Functional Verification Strategy for an Open-Source High-Performance L1 Data-Cache for RISC-V cores

HP Dcache TOP

- Data-Cache
  - High performance
  - Highly configurable
  - For RISC-V cores

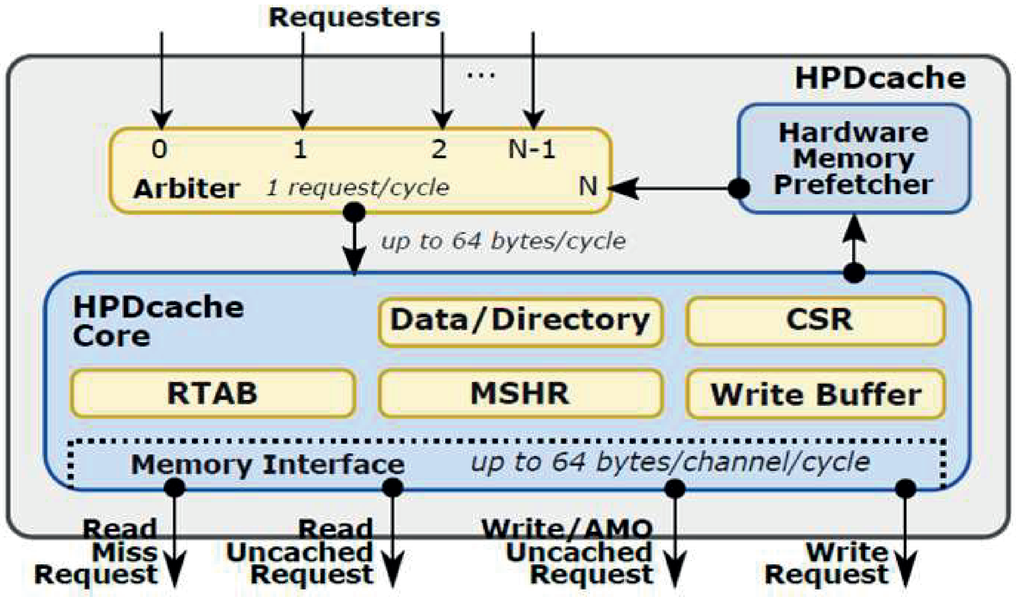

Fig 1. HPDcache TOP

UVM Testbench

- An out-of-order memory response model
- HPDcache request agent
- Memory partition agent
- Reset, clock and back-pressure drivers, watch dog, etc
- SV sources will be delivered in Open-Source

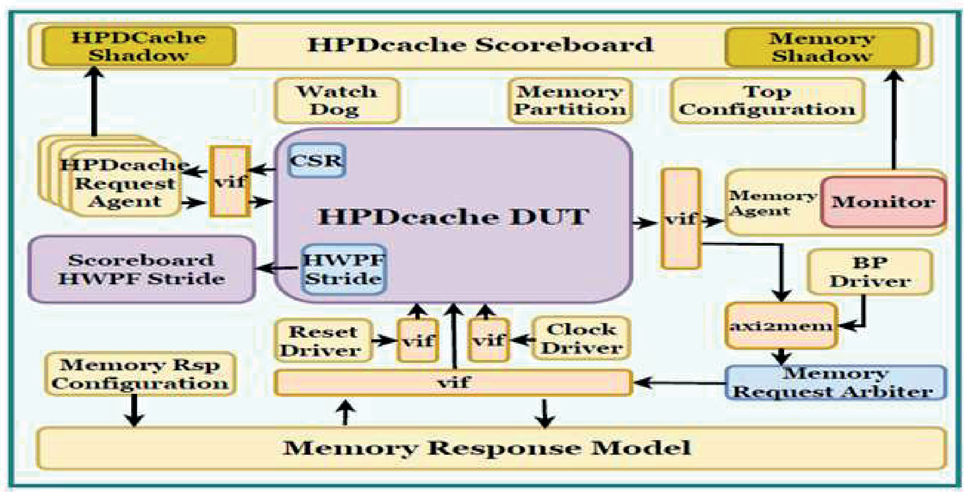

Fig 2. UVM Testbench Environement

Coverage/Assertion Driven Verification

- Assertion Schmoo

```
for(clk_delay_itr=0; clk_delay_itr<= 5 ; clk_delay_itr++) begin: clk_delay_itr
  property mem_req_rd_miss_tmp_schmoo_prop;
     dcache_set_t set;
     dcache_tag_t tag;
      @( posedge clk_i )

     (arb_req_valid & arb_req_ready,
       set = dcache_req_set,
       tag = dcache_req_tag)   |-> ##clk_delay_itr
     (mem_req_miss_read_valid_o & mem_req_miss_read_ready_i
     & mem_rd_miss_set == set & mem_rd_miss_tag == tag) ;
  endproperty
  mem_req_rd_miss_tmp_schmoo_cov:cover property (
   em_req_rd_miss_tmp_schmoo_prop )
end
```

- Cover bins

```
cov_size: coverpoint packet.size
{
  bins size_0 = {'h0};
  bins size_1 = {'h1};
  ……
  ……
  bins size_7 = {'h7};
}
```

- Cross coverage

```
cov_cross_op_need_rsp        : cross cov_need_rsp, cov_op;
cov_cross_op_uncacheable     : cross cov_uncacheable, cov_op;
cov_cross_op_set             : cross cov_set, cov_op;
cov_cross_op_size            : cross cov_op, cov_size;
```

```
cov_op: coverpoint packet.op
{
  bins op_load          = {DCACHE_REQ_LOAD    };
  bins op_store         = {DCACHE_REQ_STORE   };
  bins op_amo_lr        = {DCACHE_REQ_AMO_LR  };
  …….
  ……..
  bins op_amo_minu      = {DCACHE_REQ_AMO_MINU};
  bins op_cmo           = {DCACHE_REQ_CMO     };
}
```

Compile Time Parameters

- HP Dcache has 19 different paremeters
- Can give millions of possible configuration
- A new generic tool is developed to generate different sets of configurations

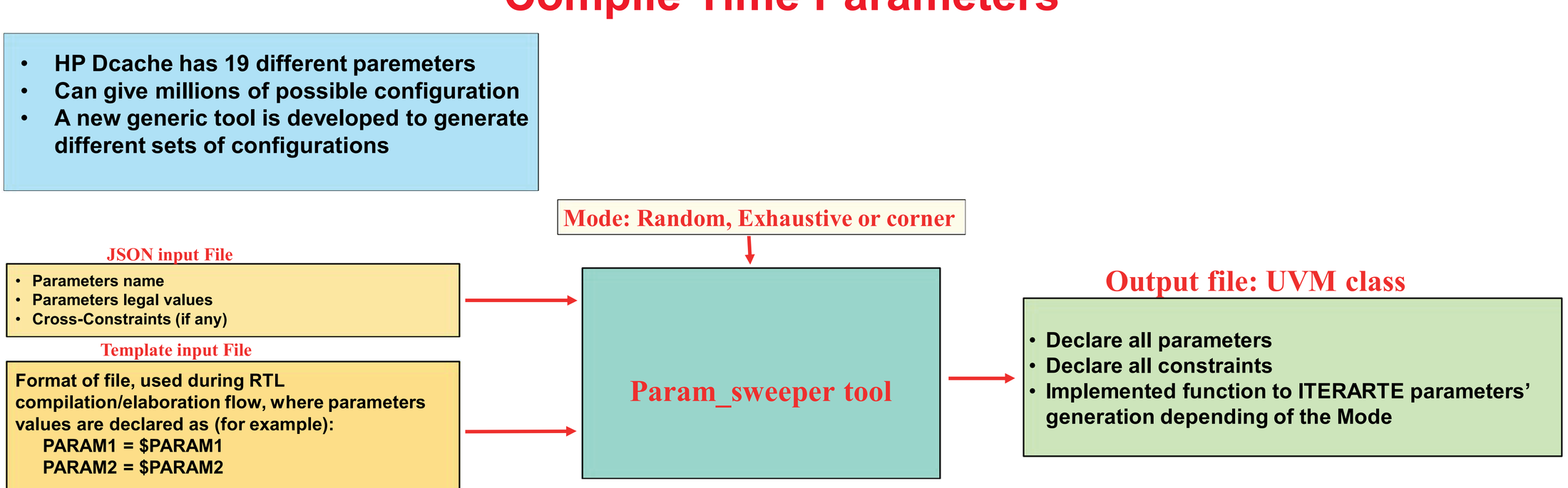

Fig 3. Compile Time Parameters

T. Khandelwal[1], L. Pion[1], C. Fuguet[1], A. Evans[1]

1 Univ. Grenoble Alpes, CEA, LIST, 38000 Grenoble

This work has been performed in the context of the TRISTAN project.

TRISTAN received funding from the Key Digital Technologies Joint Undertaking (KDT JU) under Grant Agreement no. 101095947.