Testing of Changes in Software System Based on Source Code Coverage

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Regression testing

• Testing process which is applied after a program is modified

• Testing results are compared to the previous ones (reference results)

• The main purpose is to find new bugs (regressions)

• Bug-fixes are appreciated
Regression testing

“As a consequence of the introduction of new bugs, program maintenance requires far more system testing per statement written than any other programming. Theoretically, after each fix one must run the entire bank of test cases previously run against the system, to ensure that it has not been damaged in an obscure way. In practice such regression testing must indeed approximate this theoretical ideal, and it is very costly.”

[Frederick P. Brooks, Jr. The Mythical Man-Month]
Pre-commit testing

• It’s better to keep serious bugs out of trunk and important branches

• The best way is to require for every change to pass some essential set of tests before the commit

• Good testing infrastructure allows developer to type e.g. “test_my_changes.sh” in the workspace and get the list of “new passes” and “new fails” on all platforms

• Too long pre-commit testing significantly slows down the development process

• Too small pre-commit testing leads to unstable codebase
How to form a pre-commit testing

- Tests for important features
- "Importance" is questionable
- Tests are not always bound to specific features
- Tests that had failed before
- Will never catch a truly "new fail"
- Test failed once will stay there forever
- Redundant: single bug often causes a number of fails
- Unique minimal defect reproducers
- More efficient but still one step behind
- Minimal testing for each component (or even feature)
- Reliable but may be too big
Tests for a specific change-set

Select tests for the modified component

• Effective but dangerous: affected ≠ modified
Coverage-based test selection

• Concept:

• Start with a wide tests set covering all (or most) components

• **Exclude** tests that **do not cover** the modified parts of the program

• Classic approach:

• Collect coverage of basic blocks

• Build control flow graphs (CFGs) for original and modified programs

• Exclude the tests that don’t cover changes in the CFG

• Run the rest of test and update the code coverage

[Rothermel, G., Harrold, M.J. *A Safe, Efficient Regression Test Selection Technique*]

Issues with classic approach

• Basic block coverage

• For every test it requires lots of a disk space (in our case more than 1Tb per platform)

• For each test suite (merged) it’s still big and hard to analyze (more than 50Gb in our case)

• It changes very often and should be updated frequently (collection of coverage is 3 times longer than a regular testing)

• Building a complete CFG is expensive and redundant
Code coverage optimized testing

- Last code coverage test run
- Generate optimized testing
- Changed functions
- Build
  - Change
  - Checkout

mainline
Regular code coverage test runs

• Needed to collect information about existing testing coverage

• Result is mapping of source function names to a set of test suites/optsets that covers them (about 300Mb Perl hash file for each platform)

• Basic block coverage is not used for simplicity

• Performed once per week automatically

• Done on four platforms: Linux/Windows x32/x64

• Performed using specially build version of application with code coverage information generation enabled (-profgen Intel compiler switch)
Specifics of using Intel compiler as test application

• After each individual test coverage data is merged to suite/optset to save disk space (still each platform requires about 50Gb to store it in a packed form)

• Coverage testing can take up to 6 days

• Special compiler wrappers are used to merge code coverage data after each 100th compilation to handle huge tests

• Tests are run in compile/link mode only but not all tests are designed for that thus some tests still execute and sometimes leave their code coverage too

• Not all platforms can be covered due to lack of testing pool resources
Find changed functions

• Reused functionality of existing version control system
• Get list of modified sources
• Get original and modified version of sources
• For modified header files build dependency files are used to find dependent source files
• Build log is used to get correct compilation commands (macros and generated header files are important)
• Need some syntax parser solution to remove dependency on source formatting changes
Rejected source parsing solution

- Tried to use Python parser generated by ANTLR3 from already existing grammar
- Too slow (about 10 minutes to parse average source)
- Too much memory consumption (over 2GB per one modified/original source of average size)
- Need industry quality syntax parser
Currently used parsing solution

- Based on compiler internal representation dumps (currently Intel compiler is used for that, also gcc -fdump-syntax-tree, GCC::TranslationUnit can be used for that)
- Global/routine symbol tables are already constructed in these dumps (so it is not just plain AST)
- Need to handle other ambiguity such as variable name suffixes, timestamp sensitive C++ mangling and __LINE__ type macros
- __LINE__/__DATE__/__TIME__ predefined macros are manually removed/restored in sources
- Multiple sources are dumped in parallel to save time
Internal representation example

Routine IL0 dump

PACK| (i2.1) align: 0 MOD 4, size: 4, ...

VAR| (i2.1_V$1) type: SCALAR, size: 4,
   | offset: 0, esize: 4, ..., edtype: SI32, ...

...  

3   0 entry extern SI32 main
   
   { 

4   1 i2.1_V$1 = 0(SI32); 

5   2 return ( (SI32) i1_V$0 + i2.1_V$1 );

6   3 return ;

   }

Module symtab dump

PACK| (i1) align: 0 MOD 4, size: 4,
   | ..., offset: 0, ...

VAR| (i1_V$0) type: SCALAR, size: 4,
   | offset: 0, esize: 4, ...

INIT| offset: 0, repeat: 1, ...
   | data: 0(SI32)

Root Context C0.1 {

} C0.1
Finding changed functions

• Each function that has changed internal compiler representation is considered to be changed

• Each variable usage it replaced by its basic name, type, align and other definition information, including complete initialization

• Changes in externally visible variable (or their initialization) are considered as a whole program change and code coverage testing optimization is not performed
Issues with current parsing solution

• Need to demangle function names used in compiler dumps and code coverage runs since it was found that in some cases their mangling can differ

• Issues with not always reliable build dependence file information (some header dependent source names are missing in the build log files)

• Debug version of Intel should be used to get all required internal representation dumps

• Dumps can take up to 30Mb and can be generated several minutes in the worst case
Issues with overall approach

• Uses a week old (in a worst case) code coverage information
• Can’t adequately cover recent code
• Do not work so well with development branches (not mainline)
• Works well in case of small checkins, since component promotions:
  • usually do not give significant testing reduction
  • have high overhead in source dumping time (which adds to build time and is not paralleled on testing pool)
Results

Percent of test suites selected for the testing

Percent of commits

Full
Pre-commit

0 - 20
20 - 40
40 - 60
60 - 80
80 - 100

0,00%
5,00%
10,00%
15,00%
20,00%
25,00%
30,00%
35,00%
40,00%
45,00%
50,00%
Conclusions

Amount of the pre-commit testing can be reduced considerably (55% on the average) even using less precise methods than classic ones

Overhead of the coverage-based technique can be significantly less than gain from shortened testing
To the future adopters

• Keep your makefiles in order
• Correct prerequisite lists are needed to analyze the diffs
• Ideally incremental builds should work 100% correct
• Use code coverage on a regular basis
• It makes things easier if coverage test runs are set up already
• Coverage rate should be good for these methods to work properly
Thank you!

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