Designing PSS Environment Integration for Maximum Reuse

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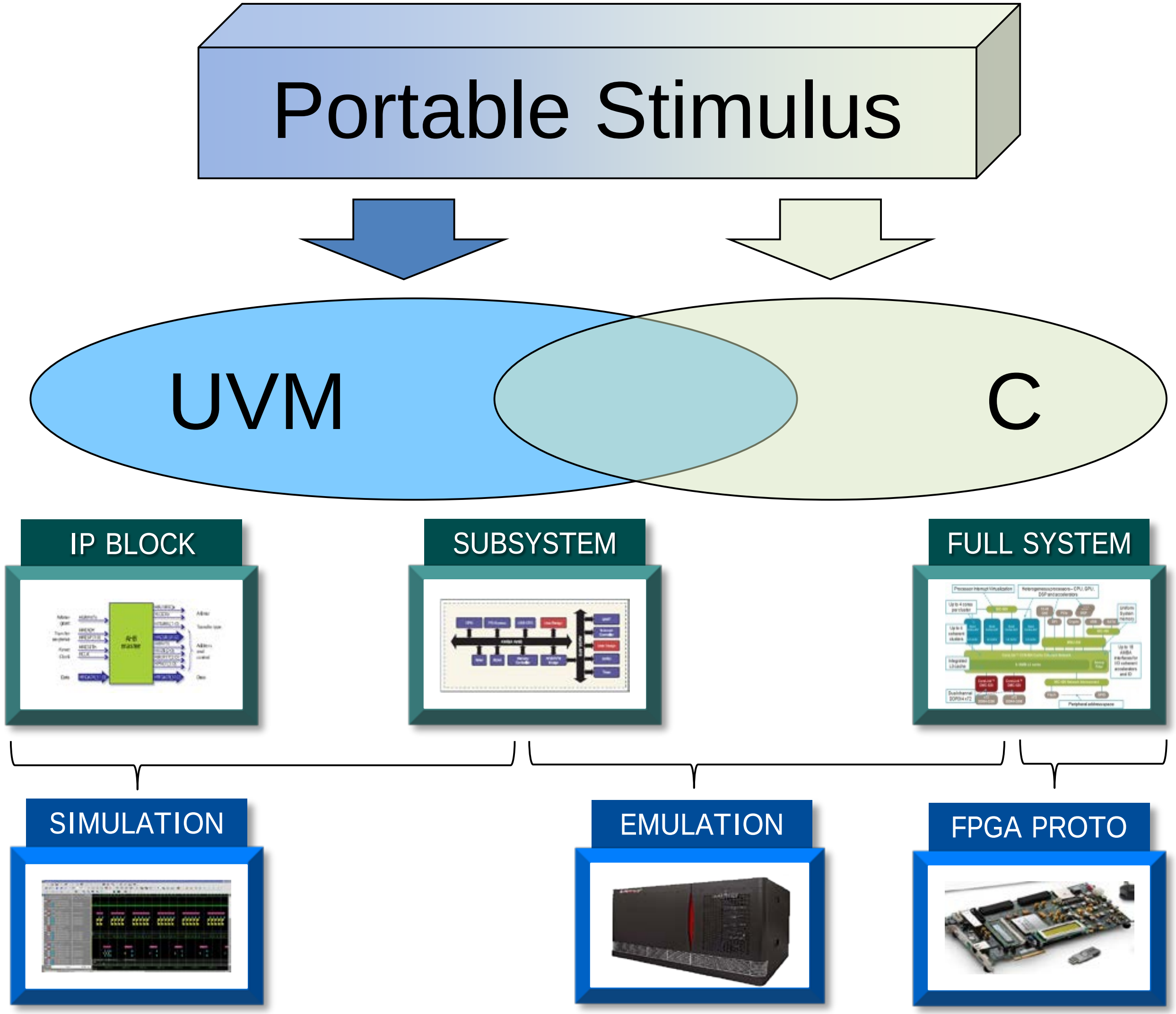
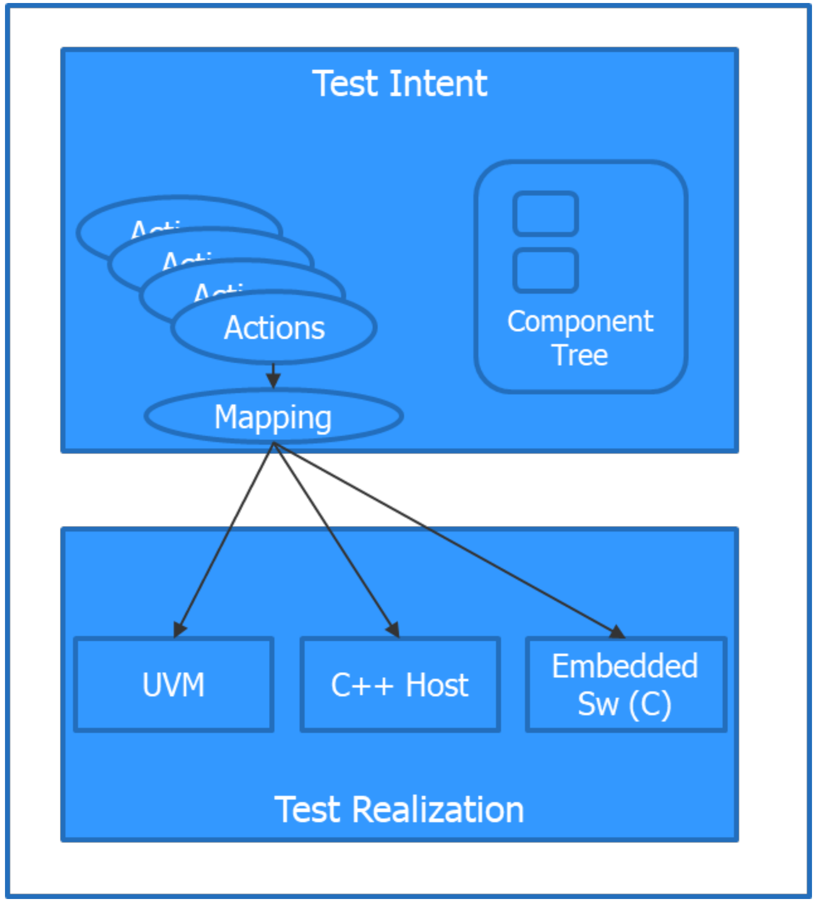
Portable Stimulus Vision

- Ambitious Scope
  - Portable across verification levels
  - Portable across verification engines
- Enables model-driven test creation
- Enables reuse of test intent



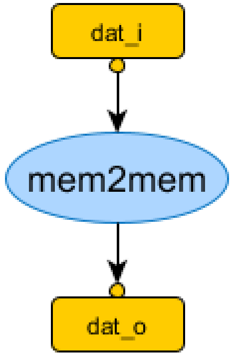
Test Intent vs Test Realization

- PSS is primarily a declarative language
  - Think “constraint-based”
- PSS separates test intent and realization
  - Test intent is declarative
  - Test realization is procedural
- Must address both test intent and realization



Example

- Let's look at a simple example
  - DMA Engine with 8 channels
  - Basic memory-to-memory transfer
- Test Intent focuses on
  - Pre- and post-conditions
  - Constraints on operation
- Test realization
  - Programs registers
  - Waits for interrupts




```
action wb_dma_xfer_a : wb_dma_a {
  // The channel this transfer runs on
  rand bit[3]                       channel;

  // Total transfers to perform
  rand bit[16]                      tot_sz;

  // Bytes to transfer at a time (1, 2, 4)
  rand bit[4]     in [1,2,4]        trn_sz;
}

action mem2mem_a : wb_dma_xfer_a {
  input data_mem_b
        dat_i;
  output data_mem_b                 dat_o;

  constraint {
    dat_i.sz == (tot_sz * trn_sz);
    dat_i.sz == dat_o.sz;
  }
}
```

Example – Test Realization

- PSS is very flexible with test realization
- Can specify precise code to generate
  - Can literally generate ***anything***
- But, this has a cost for reuse
  - Specific language
  - Specific environment
  - Limited to pre-generated flat tests

```
extend action wb_dma_c::mem2mem_a {
  exec body SV = """
    begin
      wb_dma_descriptor              desc =
          wb_dma_descriptor::type_id::create();
      desc.channel = {{channel}};
      desc.mode = 0;
      desc.inc_src = 1;
      desc.inc_dst = 1;
      desc.src_sel = 0;
      desc.dst_sel = 1;
      desc.tot_sz = {{tot_sz}};
      desc.trn_sz = {{trn_sz}};
      desc.chk_sz = 16;
      desc.src_addr = {{dat_i.addr}};
      desc.dst_addr = {{dat_o.addr}};

      start_item(desc);
      finish_item(desc);
      end
  """;
}
```

Example – Test Realization

- Calling an API improves reuse
  - Can pre-generated tests or generate on-the-fly
  - Better separation between Model and Realization
- Implementation code is nearly identical!

```
function void mem2mem(
  bit[31:0] channel, bit[31:0] src,
  bit[31:0] dst, bit[31:0] tot_sz,
  bit[31:0] trn_sz);
import target function mem2mem;

extend action wb_dma_c::mem2mem_a {
  exec body {
    mem2mem(channel, dat_i.addr,
      dat_o.addr, tot_sz, trn_sz);
  }
}
```

```
task mem2mem(
  bit[31:0]                 channel,
  bit[31:0]                 src,
  bit[31:0]                 dst,
  bit[31:0]                 tot_sz,
  bit[31:0]                 trn_sz);
    wb_dma_descriptor  desc =
     wb_dma_descriptor::type_id::create();

    desc.channel = channel;
    desc.mode = 0;
    // . . .
    desc.tot_sz = tot_sz;
    desc.trn_sz = trn_sz;
    desc.chk_sz = 16;
    desc.src_addr = src;
    desc.dst_addr = dst;

    start_item(desc);
    finish_item(desc);

 endtask
```

Anatomy of Test Realization

- Reusable test realization goes beyond calling an API
- Three key aspects of test realization
  - API
    - Consistent interface to driver functionality
  - Configuration and context data
    - Configures driver code
    - Maintains state
  - Events
    - Notifies driver code to react to system

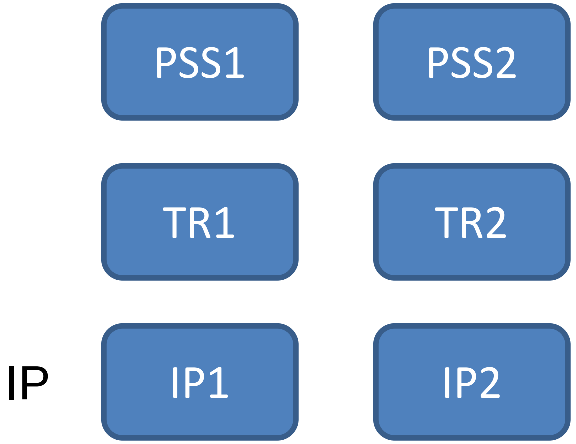
```
void wb_dma_dev_mem2mem(
  wb_dma_dev_t *dev,
  uint32_t     channel,
  uint32_t     src,
  uint32_t     dst,
  uint32_t     sz,
  uint32_t     trn_sz);
```

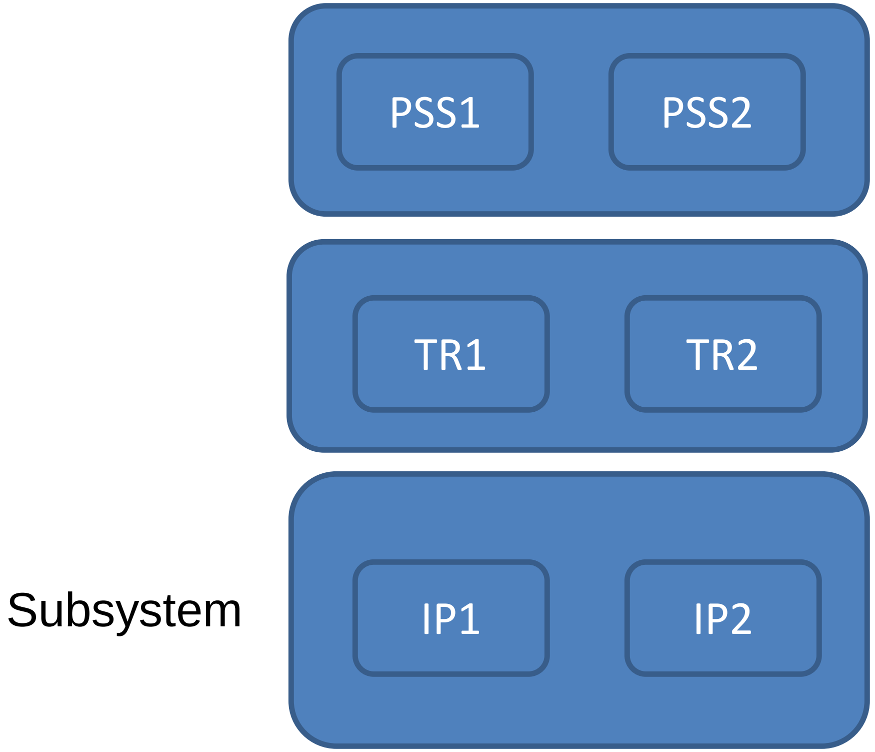
```
typedef struct wb_dma_dev_s {
  wb_dma_regs_t  *regs;

  // Status flags for state of channels
  uint32_t       status[8];
  // Notification objects for interacting with IRQ
  pvm_event_t    xfer_ev[8];
} wb_dma_dev_t;
```

Test Realization Reuse Requirements

- PSS models elements compose easily
- Must be able to do the same with test realization



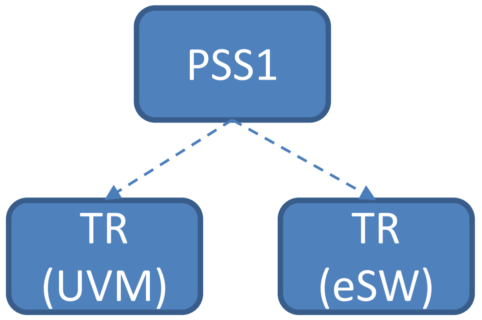


Test Realization Reuse Requirements

- PSS models easily support multiple IP instances
  - Component tree models IP instances
  - Maintains Action / Component instance association
- Must be able to do the same with test realization

Test Realization Reuse Requirements

- The PSS model is independent of execution platform
  - UVM, embedded software, etc
- Test realization API must support this as well
- Implies consistent API across platforms



Test Realization Best Practices

- Interact via scalar values
  - PSS modeling works well with scalar variables since they can be constrained
  - Scalar values are also treated similarly across platforms (UVM / eSW)

- Minimize data exchange
  - Best practice with most cross-language interfaces
  - Generally want data to move from Test Intent to Test Realization

Test Realization Best Practices

- Abstract Up
  - Helps to achieve goal of minimizing data exchange
  - Test Intent invokes high-level behavior, delegating details to Realization
- Use the procedural interface
  - Ensures PSS model is independent of realization language
- Use a test realization framework
  - Helps to ensure consistency

Test Realization Reuse Framework

- Base component type provides 'devid'
  - Used in exec blocks to identify test-realization instance

```
component pvm_dev_c {
        int                       devid;

}
```

```
component wb_dma_c : pvm_dev_c {
  import pvm_types_pkg::*;

}
```

```
function void wb_dma_dev_mem2mem_d(
        bit[31:0] devid,
        bit[31:0] channel,
        bit[31:0] src,
        bit[31:0] dst,
        bit[31:0] tot_sz,
        bit[31:0] trn_sz);
import target function mem2mem;

extend action wb_dma_c::mem2mem_a {
        exec body {
                wb_dma_dev_mem2mem_d(comp.devid,
                        channel,dat_i.addr,
                        dat_o.addr, tot_sz, trn_sz
                );
        }
}
```

Test Realization Reuse Framework

- A base component is provided for UVM environments
- Each test-realization component must extend
- Test-realization class contains context data

```
class wb_dma_dev extends pvm_dev;
         `uvm_object_utils(wb_dma_dev);
         wb_dma_reg_block                     m_regs;
         bit                                  m_active[];
         semaphore                            m_sem[];


endclass
```

Test Realization Reuse Framework

- A macro is used to translate global task to Class-method calls
- Uses the devid passed from PSS to identify the appropriate object

```
`pvm_dev_task_decl_5(wb_dma_dev, mem2mem,
uint32_t, uint32_t, uint32_t, uint32_t,
uint32_t)
```

```
task automatic wb_dma_dev_mem2mem_d(
         uint32_t devid,
         uint32_t p1,
         uint32_t p2,
         uint32_t p3,
         uint32_t p4,
         uint32_t p5);
         wb_dma_dev dev_inst;
         $cast(dev_inst, pvm_get_device(devid));

         dev_inst.mem2mem(p1, p2, p3, p4, p5);
endtask
```

```
task wb_dma_dev::mem2mem(
  int unsigned     channel,
  int unsigned     src,
  int unsigned     dst,
  int unsigned     sz,
  int unsigned     trn_sz);

  init_single_transfer(channel, 0, src,
        1, dst, 1, sz, trn_sz);

  wait_complete_irq(channel);
endtask
```

Test Realization Reuse Framework

- Embedded software stores context data in a struct
  - Contains a data-structure instance (pvm_dev_t) with core data
- Test realization functions operate on this data structure

```
typedef struct wb_dma_dev_s {
  pvm_dev_t        dev;
  wb_dma_regs_t    *regs;
  uint32_t         status[8];

  pvm_event_t      xfer_ev[8];
} wb_dma_dev_t;
```

```
void wb_dma_dev_mem2mem(
  wb_dma_dev_t     *drv,
  uint32_t         channel,
  uint32_t         src,
  uint32_t         dst,
  uint32_t         sz,
  uint32_t         trn_sz);
```

Test Realization Reuse Framework

- A macro used to setup redirect functions
  - Accept device-id from PSS, call function with context data

```
void wb_dma_dev_mem2mem(
  wb_dma_dev_t      *dev,
  uint32_t          channel,
  uint32_t          src,
  uint32_t          dst,
  uint32_t          sz,
  uint32_t          trn_sz);
pvm_devid_api_decl_5(wb_dma_dev, mem2mem,
  uint32_t, uint32_t, uint32_t, uint32_t, uint32_t);
```

```
void wb_dma_dev_mem2mem(
  wb_dma_dev_t      *drv,
  uint32_t          channel,
  uint32_t          src,
  uint32_t          dst,
  uint32_t          sz,
  uint32_t          trn_sz) {
  // ...
}
```

```
static inline void wb_dma_dev_mem2mem_d(
  uint32_t devid, uint32_t p1, uint32_t p2,
  uint32_t p3, uint32_t p4, uint32_t p5) {
  wb_dma_dev_mem2mem((wb_dma_dev_t *)pvm_get_dev(devid),
                          p1, p2, p3, p4, p5);
}
```

PSS 1.1. and Test Realization Reuse

- PSS 1.1 new features enable Portable Test Realization
  - Capture test realization predominantly in PSS, not C/C++ or SystemVerilog
  - Requires rewriting test realization
  - Once rewritten, can target any platform supported by the PSS processing tool
- Register Model
  - Provides a PSS abstraction for accessing registers
- Storage Allocation
  - APIs and data structures for managing and accessing memory
- Procedural Interface
  - PSS procedural “programming language”
  - Can write simple routines for managing IPs directly in PSS

Conclusion

- PSS defines modeling constructs that enable reuse and portability
- Must also ensure test realization is reusable and portable
- Following a few key best practices
- Using a test-realization reuse framework brings consistency
- Look for new opportunities in test realization reuse in PSS 1.1!