Applying CPAchecker to Large Explicit State Spaces

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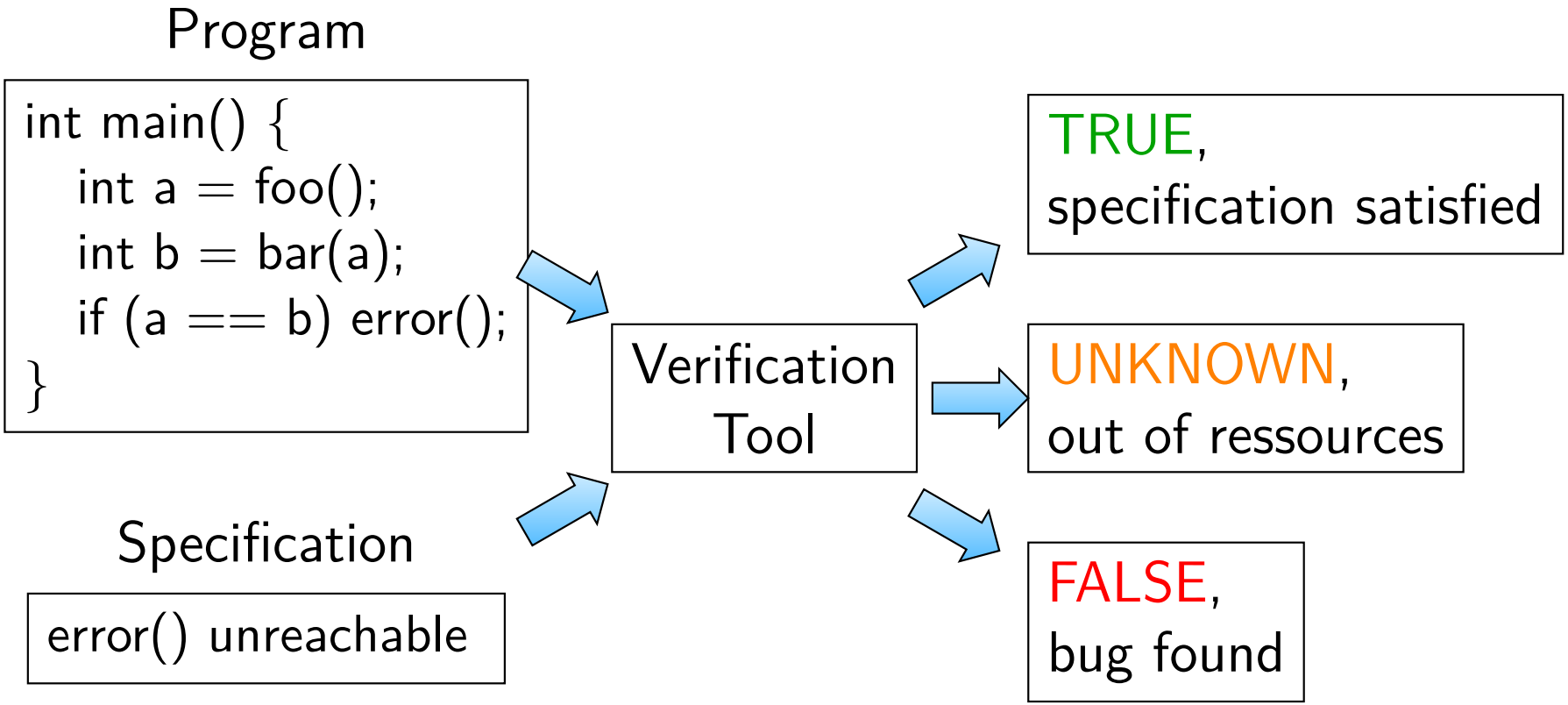
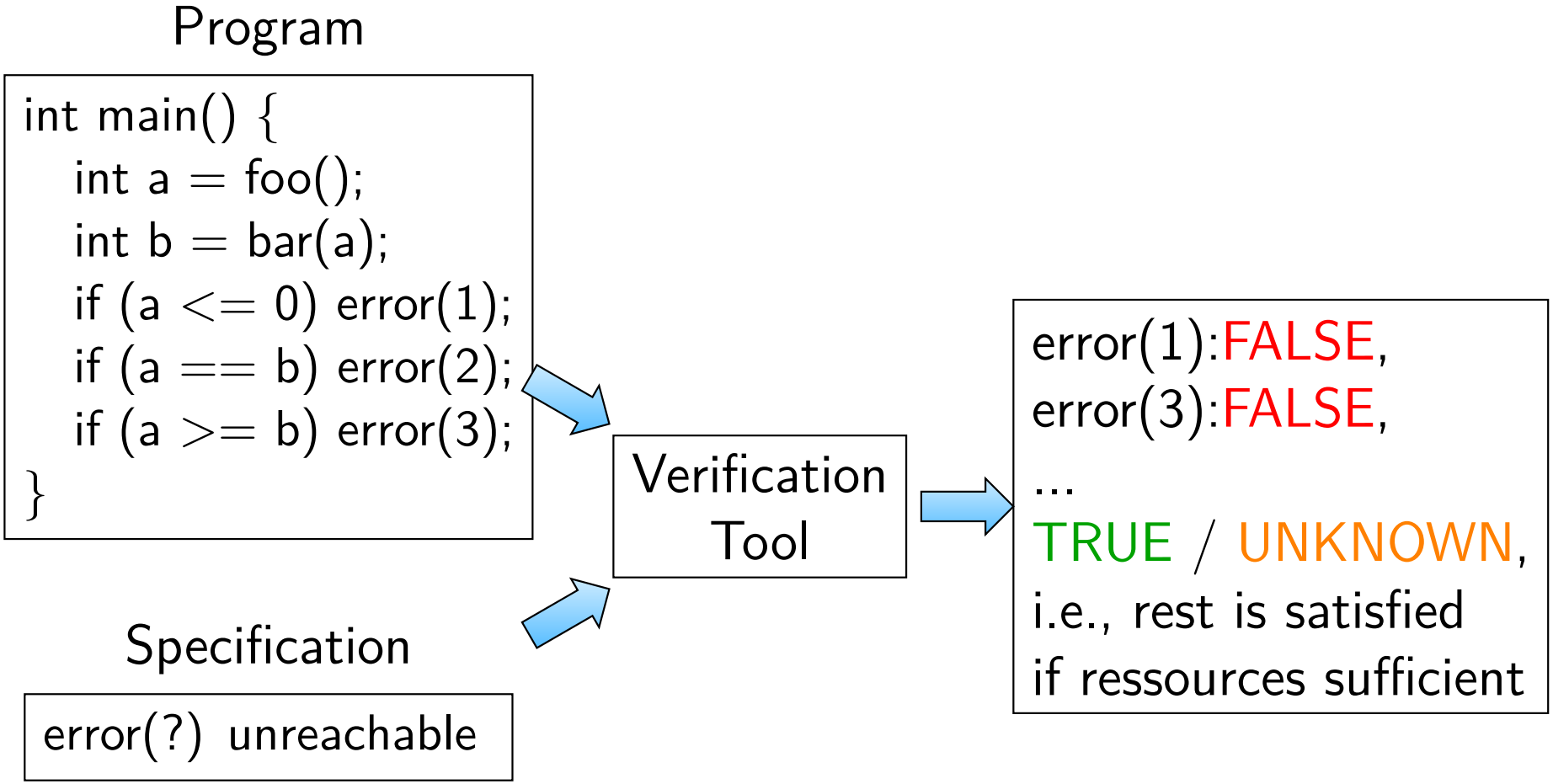
Nov 8, 2018, RERS, ISoLA

Single-Property Verification



Multi-Property Verification

Each RERS task contains 100 possible property violations
→ reduce repeated work by verifying all of them in one verification run



Configurations of CPAchecker for RERS'19

We tried the following approaches unsuccessfully:

- Precidate Analysis / BMC / kInduction [4]
  → large SMT formulas due to branching of control flow
  → non-linear arithmetic
- BDD analysis [1, 6]
  → non-linear arithmetic and pointers unsupported
- SMG analysis (for data-structures tasks) [7, 8]
  → very precise analysis for heap and stack memory
  → too expensive for large tasks
- BAM [9]
  → split task into blocks and analyze them separately
  → more overhead than benefit

Configurations of CPAchecker for RERS'19

Simple and most effective approach: Explicit-Value Analysis [5]

- Explicitly enumerate all reachable states
- Report all specification violations
- Simple specification automaton

Optimization:

- No CEGAR, full precision is needed anyway
- Large-block encoding to reduce memory consumption and runtime, i.e., only check for coverage at loopheads
- Combine with primitive pointer analysis

Specification for Optimized Explicit-Value Analysis

```
CONTROL AUTOMATON MultiErrors
INITIAL STATE Init;
STATE USEALL Init:
  MATCH {__VERIFIER_error($?)}
    -> PRINTONCE "$rawstatement in line $line"
       GOTO Init;
END AUTOMATON
```

- Based on Blast Query Language (SAS 2004, [2])
- Simply report all function calls of `__VERIFIER_error`
- Multi-property-verification:
  do not stop after first result, but explore whole state space

Environment and Results

- Intel i7-6700 CPU with 8 cores
- 25 GB RAM and 48 h CPU time for each of the nine tasks
- Small script converts CPAchecker output into RERS format

#	size	structure	# found violations	# proofs
10	small	plain	14	86
11		arithmetic	20	-
12		data structures	2	-
13	medium	plain	20	-
14		arithmetic	14	-
15		data structures	1	-
16	large	plain	37	-
17		arithmetic	26	-
18		data structures	2	-

Conclusion

- Very flexible specification language for automata
- No changes necessary to existing analyses and concepts

Future Work (until next year):

- Add SMT-based counterexample check
  to avoid false results from pointer analysis
- Add execution-based counterexample check [3]
- We need ClusterBAM!

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