Bridging Hardware and Software Analysis with Btor2C

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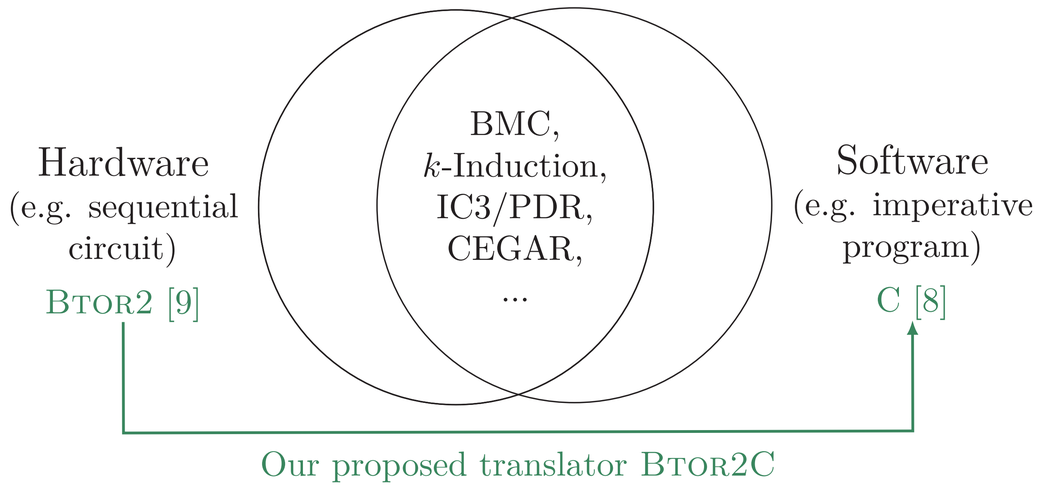
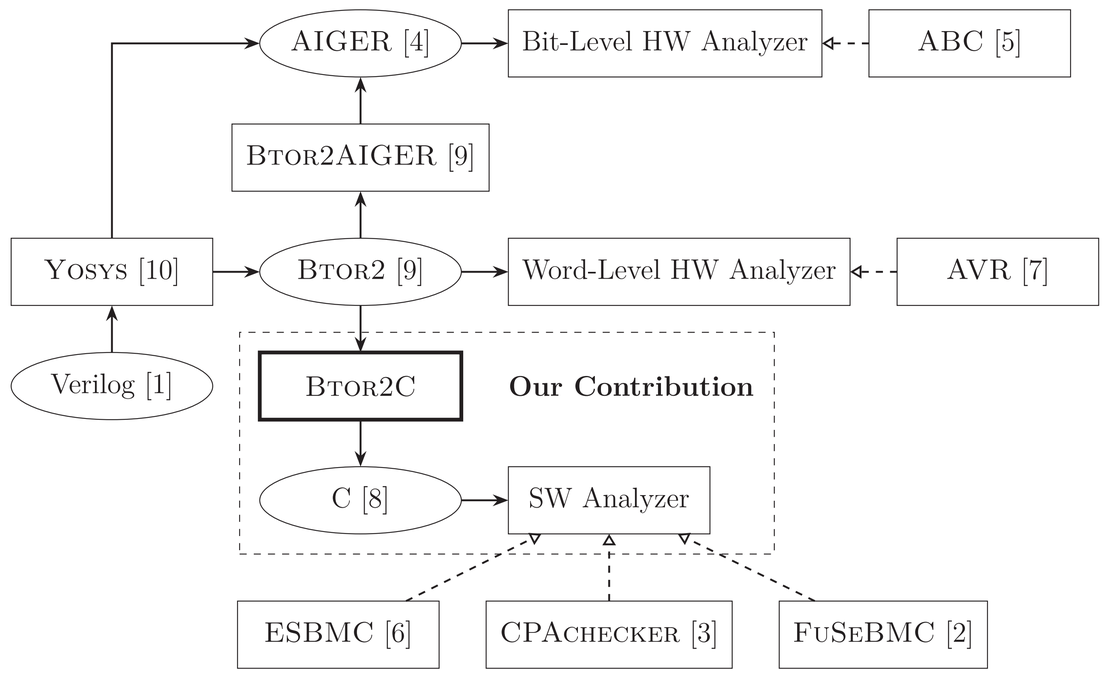
Attend our TACAS talk! 11:00 April 26 (Wednesday), Room: 44-45/108

Motivation

- Quality assurance is important for computational systems
- Common theoretical foundations are shared among different fields
- Analysis tools/algorithms are usually developed for a specific model
- Leveraging knowledge from one field to another is **difficult!**

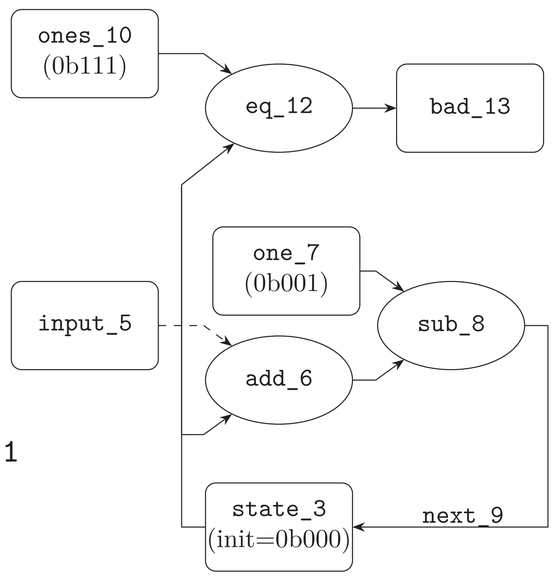


Analysis Tool Chain



Translating Btor2 to C

```
1 sort bitvec 3
2 zero 1
3 state 1
4 init 1 3 2
5 input 1
6 add 1 3 5
7 one 1
8 sub 1 6 7
9 next 1 3 8
10 ones 1
11 sort bitvec 1
12 eq 11 3 10
13 bad 12
```



(a) Example Btor2 circuit

- Each line represents a node and has a unique id
- A typical Btor2 operation is written as
  `<nid0> <op> <sid> <nid1> [<nid2 [nid3]>]`

Btor2	C
`sort bitvec`	unsigned integers
`sort array`	2D static array
`input`	non-deterministic function
`bad`	if guard w/ an `ERROR` label
`a add x b c`	`var_a = var_b + var_c;`
`a and x b c`	`var_a = var_b & var_c;`
`a ite x b c d`	`var_a = var_b ? var_c : var_d;`
`a concat x b c`	`var_a = var_b << N | var_c;` (`N` is the bit-width of `var_c`)
`a udiv x b c`	`var_a = (var_c == 0) ? MAX_X : (var_b / var_c);` (`MAX_X` is the max value of `SORT_x`)

(b) Model Btor2 constructs with C

```c
void main() {
  // Define sorts
  typedef unsigned char SORT_1;
  typedef unsigned char SORT_11;
  // Initialize states
  SORT_1 state_3 = 0b000;
  for (;;) { // model circuit behavior
    // Evaluate safety properties
    SORT_1 input_5 = nondet_uchar();
    SORT_11 var_12 = state_3 == 0b111;
    SORT_11 bad_13 = var_12;
    if (bad_13) { ERROR: abort(); }
    // Compute and assign next states
    SORT_1 var_6 = state_3 + input_5;
    SORT_1 var_8 = var_6 - 0b001;
    var_8 = var_8 & 0b111;
    state_3 = var_8;
  }
}
```

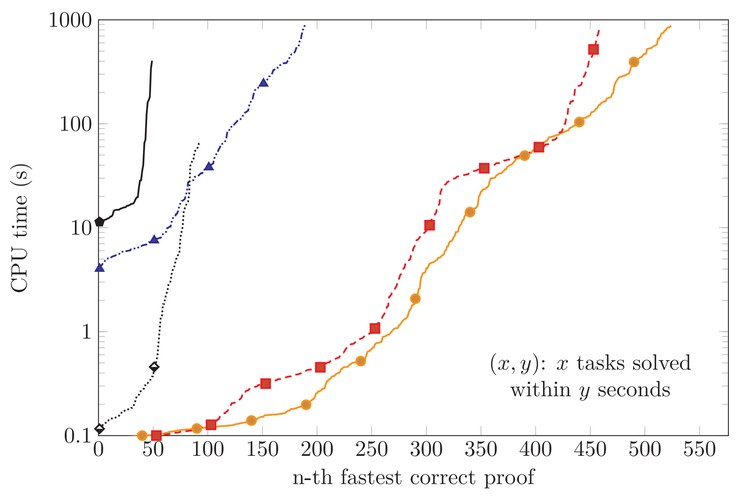
(c) Translated C program

Try Btor2C!

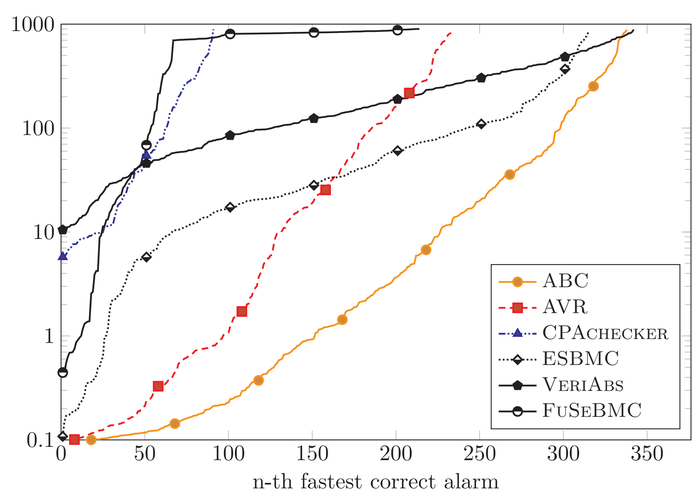
- Btor2C is a lightweight tool written in C
- Open-source under Apache 2.0 License

gitlab.com/sosy-lab/software/btor2c

Software vs. Hardware Analyzers on HWMCC Tasks



(d) Correct Proofs



(e) Correct Alarms

Summary

- Btor2C: a translator from word-level Btor2 sequential circuits to C programs
- **43** HW-verification tasks were uniquely solved by SW analyzers in our evaluation
- With Btor2C, we can
  - verify HW designs with off-the-shelf SW analyzers, and
  - improve quality assurance for HW systems
- In the future, we plan to bridge the gap from the other direction, i.e., translate SW programs into HW circuits.

References

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