Generation and Analysis of Transition Systems

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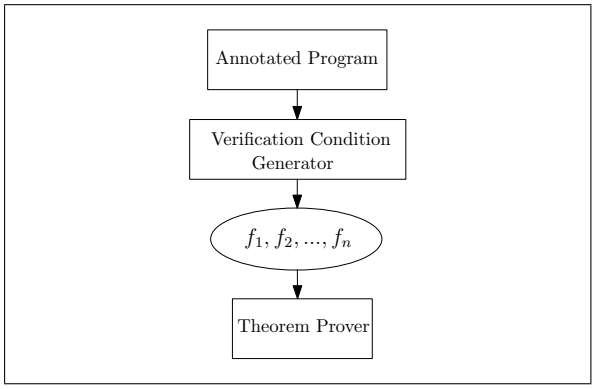

Figure 1: The overall process of VCG generaion

Abstract

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1 Introduction

One of the main approaches in software formal verfication is assertional reasoning based on Hoare logic [5]. This way a code is annotated in certain points with some assertions about the correctness of the program. An assertion guarantees that the program has the desired properties at the definition point From an annotated code a tool extracts a set of verification conditions (VC), which are then fed to a theorem prover for correctness proof. The big picture of the VC generation process is depicted in Figure 1.

The complex features such as pointers, memory allocation, data structures and cuncurrency can make VC generation challenging. In the program verifiers usually the original source code is first translated to a simple intermediate language. Deriving VC conditions from the simple intermediate language is easier. It is also useful when extending the verifier with more features, since the new capabilites may be translated to the intermediate language without the need to change the VC generator. The intermediate language is usually some flavor of the Dijkstra's guarded command language [3], and the VC conditions are generated using liberal precondition semantics. Some successful verifiers for the Java language include Krakatoa [6], ESC/JAVA [4] and Jahob [2]. Krakatoa translates JML-annotated Java programs to proof obligations for various interactive theorem provers. ESC/JAVA uses automated theorem proving for some particular classes of errors, and it is not sound. The main strength of Jahob in comparison to the others is its capability in reasoning about data structures.

In this project we suggest an intermediate language for the language Scala. Scala is a programming language being developed at the EPFL University. As a mixture of object oriented and functional paradigms, Scala allows a great deal of flexibility in programming. For a complete documentation for the language we refer to its webpage [1]. The proposed intermediate language uses the control flow graph (CFG) of a program. CFG shows all the paths that might be traversed through a program during its execution. We represent the graph using a logical formula. The corresponding formula of a CFG describes how the state of the program is changed during the transitions. A transition is described as a guarded command that executes only when the condition of the transition is satisfied. We use the Isabelle/HOL interactive theorem prover [7] to reason about the formula of a system.

An important merit of using a CFG as an intermediate language is it simplicity. CFGs are a common way to reason about the execution of most of the programs.

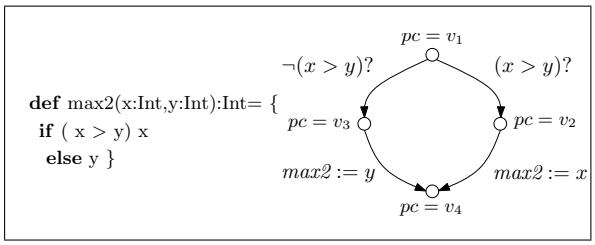

Figure 2: The CFG of a maximum function

However, we are not sure know they can be compared with the previous approaches. We are in the process of implementing an automated compiler from Scala to a formula in Isabelle, and until then we cannot give a precise comparison.

1.1 Small Example

In this section we give a small motivating example which shows how are mapping works in general. Figure 2 shows both the code and CFG of a function that takes two integer arguments and returns their maximum value.

We exploit a similar approach to [8] in describing a transtion system in Isabelle.

datatype *label* = $v1 \mid v2 \mid v3 \mid v4$
record *state* =
pc :: label
x :: int
y :: int
$max2$ :: int
definition *program* :: "(*state* × *state*) **set**"
where "*program* ≡{(s,s').
$(s' = s(\!|pc := v2|\!) \wedge (xs > ys) \wedge (pcs = v1)) \vee$
$(s' = s(\!|pc := v3|\!) \wedge \neg(xs > ys) \wedge (pcs = v1)) \vee$
$(s' = s(\!|pc := v4, max2 := xs|\!) \wedge (pcs = v2)) \vee$
$(s' = s(\!|pc := v4, max2 := ys|\!) \wedge (pcs = v3))\}$"

Here s and s' denote the initial and final states, and the condition afterwards is the guard of the command. The variable pc controls the overall execution of the program in its path and prevents illegal jumping into another transitions. Let r be the relation representing the program and s be the relation representing the specification, program meets specification iff $r* \subseteq s$. Proving the correctness of the requirement in its general form is cumbersome and turns out to be difficult. We can test the program by unrolling the relation for some constant n, and then prove the weaker condition $r^n \subseteq s$. In the "max2" function there is no loop and all paths of the program finish in two steps, so we can unroll the relation two times and show its correctness.

lemma *maximum* [*simp*]:
"(*program* ∘ *program* ∘ *program*) ⊆
$\{(s, s').(pcs = v1) \rightarrow (max2s' = max(xs)(ys))\}$"
apply (unfold program_def)
apply *auto*
done

References

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