DVCon 2013
Design & Verification Conference & Exhibition

February 25-28, 2013
DoubleTree, San Jose

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Unconstrained UVM SystemVerilog Performance

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Randomization Performance is Important!

- Randomization is an integral part of UVM
  - It is used most often in configuring the environment and in writing sequences
- A typical UVM environment can easily contain tens of thousands of randomize calls.
  - Large environments can contain orders of magnitudes more.
- Writing high performance constraints is not hard, but requires engineers to think about it.
- Start thinking about randomization performance from the beginning of the project.

Set some reasonable goals for randomization times

- Understand how constraints are used in the UVM environment
  - Configuration constraints – Test level constraints
    - Only randomized a few times in a run
    - Medium to very high complexity
    - Can afford to run for longer times
  - Data Item constraints – data flow
    - Used many, many times in a run
    - Low to medium complexity
    - Needs to be optimized to run very fast. Small performance differences can greatly impact simulation run times

Coding for Speed

- Relationships between variables cause the solver to work harder. Remove unnecessary relationships.
- Constraint expressions are often invoked many times. Simplifying expressions lets the solver run faster.
  - Move complex math out of constraint code.

Note the lack of “rand”

```
class item extends uvm_sequence_item;
   rand int x_pos, y_pos;
   int y_offset, var_a, var_b. var_c;
   constraint position_c {
     x_pos ==( (12 * (y_pos + y_offset) *
               (var_a + var_b) ) / var_c) -
               ( (var_a * var_b) /var_c);
   }
endclass
```

Coding for Speed

- Use solve...before to simplify complex relationships
  - Constraints are bi-directional by default.
  - We often don’t expect them to be bi-directional.
  - Creating an order can greatly reduce the amount of work needed to solve.

```
class meal extends uvm_sequence_item;
  rand day_t weekday;
  rand meal_t lunch;
  constraint lunch_choice_c {
    (weekday == TUESDAY) -> (lunch != PIZZA);
    (weekday == WEDNESDAY ) -> (lunch == SOUP);

     solve weekday before lunch;
  }
endclass
```

Coding for Speed

- Understand the impact of arrays with foreach constraints
  - foreach constraints result a new constraint for each loop
    - A few lines of foreach code can result in many new constraints
  - Especially watch out for foreach constraints that result in creating new dependencies

Foreach better in procedural

```
class config extends uvm_sequence_item;
  rand int table[];
  constraint table_values {
    table.size() == 50;
    foreach( table[i] ) {
      foreach( table[j] ) {
        if( i != j )
          table[i] != table[j];
      }
    }
  }
endclass
```

Coding for Speed

- Use pre_randomize() and post_randomize() to assign values procedurally.
- Procedural code is most often less complex than similar looking constraint expressions
- Particularly useful in reducing the need for foreach constraints

foreach moved from constraint block from previous slide

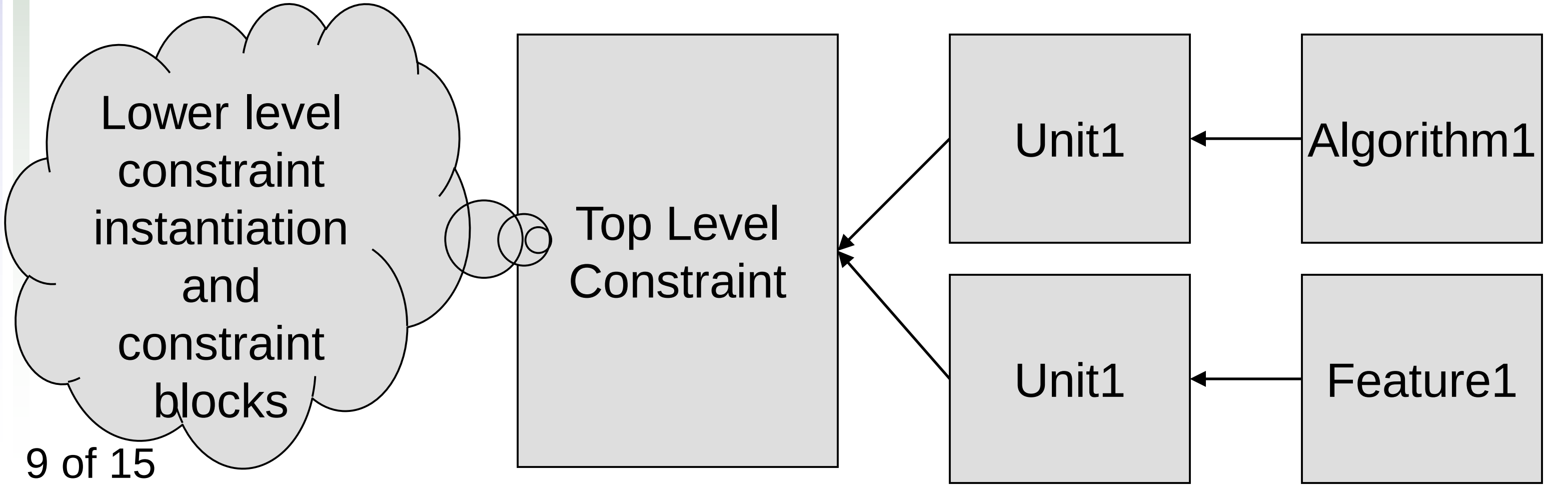
```
class config extends uvm_sequence_item;

  function void post_randomize();
     foreach( table[i] ) {
      foreach( table[j] ) {
        if( i != j )
          table[i] != table[j];
      }
  endfunction
endclass
```

Coding for memory usage

- Speed is not the only measure of randomization performance.
- Large memory usage can drive slow solver performance.
- Very large memory usage can push 32bit simulations to 64bit mode, resulting in a double performance impact.
- Particular trouble spot - look out for classes randomizing large tables simultaneously.

Coding for productivity

- Organize your classes and constraints for re-use & ease of maintenance. Break up into units and features or algorithms
  - Crucial for large classes with many complex constraints
- Separate variables from constraint code.
  - As UVC's evolve and grow, a clear separation makes it easier to upgrade and modify.



Coding for productivity

- Organize your constraints into multiple constraint blocks
  - A single large constraint block is harder for others to understand & debug.
  - Break constraints into blocks based on purpose.
  - This also makes it easier when classes are extended and constraint functionality is augmented or replaced.

```
class device_config extends uvm_object;
  rand mode_type mode;
  rand int max_size;

  constraint half_mode_defaults {
    if( mode == HALF ) { max_size == 1024; }
  }
  constraint full_mode_defaults {
    if( mode == FULL ) { max_size == 512; }
  }
endclass
```

Coding for productivity

- Use macros to replace repetitive code.
  - Simplification and readability

```
constraint_macro_example {
x inside {[-50:50]};
y inside {[-50:50]};
max_value inside {[ 0:100 ]};
if(x < 0 && y < 0 ) –x-y <= max_value;
if(x > 0 && y < 0 )  x-y <= max_value;
if(x < 0 && y > 0 )  y-x <= max_value;
if(x > 0 && y > 0 )  x+y <= max_value;
}
```

Same as above with simplification through macros

```
`define ABS(value) (((value) < 0) ? (-(value)) : (value))

constraint_macro_example {
x inside {[-50:50]};
y inside {[-50:50]};
max_value inside {[ 0:100 ]};
`ABS(x) + `ABS(y) <= max_value;
}
```

Coding for productivity

- Avoid modifying random fields manually after randomization
  - There is a temptation to hand modify the results of a randomize call to achieve a specific result.
  - It can be difficult for users other than the original developer to understand what is happening.
  - Limit modification of rand variables to constraint expressions, and pre_/post_randomize calls.
  - If it is difficult to achieve a specific result, consider restructuring the problem – perhaps breaking it into a number of smaller expressions/
  - *Let the constraint solver do the work for you!*

Coding for productivity

- Build stand alone environments to test classes with complex randomization.
- These environments can often be built in just a few minutes.
- They make it easier to:
  - Compile, build, and simulate
  - Prototype new code and try new experiments quickly
  - Run many more iterations than in a regular test
- These standalone environments can be placed in a regression suite to catch inadvertent errors caused by code changes.

Sponsored By:

Thank You!

- Developing fast, easy to work with randomization code in UVM environments is critical.
- By following simple rules, this is a straightforward process.

- Special thanks to the IBM Cores team for ideas, suggestions, and real world examples that have tested these concepts.