Bounded Model Checking of C++ Programs Based on the Qt Framework

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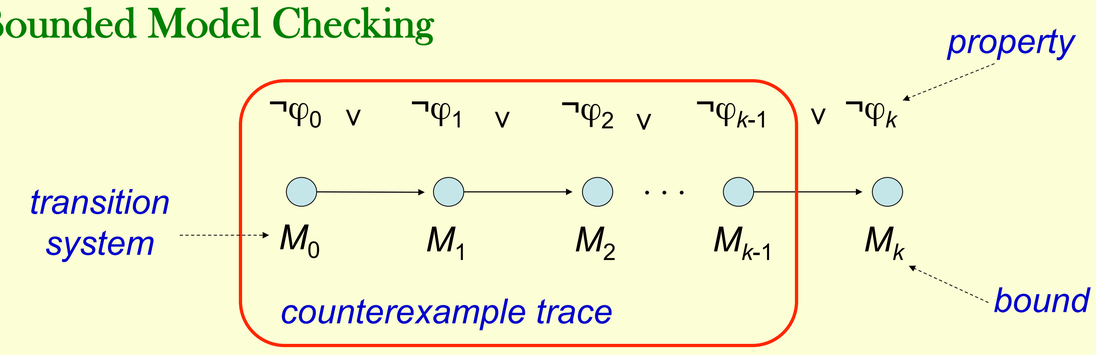
I. Introduction

- **The present work identifies the main Qt features used in real applications and, based on that, creates an operational model, which provides a way to analyse and check properties related to those features.**

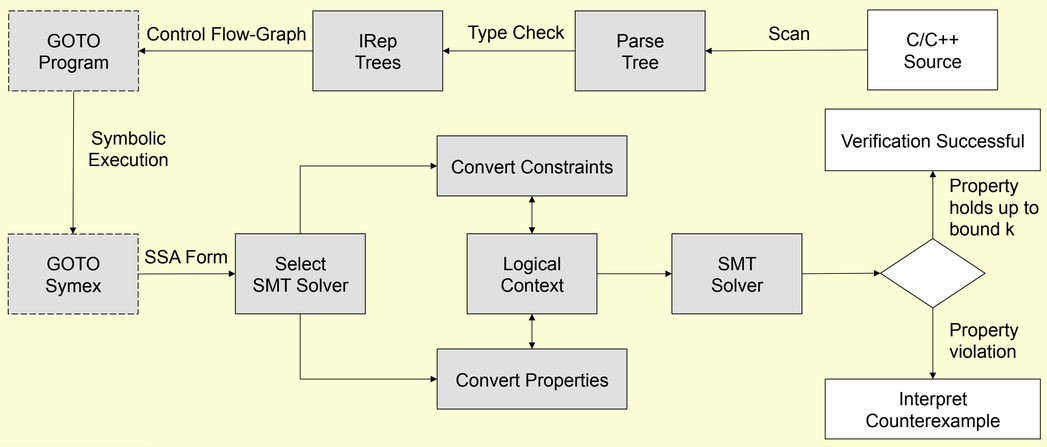
Bounded Model Checking



Translated into a VC ψ such that: ***ψ* is satisfiable iff *φ* has counterexample of max. depth *k***

ESBMC++

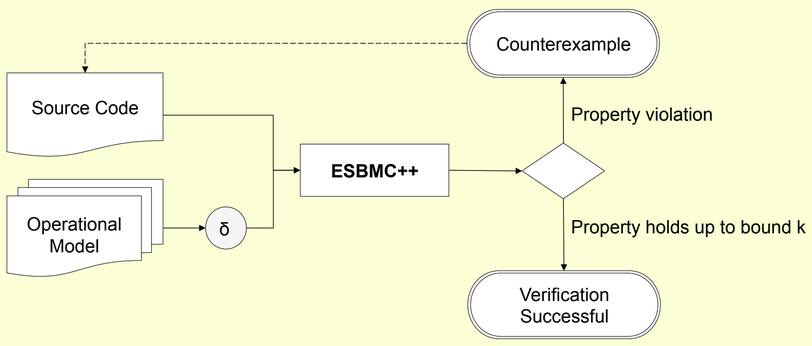
- **ESBMC++ is a bounded model checker based on SMT solvers, which is used for ANSI-C/C++ single- and multi-threaded programs. Properties checked:**
  - arithmetic under- and overflow, division by zero, out-of-bounds index, pointer safety, deadlocks, and data races, and assertions defined by user.



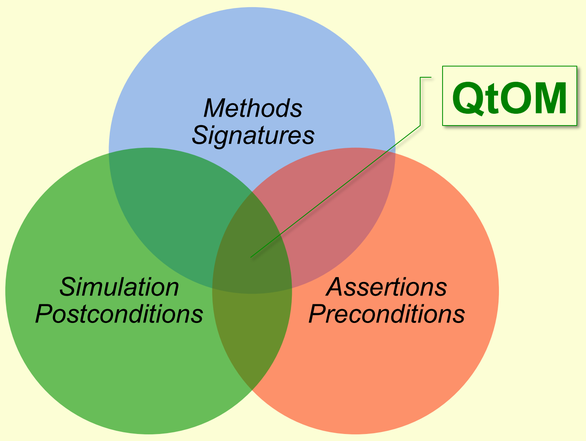
Proposal

Apply bounded model checking to verify C++/Qt programs

II. Verifying C++ Programs Based on the Qt Cross-Platform Framework



- **Based on the framework documentation, the operational model was developed (QtOM), which considers the structure of each library and its classes, including attributes, method signatures, and function prototypes.**



For further information, publications, and downloads, see:

http://www.esbmc.org/

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Pre-conditions

- **A condition that must be fulfilled before a function or method can be executed.**
  - Checked through assertions in the operational model;
  - When the a method/function is called, ESBMC++ interprets its behaviour as implemented in the operational model.

Post-conditions

- **An assertion that characterizes the state of the program immediately after execution of a certain function or method.**

- **One needs to simulate the behaviour of a certain method to consistently verify properties related to the manipulation or storage of values in a structure.**

Code Fragment

```
#include <QList>
#include <cassert>
...
int main ()
{
    ...
    QList<int> mylist;
    mylist.push_front(300);
    assert(mylist.front() == 300);
    mylist.push_front(200);
    assert(mylist.front() == 200);
    ...
}
```

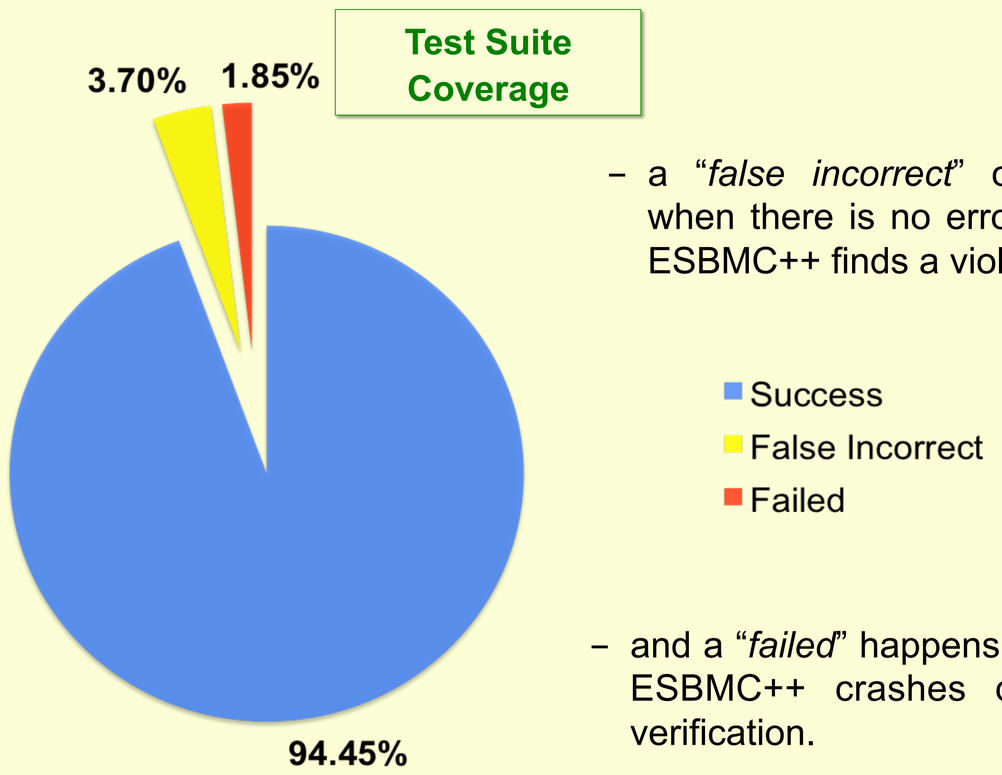
Operational Model

```
template<class T>
class QList {
    ...
    void push_front( const value_type& x ){
        if(this->_size != 0) {
            for(int i = this->_size -1; i > -1; i--)
                this->_list[i+1] = this->_list[i];
        }
        this->_list[0] = x;
        this->_size++;
    }
    T& front() {
        __ESBMC_assert(!isEmpty(),
                       ``The list must not be empty'');
        return this->_list[0];
    }
    ...
}
```

III. Experimental Evaluation

- **Currently, *esbmc-qt* test suite contains 52 benchmarks, which take about 48 seconds to be verified.**

Test Suite Coverage



- a "*false incorrect*" occurs when there is no error and ESBMC++ finds a violation.
- and a "*failed*" happens when ESBMC++ crashes during verification.

CONCLUSIONS

- **This paper proposes an approach to verify C++/Qt programs using an operational model.**
- **The experimental results show the efficiency of this approach for verifying Qt programs and present, for the developed test suite, a success rate of 94.45%.**
- **As future work, more classes and libraries will be integrated into the operational model, in order to increase Qt framework coverage and validate its properties.**