Sbuilder Benchmarks

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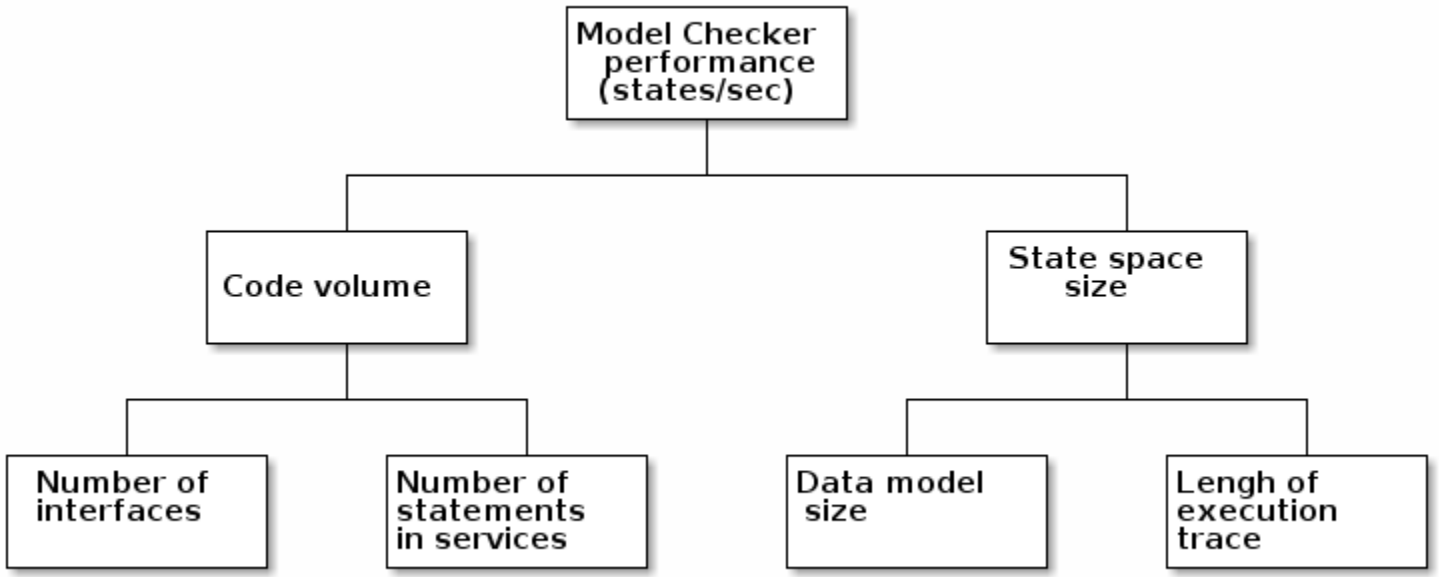
Time to Run TLA+tools Model Checker

- State space size (states) / Model Checker Performance (states/sec)
- These benchmarks focus in "performance", for "state space size" refer to Heuristics Used in Creating Runnable Formal Models
- Scale Model Checker Performance (conclusions spoiler :)
  - model check large application in chunks
  - use more workers in model checker (interface binding)
  - run model checker on distributed hardware (AWS)
- Performance (states/sec) influenced by code volume and state space:



Benchmark application & Benchmark Parameters

CONTRACT:

- add interface -> code volume
- executed -> state space (~ 3 states + statements)

STMT:

- add statement -> code volume
- executed -> state space (~ 1 state)

DOMAIN:

- add domain range -> larger data model -> larger state space
- no increase in code volume
- possibility for distribute job to workers!!

ITERATION

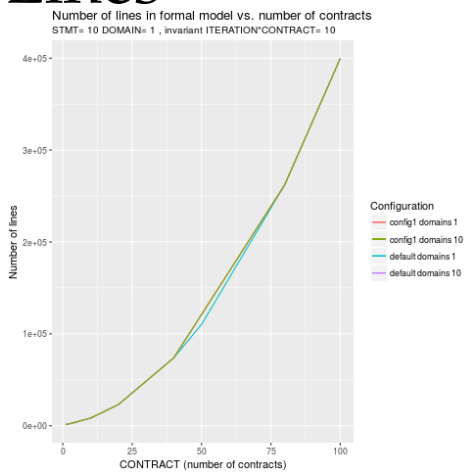
- invoke interface w. bind data -> control state space growth
- no increase in code volume
- simulate "dead code" (with invariant `ITERATION * CONTRACT`)

Simple Ethereum contract (as a Mustache template)

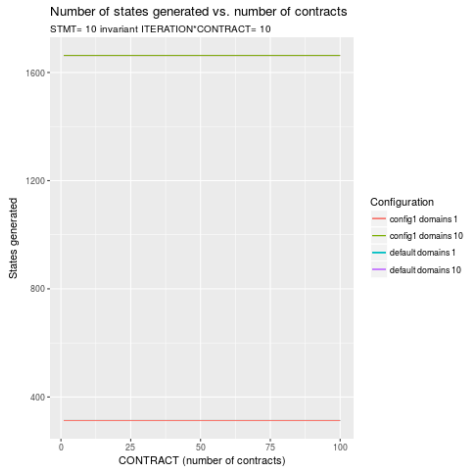
```
// Iterate CONTRACT -times
{{#CONTRACT}}
// Create unique contract
Contract Benchmark_{{contract}} {
    struct s {
      int intVal;
    }

    // Persistent state
    s memberVariable;

    // Constructor
    Benchmark_contract( string inp1 ) {
      // Iterate STMT times
      {{#STMT}}
      memberVariable.intVal = {{i}};
      {{#STMT}}
    }
}
{{/CONTRACT}}
```

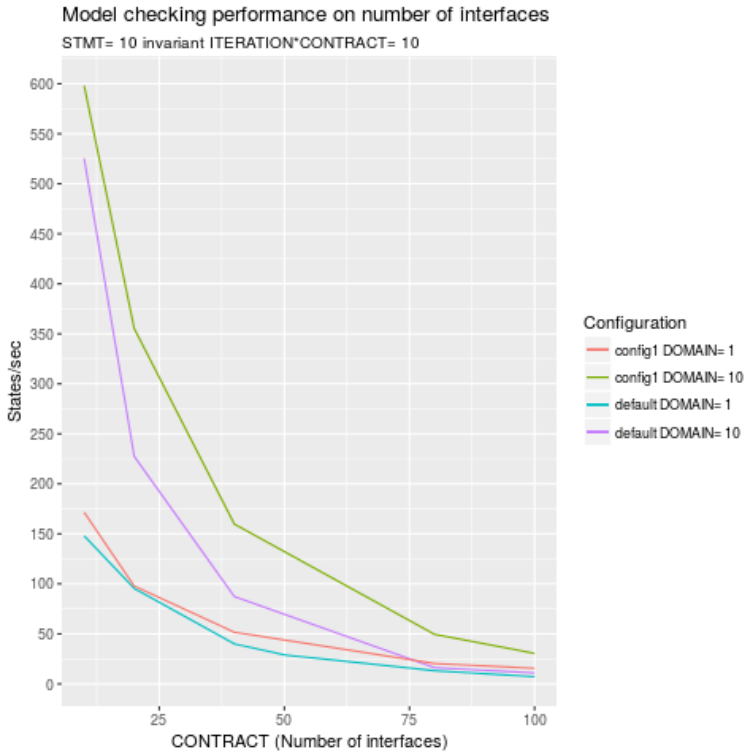
Impact of Adding Interfaces

Lines



States





Benchmark runs:

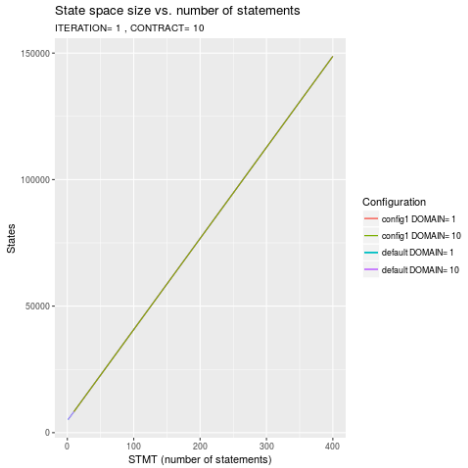
- vary number of interface, each interface 10 statements, call exactly 10 interfaces (rest "dead code"), configuration: 8/1 workers; 10/1 DOMAINS
- Number states (for a `DOMAIN` value) fixed, LOC increase with more interfaces

Results:

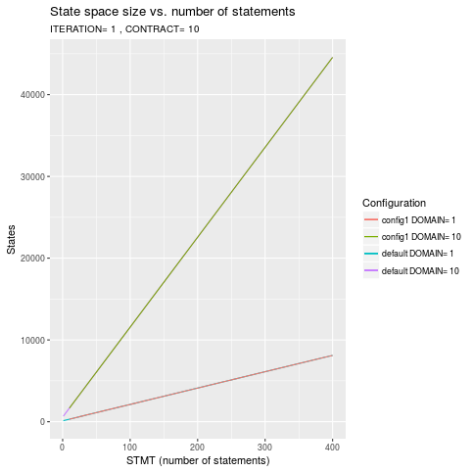
- performance slopes down from @600 states/sec
- benefits for more workers & larger data model size

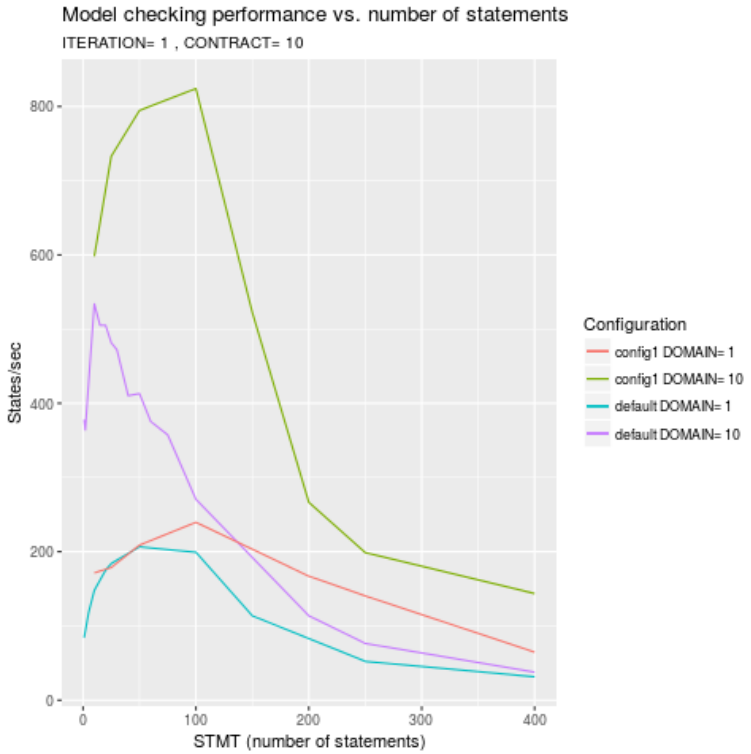
Impact of Adding Statements

Lines



States





Benchmark runs:

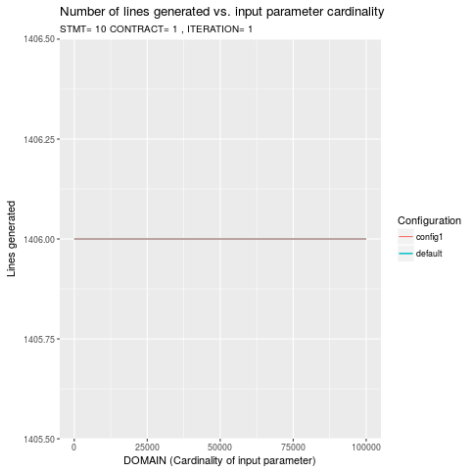
- vary `STMT` in interfaces, use 10 interfaces, configuration: 8/1 workers, 10/1 DOMAINS
- LOC & state grow linearly with `STMT`, slope of state growth steeper with `DOMAIN = 10`

Results:

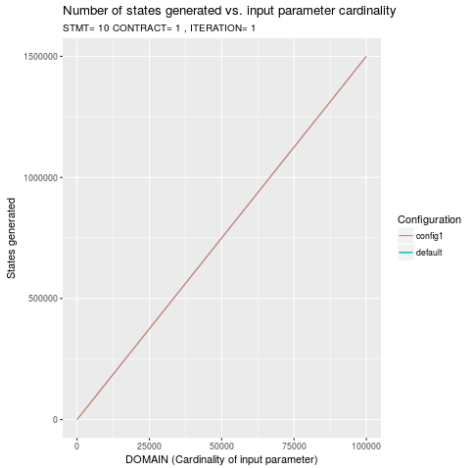
- performance peaks (@800 states/sec for 10 contracts with 100 statements ~ 1000 statements in application), steep slope down
- clear benefits when workers can be distributed to

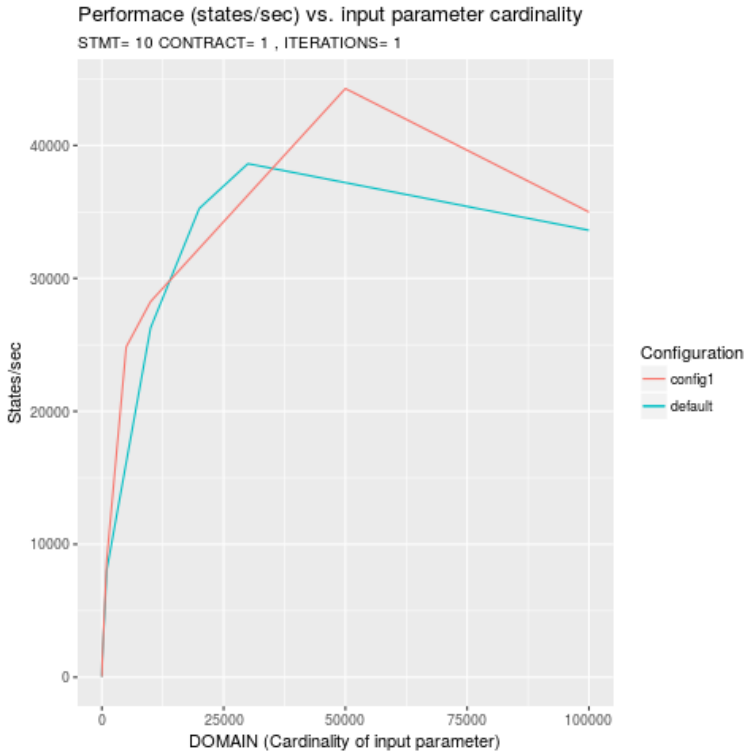
Impact of Increasing Data Model Size

Lines



States





Benchmark runs:

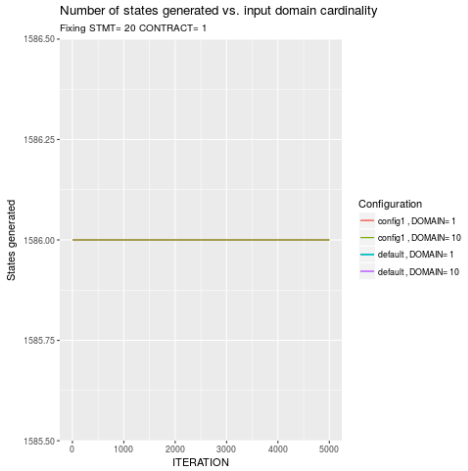
- one call to one interface, vary data model size (`DOMAIN` cardinality), with 8 workers/1 worker
- fixed LOC, state space size grows linearly with `DOMAIN` param from 0 to > 150.000 states

Results:

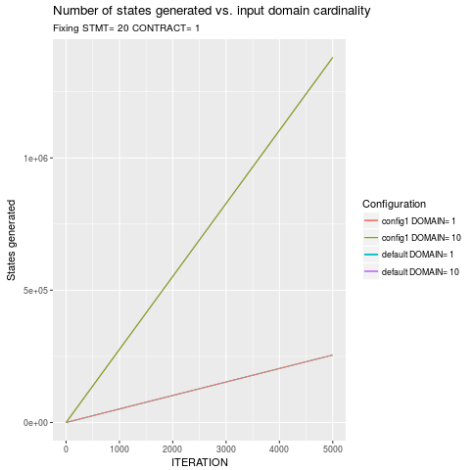
- quite impressive state & domain sizes
- peaks @44.000 states/sec for 50.000 domains, gradual slope in performance
- benefits for more workers

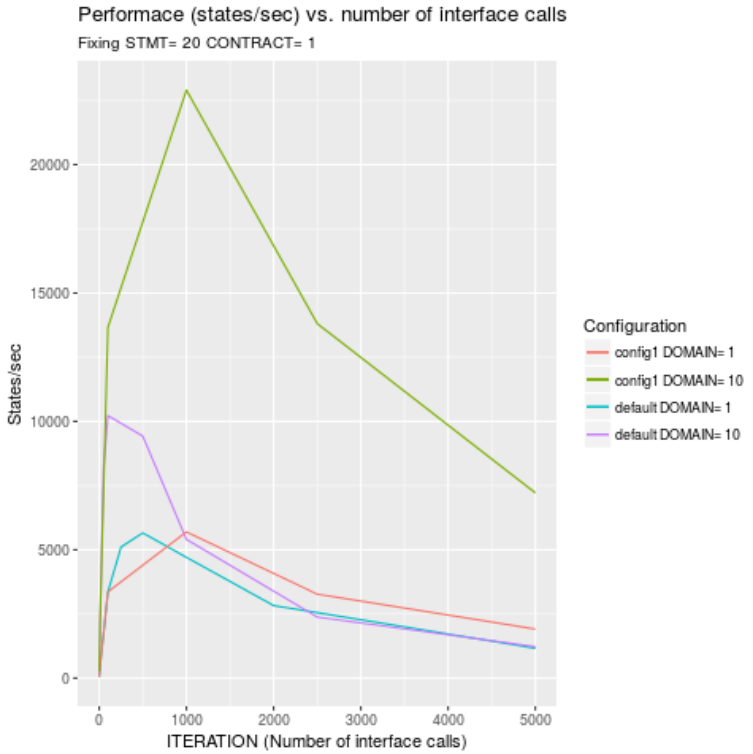
Impact of Longer Execution Traces

Lines



States





Benchmark runs:

- vary number interface invocations (1 interface w. 20 stmts), configuration 8/1 workers, 1/10 domains
- lines of code: same all configurations
- states: linear on ITERATION, slope f(DOMAIN)

Results:

- clear benefits from multiple workers, especially when data model cardinality allows splitting job to workers

Conclusions

- Running benchmarks on hardware
  - HP ENVY 17 - Notebook PC
  - memory 12GB
  - CPU: Intel(R) Core(TM) i7-4702MQ CPU @ 2.20GHz, 4 Cores of 8 Threads
- TLA+tool model checker CPU bound (at least for the benchmarks)
- Model checking performance (states/sec) slows down severely on formal model size
  - Can maintain performance > 100 states/sec for models with 60 interfaces (when formal model supports scaling using multiple model checker workers)
  - 1 state ~ 1 statement in application –> 1 minute model checking run ~ execution traces of 6000 statements
- Scale to real world (large) applications
  - Split model checking in chunks (in Use Cases): Sbuilder prunes unreachable out code from the formal model of a setup –> smaller code volume to model check –> faster model check (states/sec)
  - Clearly benefits from multiple Core w. multiple thread CPU
  - TLA+tools model checker can be run in distributed mode (on AWS infra), (TBD: run benchmarks using distributed TLA model checker)