Domain-Independent Multi-threaded Software Model Checking

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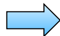
Software Verification

C Program

```
int main() {
   int a = foo();
   int b = bar(a);

   assert(a == b);
}
```

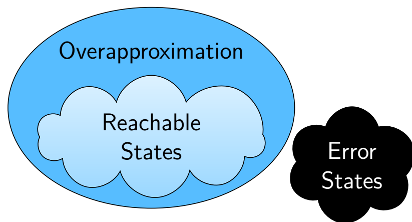


Verification Tool

TRUE
i.e., specification is satisfied

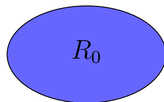
FALSE
i.e., bug found

General method:
Create an overapproximation of the program states / compute program invariants



Software Verification by Model Checking
[Clarke/Emerson, Sifakis 1981]

Iterative fixpoint successor computation



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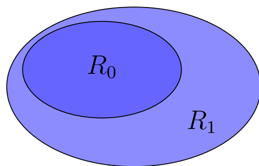

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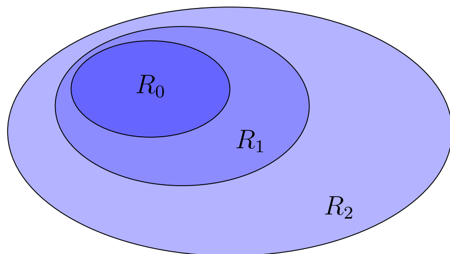

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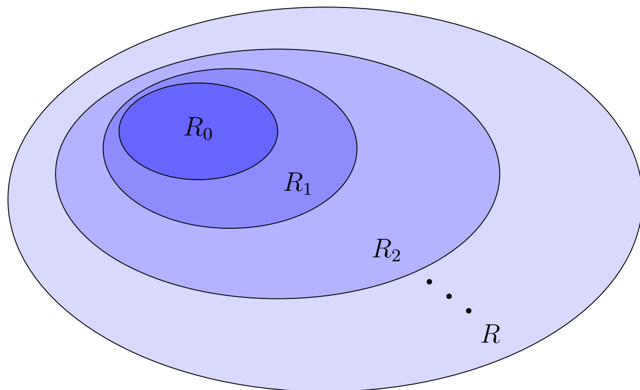
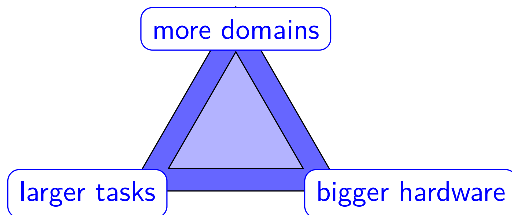


Basic Challenges with Software Verification



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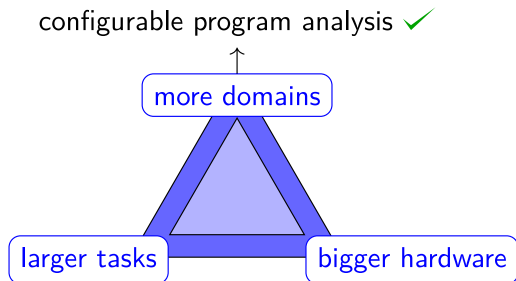

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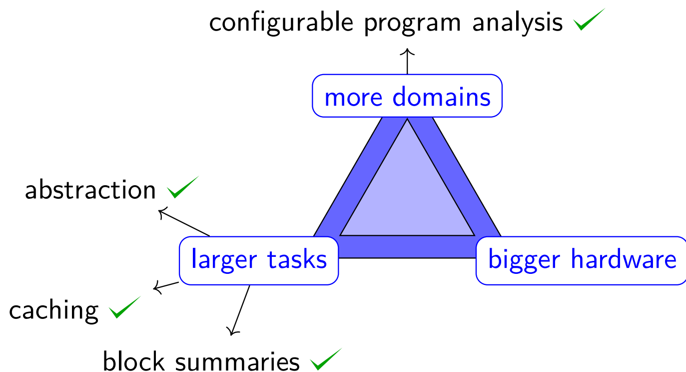

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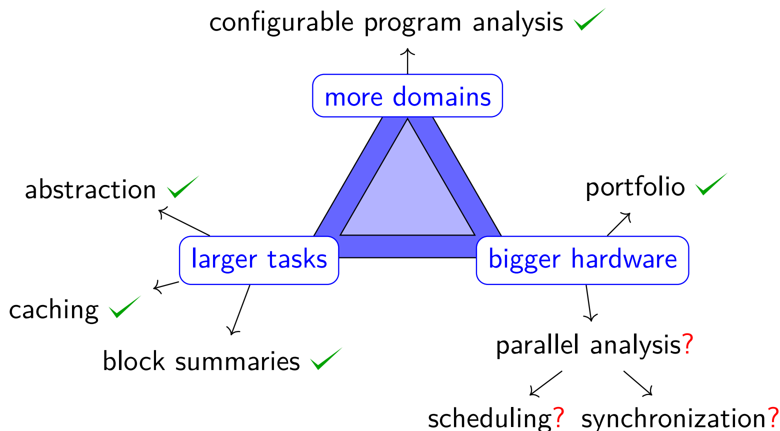

Configurable Program Analysis (CPA)
[Beyer/Henzinger/Théoduloz, 2007]

- CPA algorithm computes a fixed-point based on two sets of abstract states
  - *reached*: already analyzed abstract states
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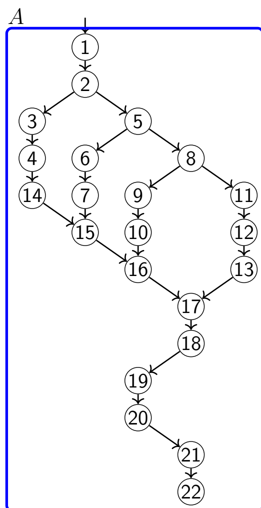
Schematic Example of an Analysis



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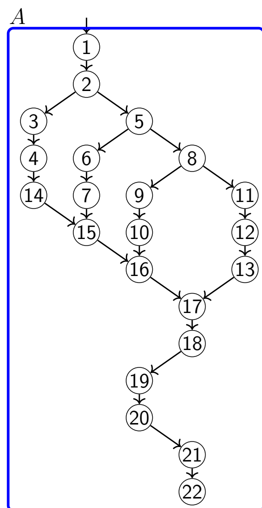
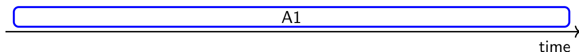


plain analysis



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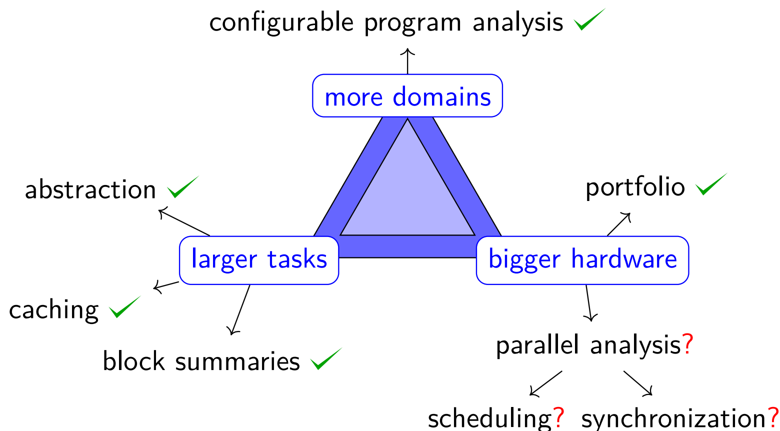

Block Summarization

- Block-abstraction memoization (BAM) defined as CPA [Wonisch/Wehrheim, 2012]
- Split large verification task into smaller problems and solve them separately
- Use CPA algorithm for a domain-specific analysis
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✓ Configurable block size

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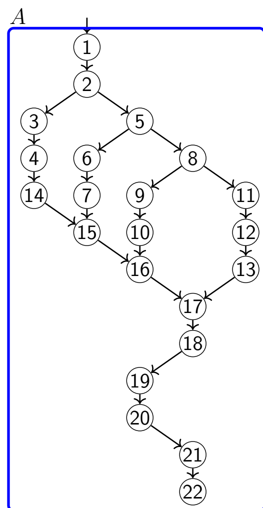

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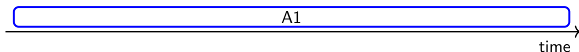

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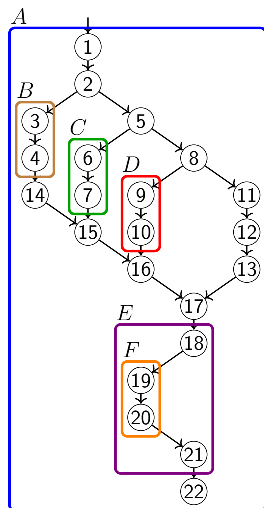

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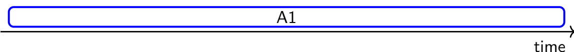

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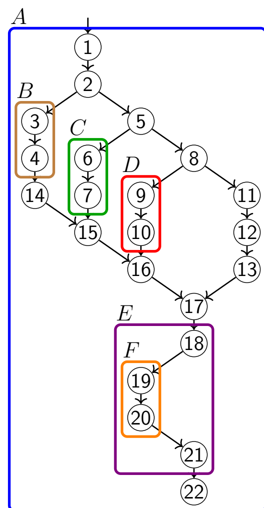

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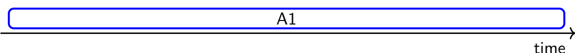
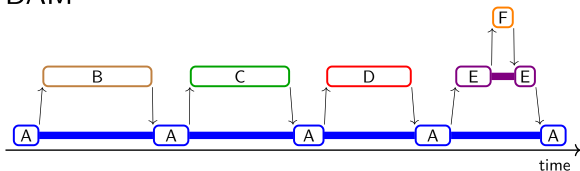


BAM



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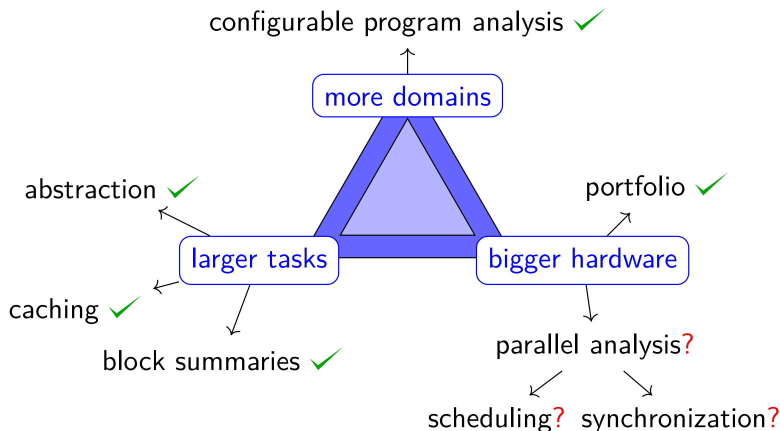

Parallel Block-Abstraction Memoization

Challenges with an efficient parallel algorithm:

- X CPA operators strictly sequential (per analysis!)
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- Lazy application of computed block abstractions
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- ✓ Combines benefits of existing approaches
- ✓ Small synchronization overhead (depends on block size)

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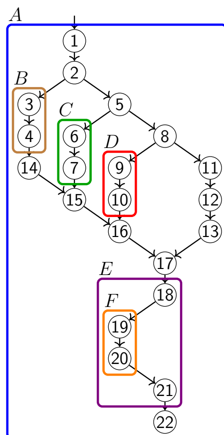

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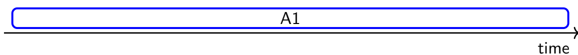

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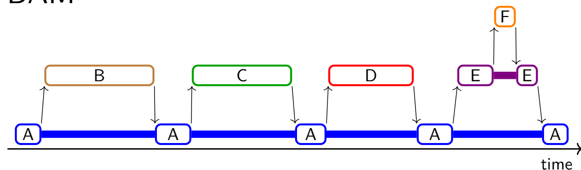

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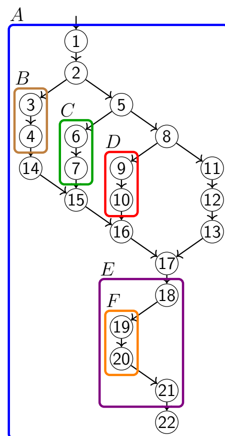

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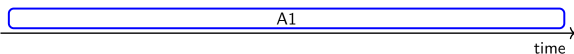

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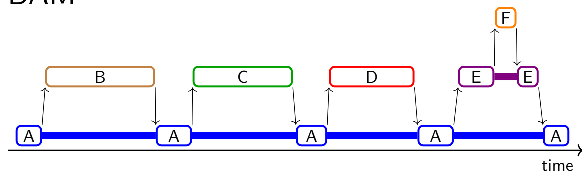

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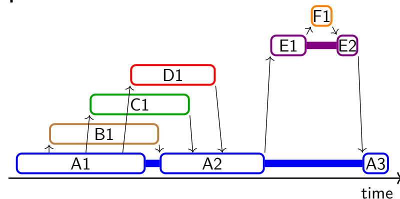

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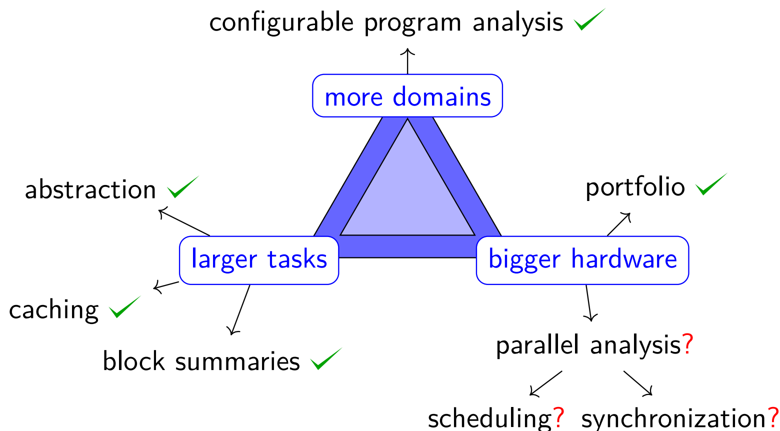
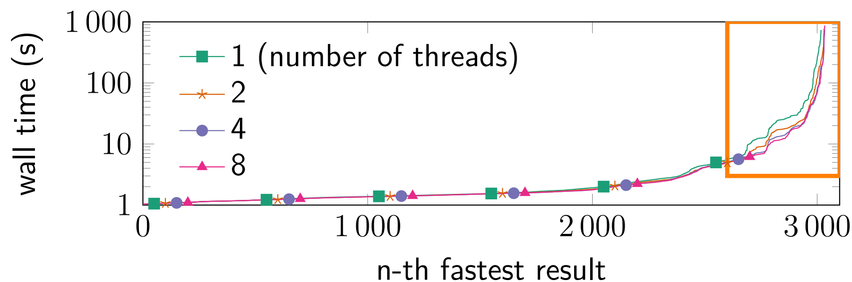


Evaluation

- Configuration
  - CPAchecker `r28809`
  - Explicit Value Domain
- Environment
  - Intel Xeon E3-1230 v5 CPU with 4 physical cores
  - 5400 tasks from SV-COMP benchmark set
- Limitations
  - 15 GB RAM
  - 15 minutes

Evaluation



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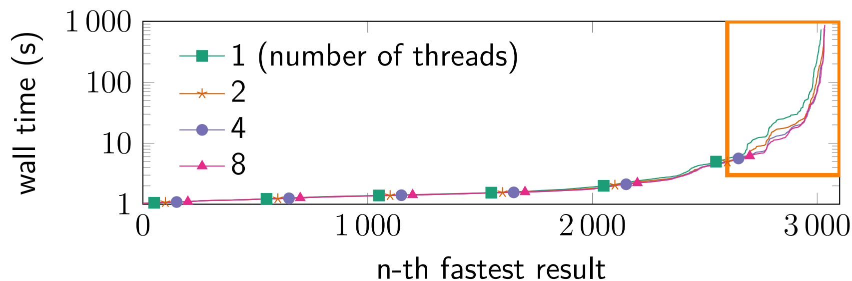

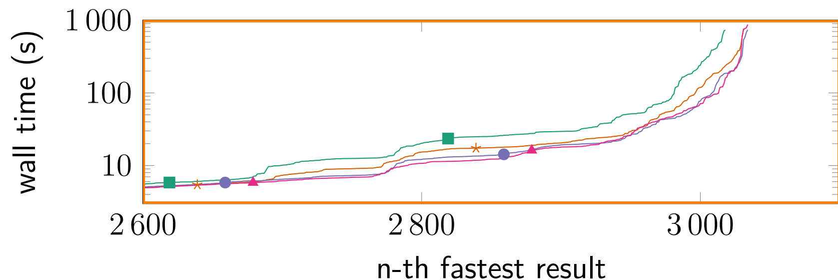

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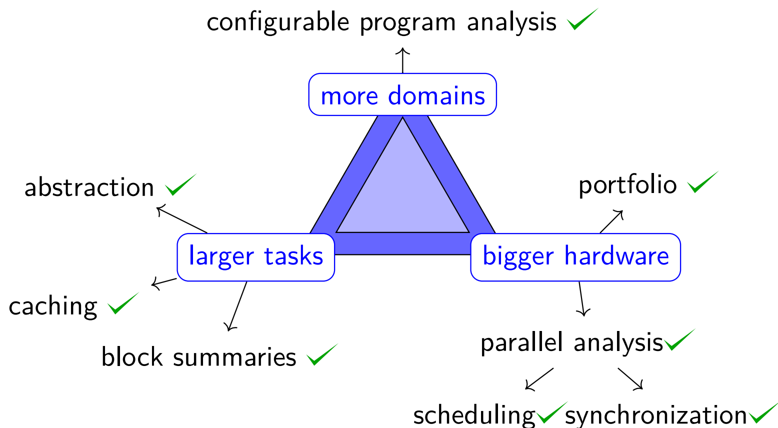


Conclusion

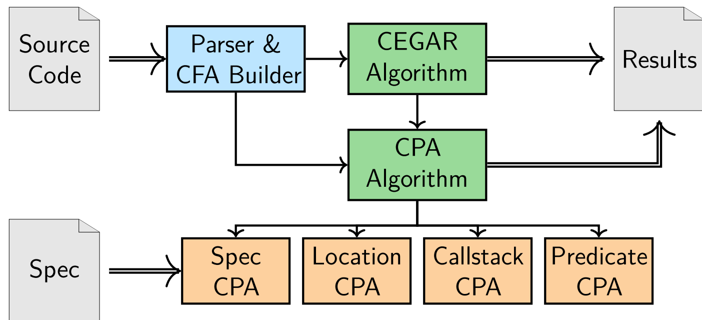
- Configurable program analysis
- Configurable block size
- Small overhead for synchronization in parallel analysis
- Elegant integration into the framework CPAchecker
- No changes necessary to existing analyses and components
  - CEGAR, proof and counterexample witnesses

Future work

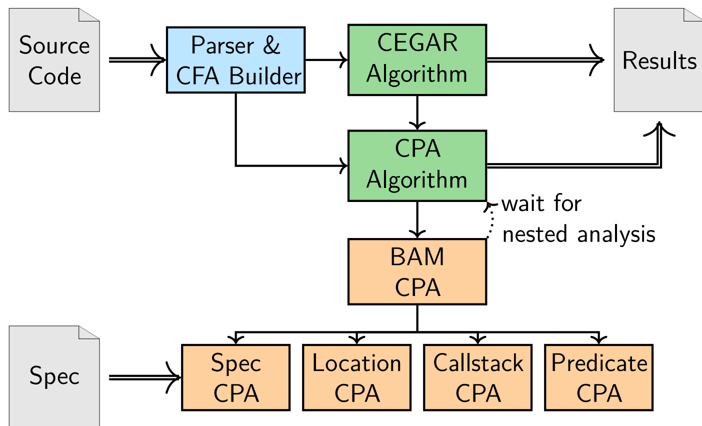
- Scheduling: Prefer parts deeper in the program?
- Processes instead of threads
  - Cluster instead multi-core machine

Questions?

CPAchecker Framework



BAM in CPACHECKER



Parallel BAM in CPAchecker