Formal Verification of C/C++ Programs

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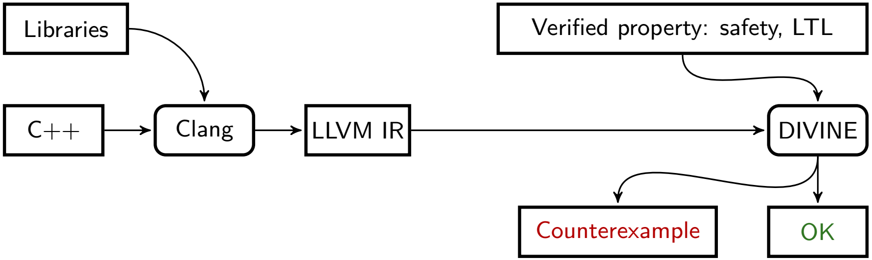
The Current Situation

My Work on DIVINE

- compression of the state space
  - bachelor's thesis, published in SEFM 2015
- export of explicit state space from DIVINE
  - useful for chaining with other tools
  - case study for probabilistic verification to appear in ACM SAC 2016
- verification under more realistic memory models
  - master's thesis, preliminary version in MEMICS 2015, extended version submitted for publication
- code maintenance

LLVM Transformations

- LLVM IR can be transformed (pre-processed) before verification
- use static analysis to extend model checker's abilities, improve performance



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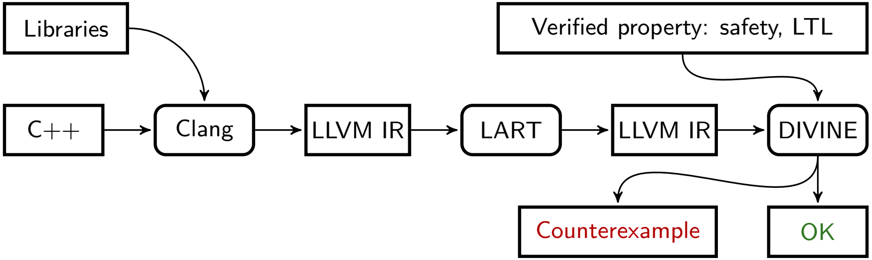

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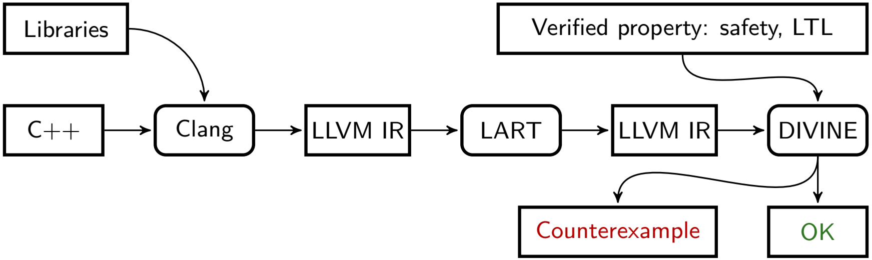

- case study: verification of weak memory models through LLVM transformation

Weak Memory Models

- a write performed by one thread need not be visible to other threads immediately
- writes can be reordered – with reads or with reads and writes
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Solution

- the program is instrumented to simulate delayed/reordered writes
- adds more nondeterminism to the program
- LLVM transformation

Plans

Plans – Overview

Long Term

- improve practical usability of model checking for development of programs
- explore the use of static analysis for pre-processing of programs for DIVINE

Short Term (this year)

- more robust compilation of programs for DIVINE
- register allocation for LLVM
- verification of programs with inputs using SMT (merge SymDIVINE into DIVINE)

Compilation of Programs for DIVINE

- currently, DIVINE facilitates a simple wrapper over clang for compilation
- DIVINE has to provide own implementation of C/C++/`thread`/... libraries
- system configuration and even system headers can leak into DIVINE compilation
- hard to integrate into nontrivial build processes (makefiles, cmake,...)

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Solution

- an isolated environment which can access only user-provided sources and DIVINE libraries
- DIVINE compiler which can be used as a drop-in replacement for GCC/clang
- produce LLVM bitcode for DIVINE alongside native code in a single ELF binary

Verification of Programs with Inputs

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- SymDIVINE can do this for simple programs
  - a proof-of-concept tool for verification of LLVM programs with inputs

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Solution

- merge SymDIVINE into DIVINE using an LLVM transformation
- the program is to be changed so that it manipulates (parts of) data symbolically
- this hybrid program is then executed by DIVINE which uses special algorithm to explore state space of such programs

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Thanks for your attention!