Progess Report

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Overview

- A simple example for symbolic execution.
- Modifying SMACK: symbolic execution for `malloc` and `bitcast` from pointer to pointer(with assumption).
- Proposed a framework based on problems encountered.

The Simplest Example

Here is the simplest example in C related to memory operations.

```c
int main(){
    int *i;
    i = (int*)malloc(sizeof(int));
    free(i);
}
```

And its corresponding LLVM IR:

```
define dso_local i32 @main() {
    %1 = call noalias i8* @malloc(i64 4)
    %2 = bitcast i8* %1 to i32*
    %3 = bitcast i32* %2 to i8*
    call void @free(i8* %3)
    ret i32 0
}
```

Symbolic Execution Rules

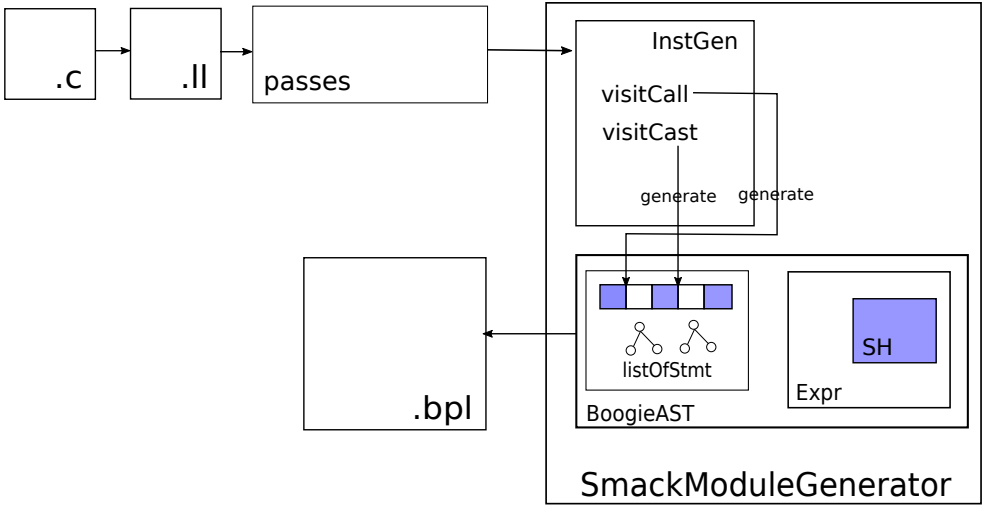
Symbolic Heap: $Q \equiv \Pi \mid \Sigma$

$$\Pi \mid \Sigma \Rightarrow_{\{x=\texttt{malloc}(e)\}} \Pi[x'/x] \mid \Sigma[x'/x] * x \mapsto e[x'/x] * \texttt{blk}(x+1, x+1+e[x'/x])$$

$$\Pi \mid \Sigma_0 * x \mapsto e * \texttt{blk}(x+1, x+1+e) * \Sigma_2 \Rightarrow_{\{\texttt{free}(x)\}} \Pi \mid \Sigma_0 * \Sigma_2$$

```
procedure {:entrypoint} main()
  returns ($r: i32)
{
  var $p0: ref;
  var $p1: ref;
  var $p2: ref;
$bb0:
  SymbHeap(true|emp)
  call {:cexpr "smack:entry:main"} boogie_si_record_ref(main);
  call $p0 := malloc(4);
  SymbHeap(true|emp # $p0 >--> 4 # Blk(($p0 + 1), (($p0 + 1) + 4)))
  $p1 := $bitcast.ref.ref($p0);
  SymbHeap(true|emp # $p0 >--> 4 # Blk(($p0 + 1), (($p0 + 1) + 4)))
  $p2 := $bitcast.ref.ref($p1);
  call free_($p2);
  $r := 0;
  return;
}
```

Framework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passes
InstGen
visitCall
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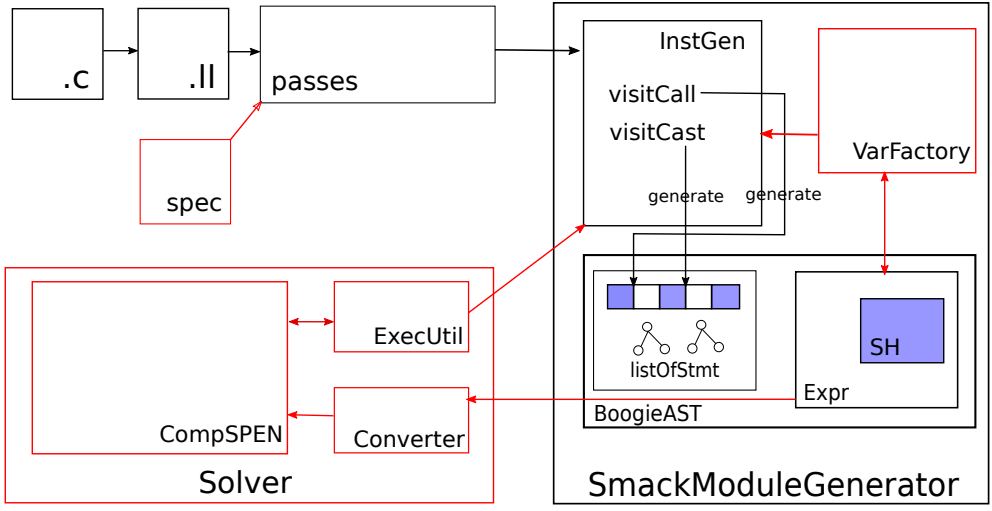
.bpl
listOfStmt
SH
Expr
BoogieAST
SmackModuleGenerator

Framework


.c
.ll
passes
spec
InstGen
visitCall
visitCast
generate
generate
VarFactory
ExecUtil
CompSPEN
Converter
Solver
listOfStmt
SH
Expr
BoogieAST
SmackModuleGenerator

TODOs

- Translation: Incrementally investigate the instruction for execution. Thoroughly went through `InstGen` and find data structure available for the symbolic execution.
- AST: Implement a `VarFactory` module for better syntactical variable manipulation, extend `BoogieAST` to get more information and unify the basic memory unit.
- VCGen: Add `Solver` component to assist symbolic execution and together with `spec` for verification condition generation.

Current Problems and Needs

- Symbolic Execution: Directly using Z3/CompSPEN or use `BoogieAST`? Concentrate more on syntax or semantic? The problem of `free`.
- The conversion between different types of basic data structure: intermediate language unifying the basic unit of memory.
- Feasibility of current framework.