The rendered dot file (with `dot` ) could look *roughly* as complex as this:



The above output was my graph. The contents of the DOT file were

```
digraph {
graph [fontname=Arial, nodesep=0.125, ranksep=0.25];
node [fontcolor=white, fontname=Arial, height=0, shape=box, style=filled, width=0];
edge [fontname=Arial];
2 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufPutcFN\n100.00%\n(100.00%)\n9
3 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufFree\n100.00%\n(100.00%)\n651
4 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseChar\n100.00%\n(100.00%)\n42
4 -> 30 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
4 -> 34 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
5 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="StrCmpi\n100.00%\n(100.00%)\n3525
6 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="InsertIntoSortBuffer\n100.00%\n(1
7 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufInit\n100.00%\n(100.00%)\n233
8 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseExprToken.constprop.1\n100.0
8 -> 2 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n3
8 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n1
9 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindToken\n100.00%\n(100.00%)\n99
9 -> 6 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n2
10 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindOperator\n100.00%\n(100.00%)
10 -> 5 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
11 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufPuts\n100.00%\n(100.00%)\n64
11 -> 18 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
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```
12 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufGets\n100.00%\n(100.00%)\n63
12 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
12 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
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12 -> 71 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
13 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ReadLine\n100.00%\n(100.00%)\n60
13 -> 115 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
14 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindInitialToken\n100.00%\n(100.
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14 -> 29 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
15 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ReadLineFromFile\n100.00%\n(100.
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19 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseToken\n100.00%\n(100.00%)\n
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19 -> 4 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
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21 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FromJulian\n100.00%\n(100.00%)\n
22 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="Evaluate\n100.00%\n(100.00%)\n60
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22 -> 80 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
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25 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="HashVal\n100.00%\n(100.00%)\n247
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29 -> 48 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
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31 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DaysInHebYear\n100.00%\n(100.00%
31 -> 17 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
32 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="CallFunc\n100.00%\n(100.00%)\n16
32 -> 27 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
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32 -> 110 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
33 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseNonSpaceChar\n100.00%\n(100
33 -> 4 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
34 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoCoerce\n100.00%\n(100.00%)\n13
34 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
34 -> 24 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
35 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindVar\n100.00%\n(100.00%)\n127
35 -> 20 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
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35 -> 25 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
35 -> 36 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
36 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="StrnCpy\n100.00%\n(100.00%)\n123
37 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseIdentifier\n100.00%\n(100.0
37 -> 2 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
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37 -> 4 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
38 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FnPopValStack\n100.00%\n(100.00%
39 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ComputeTrigger\n100.00%\n(100.00
39 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
39 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
39 -> 102 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
40 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoRem\n100.00%\n(100.00%)\n104"]
40 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
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40 -> 89 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
41 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="EvaluateExpr\n100.00%\n(100.00%)
41 -> 30 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
42 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FreeTrig\n100.00%\n(100.00%)\n10
43 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseRem\n100.00%\n(100.00%)\n10
43 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
43 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
43 -> 9 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
43 -> 12 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 19 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 29 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 36 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 45 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
43 -> 71 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
44 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ShouldTriggerReminder\n100.00%\n
45 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DateOK\n100.00%\n(100.00%)\n80"]
46 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DestroyUserFunc\n100.00%\n(100.0
47 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="CallUserFunc\n100.00%\n(100.00%)
47 -> 20 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
47 -> 22 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="70", lab
47 -> 25 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
47 -> 38 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
47 -> 46 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
48 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseLiteralDate\n100.00%\n(100.
48 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
```

```
48 -> 45 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
49 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoSet\n100.00%\n(100.00%)\n68"];
49 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
49 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
49 -> 30 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
49 -> 33 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
49 -> 37 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
49 -> 41 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
49 -> 50 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
50 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="SetVar\n100.00%\n(100.00%)\n68"]
50 -> 35 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
51 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GetValidHebDate\n100.00%\n(100.0
51 -> 31 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
52 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="HebToJul\n100.00%\n(100.00%)\n63
52 -> 17 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
52 -> 31 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
53 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="Add\n100.00%\n(100.00%)\n54"];
53 -> 34 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
54 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FHebdate\n100.00%\n(100.00%)\n52
54 -> 55 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
54 -> 56 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
55 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GetNextHebrewDate\n100.00%\n(100
55 -> 51 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
55 -> 52 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
55 -> 57 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
56 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="HebNameToNum\n100.00%\n(100.00%)
56 -> 5 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
57 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="JulToHeb\n100.00%\n(100.00%)\n52
57 -> 17 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
57 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
57 -> 31 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
58 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="Subtract\n100.00%\n(100.00%)\n42
59 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="VerifyEoln\n100.00%\n(100.00%)\n
59 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
59 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
59 -> 19 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
60 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FToday\n100.00%\n(100.00%)\n41"]
61 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="Compare\n100.00%\n(100.00%)\n33'
62 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="PurgeEchoLine\n100.00%\n(100.00%
63 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoFset\n100.00%\n(100.00%)\n23"]
63 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
63 -> 4 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
63 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
63 -> 20 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 23 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 24 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 25 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 33 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 36 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 37 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
63 -> 46 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
```

```
64 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoIf\n100.00%\n(100.00%)\n23"];
64 -> 30 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
64 -> 41 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
64 -> 59 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
65 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FTrigdate\n100.00%\n(100.00%)\n2
66 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="truephase\n100.00%\n(100.00%)\n1
67 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FDay\n100.00%\n(100.00%)\n15"];
67 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
68 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LogNot\n100.00%\n(100.00%)\n13"]
69 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoSatRemind\n100.00%\n(100.00%)\
69 -> 30 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
69 -> 39 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
69 -> 41 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
70 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoOmit\n100.00%\n(100.00%)\n11"]
70 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
70 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
70 -> 9 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
70 -> 19 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
70 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
70 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
70 -> 29 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
71 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="PushToken\n100.00%\n(100.00%)\n1
71 -> 2 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
71 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
71 -> 11 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
72 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FWkdaynum\n100.00%\n(100.00%)\n1
73 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LogAND\n100.00%\n(100.00%)\n10"]
74 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="CalcMinsFromUTC\n100.00%\n(100.0
74 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
75 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoElse\n100.00%\n(100.00%)\n9"];
76 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="EqualTo\n100.00%\n(100.00%)\n8"]
77 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FIif\n100.00%\n(100.00%)\n7"];
78 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FYear\n100.00%\n(100.00%)\n7"];
78 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
79 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LessThan\n100.00%\n(100.00%)\n7"
80 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="Mod\n100.00%\n(100.00%)\n7"];
81 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindSysVar\n100.00%\n(100.00%)\n
81 -> 5 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
82 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GetSysVar\n100.00%\n(100.00%)\n6
82 -> 81 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
83 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LessOrEqual\n100.00%\n(100.00%)\
84 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="NotEqual\n100.00%\n(100.00%)\n6"
85 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GreaterOrEqual\n100.00%\n(100.00
86 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LogOR\n100.00%\n(100.00%)\n5"];
87 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="QueueReminder\n100.00%\n(100.00%
88 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="SystemTime\n100.00%\n(100.00%)\n
89 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="TriggerReminder\n100.00%\n(100.0
89 -> 2 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
89 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
89 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
89 -> 95 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
```

```
89 -> 97 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
89 -> 106 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
90 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FMoondate\n100.00%\n(100.00%)\n4
91 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="HuntPhase\n100.00%\n(100.00%)\n4
91 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
91 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
91 -> 66 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
91 -> 92 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
91 -> 94 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
91 -> 96 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
92 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="LocalToUTC\n100.00%\n(100.00%)\n
92 -> 74 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
93 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="MoonStuff\n100.00%\n(100.00%)\n4
93 -> 91 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
94 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="UTCToLocal\n100.00%\n(100.00%)\n
94 -> 74 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
95 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="UserFuncExists\n100.00%\n(100.00
95 -> 20 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
95 -> 25 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
96 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="jdate\n100.00%\n(100.00%)\n4"];
97 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoSubst\n100.00%\n(100.00%)\n3"]
97 -> 2 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
97 -> 4 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
97 -> 11 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
97 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
97 -> 88 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
98 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FTrigdatetime\n100.00%\n(100.00%
98 -> 24 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
99 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FChar\n100.00%\n(100.00%)\n2"];
100 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FMon\n100.00%\n(100.00%)\n2"];
100 -> 98 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
101 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FValue\n100.00%\n(100.00%)\n2"]
101 -> 35 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
102 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="IsOmitted\n100.00%\n(100.00%)\n
102 -> 21 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
103 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="CheckSafety\n100.00%\n(100.00%)
104 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="CreateParser\n100.00%\n(100.00%
105 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoRun\n100.00%\n(100.00%)\n1"];
105 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
105 -> 5 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
105 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
105 -> 19 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
105 -> 59 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
106 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoSubstFromString\n100.00%\n(10
106 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
106 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
106 -> 16 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
106 -> 88 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
106 -> 97 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
106 -> 104 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00
107 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FChoose\n100.00%\n(100.00%)\n1"
```

```
108 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FEasterdate\n100.00%\n(100.00%)
108 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
109 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FIsomitted\n100.00%\n(100.00%)\
110 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FVersion\n100.00%\n(100.00%)\n1
111 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GetAccessDate\n100.00%\n(100.00
111 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
112 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="GreaterThan\n100.00%\n(100.00%)
113 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="IncludeFile\n100.00%\n(100.00%)
113 -> 114 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00
114 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="OpenFile\n100.00%\n(100.00%)\n1
114 -> 24 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
114 -> 103 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00
115 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="PopFile\n100.00%\n(100.00%)\n1"
116 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="SystemDate\n100.00%\n(100.00%)\
116 -> 26 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%
117 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="trig_wday_func\n100.00%\n(100.0
}
```

5. With TikZ, draw the root and first level of the tree produced by `gprof2dot`, and render it (as a PDF). Assuming that the root is `DoRem` (arbitrarily), I look in the DOT file to find all the ocurrences (outgoing edges) of the `DoRem` node:

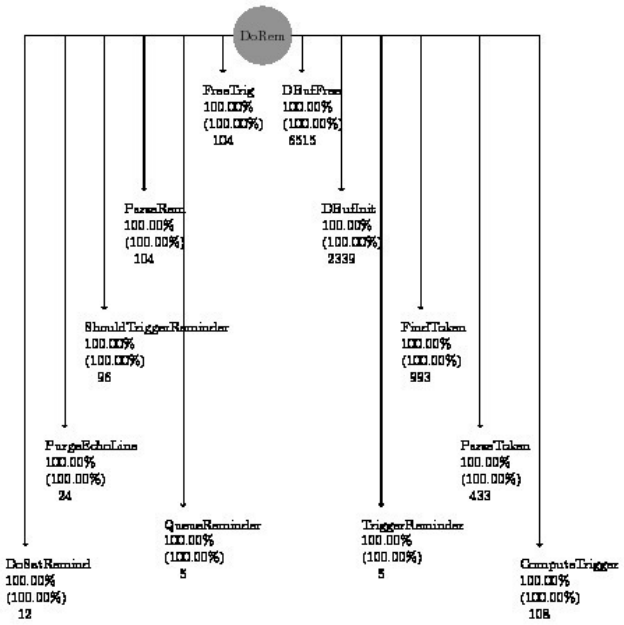
```
40 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoRem\n100.00%\n(100.00%)\n104"]
40 -> 3 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
40 -> 7 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
40 -> 9 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\n
40 -> 19 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 39 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 42 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 43 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 44 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 62 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 69 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 87 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
40 -> 89 [arrowsize="1.00", color="#ff0000", fontcolor="#ff0000", fontsize="10.00", label="100.00%\
```

Then I find the nodes at the end of each edge above:

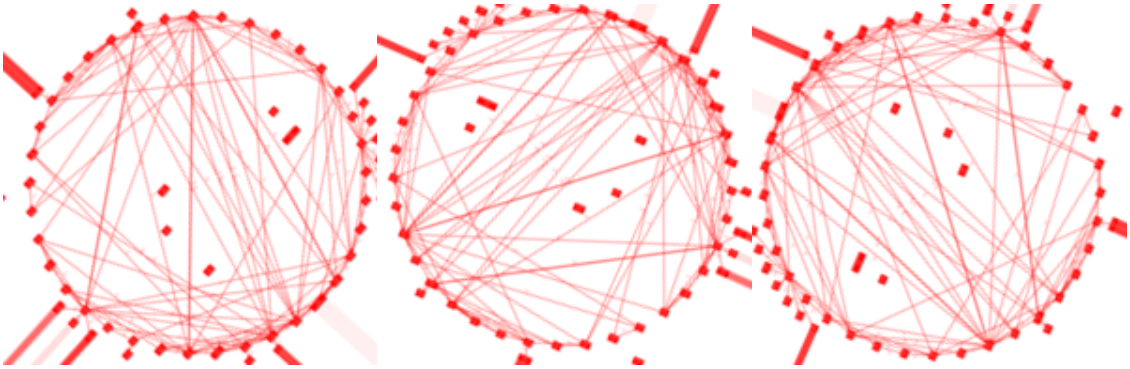
```
3 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufFree\n100.00%\n(100.00%)\n651
7 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DBufInit\n100.00%\n(100.00%)\n233
9 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FindToken\n100.00%\n(100.00%)\n99
19 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseToken\n100.00%\n(100.00%)\n
39 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ComputeTrigger\n100.00%\n(100.00
42 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="FreeTrig\n100.00%\n(100.00%)\n10
43 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ParseRem\n100.00%\n(100.00%)\n10
44 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="ShouldTriggerReminder\n100.00%\n
62 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="PurgeEchoLine\n100.00%\n(100.00%
69 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="DoSatRemind\n100.00%\n(100.00%)\
87 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="QueueReminder\n100.00%\n(100.00%
89 [color="#ff0000", fontcolor="#ffffff", fontsize="10.00", label="TriggerReminder\n100.00%\n(100.0
```

The labels contain the names of the functions called. These will be the text inside the TikZ nodes.

```
\documentclass{article}
\usepackage{tikz}
\begin{document}
\begin{tikzpicture}
\node[shape=circle,fill=gray] (dorem) at (3,0) {DoRem};
\node[shape=circle,text width=1cm, align=center] (1) at (4,-2) {DBufFree\\100.00\%\\(100.00\%)\\651
\node[shape=circle,text width=1cm, align=center] (2) at (5,-5) {DBufInit\\100.00\%\\(100.00\%)\\233
\node[shape=circle,text width=1cm, align=center] (3) at (7,-8) {FindToken\\100.00\%\\(100.00\%)\\99
\node[shape=circle,text width=1cm, align=center] (4) at (8.5,-11) {ParseToken\\100.00\%\\(100.00\%
\node[shape=circle,text width=1cm, align=center] (5) at (10,-14) {ComputeTrigger\\100.00\%\\(100.00
\node[shape=circle,text width=1cm, align=center] (6) at (2,-2) {FreeTrig\\100.00\%\\(100.00\%)\\104
\node[shape=circle,text width=1cm, align=center] (7) at (0,-5) {ParseRem\\100.00\%\\(100.00\%)\\104
\node[shape=circle,text width=1cm, align=center] (8) at (-1,-8) {ShouldTriggerReminder\\100.00\%\\(
\node[shape=circle,text width=1cm, align=center] (9) at (-2,-11) {PurgeEchoLine\\100.00\%\\(100.00\
\node[shape=circle,text width=1cm, align=center] (10) at (-3,-14)  {DoSatRemind\\100.00\%\\(100.00\
\node[shape=circle,text width=1cm, align=center] (11)  at (1,-13) {QueueReminder\\100.00\%\\(100.00
\node[shape=circle,text width=1cm, align=center] (12)  at (6,-13) {TriggerReminder\\100.00\%\\(100.
\draw[->] (dorem) -| (1);
\draw[->] (dorem) -| (2);
\draw[->] (dorem) -| (3);
\draw[->] (dorem) -| (4);
\draw[->] (dorem) -| (5);
\draw[->] (dorem) -| (6);
\draw[->] (dorem) -| (7);
\draw[->] (dorem) -| (8);
\draw[->] (dorem) -| (9);
\draw[->] (dorem) -| (10);
\draw[->] (dorem) -| (11);
\draw[->] (dorem) -| (12);
\end{tikzpicture}
\end{document}
```




6. **Extra Credit** Use graphviz to create a circular call graph, and use Imagemagick to create a looping GIF of the call graph making a full rotation.



(a) 132° (b) 24° (c) 294°

Figure 1: Sample output of the circular call graph rotation

*Hint:* You will want to use Imagemagick's `-distort` flag with the `SRT` distortion. Don't use the `-rotate` flag!
*Note:* There will be some distortion around the edges with SRT; this is OK.

```
# replace dot with circo
gprof ./remind | ../../../.local/bin/gprof2dot | circo \
    -Tpng -o circo_remind_graph.png

# make the image square (cut off part) and smaller
convert circo_remind_graph.png -resize '300x300^'\
    -gravity East -crop 300x300+0+0 +repage square_circo.jpg
```

```
# rotate images
for i in `seq 0 6 360`; do
    convert square_circo.jpg -distort SRT "$i"  ${i}_graph.jpg;
done

# combine rotated images into gif
convert `ls -t *_graph.jpg` rotating_remind.gif
```

**Submission**:
Upload all the files in a single `tar` or `zip` file by the due date.