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gcov 和 clang 的实现

MaskRay

https://maskray.me

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- 1 Code coverage
- 2 gcov
- 3 gcov in Clang
- 4 Linux kernel
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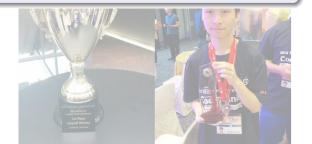
References





MaskRay

■ LLVM contributor



MaskRay

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MaskRay

- LLVM contributor
- ccls owner (C++ language server)



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MaskRay

- LLVM contributor
- ccls owner (C++ language server)
- 退休的算法竞赛 + 超算 +CTF 选手



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全 决战解释

題目

决赛直播 积分榜 BCTF*百度杯*全国网络安全技术对抗赛·是由百度公司主办、清华和北大的安全技术专家提供技术支持、常金江宁、南京赛宁承办、面向全国范围网络安全技术实战竞赛!



MaskRay

■ 退休的算法竞赛 + 超算 +CTF 选手





大赛三大特色

最興文化的赛事:百度和清华・北大的安全技术人员邀请战队一起重温米特尼克的冒险传奇・体验最興神を色彩的黑客文化 和技术!

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Motivation

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References

Motivation

- Found a Bug
- - Why is it not covered?

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Motivation

- Found a Bug
- Why is it not covered?
- Find dead code

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References

Code coverage tools

- gcc --coverage + gcov
- Clang coverage mapping clang -fprofile-instrgenerate -fcoverage-mapping + Ilvm-cov
- clang -fsanitize-coverage=trace-pc-guard, {edge,bb,func}
 - -fsanitize={address,memory,thread,...} + sancov

gcov 和 clang 的实现 MaskRay

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gcov lcov Compatibility

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References

gcov

- gcc -fprofile-arcs -ftest-coverage a.c b.c #
 --coverage
- compile-time -fprofile-arcs ⇒ a.gcno b.gcno (notes file)
- ./a.out ⇒ a.gcda b.gcda (count data file)
- gcov a.c # or a. \Rightarrow a.c.gcov
- gcov b.gcno # or b. ⇒ b.c.gcov
- gcov -h

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Pass Instrumenter

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References

Icov

- https://github.com/linux-test-project/lcov, gcov's graphical front-end
- lcov --gcov-tool gcov -c -d . -o a.info
- genhtml a.info -o html

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gcov 和 clang 的实现
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References

% lcov --gcov-tool gcov-9 -c -d . -o a.info Capturing coverage data from . Found gcov version: 9.3.0 Using intermediate gcov format Scanning . for .gcda files ... Found 2 data files in . Processing b.gcda Processing a.gcda Finished .info-file creation % genhtml a.info -o html Reading data file a.info Found 2 entries Found common filename prefix "/tmp" Writing .css and .png files. Generating output. Processing file c/a.c Processing file c/b.c Writing directory view page. Overall coverage rate: lines.....: 100.0% (4 of 4 lines)

functions..: 100.0% (2 of 2 functions)

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Compatibility

.gcno/.gcda format changed several times: GCC 3.4, 4.7, 4.8, 8, 9

```
% gcc-9 --coverage a.c; ./a.out; gcov-10 a.
a.gcno:version 'A93*', prefer 'B00e'
a.gcda:version 'A93*', prefer version 'B00e'
File 'a.c'
Lines executed:100.00% of 2
Creating 'a.c.gcov'

% gcov-8 a.
a.gcno:version 'A93*', prefer 'A84*'
a.gcno:no functions found
a.gcda:version 'A93*', prefer version 'A84*'
```

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gcov in Clang

- clang --coverage # -fprofile-arcs -ftestcoverage
- clang --coverage -Xclang -coverageversion='408*' gcov 4.8 7 compatible
- instrumenter (write .gcno, generate calls into runtime) ⇔ gcc/coverage.c
- runtime (write .gcda) ⇔ libgcov.a (libgcc/libgcov-driver.c & friends)
- Ilvm-cov gcov ⇔ gcov

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gcov 和 clang 的实现
 gcov in Clang
    My contribution
                          2020-05-10 [gcov] Fix .gcda decoding and support GCC 8, 9 and 10
gcov 和 clang
                          2020-05-10 [gcov] Don't skip leading zeros when reading a string
  的实现
                          2020-05-10 [gcov] Temporarily unsupport host-byteorder-big-endian
                          2020-05-10 [compiler-rt] [test] Add feature host-byteorder-big-endian
                          2020-05-10 [gcov] Temporarily unsupport host-byteorder-big-endian
                          2020-05-10 [gcov] Delete CC1 option -coverage-no-function-names-in-data
                          2020-05-10 [gcov] Default coverage version to '407*' and delete CC1 option -coverage-ci
                          2020-05-10 [gcov] Implement --stdout -t
                          2020-05-11 [gcov] Emit GCOV_TAG_OBJECT_SUMMARY/GCOV_TAG_PROGRAM_SUMMARY correctly and i
                          2020-05-11 Revert part of D49132 "[gcov] Fix gcov profiling on big-endian machines"
                          2020-05-11 [gcov] Fix big-endian problems
                          2020-05-12 [gcov] Default coverage version to '408*' and delete CC1 option -coverage-en
                          2020-05-12 [gcov][test] Fix clang test
                          2020-06-03 [gcov] Improve .gcno compatibility with gcov and use DataExtractor
My contribution
                          2020-06-03 [gcov] Delete XFAIL: host-byteorder-big-endian
                          2020-06-03 [gcov] Make 'Creating 'filename' compatible with gcov
                          2020-06-03 [gcov] Don't error 'unexpected end of memory buffe'
                          2020-06-06 [gcov] Support big-endian .gcno and simplify version handling in .gcda
                          2020-06-06 [gcov] Delete `XFAIL: host-byteorder-big-endian` for test/
                          Transforms/GCOVProfiling/{exit-block.11,function-numbering.11}
                          2020-06-06 [gcov] Delete unneeded code
                          2020-06-06 [gcov] Improve tests and lower the minimum supported version to gcov 3.4
                          2020-06-07 [llvm-cov] Fix gcov version detection on big-endian
                          2020-06-07 [gcov] [test] Delete UNSUPPORTED: host-byteorder-big-endian from test/
                          profile tests
                          2020-06-07 [gcov] Fix instrprof-gcov-_gcov_flush-terminate.test
                          2020-06-07 [gcov] Support .gcno/.gcda in gcov 8, 9 or 10 compatible formats
                          2020-06-09 [gcov][test] Add mkdir -p %t && cd %t
                          2020-06-16 [gcov] Refactor llvm-cov gcov and add SourceInfo
                          2020-06-16 [gcov] Add -i --intermediate-format
                          2020-06-16 [llvm-cov gcov] Don't suppress .gcov output if .gcda is corrupted
                          2020-06-17 [llvm-cov gcov] Support clang<11 fake 4.2 format
                          2020-07-01 [gcov] Move llvm writeout files from atexit to a static destructor
```

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References

Position in the legacy pass manager pipeline

% clang --coverage -mllvm -debug-pass=Arguments -c a.c

Pass Arguments: -tti -targetlibinfo -ee-instrument

Pass Arguments: -tti -targetlibinfo -assumption-cache-tracker -profile-summary-info -insert-gcov-profiling -strip -forceattrs -basiccg -always-inline

Pass Arguments: -tti -targetlibinfo -targetpassconfig ... -livedebugvalues -x86-seses -cfi-

instr-inserter -x86-lvi-ret -lazy-machine-block-freq -machine-opt-remark-emitter

 $\mbox{\tt\#}$ Close to -finstrument-functions, -fprofile-instr-generate

在 new pass manager 中的位置差不多。问题:instrument 部分位置太靠前了,而生成的函数必须提前来利用 后续的优化

Instrumenter

- 添加一个 static constructor __llvm_gcov_init, 呼叫 runtime llvm_gcov_init
- 每个函数: @_llvm_gcov_ctr = internal global [\$n x i64] zeroinitializer, \$n 为边数
- basic block 转移时插入指令修改 __llvm_gcov_ctr 元 素
- __llvm_gcov_writeout: 输出所有 @__llvm_gcov_ctr

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llvm_gcov_init

- 定义在 libclang_rt.profilex86 64.a(GCDAProfiling.c.o)
- 接收 writeout, flush, reset 三个 callbacks
- writeout: 写.gcda
- reset: 清零 counters
- ___gcov_flush=writeout+reset (无用,GCC 11 被移除)
- 设置 atexit hook,在程序退出时呼叫 writeout

```
gcov 和 clang 的实现
Lgcov in Clang
Llvm-cov gcov
```

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References

Ilvm-cov gcov

- \blacksquare gcov 3.4 10 + clang's fake gcov 4.2 format
- -i, --intermediate-format
- -t, --stdout

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Linux kernel

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References

Linux kernel 的.gcda runtime

- kernel/gcov/gcc_4_7.c
- kernel/gcov/clang.c

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IIvm-cov gcov

Future work

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Future work

- 减少 counters 数目: 后移 pass
- 实现目前忽略的字段
- gcov 8 模仿 coverage mapping,可以显示不同 template instantiations 的行计数
- Ilvm-cov gcov 准确支持 GCC>=9 行计数

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Instrumenter

llvm-cov gco

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References

References

https://gcc.gnu.org/onlinedocs/gcc/Gcov.html