Context-Bounded Model Checking with ESBMC 1.17

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ESBMC: SMT-based BMC of single- and multi-threaded software

- exploits SMT solvers and its background theories to:
  - provide optimized encodings for pointers, bit operations, unions and arithmetic over- and underflow
  - efficient search methods (non-chronological backtracking, conflict clauses learning)
- supports verifying multi-threaded software that uses pthreads threading library
  - interleaves only at “visible” instructions
  - *lazy exploration* of the reachability tree
  - optional context-bound
- derived from CBMC

Lazy exploration of the Reachability Tree

Idea: iteratively generate all possible interleavings and call the BMC procedure on each interleaving

... combines

- **symbolic** model checking: on each individual interleaving
- **explicit state** model checking: explore all interleavings

Lazy exploration of the Reachability Tree

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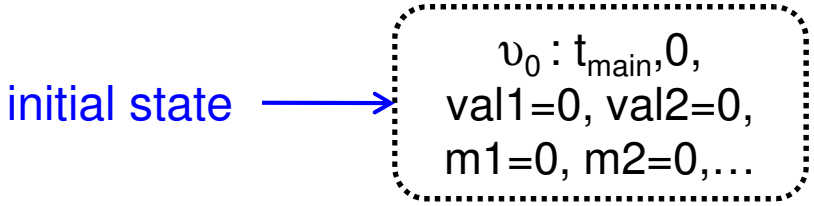

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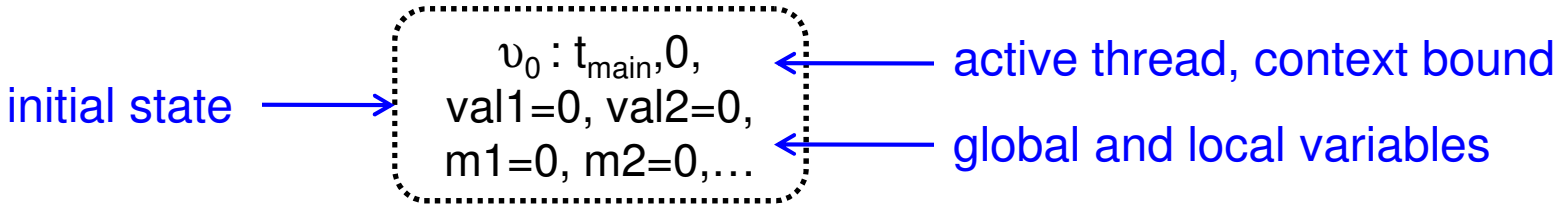

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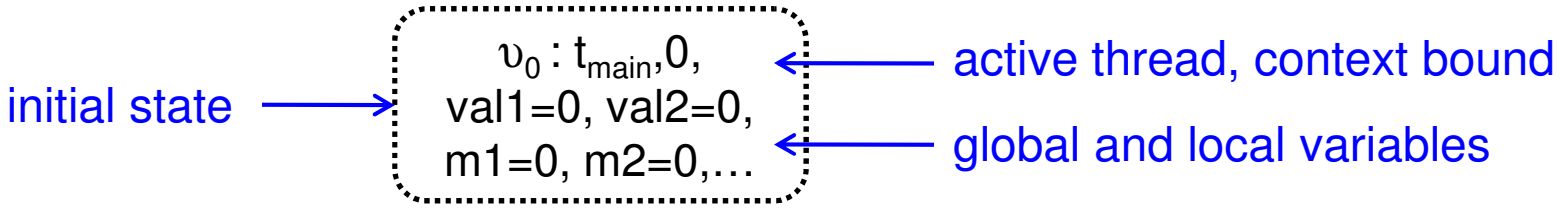
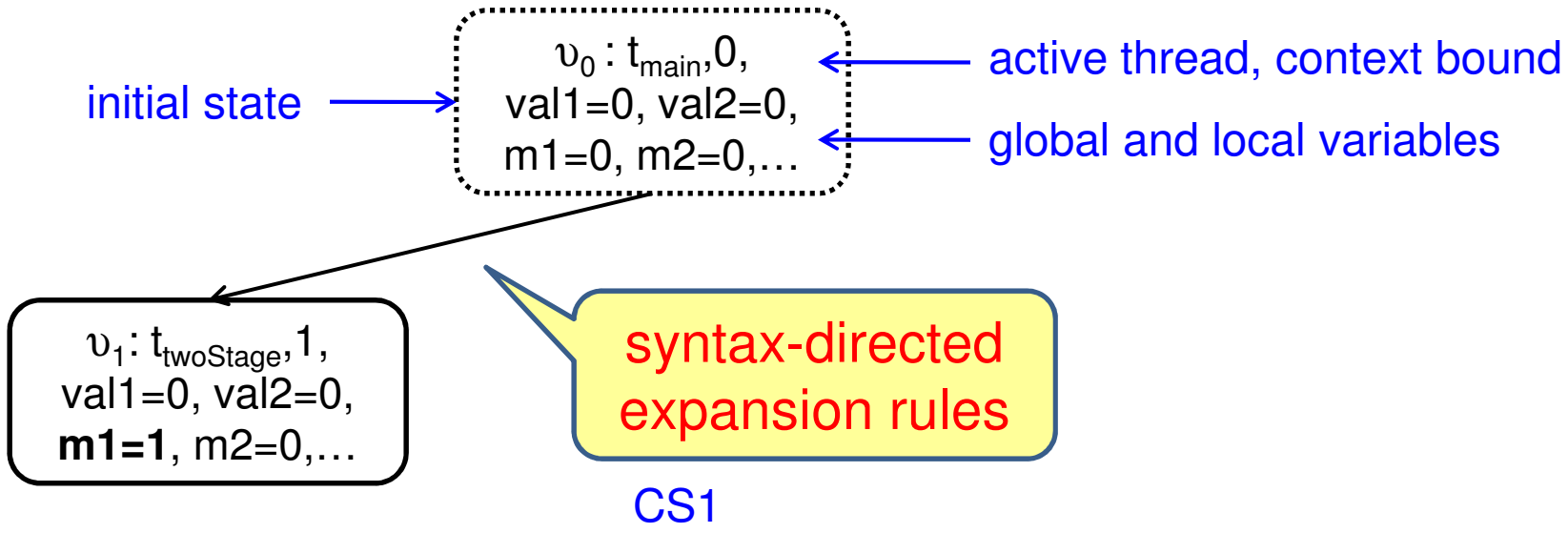


CS1

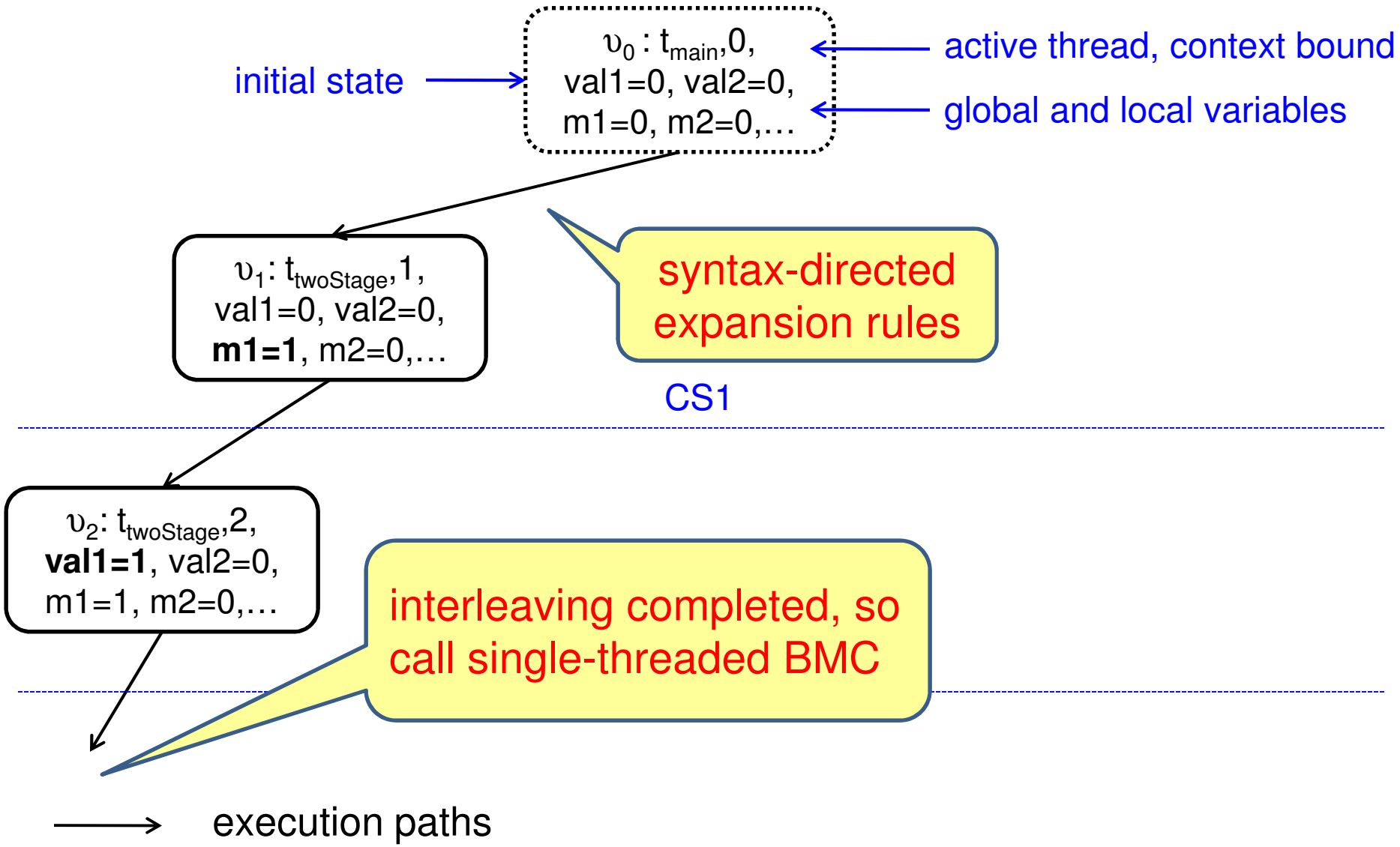
CS2

Lazy exploration of the Reachability Tree



⟶ execution paths

Lazy exploration of the Reachability Tree



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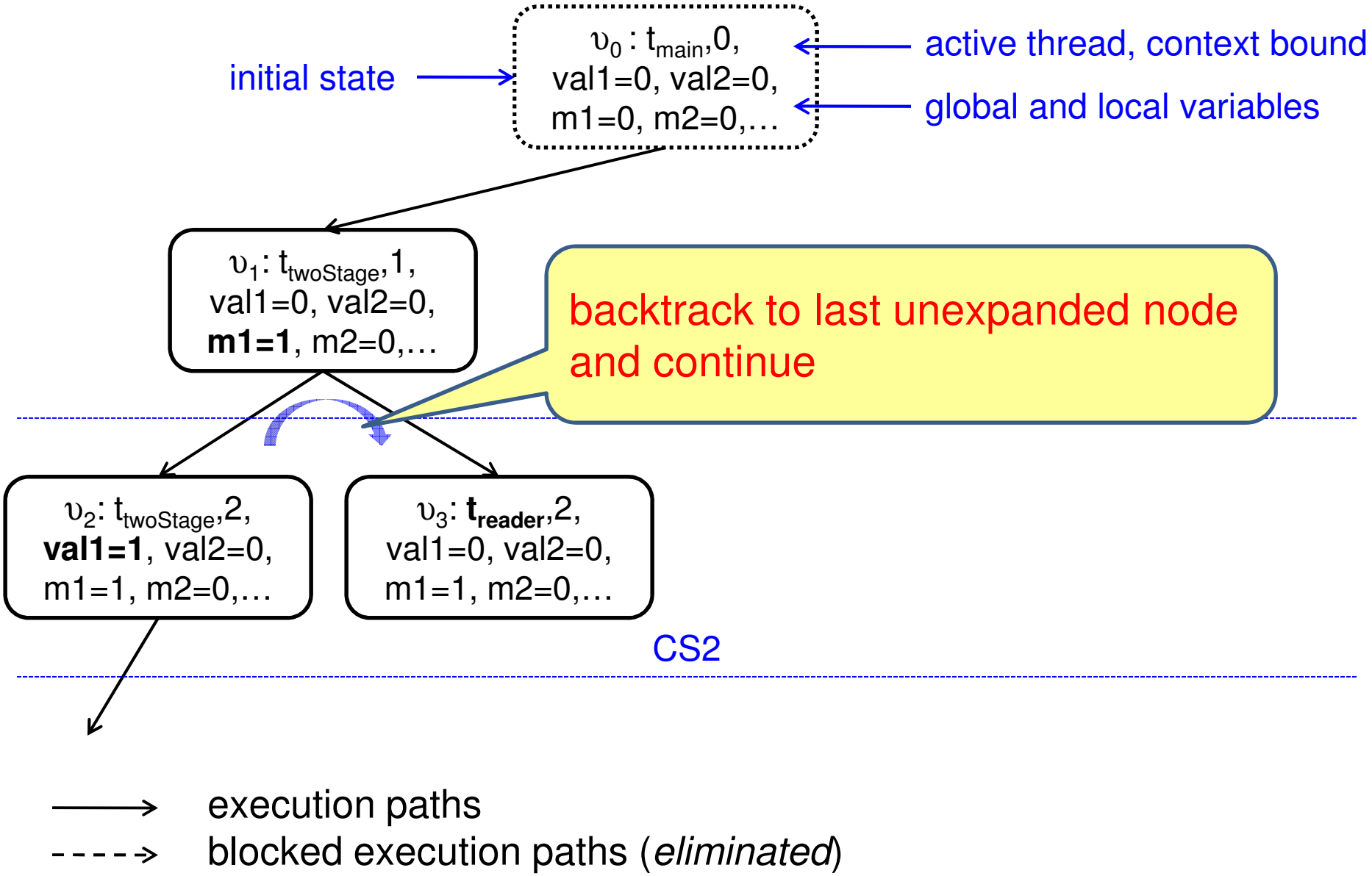

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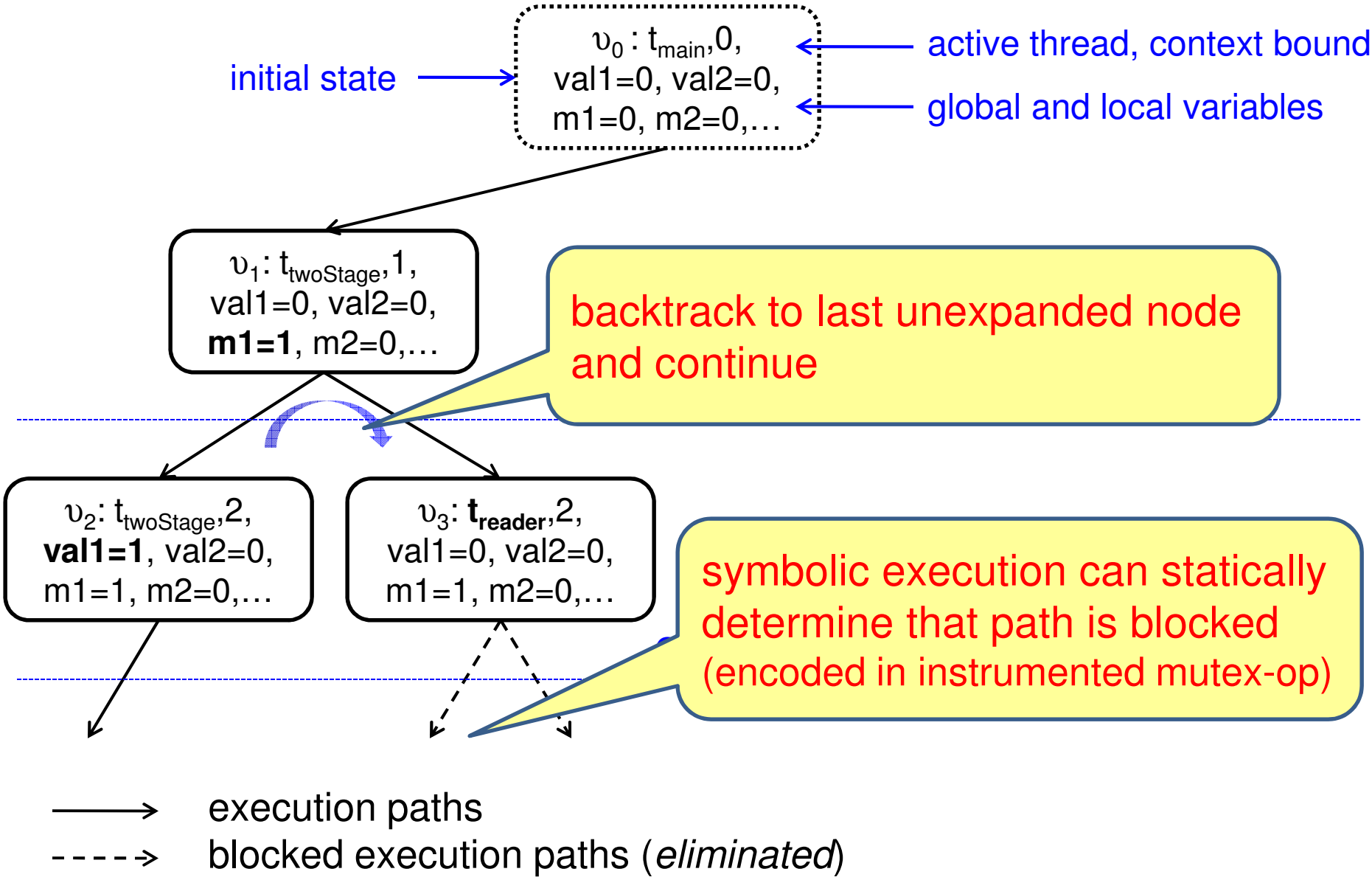

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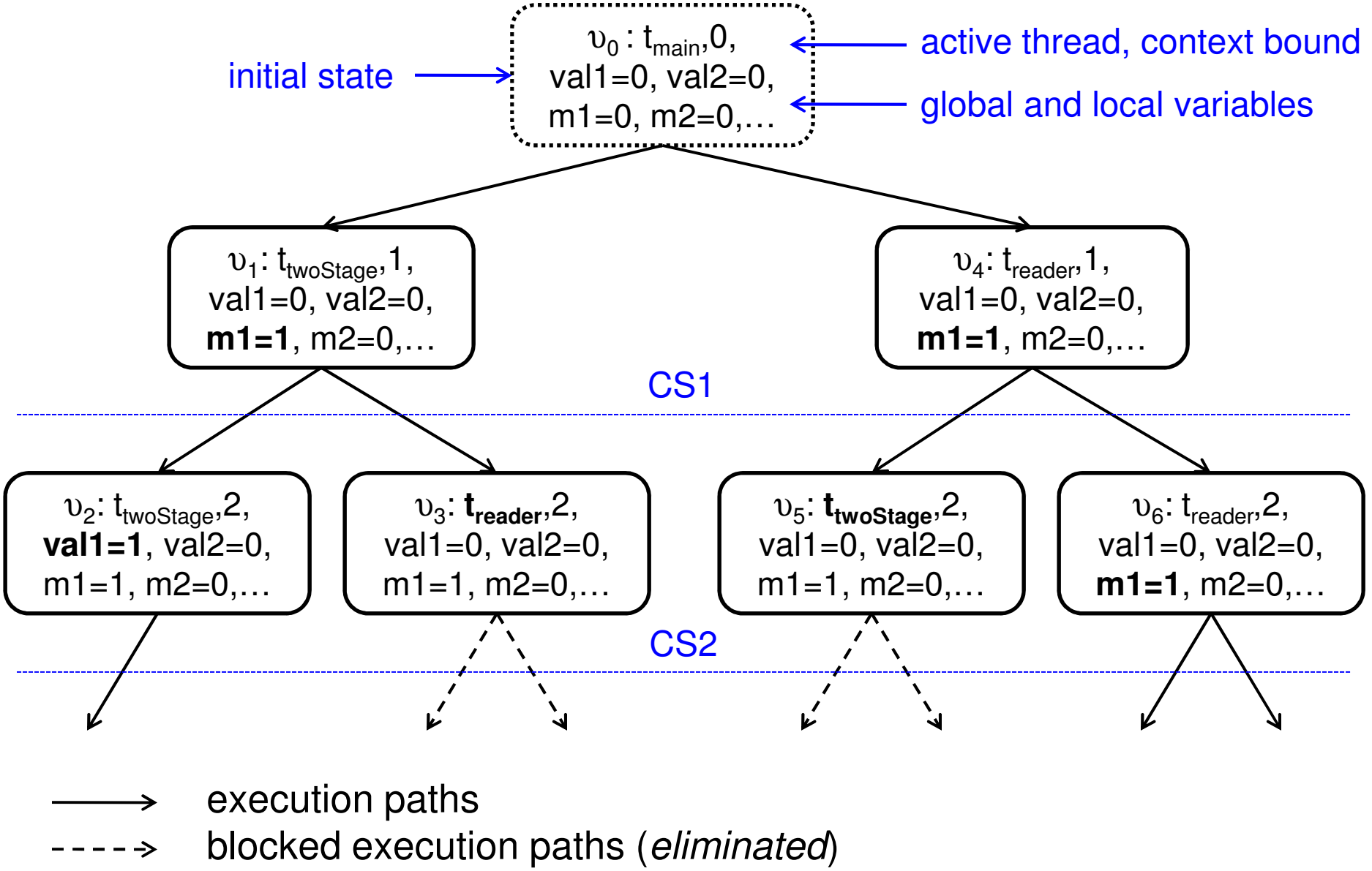
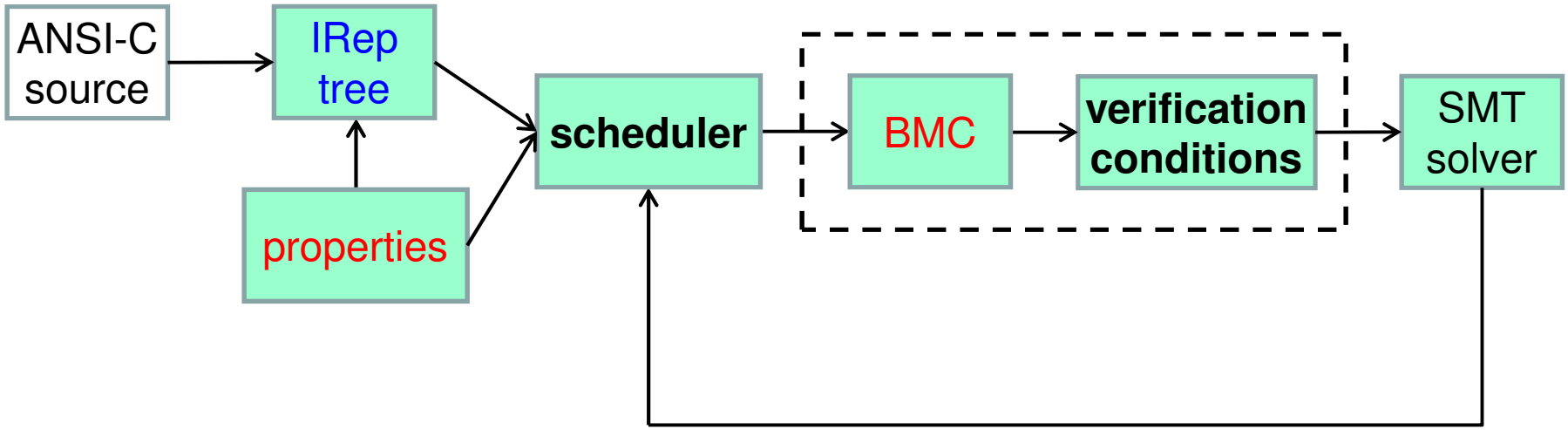


ESBMC Verification Support

- built-in properties:
  - arithmetic under- and overflow
  - pointer safety
  - array bounds
  - division by zero
  - memory leaks
  - atomicity and order violations
  - deadlock
  - data race
- user-specified assertions *(__ESBMC_assume, __ESBMC_assert)*
- built-in scheduling functions *(__ESBMC_atomic_begin, __ESBMC_atomic_end, __ESBMC_yield)*

ESBMC Architecture



reused/extended from CBMC

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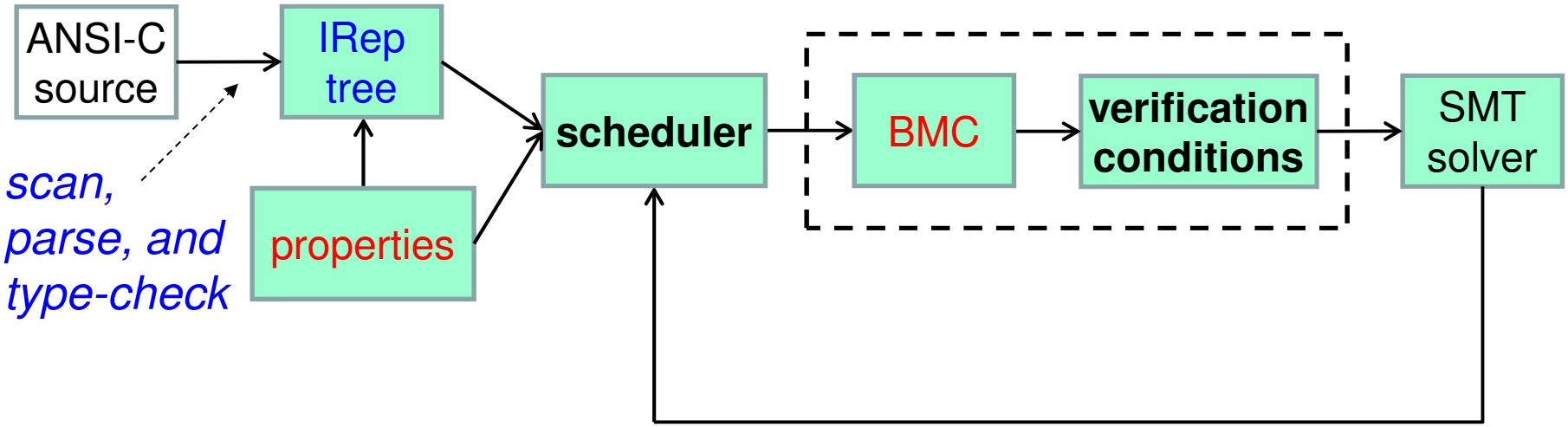

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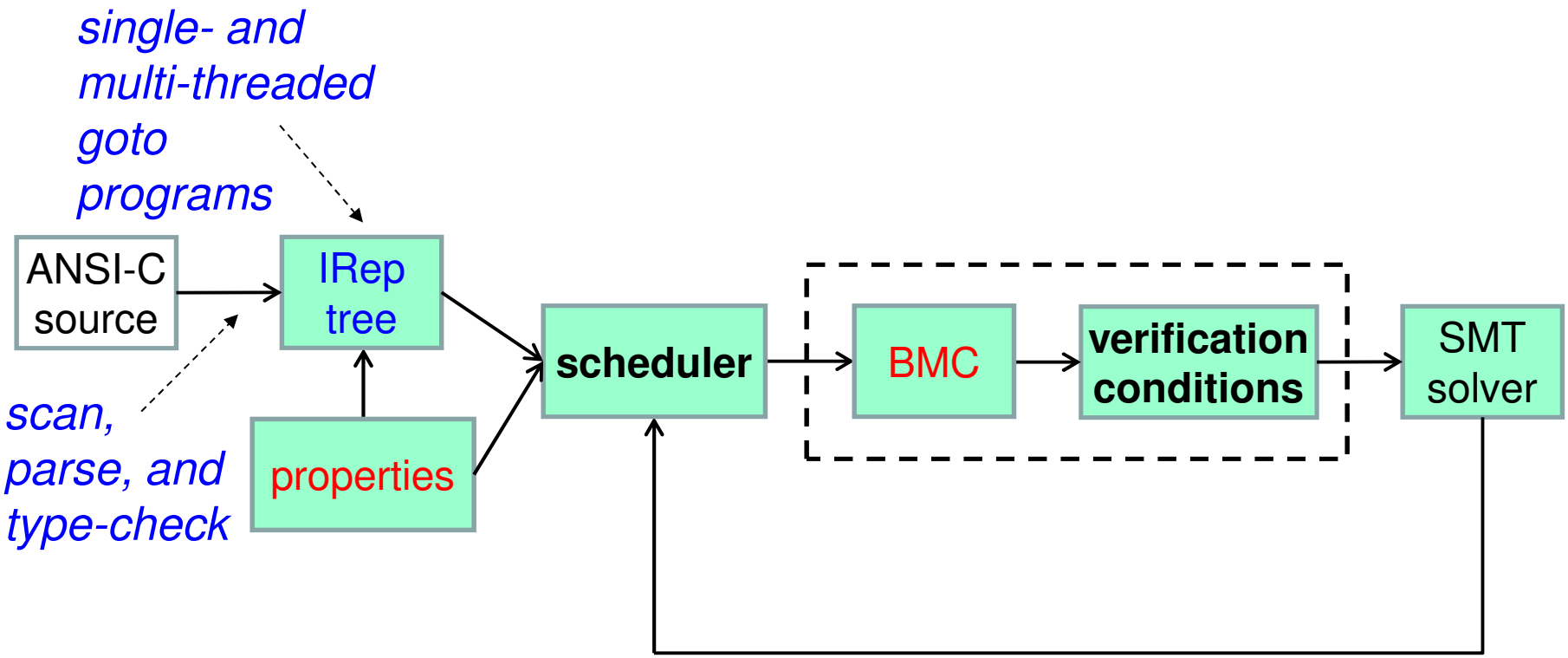

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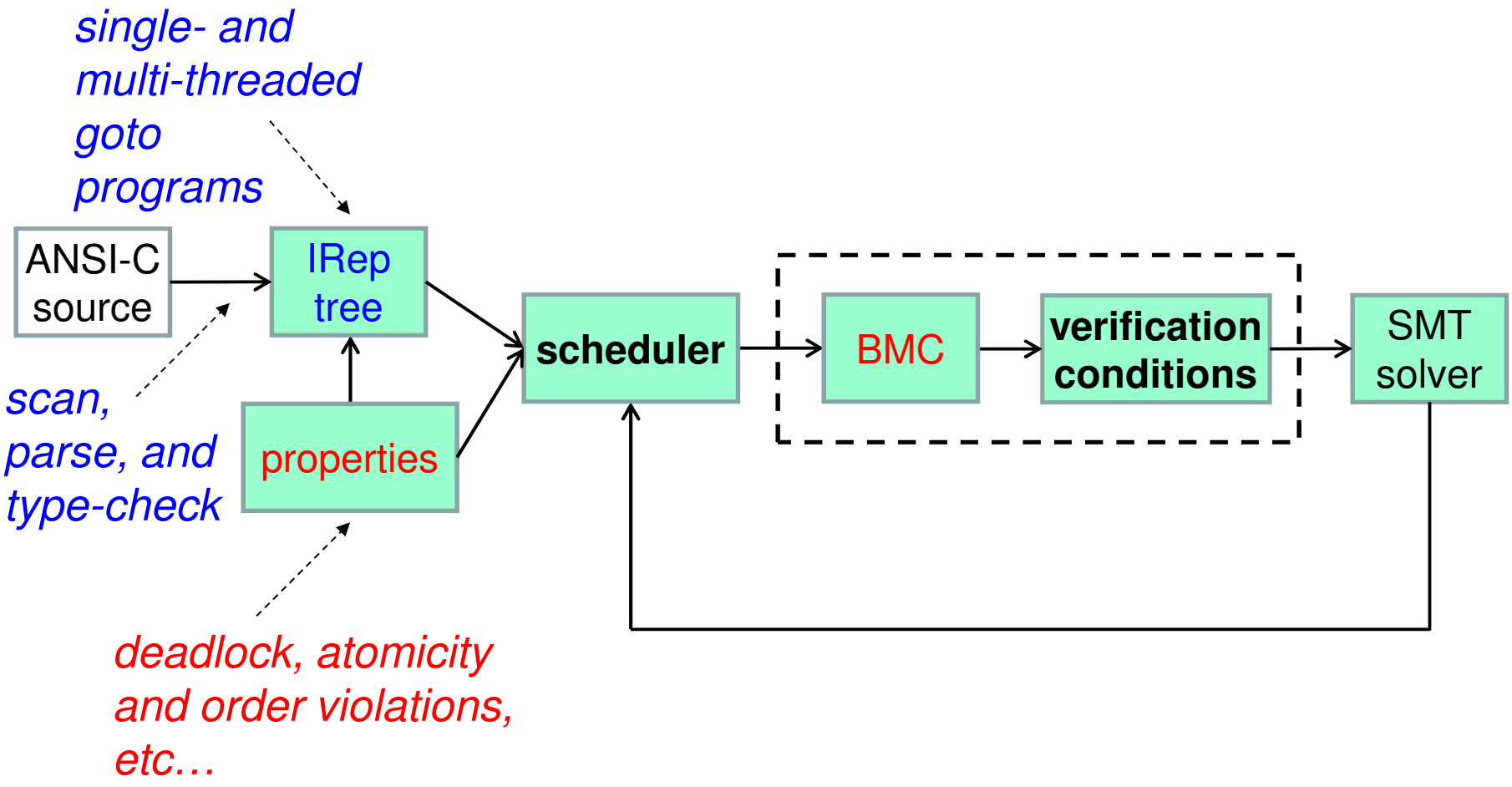

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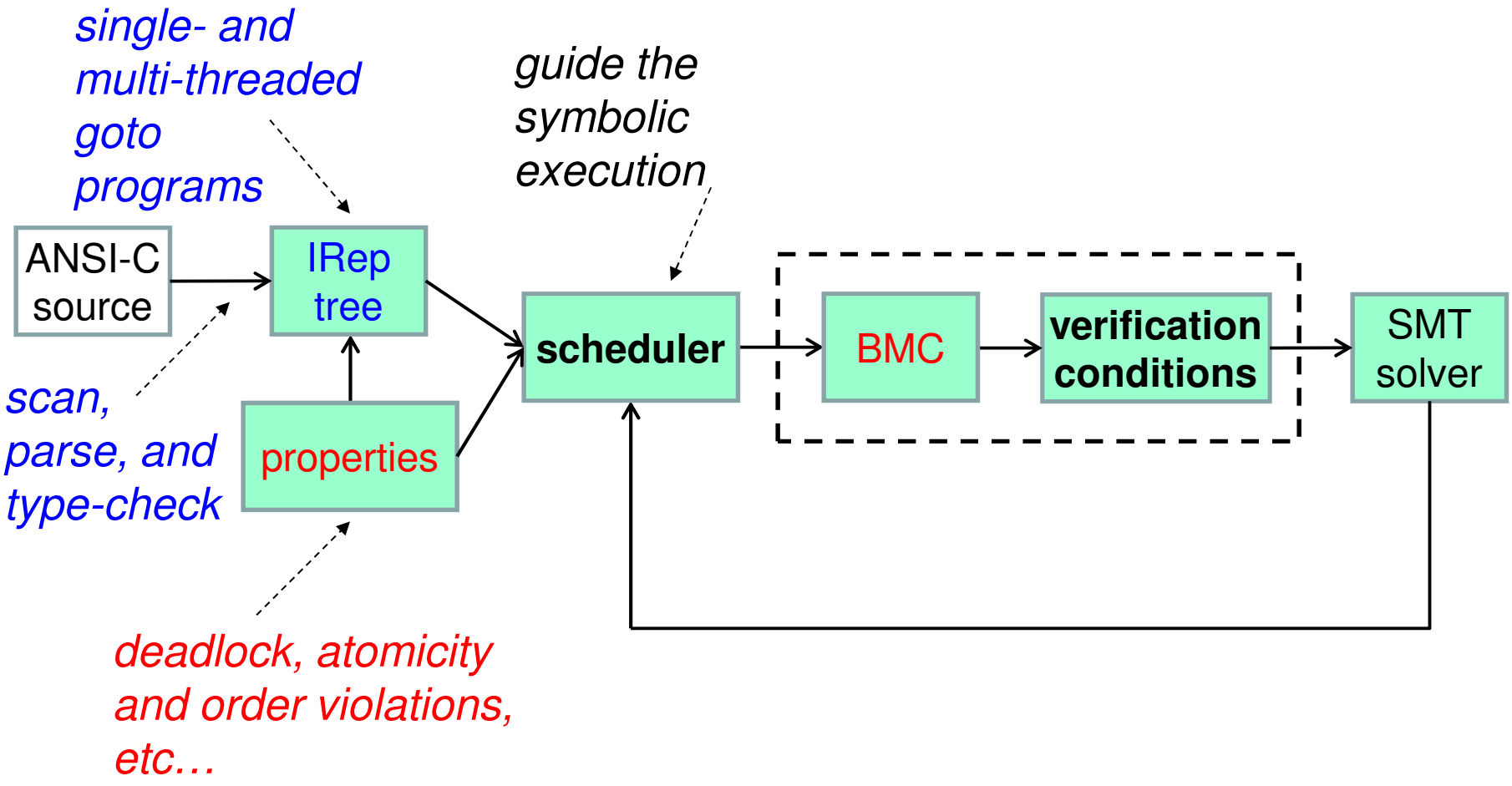

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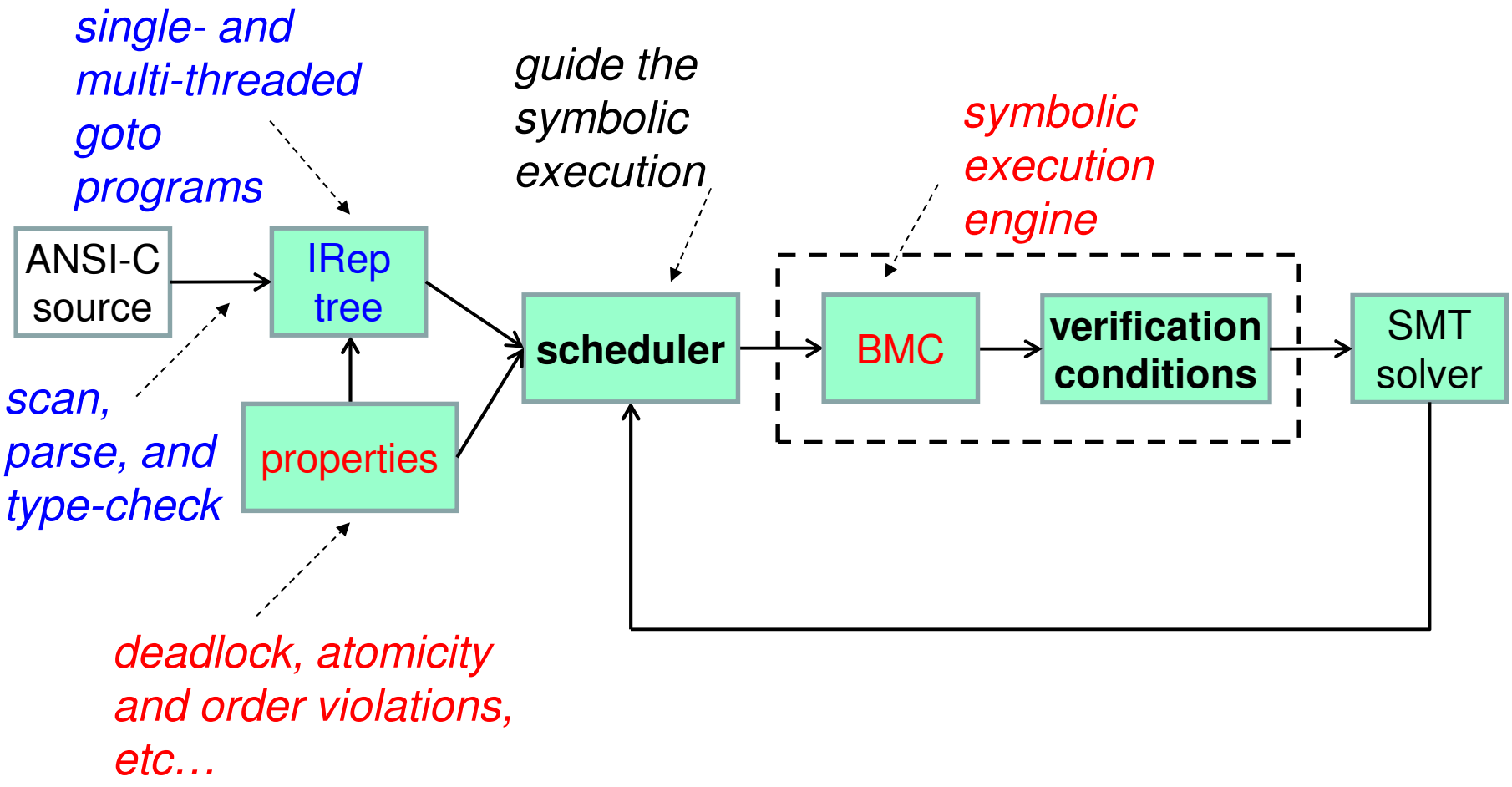

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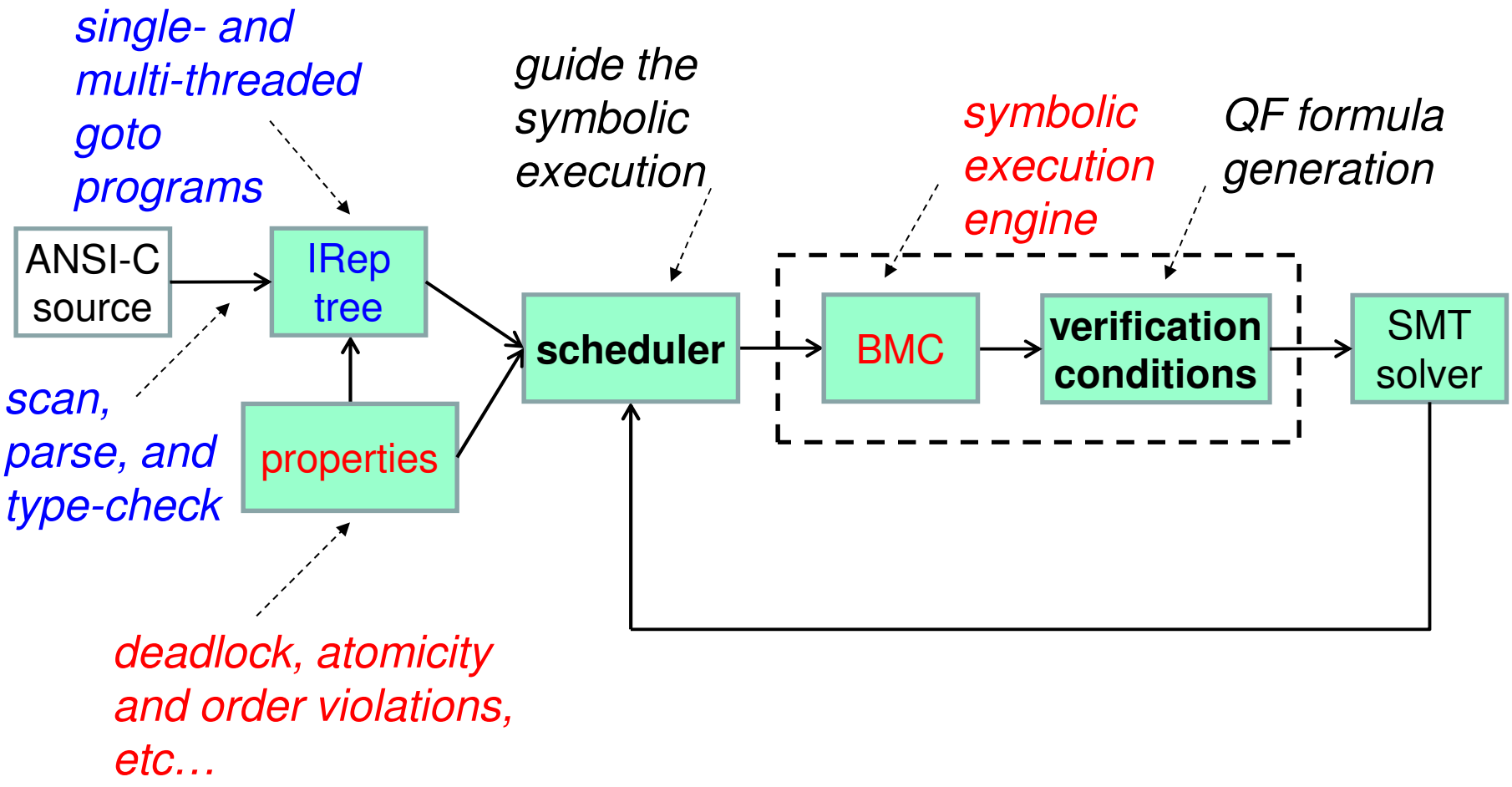

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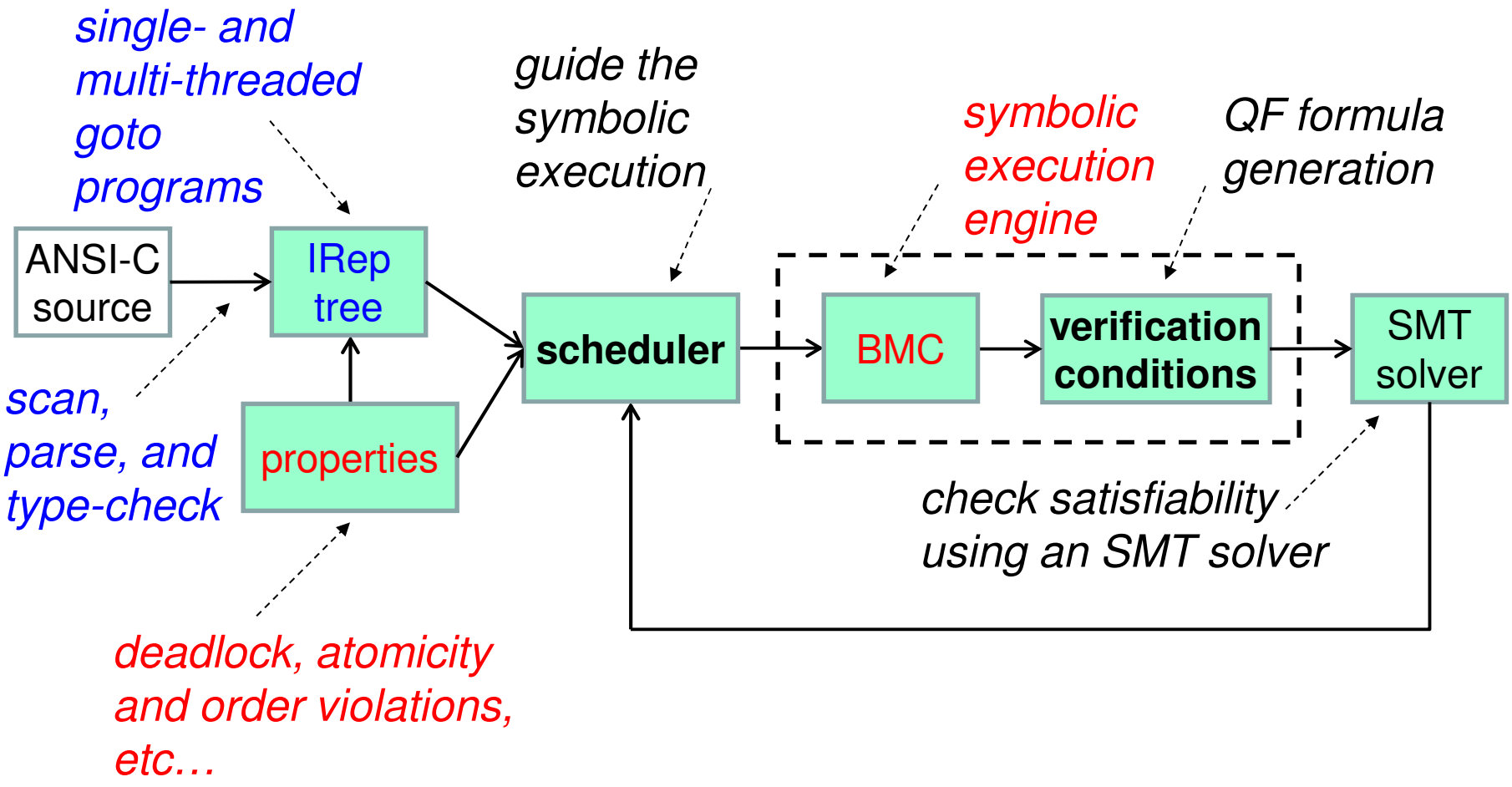

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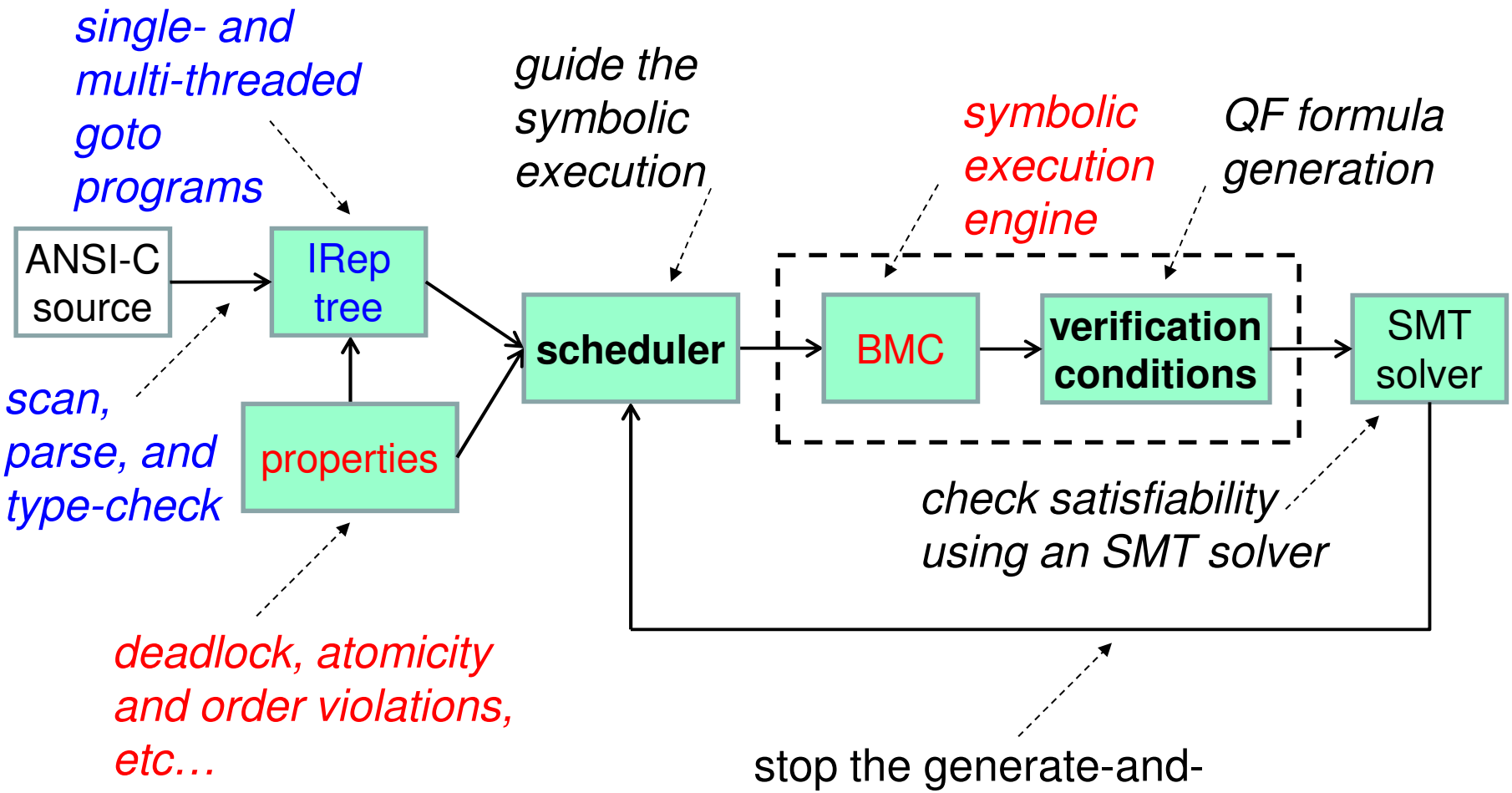

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Weaknesses:

- scalability (like other BMCs...)
  - loop unrolling
  - interleavings
- pointer handling and points-to analysis
  - exposed by excessive typecasts in the CIL-converted code
  - better memory model in progress