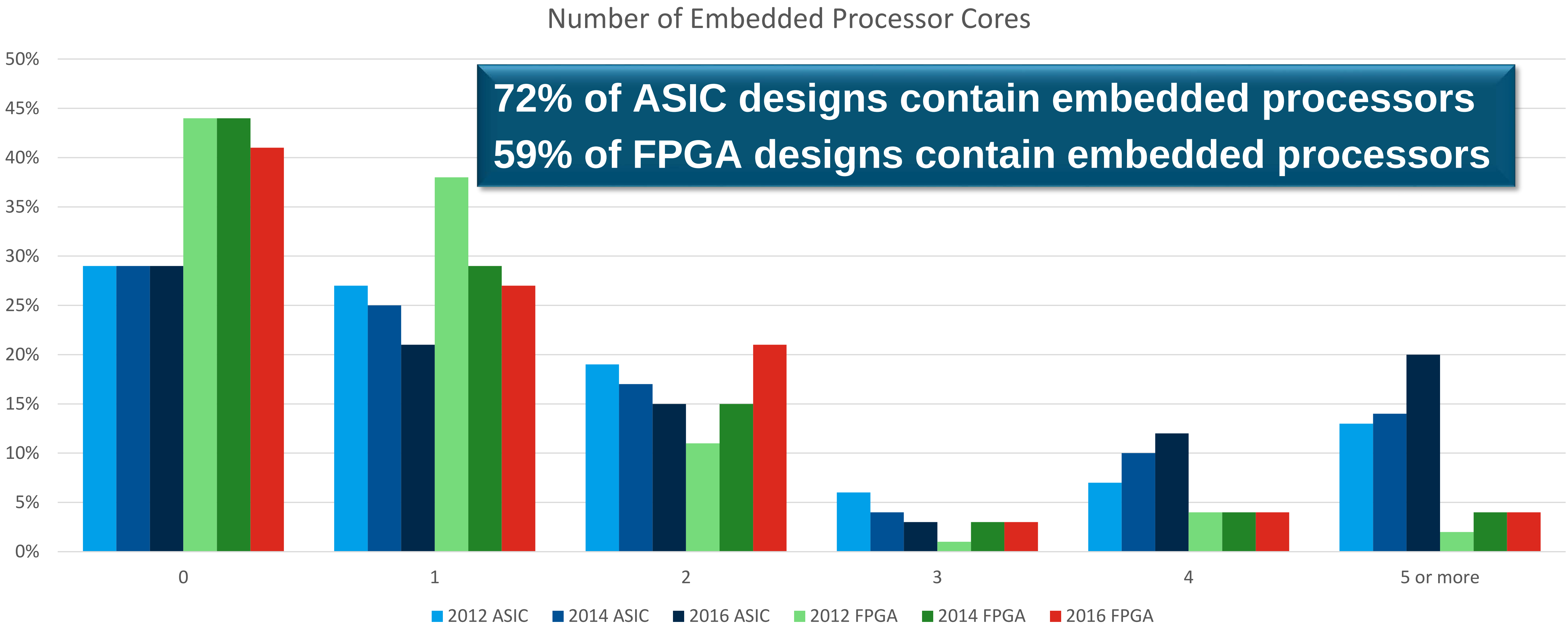
Portable Test and Stimulus: The Next Level of Verification Productivity is Here

Part 1

Accellera Portable Stimulus Working Group

2/26/2018

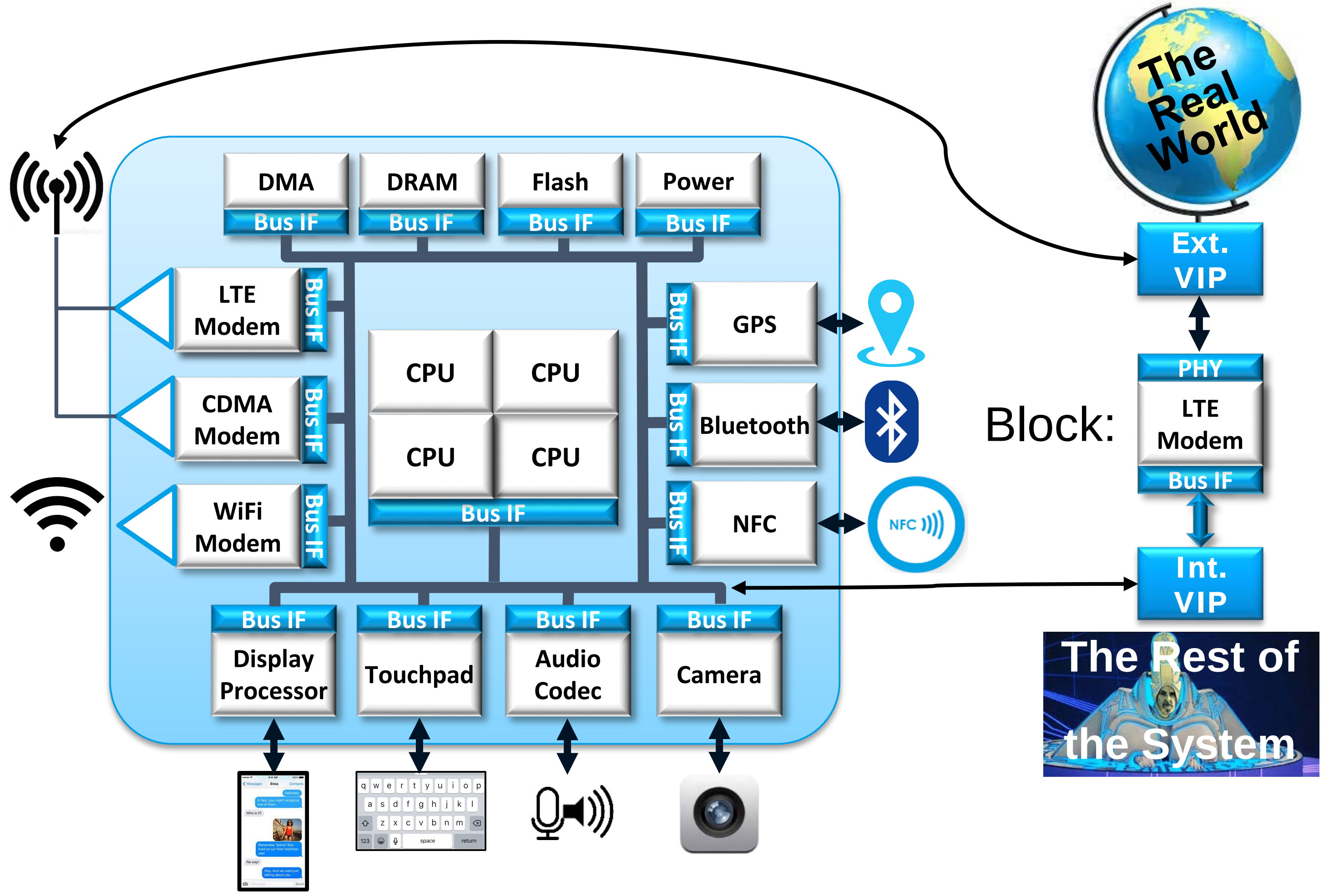
It's an SOC World



Source: Wilson Research Group and Mentor Graphics, 2016 Functional Verification Study

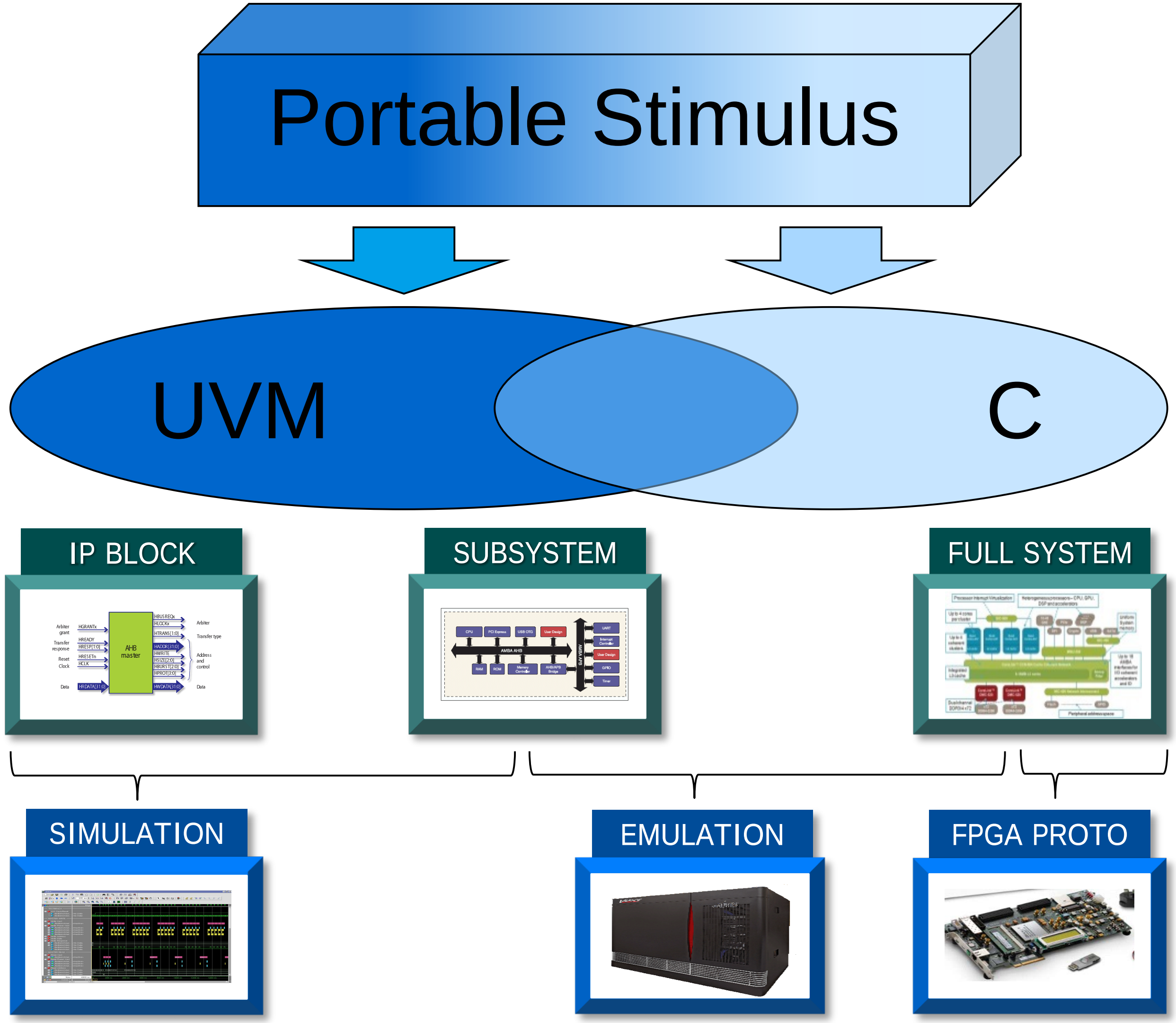
Block-to-System Test Reuse

- UVM constrained-random is great for block-level testing
  - UVM Sequences model both external & internal behavior
  - Block tested standalone
- SOC-level tests driven by use-cases
  - Embedded SW drives the test
  - Usually written in C
- Still want to test the block
  - Need to reuse *test intent*
  - Coordinate with other traffic

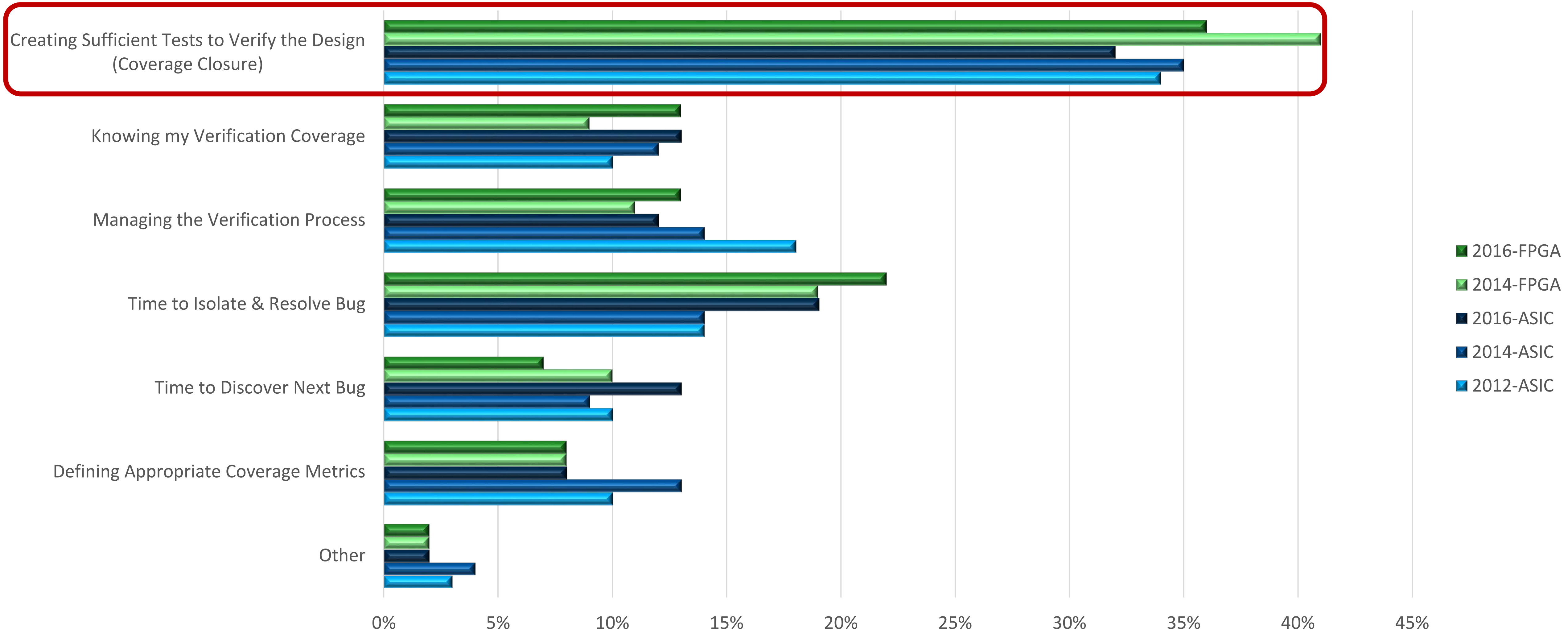


Reuse of Test Intent Across Platforms/Users

- Single specification of test intent is critical
- Define "scenario space" by capturing:
  - interactions
  - dependencies
  - resource contention
- Abstraction lets tool automate generation
  - Multiple targets
  - Target-specific customization



Biggest Verification Challenges



Source: Wilson Research Group and Mentor Graphics, 2016 Functional Verification Study

Maximize Productivity by Separating Concerns

Directed:

```
start(Boston);
drive(West, I90, Buffalo);
if(!Canada)
  drive(West, I90, Chicago);
  drive(West, I80, Salt Lake City);
  drive(West, I84, Portland);
else
  drive(North, I190, Niagra Falls);
  drive(West, ON403, Flint);
  drive(North, I75, Fargo);
  drive(West, I94, Billings);
  drive(West, I90, Ritzville);
  drive(South, US395, Stanfield);
  drive(West I84, Port
```

How do we adjust the scenarios?

Maximize Productivity by Separating Concerns

Constrained-Random:

```
class drive;
  rand city_e start, end;
  rand dir_e direction;
endclass

class directions;
  task body;
    drive.go() with {start == Boston,
                     dir == West;}
    while(drive.end != Portland)
      drive.go();
  endtask

  constraint NoCanada{
    start==Buffalo -> dir == West;}
  constraint Chi {
    start==Chicago -> dir == West;}
  ...
endclass
```

```
class drop_friend extends directions;
  constraint Chi {start==Chicago -> dir inside [North, West];
                  start==Chicago -> end==Minneapolis;}
endclass
class sightsee extends drop_friend;
  constraint DT {start==Minneapoli
  constraint MR {start==De                            ore}
  constraint MT {start==MtR                    Billings}
endclass
```

Testwriter must still manage details
Global Optimization is Difficult

Maximize Productivity by Separating Concerns

Declarative:

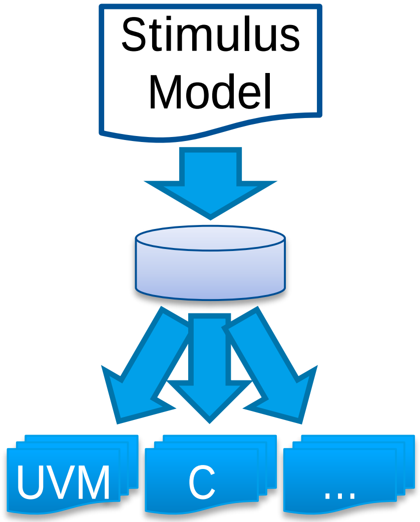
start == Boston;
end == Portland;

set_point(Minneapolis);
set_point(MtRushmore);
set_point(DevilsTower);
set_preference(West);
…

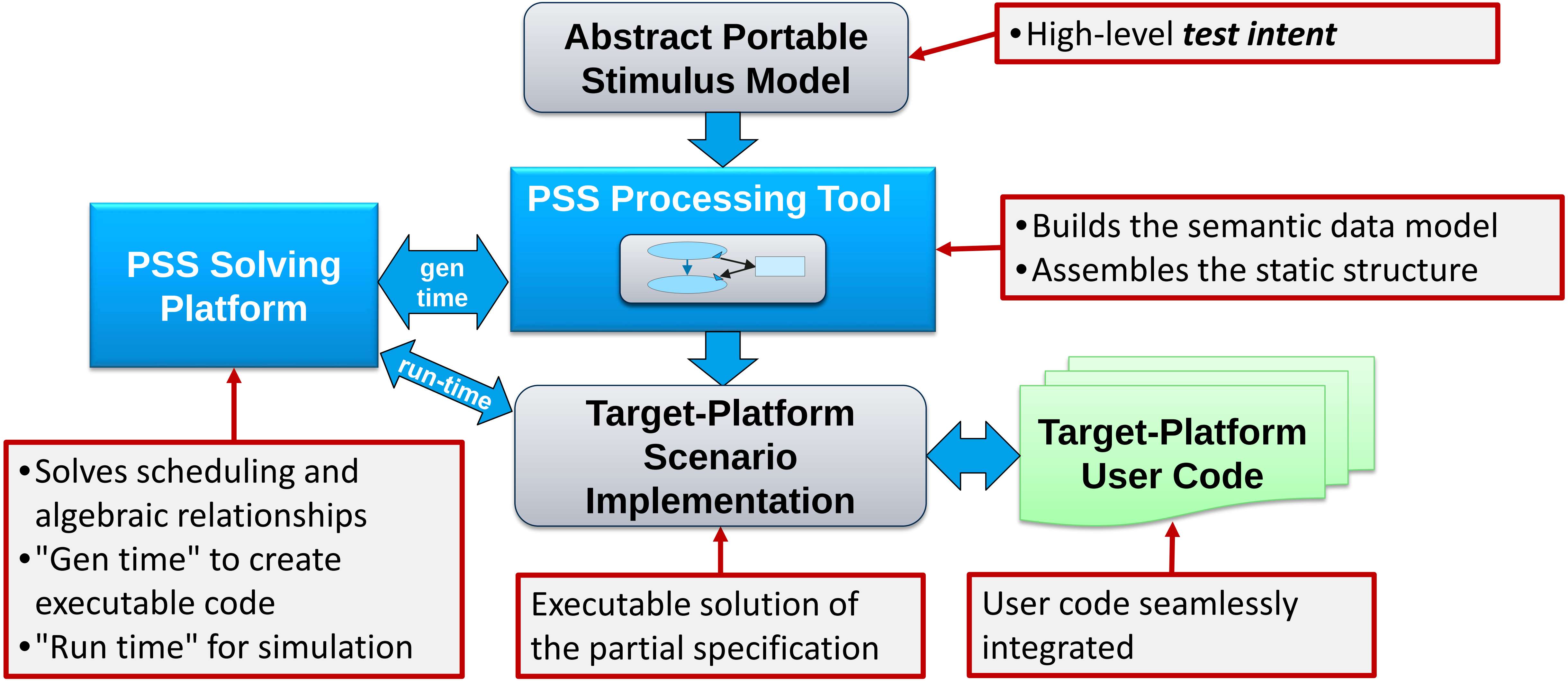
Testwriter focuses on *INTENT*
Tools handle the details

Modeling Portable Stimulus Requires Abstraction

- Begin with the end in mind
  - Translating one language into another is hard
  - Each target language has its own semantics
- Abstraction lets us focus on common semantics
  - Schedule well-defined behaviors
  - Scheduling semantics allow scenario exploration
- Single partial specification expanded into multiple scenarios



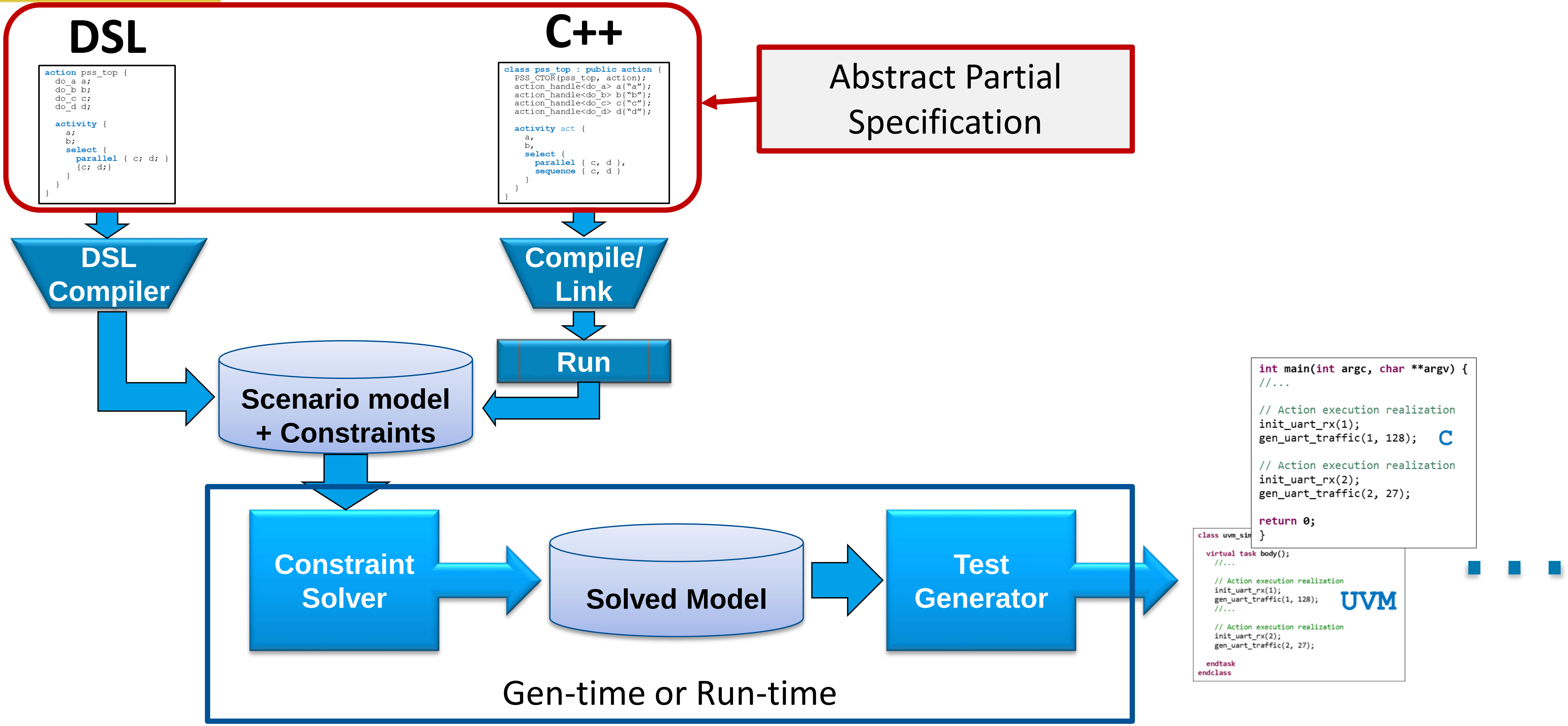
So, How Is This All Going to Work?



What Portable Stimulus Is NOT

- **NOT** a UVM replacement
- **NOT** a reference implementation
- **NOT** one forced level of abstraction
  – Expressing intent from different perspectives is a primary goal
- **NOT** Monolithic
  – Representations would typically be composed of portable parts
- **NOT** Two standards
  – PSS/DSL and PSS/C++ input formats describe 1:1 semantics
  – Tools shall consume both formats
- **NOT** Just stimulus
  – Models Verification Intent
  – Stimulus, checks, coverage, scenario-level constraints
  – Portable test realization

Projected Tool Flow



Hello, World

Hello World: Atomic Actions

component groups elements for *reuse and composition*

action defines *behavior*

exec defines *implementation*

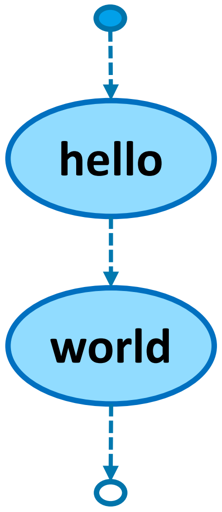
hello world

```
component pss_top {
  action hello_world_a{
    exec body SV = """
      $display("Hello World");
    """;
  }
}
```

```
class hello_world_a_seq_1 extends uvm_sequence;
      `uvm_object_utils(hello_world_a_seq_1)

      virtual task body();
            $display("Hello World");
      endtask
endclass
```

- ✓ Reuse
- ✓ Composition
- ✓ Abstract behaviors
- ✓ Retargetable Implementations

Hello World: Compound Actions



`compound action`
traverses *other actions*

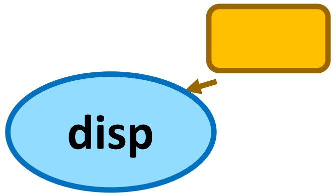
`activity`
defines *scheduling*

```
component pss_top {
  action hello_a {
    exec body C = """
      printf("Hello\n");
    """;
  }
  action world_a {
    exec body C = """
      printf("World\n");
    """;
  }
```

```
void hello_world_a_test_1() {
  printf ("Hello\n");
  printf ("World\n");
}
```

- ✓ Behavior encapsulation
- ✓ Behavior scheduling

Hello World: Data Flow Objects




```
component pss_top {
  buffer msg_buf {
    rand string s;
  }


  action display_a {
    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s}}");
    """;
  }
```

buffer defines *data flow*

stream and **state** also defined

data may be *randomized*

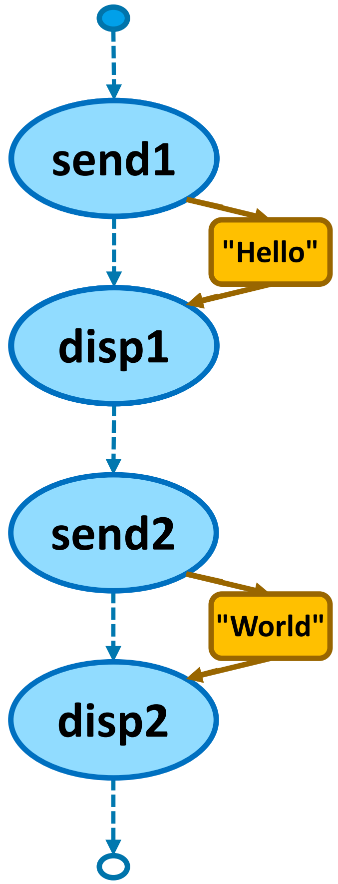
input defines *flow requirement*

output too

"moustache" passes model elements to templates

- ✓ Complex data structures
- ✓ Data flow modeling
- ✓ Constrained random data
- ✓ Reactivity

Hello World: Data Flow Objects

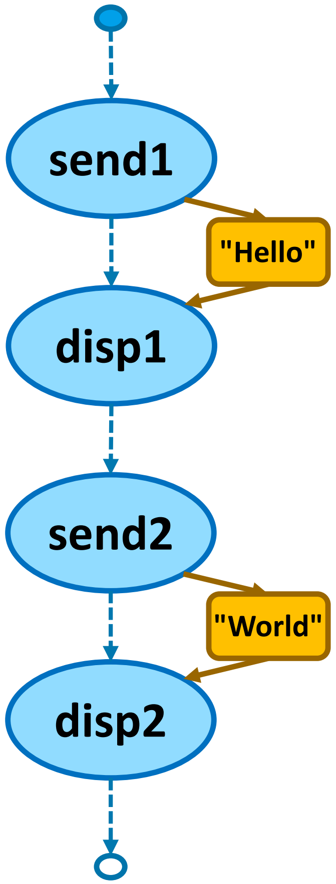



```
component pss_top {
  buffer msg_buf {
    rand string s;
  }



  action display_a {
    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s
    """;
  }
```

```
 action send_a {
    output msg_buf msg;
  }
  action hello_world_a {
    send_a send1, send2;
    display_a disp1, disp2;
    activity {
        send1 with {msg.s == "Hello ";};
        disp1 with {msg.s == "Hello ";};
        send2 with {msg.s == "World";};
        disp2 with {msg.s == "World";};
        bind send1.msg disp1.msg;
        bind send2.msg disp2.msg;
    }
  }
}
```

- ✓ Directed testing when desired
- ✓ In-line constraints

Hello World: Packages

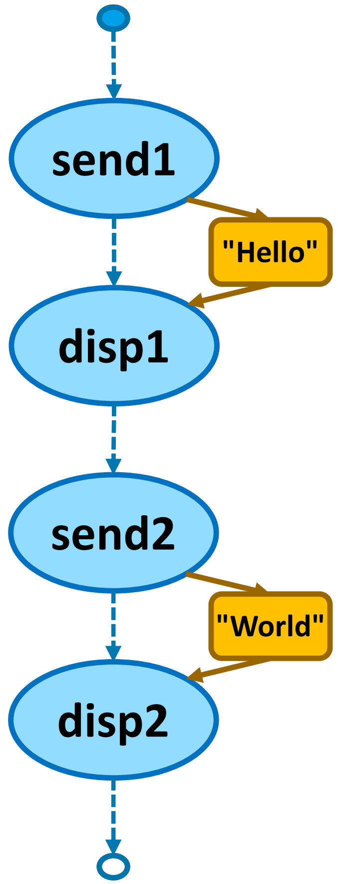



```
package hw_pkg {
  buffer msg_buf {
    rand string s;
  }
}
component pss_top {
  import hw_pkg::*;
  action display_a {
    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s}}");
    """;
  }
```

```
on send_a {
utput msg_buf msg;

ion hello_world_a {
end_a send1, send2;
isplay_a disp1, disp2;
ctivity {
   send1;
   disp1 with {msg.s == "Hello ";};
   send2;
   disp2 with {msg.s == "World";};
   bind send1.msg disp1.msg;
   bind send2.msg disp2.msg;
    }
  }
}
```

✓ Additional reuse and encapsulation

Hello World: Inferred Actions

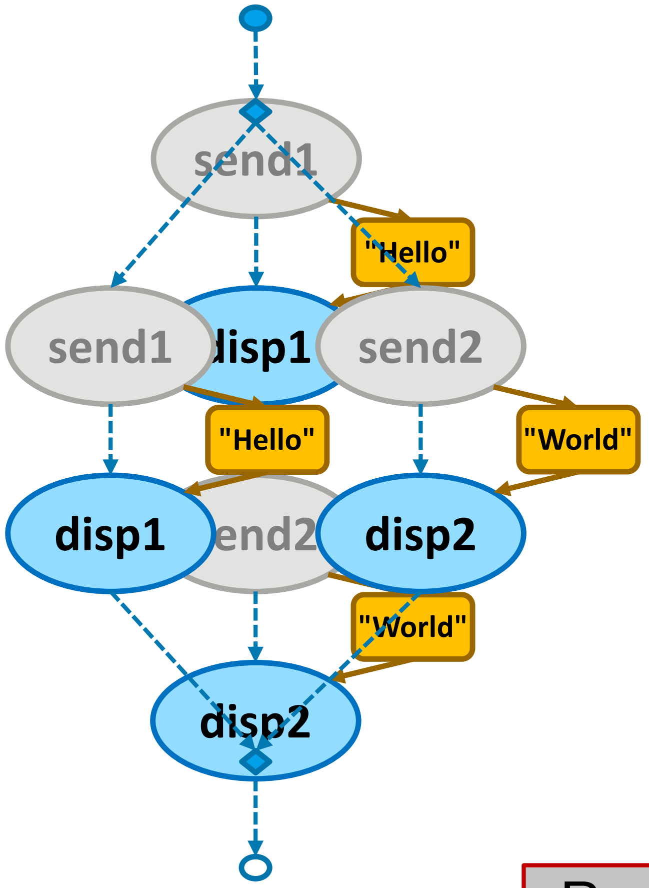



```
package hw_pkg {
  buffer msg_buf {
    rand string s;
  }
}
component pss_top {
  import hw_pkg::*;
  action display_a {
    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s
    """;
  }
```

```
 action send_a {
    output msg_buf msg;
  }
  action hello_world_a {
    send_a send1, send2;
    display_a disp1, disp2;
    activity {
        send1;
        disp1 with {msg.s == "Hello ";};
        send2;
        disp2 with {msg.s == "World";};


    }
  }
}
```

✓ Abstract partial specifications

Hello World: Activity Statements




```
package hw_pkg {
  buffer msg_buf {
    rand string s;
  }
}
component pss_top {
  import hw_pkg::*;
  action display_a {
    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s
    """;
  }
```

```
action send_a {
    output msg_buf msg;
  }
  action hello_world_a {

    display_a disp1, disp2;
    activity {
      select {
        disp1 with {msg.s == "Hello ";};

        disp2 with {msg.s == "World";};


      }
    }
  }
```

Randomly choose a branch

✓ Scenario-level randomization

Activity: Robust Expression of Critical Intent

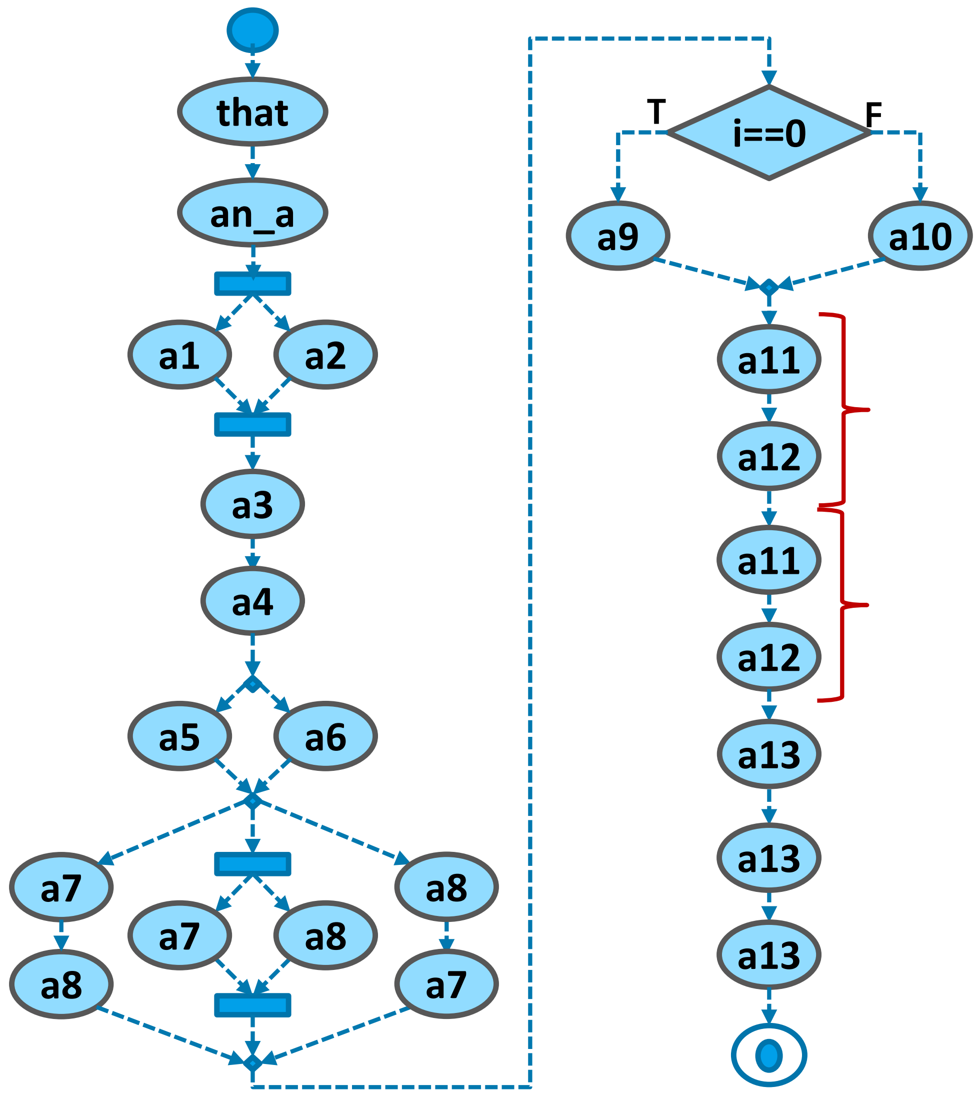
```
activity {
  that;
  do an_a;
  parallel {a1, a2};
  sequence {a3, a4};
  select {a5, a6};
  schedule {a7, a8};
  if (i == 0) {a9;}
  else {a10;}
  repeat (2) {a11, a12};
  foreach (arr[j]) {
    a13 with {a13.val == arr[j];};
}
```

Action instance *traversal*

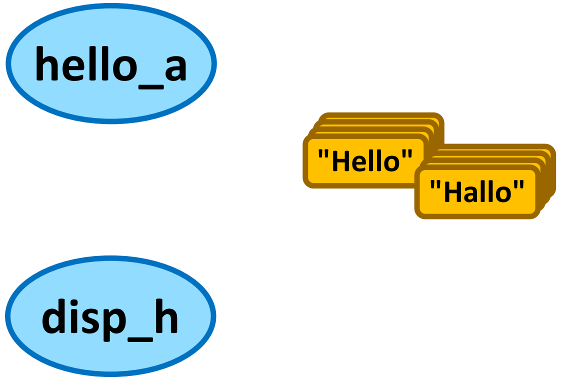
Anonymous action *traversal*

Subject to flow/resource constraints

✓ **Robust scheduling support**



Hello World: Extension & Inheritance



Type extension

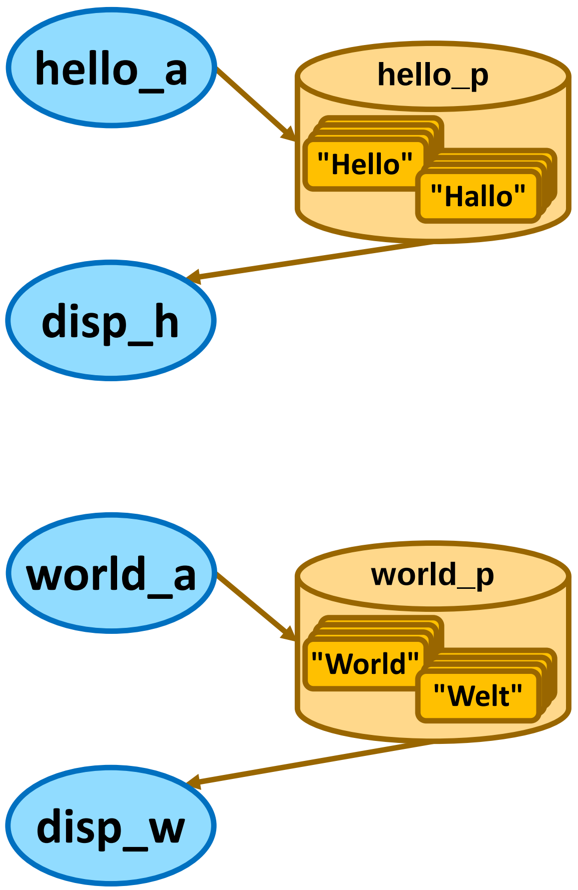
Inheritance

Override

```
extend component pss_top {
  buffer hello_buf : msg_buf {
    constraint {msg.s in["Hello", "Hallo"];}
  }
  action disp_h : display_a {
     override {type msg_buf with hello_buf};
  }
  action hello_a {
    output hello_buf msg;
  }


}
```

- ✓ Type extension
- ✓ Object-oriented inheritance
- ✓ Type (& instance) override

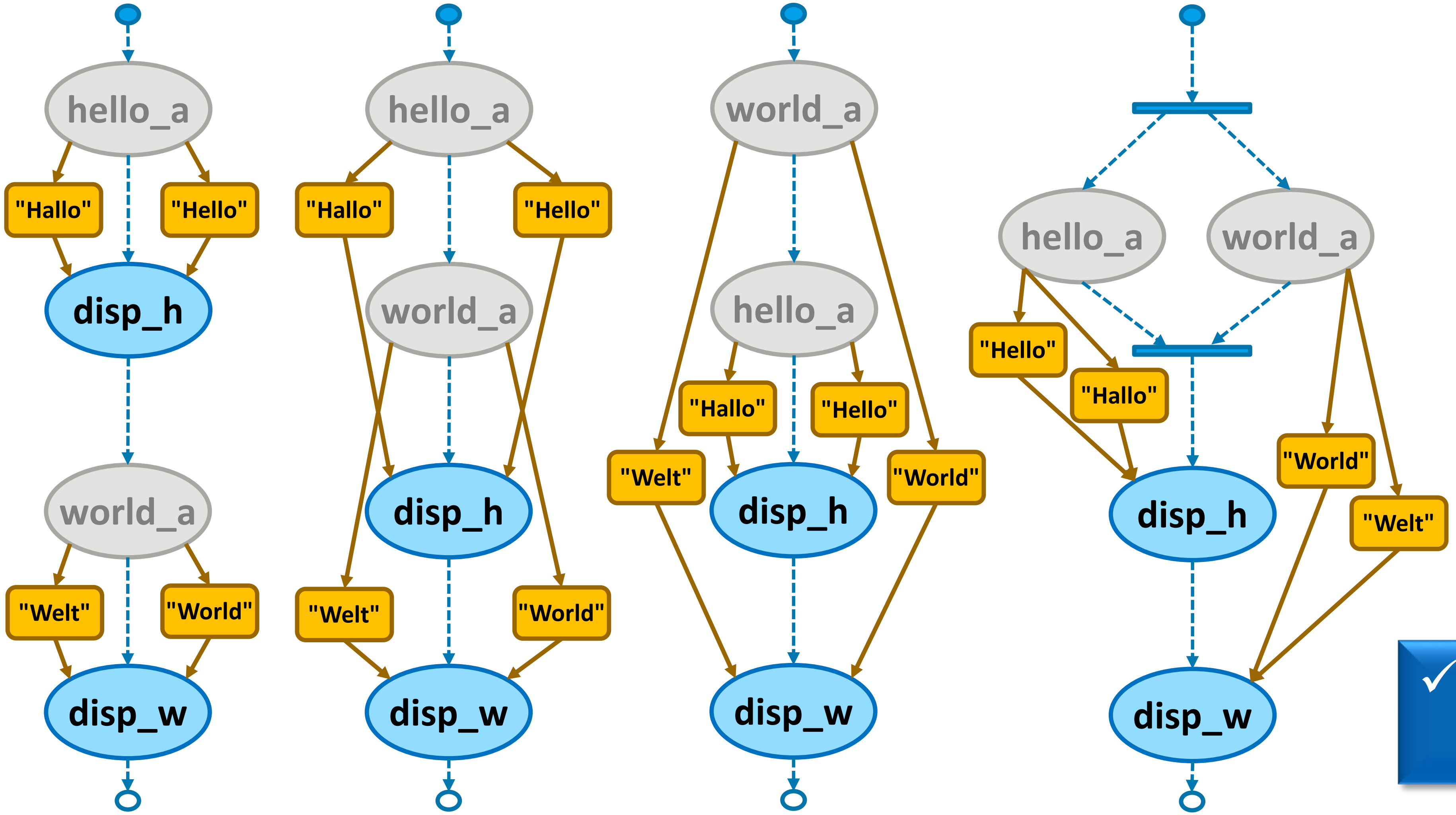
Hello World: Object Pools & Binding




```
extend component pss_top {
  buffer hello_buf : msg_buf {
    constraint {msg.s in["Hello", "Hallo"];}
  }
  action disp_h : display_a {
     override {type msg_buf with hello_buf};
  }
  action hello_a {
    output hello_buf msg;
  }
  pool hello_buf hello_p;
  bind hello_p *;
}
```

- ✓ Constrain data paths
- ✓ Preserve intent

Hello World: Scenarios




```
action hello_world_a {
  activity {
    sequence {
      do disp_h;
      do disp_w;
    }
  }
}
```

anonymous action traversal

✓ **Multiple scenarios from simple specification**

Hello World: C++

```
package hw_pkg {


    buffer msg_buf {

        rand string s;
    }
}
```

```
class hw_pkg : public package {
  PSS_CTOR(hw_pkg, package);

  struct msg_buf : public buffer {
    PSS_CTOR(msg_buf, buffer);
    rand_attr<std::string> s {"s"};
  };
};
type_decl<hw_pkg> hw_pkg_decl;
```

Hello World: C++

```
component pss_top {
  import hw_pkg::*;

  action display_a {

    input msg_buf msg;
    exec body SV = """
      $display("{{msg.s}}");
    """;
  }

  action send_a {

    output msg_buf msg;
  }
```

```
class pss_top : public component {
  PSS_CTOR(pss_top, component);

  class display_a : public action {
    PSS_CTOR(display_a, action);
    input <hw_pkg::msg_buf> msg {"msg"};
    exec e {exec::body, "SV",
                 "$display(\"{{msg.s}}\");"};
  };
  type_decl<display_a> display_a_decl;

  class send_a : public action {
    PSS_CTOR(send_a, action);
    output <hw_pkg::msg_buf> msg {"msg"};
  };
  type_decl<send_a> send_a_decl;
```

Hello World: C++

```
  pool msg_buf msg_p;
  bind msg_p *;
  action hello_world_a {

    display_a disp1, disp2;

    activity {
      select {
        disp1 with {msg.s == "Hello ";}
        disp2 with {msg.s == "World";}
      }
    }
}
```

```
  pool <hw_pkg::msg_buf> msg_p {"msg_p"};
  bind b {msg_p};
  class hello_world_a : public action {
    PSS_CTOR(hello_world_a, action);
    action_handle<display_a> disp1 {"disp1"},
                             disp2 {"displ2"};
    activity a {
      select {
        disp1.with (disp1->msg->s == "Hello"),
        disp2.with (disp2->msg->s == "World")
      }
    };
  };
  type_decl<hello_world_a> hello_world_a_decl;
};
type_decl<pss_top> pss_top_decl;
```

A Quick Recap: PSS Gives You…

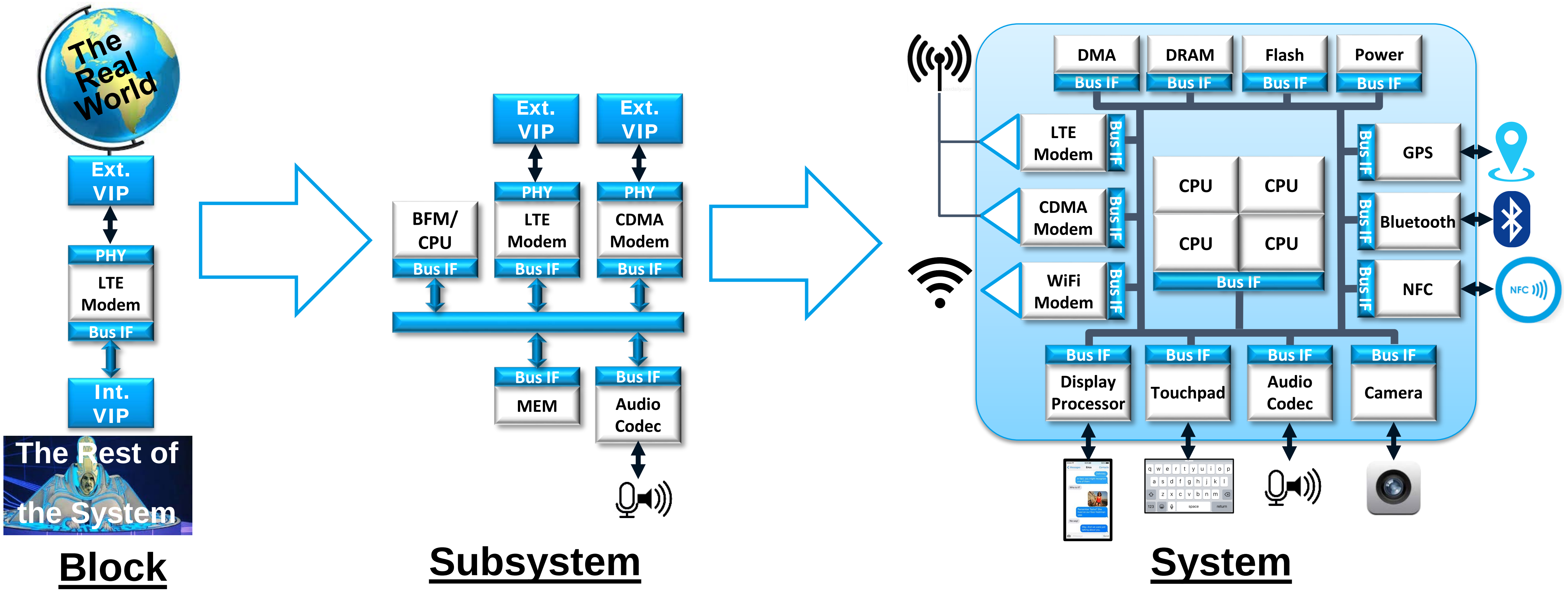
- ✓ Reuse
- ✓ Composition
- ✓ Abstract behaviors
- ✓ Retargetable Implementations
- ✓ Behavior encapsulation
- ✓ Behavior scheduling
- ✓ Complex data structures
- ✓ Data flow modeling
- ✓ Constrained random
- ✓ Reactivity
- ✓ Directed testin … en desired

- ✓ In-line constraints
- ✓ Additional reuse and encapsulation
- ✓ Abstract partial specifications
- ✓ Scenario-level randomization
- ✓ Robust scheduling support
- ✓ Type extension
- ✓ Obj … tance
- ✓ … ce) override
- ✓ … nstrain data paths
- ✓ Preserve intent
- ✓ Multiple scenarios from simple specification

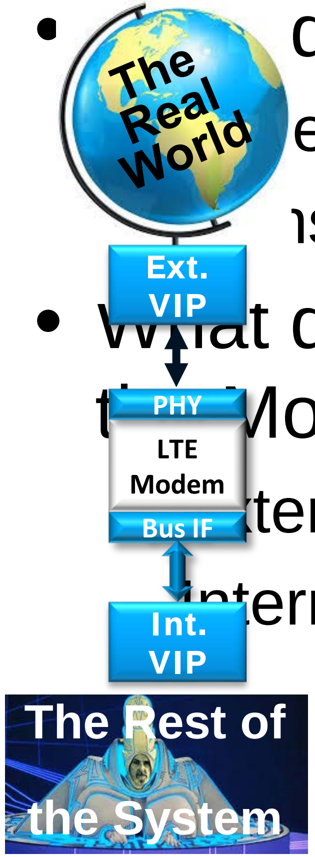
But wait! There's more!

Block-to-System Example

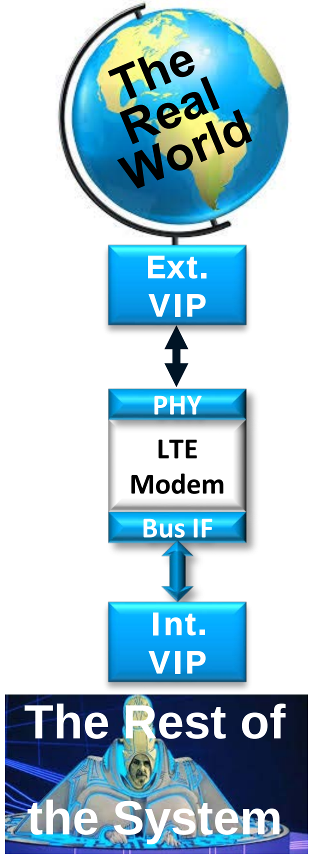
A Block-to-System Example



Define Actions



- What does the Modem do?
  - receive packet: rx
  - transmit packet: tx
- What data flow objects does the Modem use?
  - External Interface: packet
  - Internal Interface: datStr
- What does the External IP do?
  - send packets
  - receive packets
- What does the Internal IP do?
  - Store datStrs
  - Retrieve datStrs

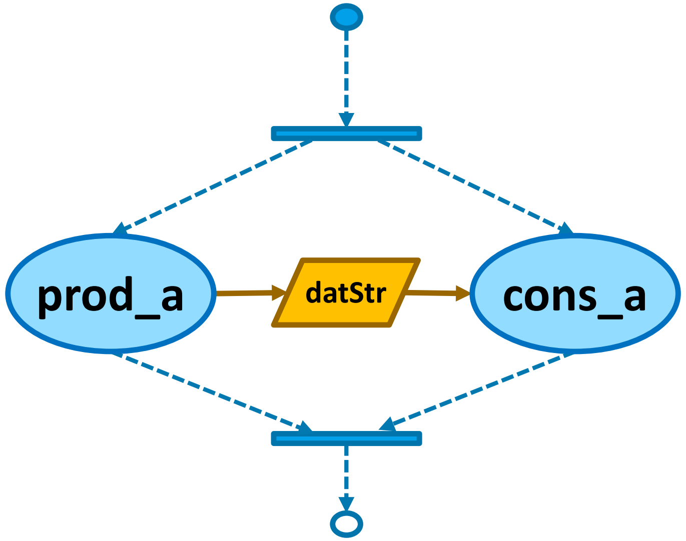


Define Data Flow Objects

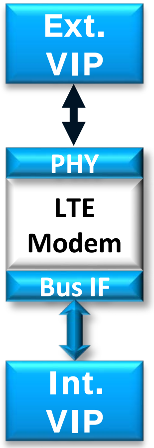
enum defines a set of *integral named constants*

stream requires *parallel* producer-consumer execution

rand fields are randomized




```
package data_flow_pkg{
  enum dir_e {inb=0, outb};
  stream datStr {
    rand dir_e dir;
    rand bit [7:0] length;
    rand bit [31:0] addr;
  }
  stream packet {
    rand dir_e dir;
    rand bit [15:0] size;
    bit [47:0] MAC_src;
    bit [47:0] MAC_dst;
  }
}
```

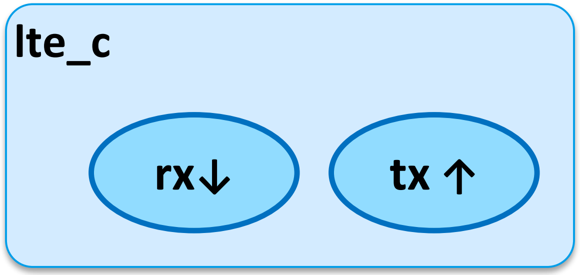


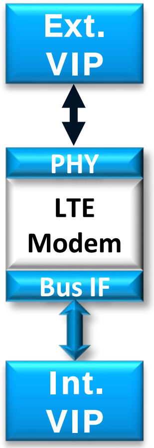
The LTE Modem Component

function imports a *procedural interface*

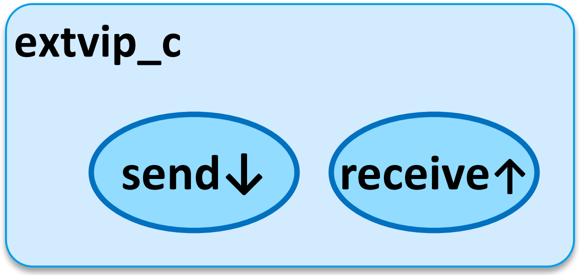
procedural interface passes elements to/from **exec** blocks

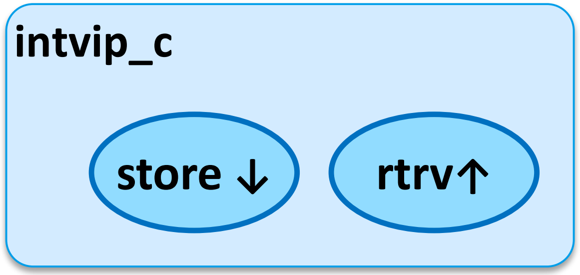
```
package modem_funcs {
  import data_flow_pkg::dir_e;
  function void set_mode(dir_e dir);
}
component lte_c {
  import data_flow_pkg::*;
  import modem_funcs::*;

  action tx_a {
    input datStr bPkt;
    output packet pkt;
    constraint {pkt.dir == outb; bPkt.dir == outb;}

    exec body {
      set_mode(pkt.dir);
    }
  }
  …
}
```





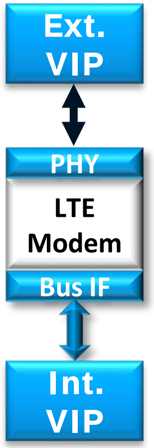
The VIP Components



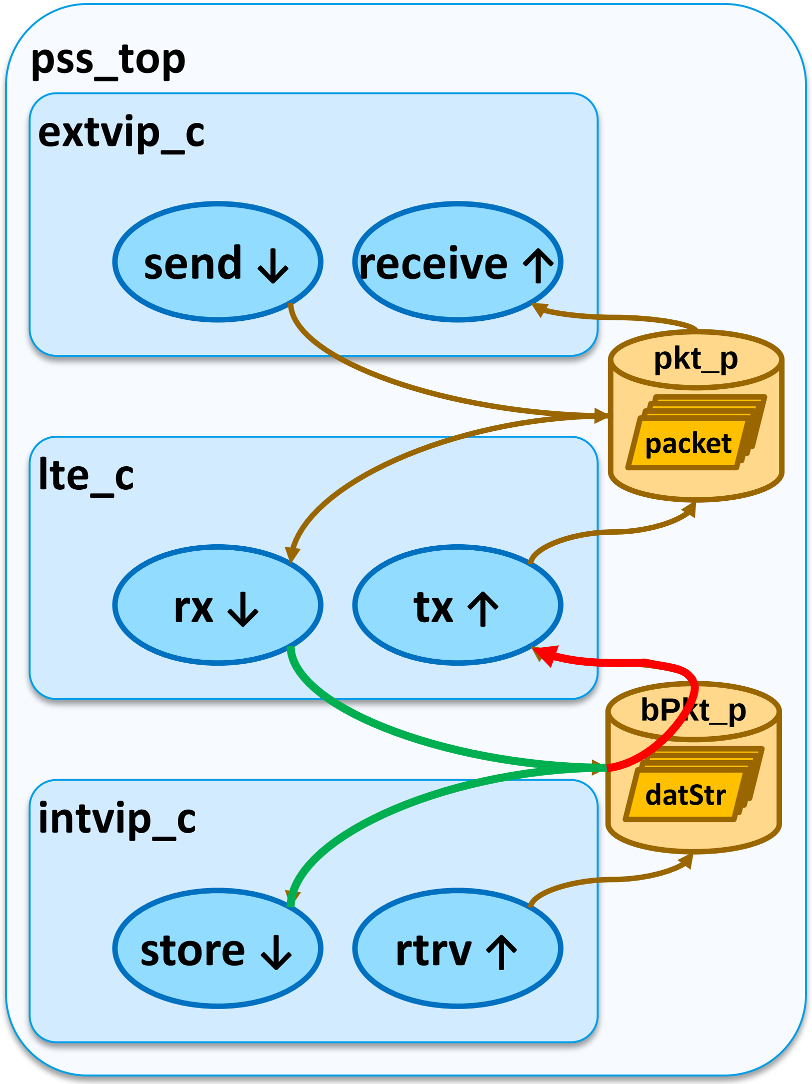



```
component extvip_c {
  import data_flow_pkg::packet;
  action send_a {
    output packet pkt;
    constraint {pkt.dir == inb;}
  }
  action receive_a {
    input packet pkt;
    constraint {pkt.dir == outb;}
  }
}
```

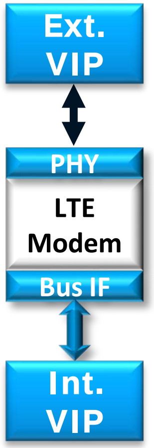
```
component intvip_c {
  import data_flow_pkg::datStr;
  action store_a {
    input datStr pkt;
    constraint {pkt.dir == inb;}
  }
  action rtrv_a {
    output datStr pkt;
    constraint {pkt.dir == outb;}
  }
}
```



Putting it Together

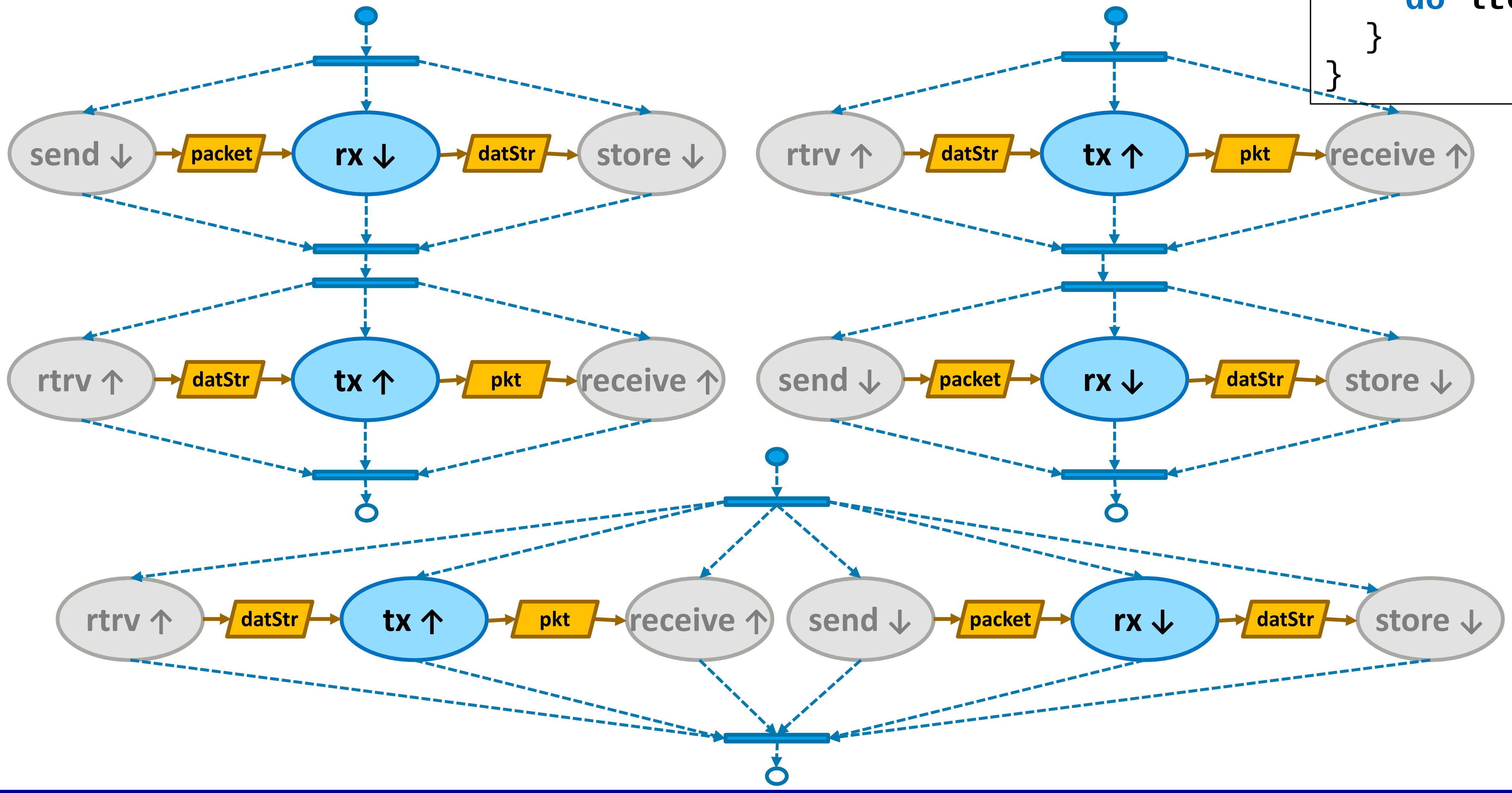


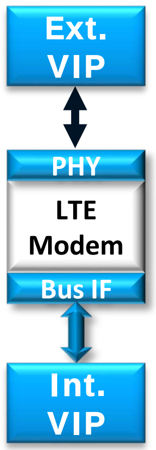

```
component pss_top {
  import data_flow_pkg::*;
  extvip_c xvip;
  lte_c lte;
  intvip_c ivip;

  pool packet pkt_p;
  bind pkt_p {xvip.*, lte.*};
  pool datStr bPkt_p;
  bind bPkt_p {ivip.*, lte.*};

  action test {
    activity {
      schedule {
        do lte_c::rx_a;
        do lte_c::tx_a;
      }
    }
  }
}
```



Putting it Together

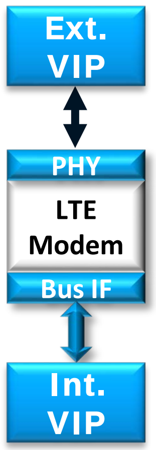
```
activity {
  schedule {
    do lte_c::rx_a;
    do lte_c::tx_a;
  }
}
```

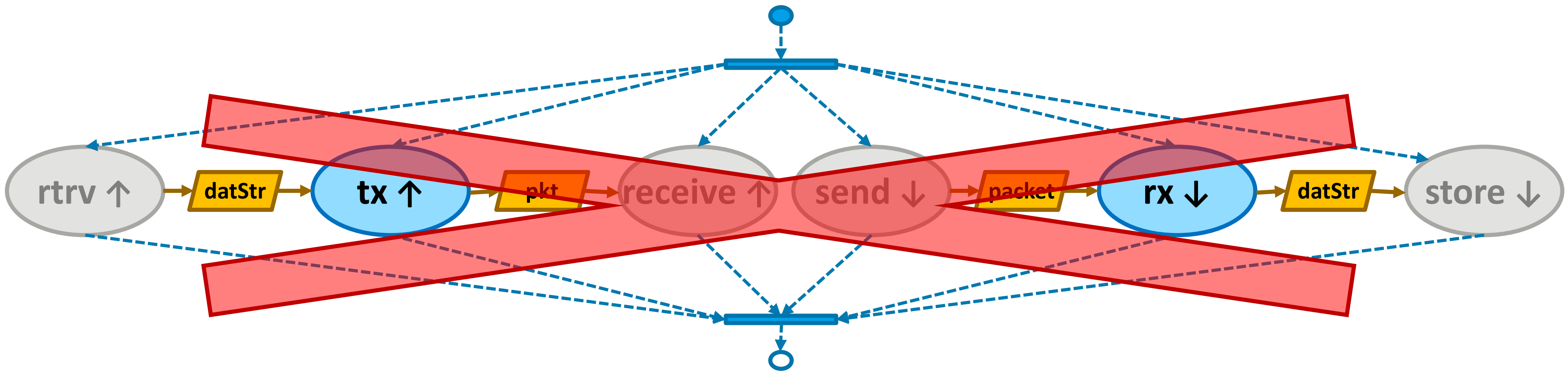




Resources: Target-Specific Constraints

- What if the Modem is half-duplex?
  - Prevent rx & tx from running in parallel
- PSS models target-specific *resources*
  - May be assigned to an action for its duration
  - Exclusive (*lock*ed) or non-exclusive (*share*d)





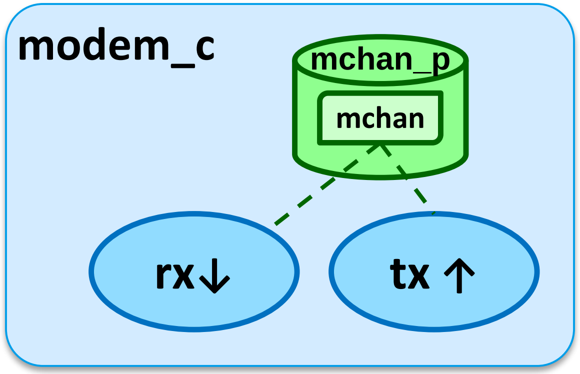
The Modem Component + Resources

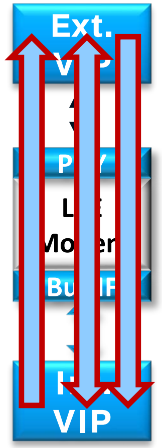
`resource` defines a *resource object*

`pool` defaults to *size == 1*

`lock` declares *exclusive access*

```
component lte_c {
  import data_flow_pkg::*;
  import modem_funcs::*;

  resource mchan_r {…/* struct */};
  pool[1] mchan_r mchan_p;
  bind mchan_p *;

  action rx_a {
    input packet pkt;
    output datStr bPkt;
    lock mchan_r mchan;
    constraint {pkt.dir == inb; bPkt.dir == inb;}

  }
  …
}
```

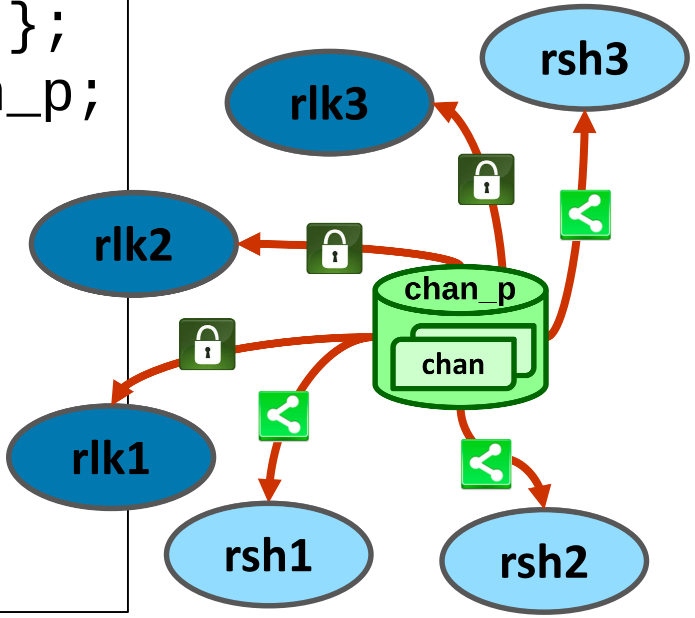


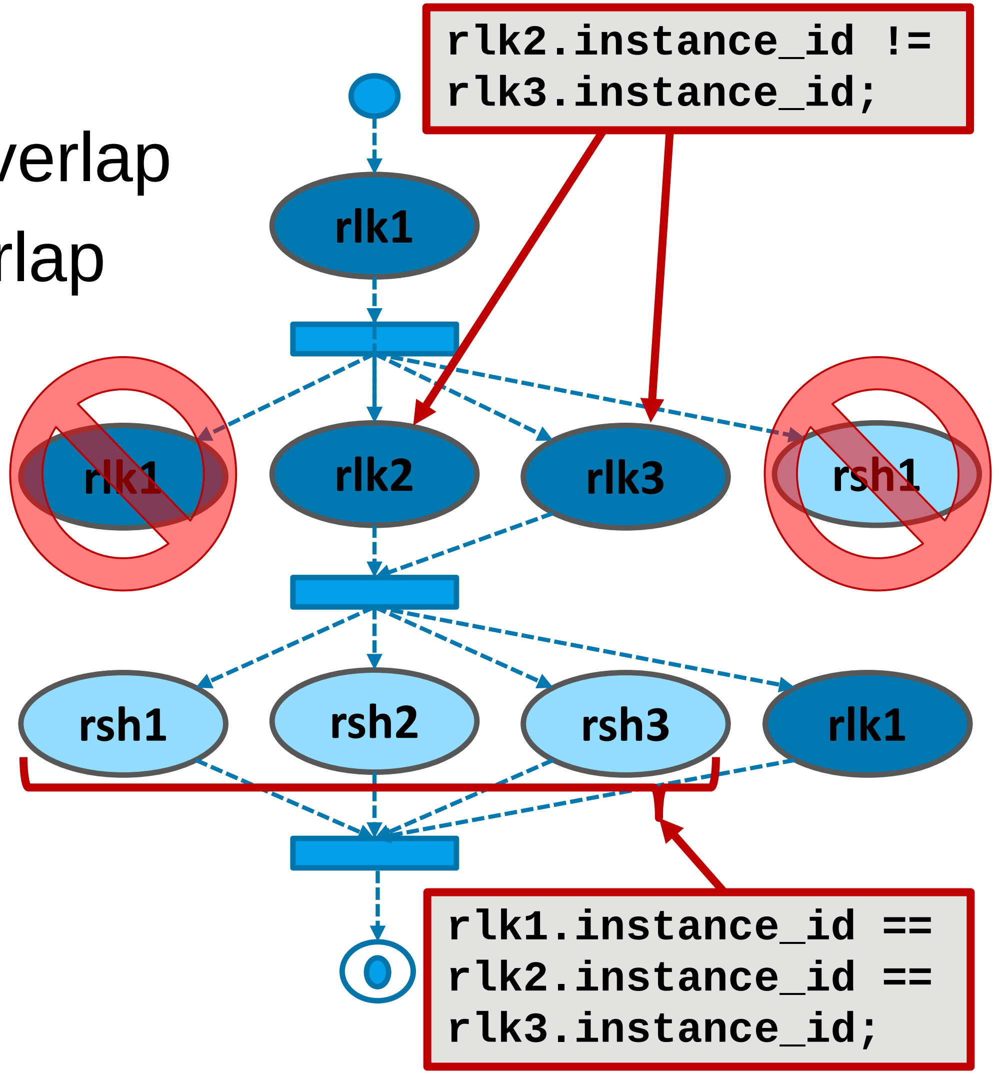


Claiming Resource Objects

- Actions may *lock* or *share* resources
  - Actions that *lock* a given resource may not overlap
  - Actions that *share* a given resource may overlap

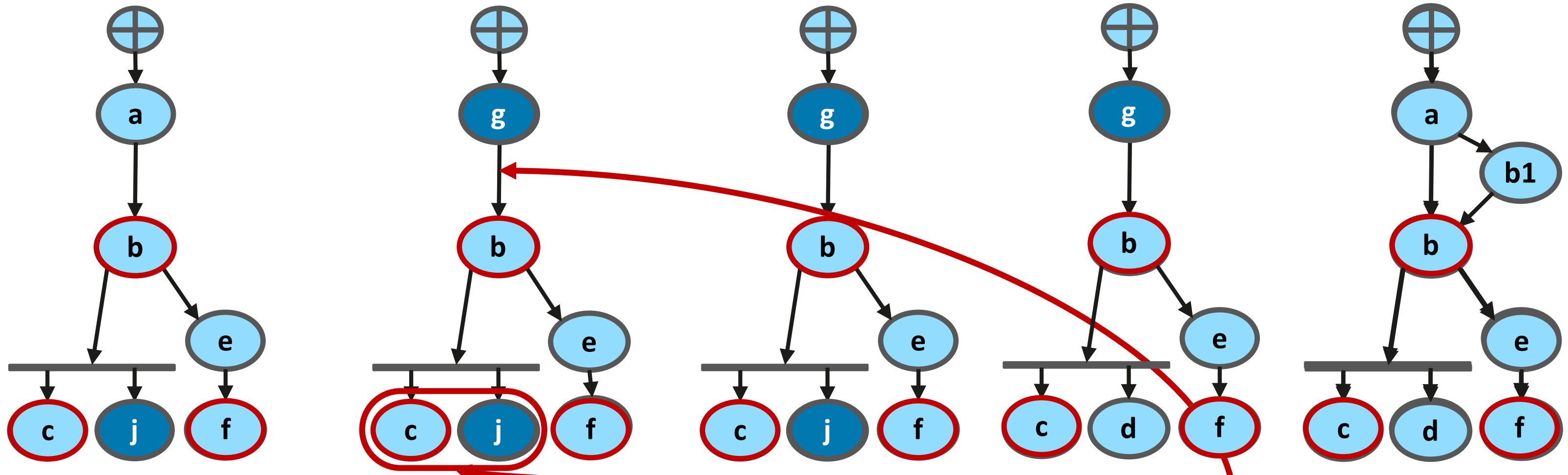
```
resource chan_r {...};
pool [2] chan_r chan_p;
bind chan_p {*};
action rlk_a {
  lock chan_r chan;
  …};
action rsh_a {
  share chan_r chan;
  …};
```





- A total of *size* locking actions may execute in parallel for a given resource pool

Solution Space Mapping



Partial Specifications are *Flexible*

```
action test_top {
  do_a a; do_b b;
  do_c c; do_d d;
  do_e e; do_f f;

  activity {
    a;
    b;
    select {
      parallel { c; d; }
      {e; f;}
    }
  }
}
```

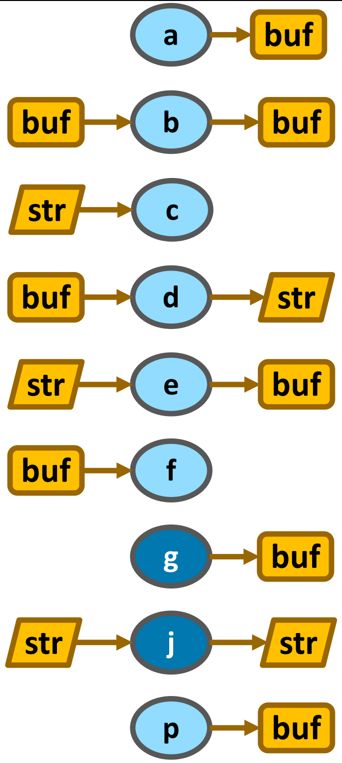
```
action test_top {
          do_b b;
  do_c c;
          do_f f;

  activity {

    b;
    select {
                c;
       f;
    }
  }
}
```

```
buffer mbuf {…};

action do_a {
  output mbuf m;
  …};

action do_b {
  input mbuf m;
  output mbuf o;
  …};

action do_g {
  output mbuf m;
  …};
```

```
stream mstr {…};

action do_c {
  input mstr s;
  …};

action do_d {
  output mstr s;
  …};

action do_j {
  output mstr m;
  …};
```

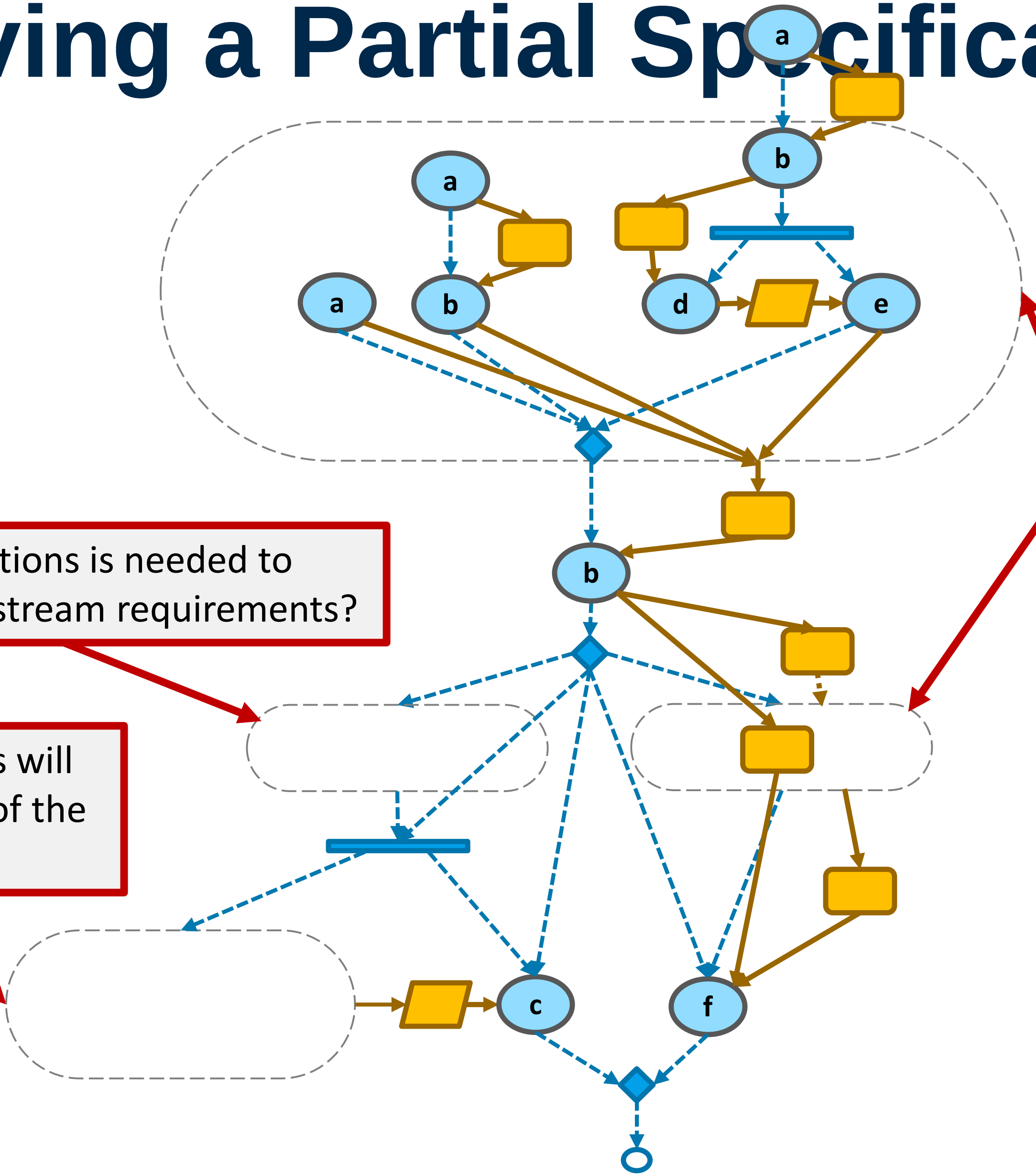
Resolving a Partial Specification

```
action test_top {

  activity {
    b;
    select {
      c;
      f;
    }
  }
}
```



What set of actions is needed to support downstream requirements?

What set of actions will produce a **stream** of the correct type?



What combination of known actions will produce a **buf** of the correct type?

Are there any **resource** conflicts that constrain the possible scheduling?

End of Part 1

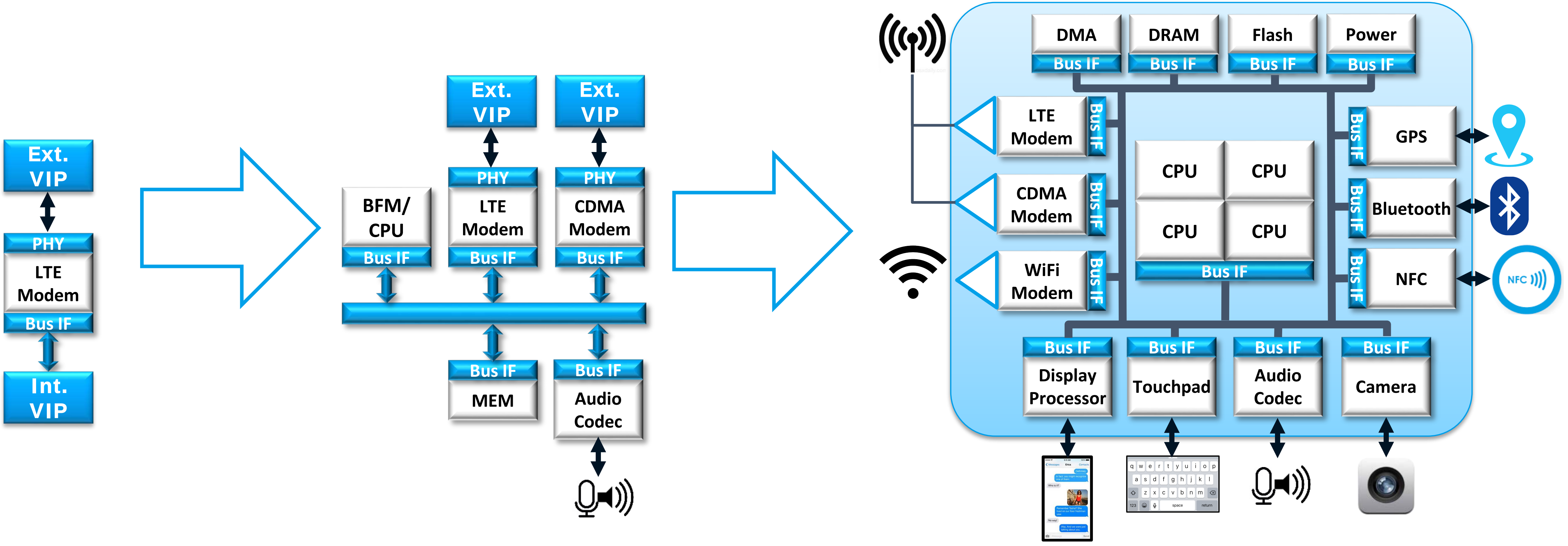
Portable Test and Stimulus: The Next Level of Verification Productivity is Here

Part 2

Accellera Portable Stimulus Working Group

2/26/2018

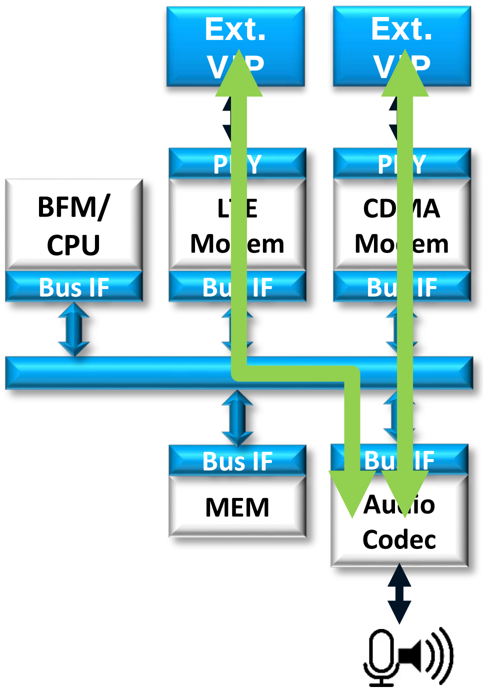
A Block-to-System Example



Block **Subsystem** **System**

Modem Sub-system

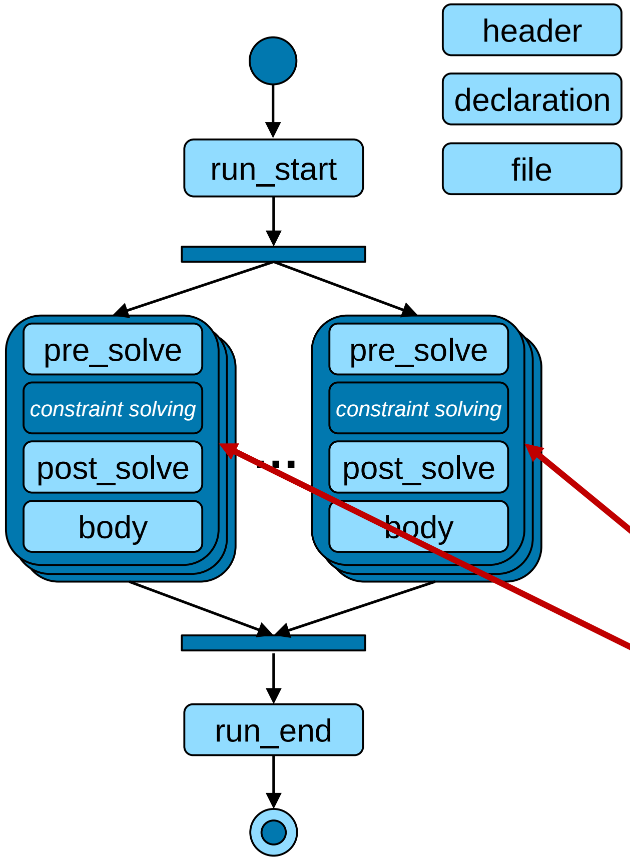
- Manage Voice Calls
- Can use either
  – LTE Modem, OR
  – CDMA Modem
- Both modems exchange common datStr data with Audio Codec
- *Stream* relationship between Modem and Audio Codec:
  – both must operate concurrently



<u>Subsystem</u>

Exec Block Types

Specify mapping of PSS entities to their implementation



test.c

```
#include <stdint.h>

void declared_func() {
…
}

void test_main() {
  do_run_start();
  fork_threads();
  do_run_end();
}

void thread0() {
…
// step N
  do_body();
…
};

void thread1() {
…
}
```

test.sh

```
gcc -c test.c -DBARE_METAL
```

Could be SV
or other language

Could be multiple threads on one core,
or threads running on different cores

The CDMA Modem Component

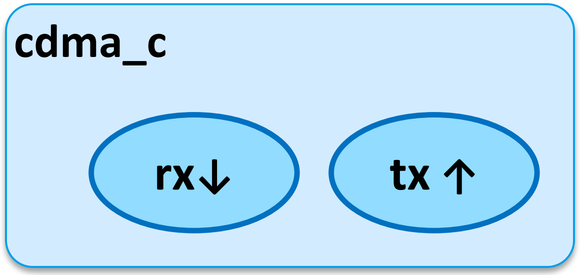
more **function** imports

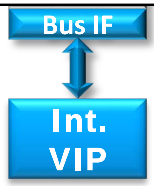
random variable

post-solve **exec** block runs after randomization

```
package modem_funcs {
  function bit [47:0] CDMA_MAC_src();
  function bit [47:0] CDMA_MAC_dst();
  function bit  [31:0] CDMA_data_buf();
}
component cdma_c {
  import data_flow_pkg::*;
  import modem_funcs::*;

  action rx_a {
    input packet pkt;
    output datStr bPkt;
    constraint {pkt.dir == inb; bPkt.dir == inb;}

    exec post_solve {
      bPkt.addr = CDMA_data_buf();
    }

  …
```

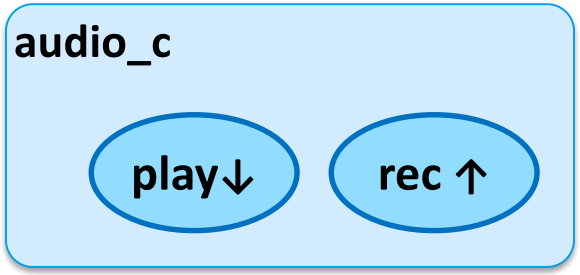
```
stream datStr {
  rand dir_e dir;
  rand bit [7:0] length;
  rand bit [31:0] addr;
}
```



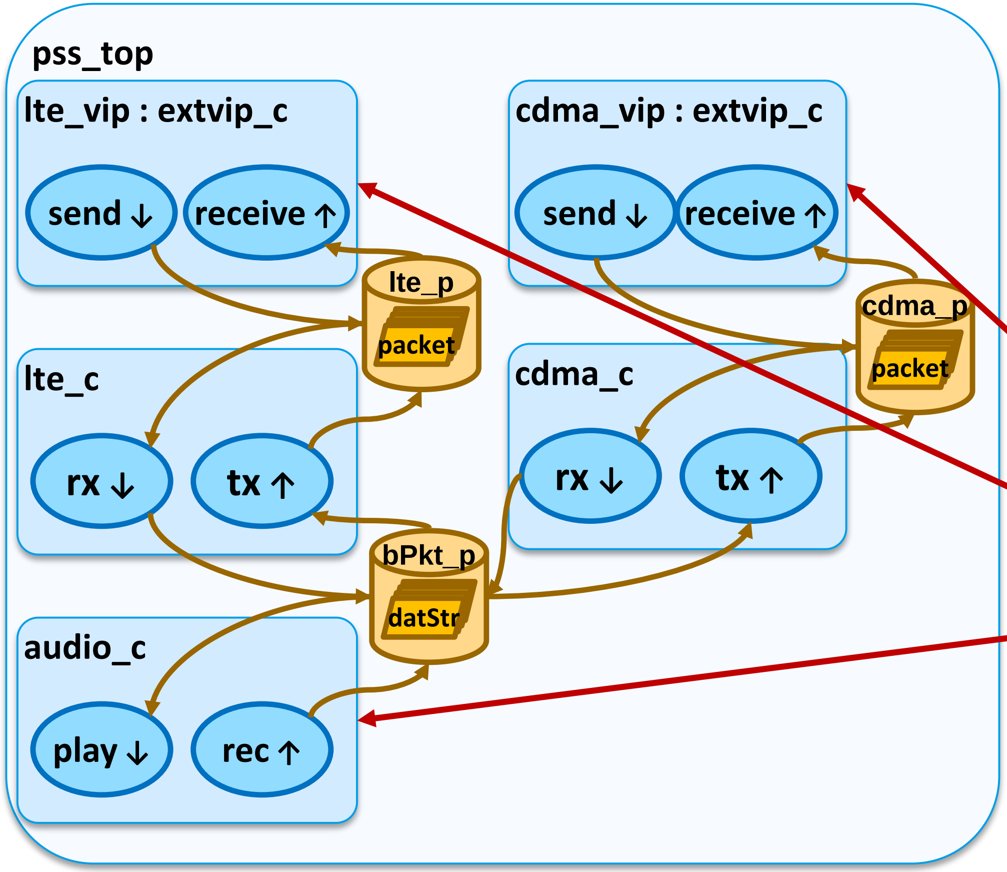


The Audio Codec Component

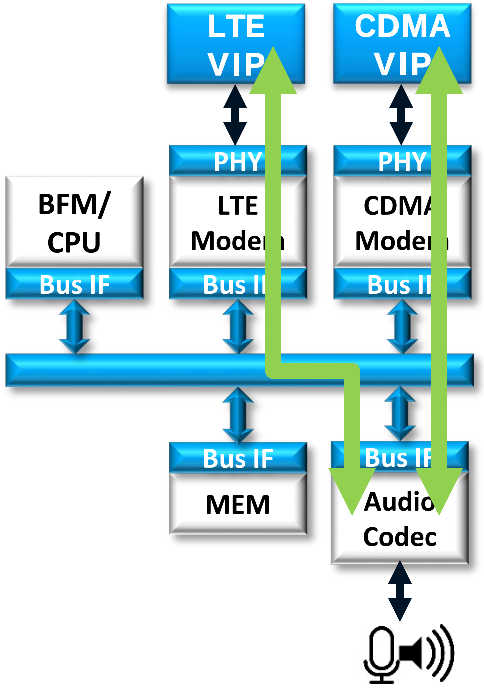
```
package audio_funcs {
  function void play(bit[31:0] addr, bit[7:0] len);
  function void record(bit[31:0] addr);
}
component audio_c {
  import audio_funcs::*;


  action rec_a {
    output datStr bPkt;
    constraint {bPkt.dir == outb;
                bPkt.length == 1024; }

    exec body {
      record(bPkt.addr);
    }
  }
}
```



Putting it Together

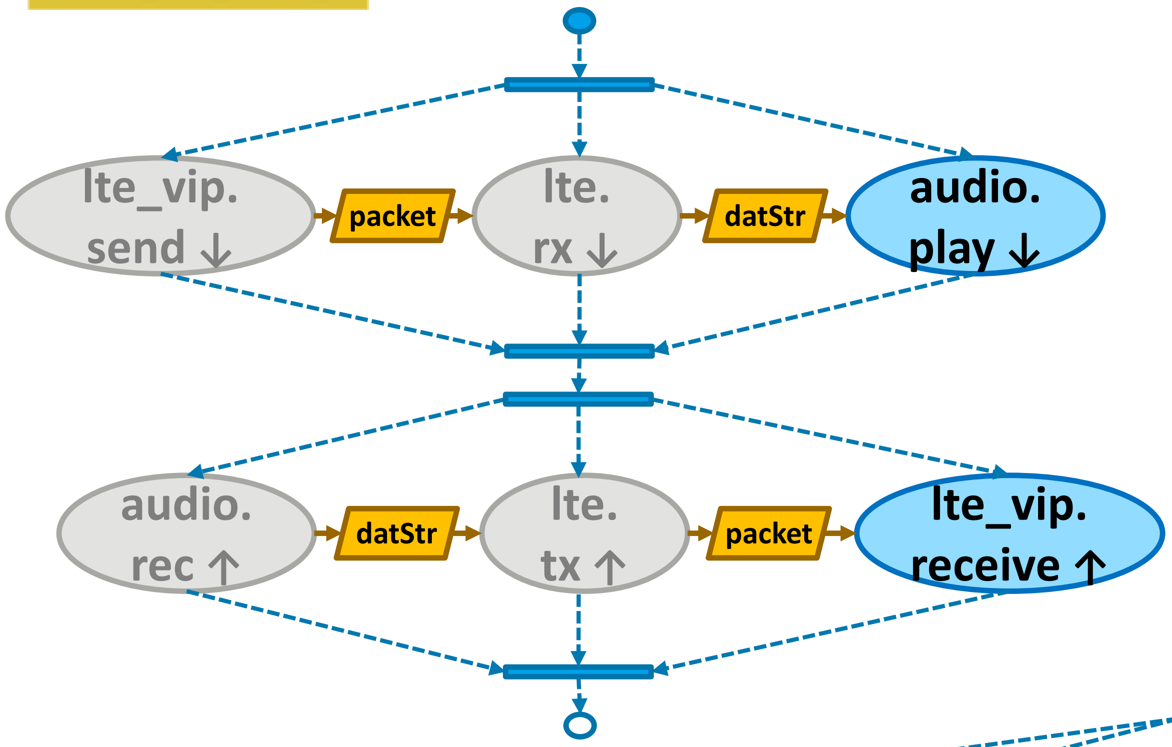


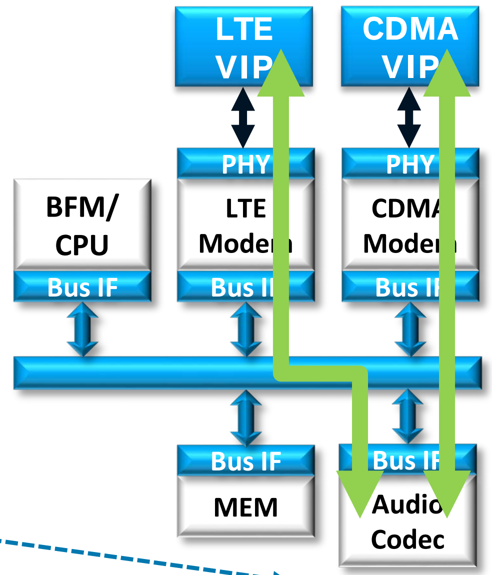

```
component pss_top {
  import data_flow_pkg::*;
  extvip_c lte_vip, cdma_vip;
  lte_c lte;
  cdma_c cdma;
  audio_c audio;

  action test {
    activity {
      schedule {
        do audio_c::play_a;
        do extvip_c::receive_a;
      }
    }
  }
}
```

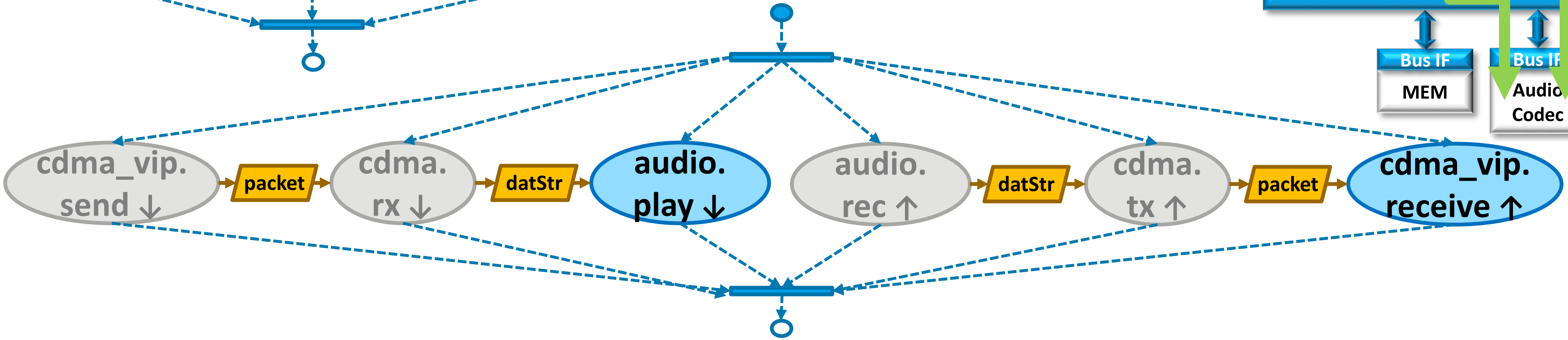


Subsystem Scenarios

```
activity {
  schedule {
    do audio_c::play_a;
    do extvip_c::receive_a;
  }
}
```





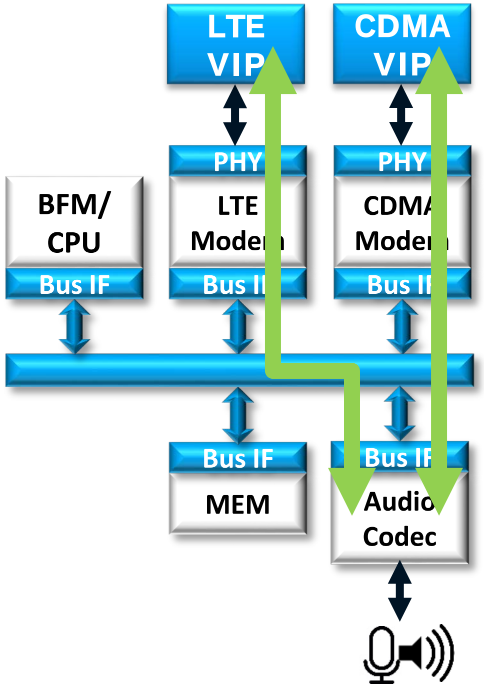


Layering in Power Scenarios

state flow object preserves persistent state

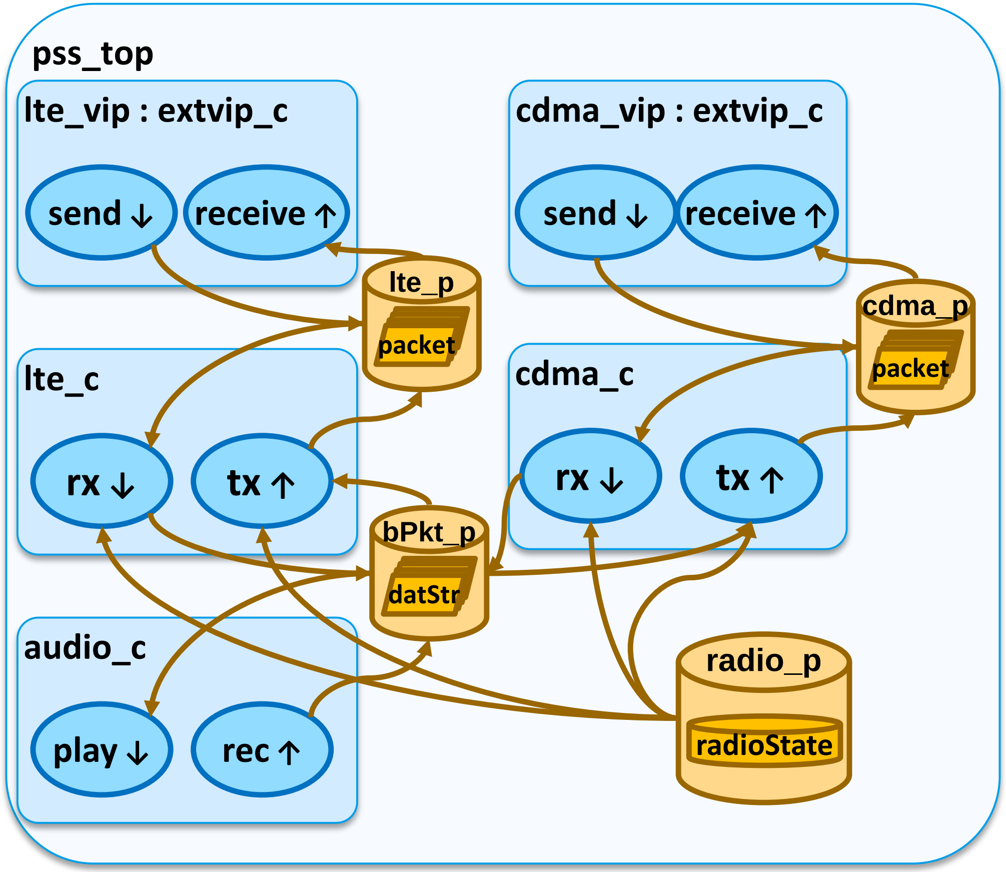
initial used to set start value of persistent state

```
package power_state {
  function void radio_on();
  function void radio_off();

  enum radio_state_e { on, off };

  state radioState {
    rand radio_state_e rstate;
    constraint
      initial -> rstate == off;
  }
  …
}

extend component pss_top { …
  pool radioState radio_p;
  bind radio_p *;
}
```

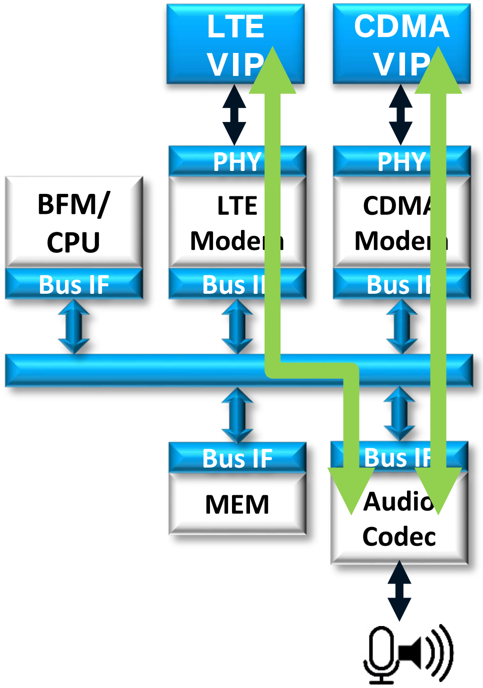


Subsystem

Layering in Power Scenarios




```
package power_state {

  extend action lte_c::tx_a {
    input radioState in_s;
    constraint
      in_s.rstate == on;
  }

  extend action cdma_c::tx_a {
    input radioState in_s;
    constraint
      in_s.rstate == on;
  }
  …
}
```



Subsystem

Layering in Power Scenarios

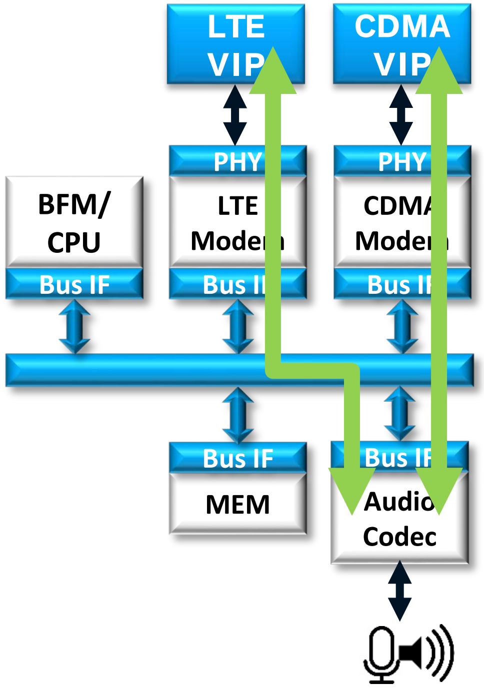
outputs a **radioState** flow object

may only run if previous **rstate** was **off**

set next **rstate** to **on**

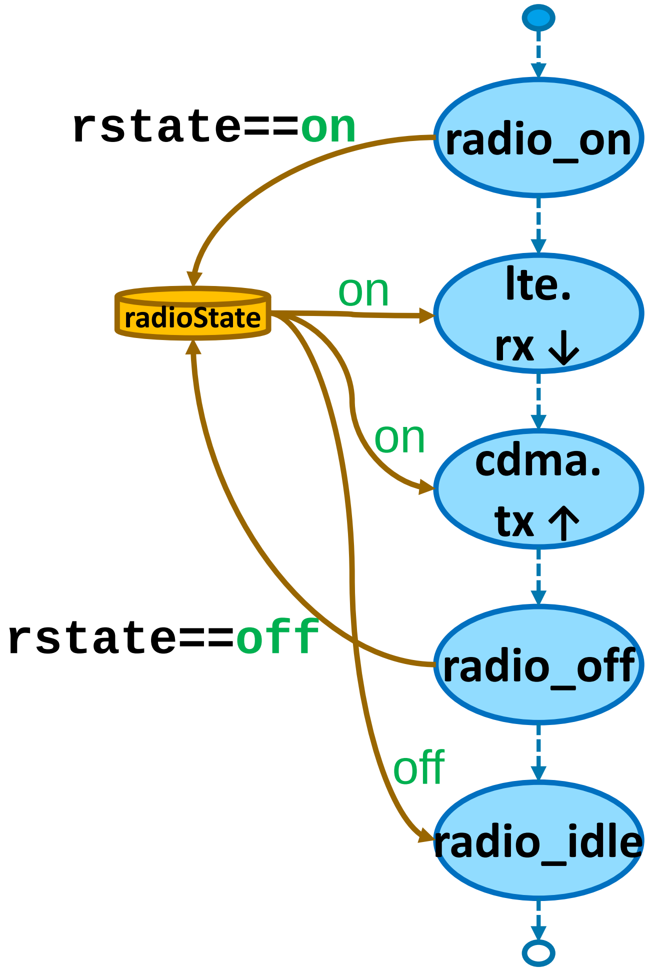
turn on the radio

```
extend component pss_top {

  action radio_off_a {
    output radioState out_s;

    constraint
      out_s.prev.rstate == on;
    constraint
      out_s.rstate == off;

    exec body {
      radio_off();
    }
  }
}
```

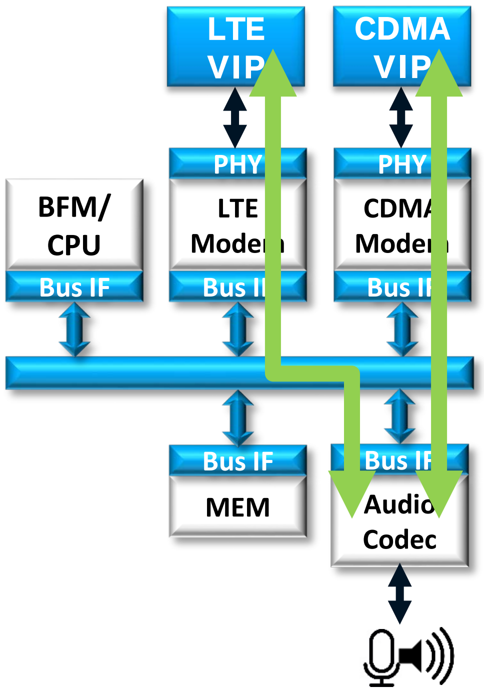


Subsystem

Layering in Power Scenarios

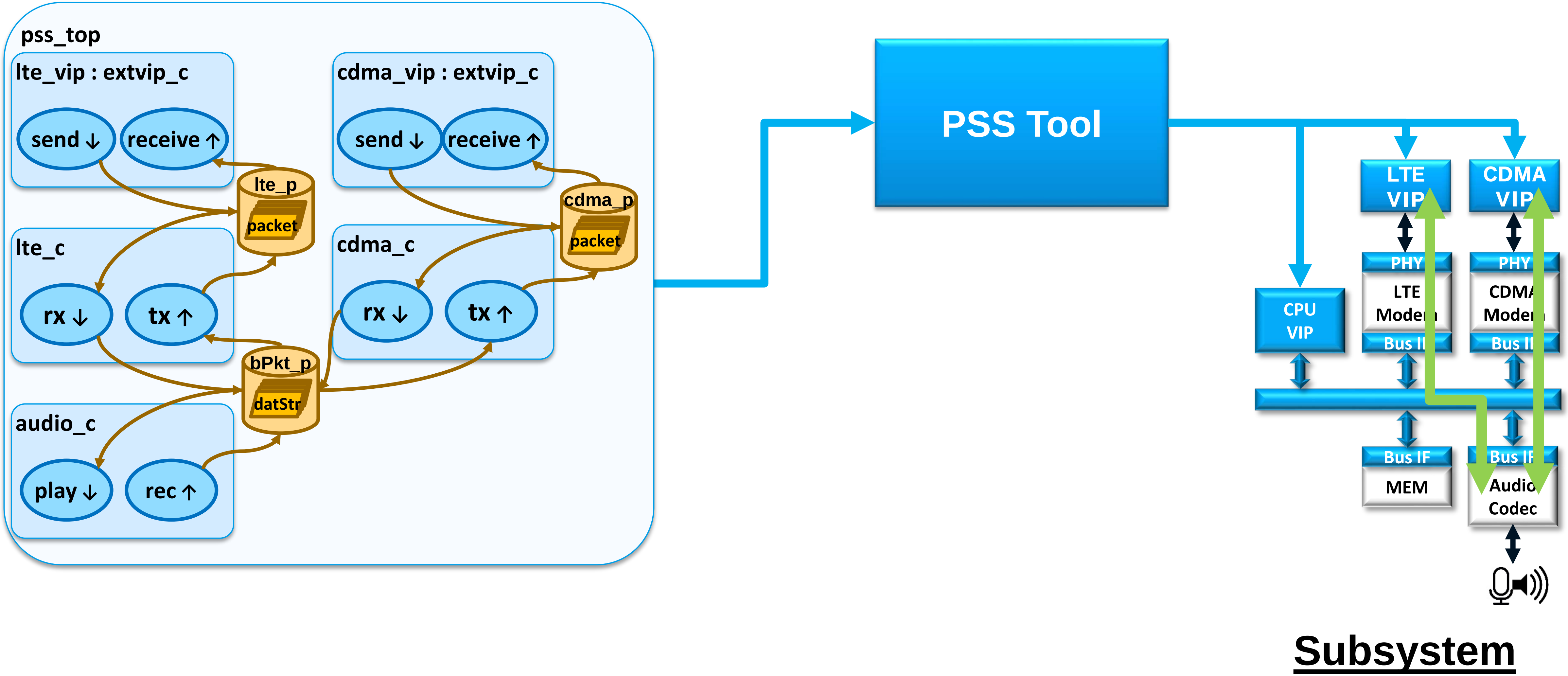



```
extend component pss_top {

  action radio_idle_a {
    input radioState in_s;
    constraint in_s.rstate == off;
  }

  action test {
    activity {
      select {
        do radio_idle_a;
        schedule {
          do audio_c::play_a;
          do extvip_c::receive;
        }
      }
    }
  }
}
```

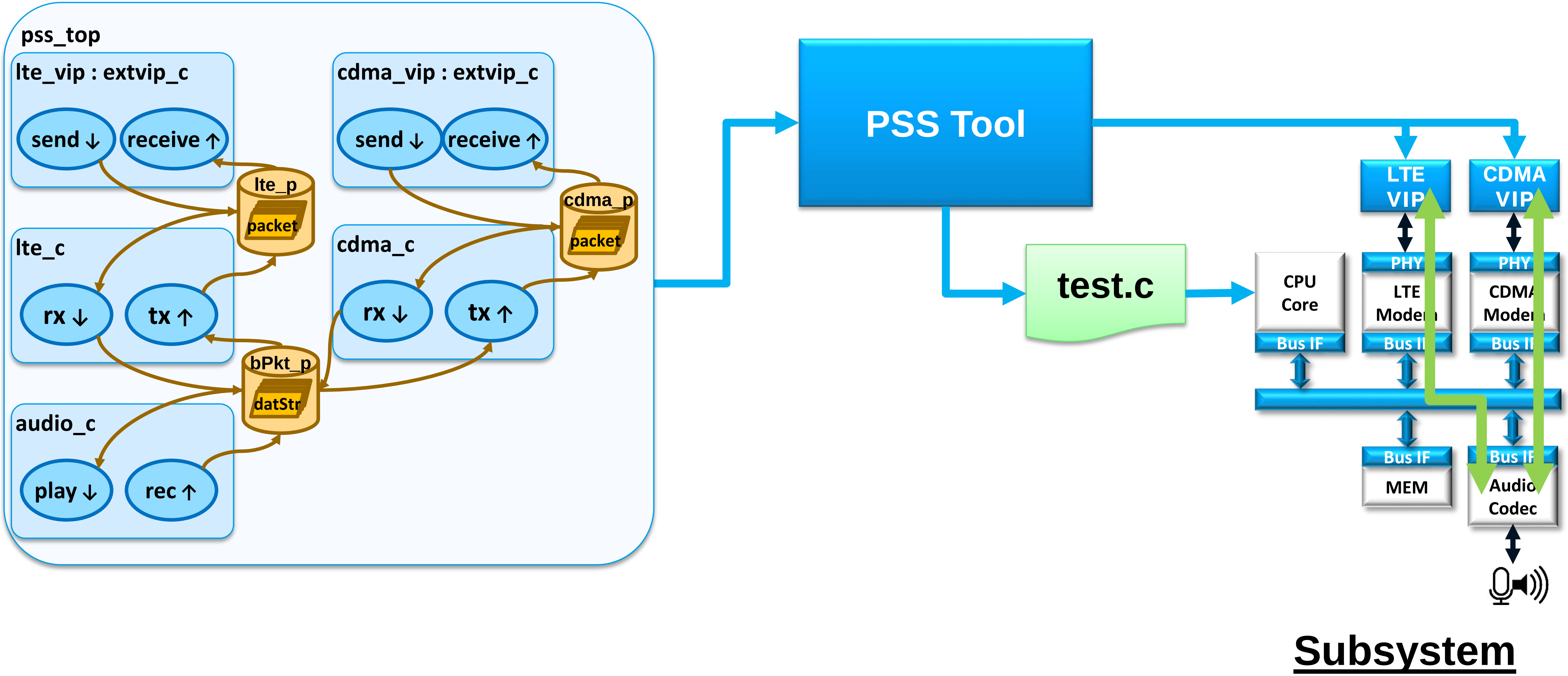


Subsystem

UVM Tool Flow



UVM + C-Test Tool Flow



Portable Stimulus Coverage

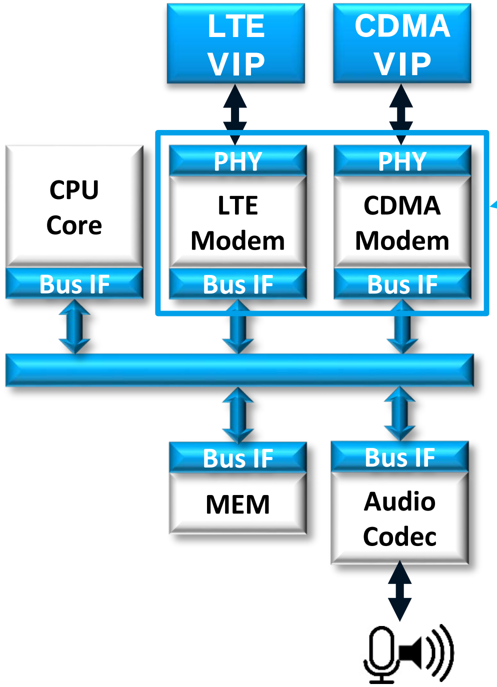
- Coverage constructs derived from SV
  - Support cross, illegal, ignore and others
  - Keyword is change from covergroup -> coverspec
- Coverage is currently data-centric
  - Monitor values and ranges on action/struct fields
- More coverage types may be added
  - Action Coverage
  - Scenario (Action Sequence) Coverage
  - Datapath Coverage
  - Resource Coverage

Formalization of system level scenarios and models

==

Ability to formally describe **coverage** of the legal scenarios and attributes

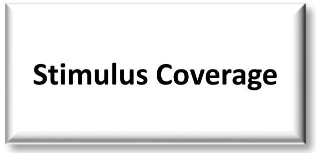
Coverage




```
action setup_modem {
  enum direction_e {TRANSMIT, RECEIVE, BOTH};
  rand direction_e direction;
  unsigned int baud_rate;
  unsigned int packet_size;
  unsigned bit [1:0] destination_addr;

  exec body {…. }

  coverspec modem_initialization (init_modem) {
    constraint baud_len_c {
      if (direction == TRANSMIT) {
        baud_rate in [28000,3192704, 4196704];
      }
    }
    baud: coverpoint init_modem.packet_size {
      bins size [28000 ... 4296704]/32;
    }
    dir : coverpoint transmit_dir_tx {
      bins transmit = {TRANSMIT};
      bins receive  = {RECEIVE};
      bins bidi   = {BOTH};
    }
    transmit_type_invld : cross transmit_dir_tx, addr {
      ignore addr ? (direction  == TRANSMIT) : 1;
    }
    address: coverpoint addr ;
  }
```

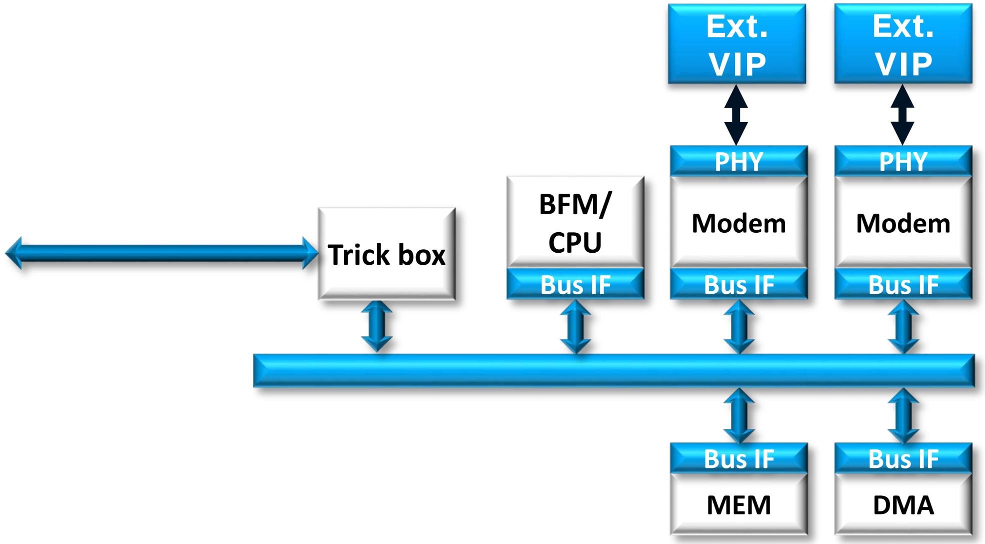
Monitoring Coverage

- Stimulus monitoring
  - Generation time tool can output what it generated/scheduled
    - As long as test “passes”, the coverage data is valid

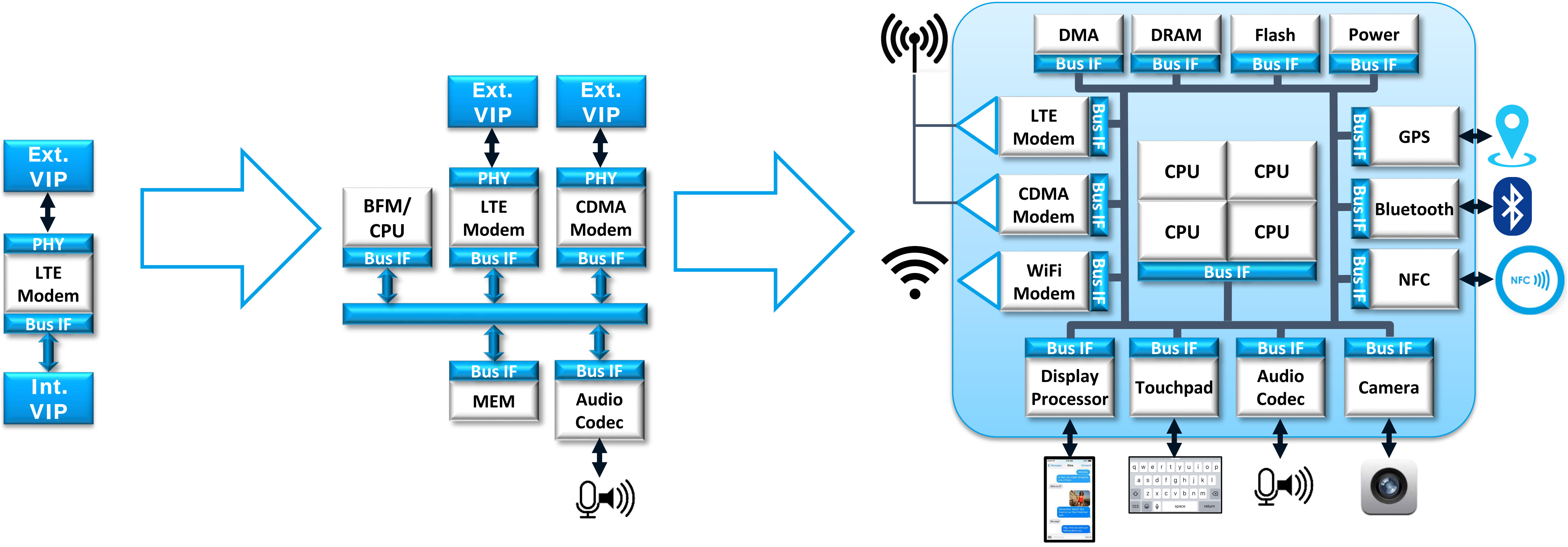


- Runtime state monitoring
  - Requires generation of monitoring code
    - May be C/C++ code running on target cpu

  –e.g. data sent out “trickbox” mechanism
    - May be “off-chip” monitoring via test ports or other communication ports



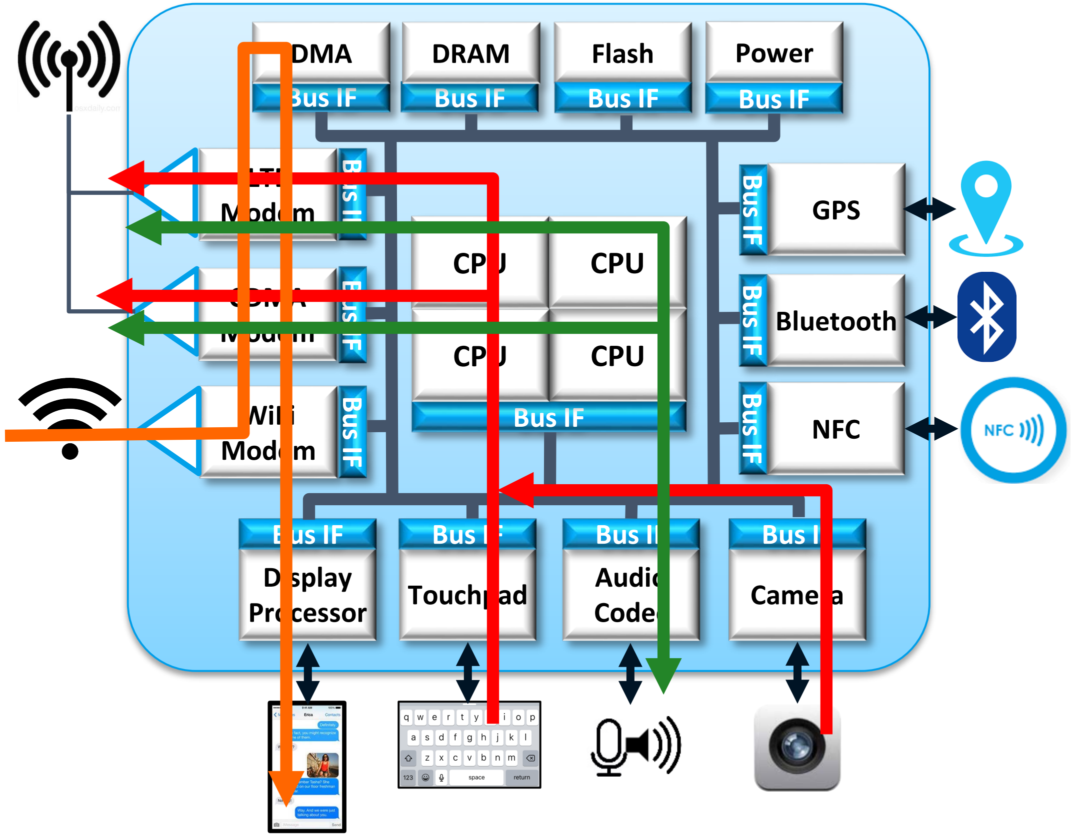
A Block-to-System Example



Block **Subsystem** **System**

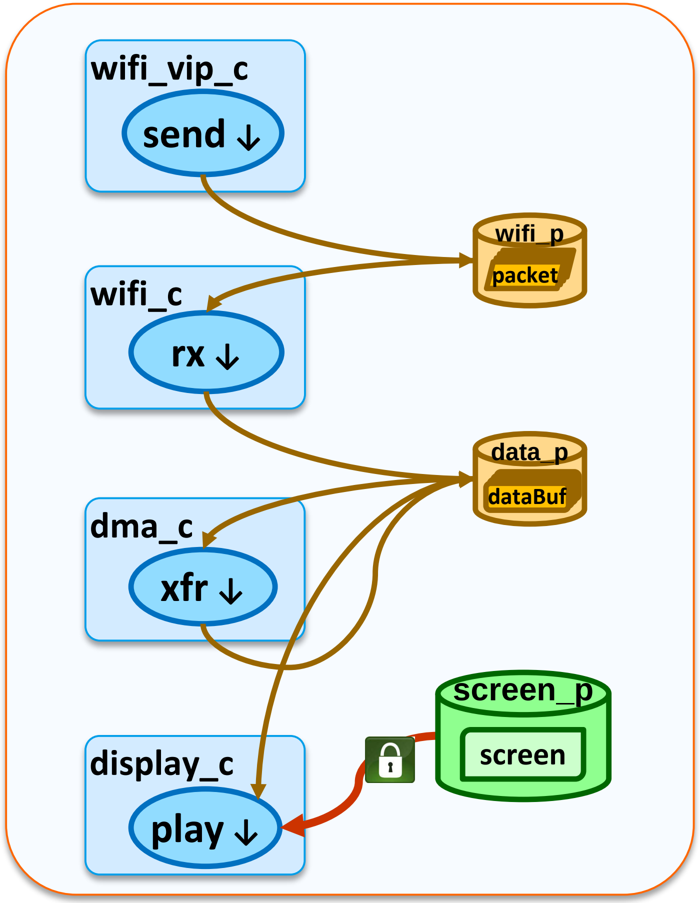
Full System Scenarios

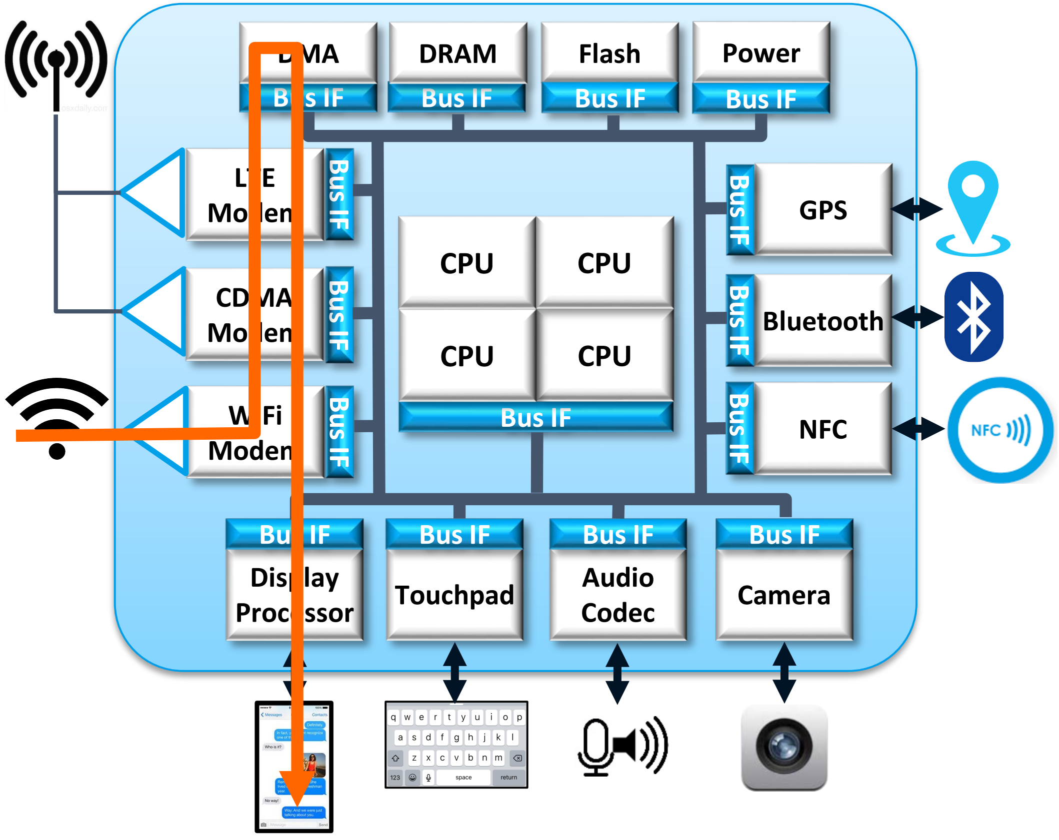
- Reuse Sub-System Voice Call model
- Add Streaming Video over Wifi
- Add Text Message with Photo



System

Streaming Video over Wifi





System

Streaming Video over Wifi

```
class screen : public resource {…};

class display_c : public component {
  PSS_CTOR(display_c, component);

  class play_a : public act
    PSS_CTOR(play_a, action
    input <datBuf> data{"data"};
    constraint c {data->                };
    lock <screen> lk {"lk"};
  …};
  type_decl<play_a> play_d;
};
type_decl<display_c> display_d;
```

declare randomizable enum

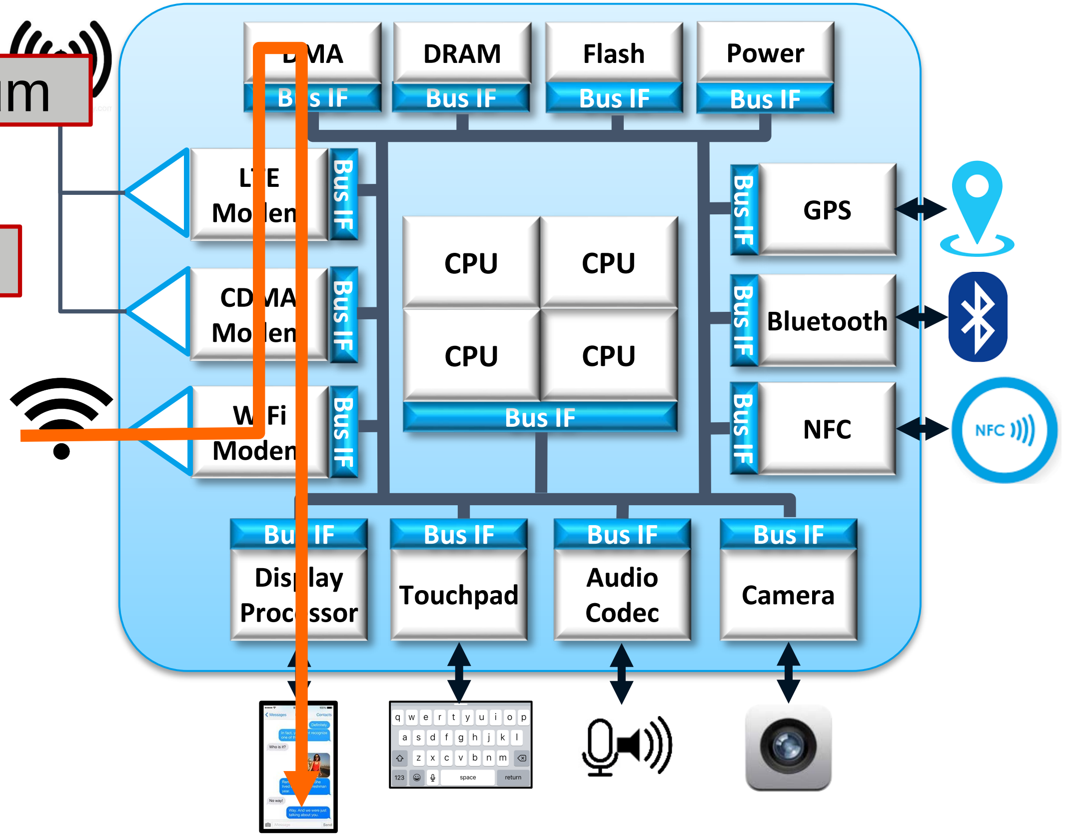
constructor macro

random attribute

constraint

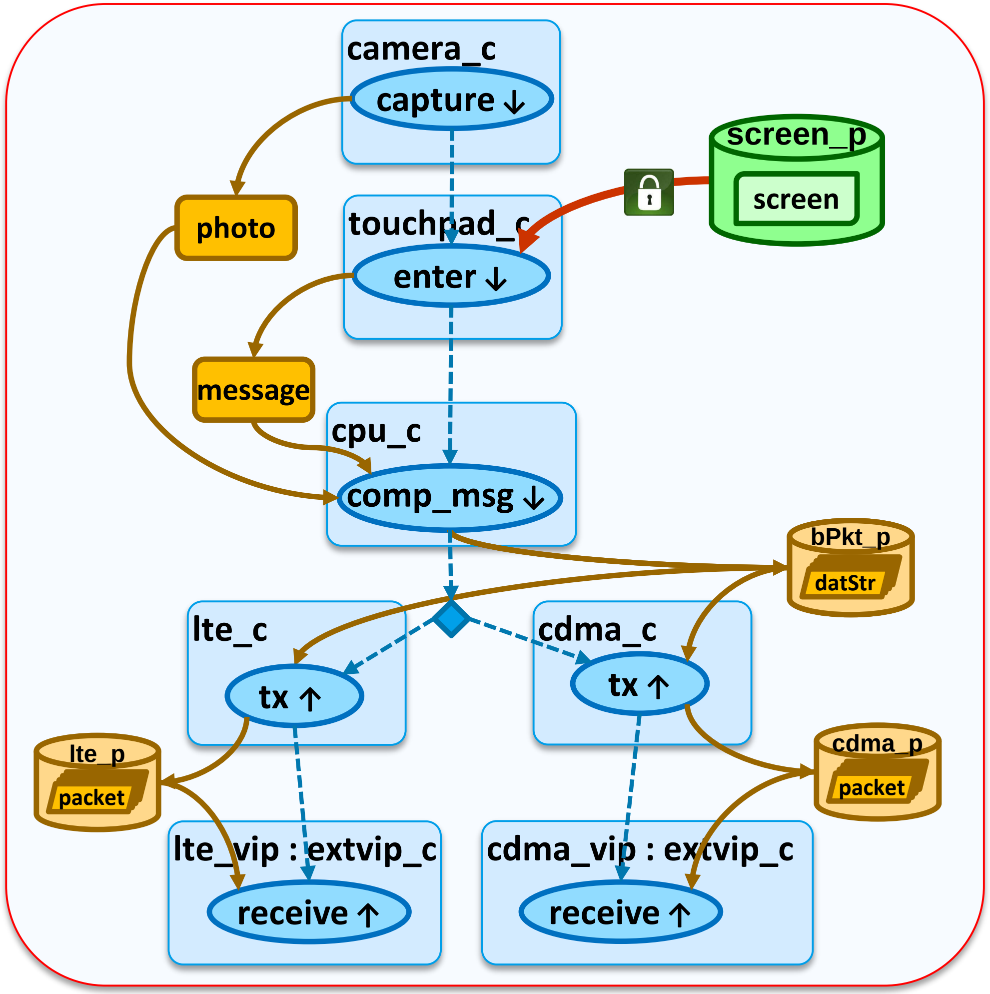
lock resource

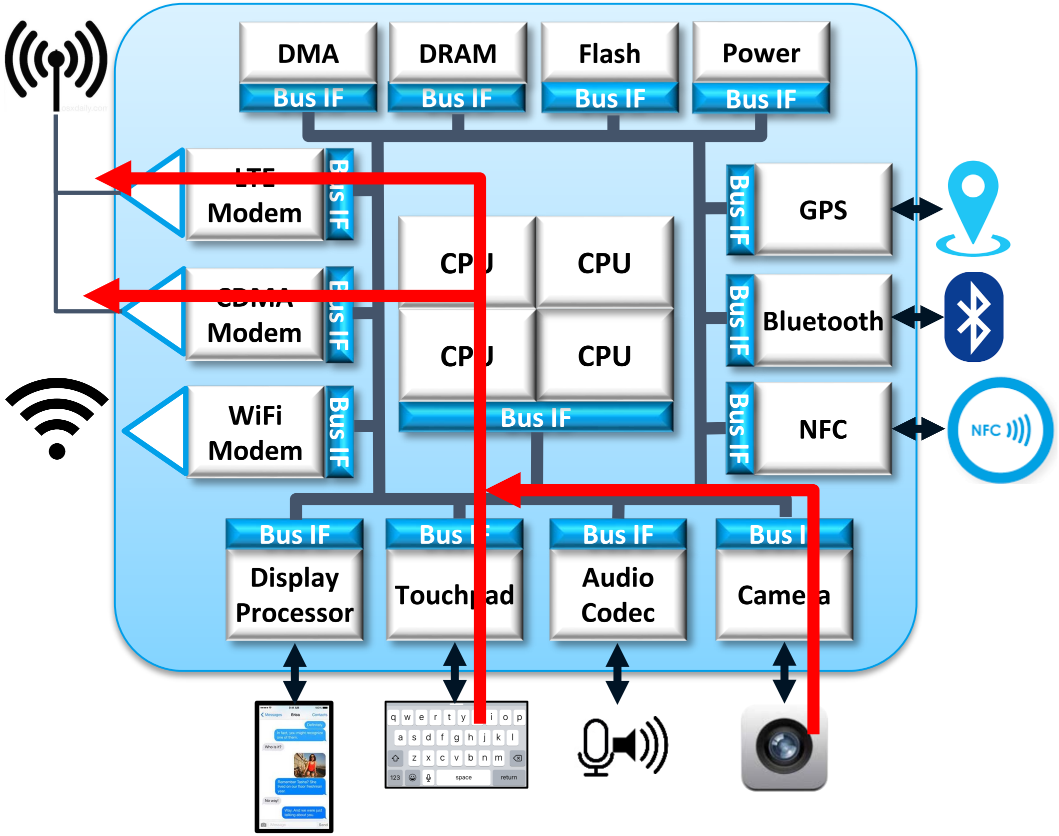
declare type



System

Text Message with Photo

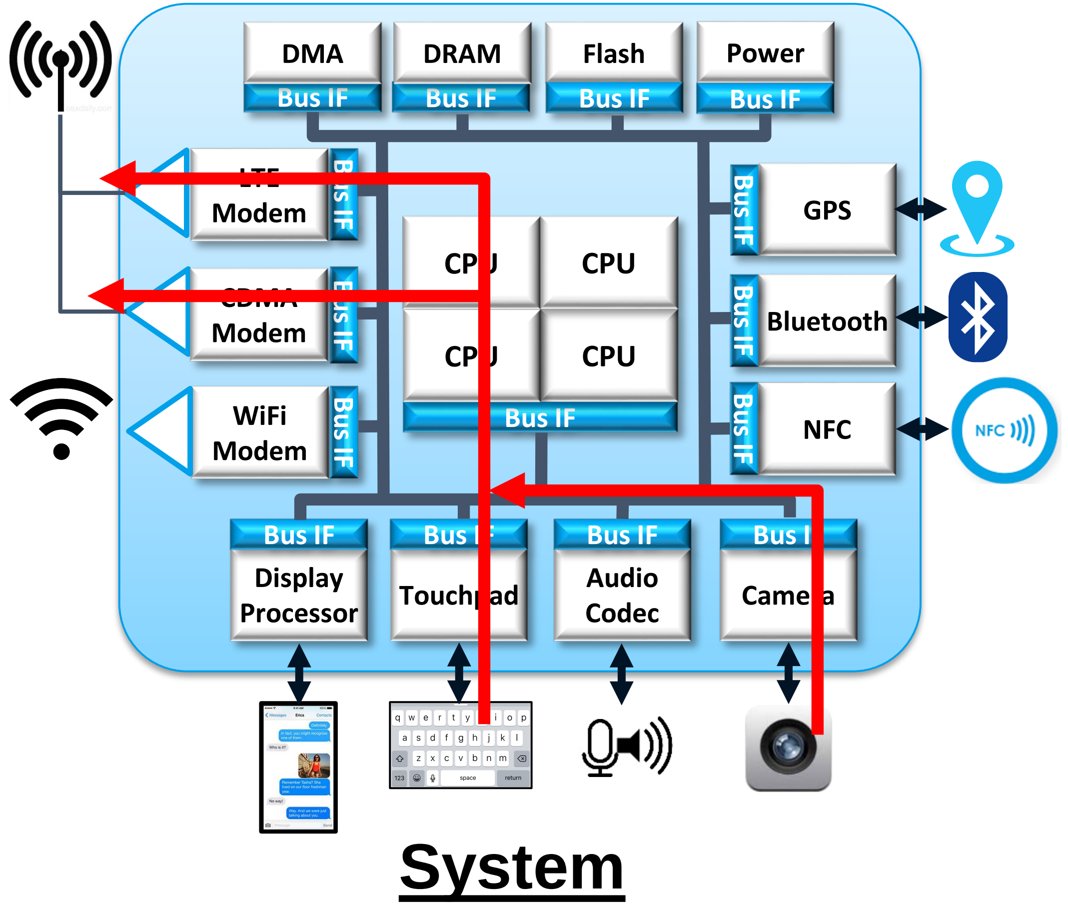




System

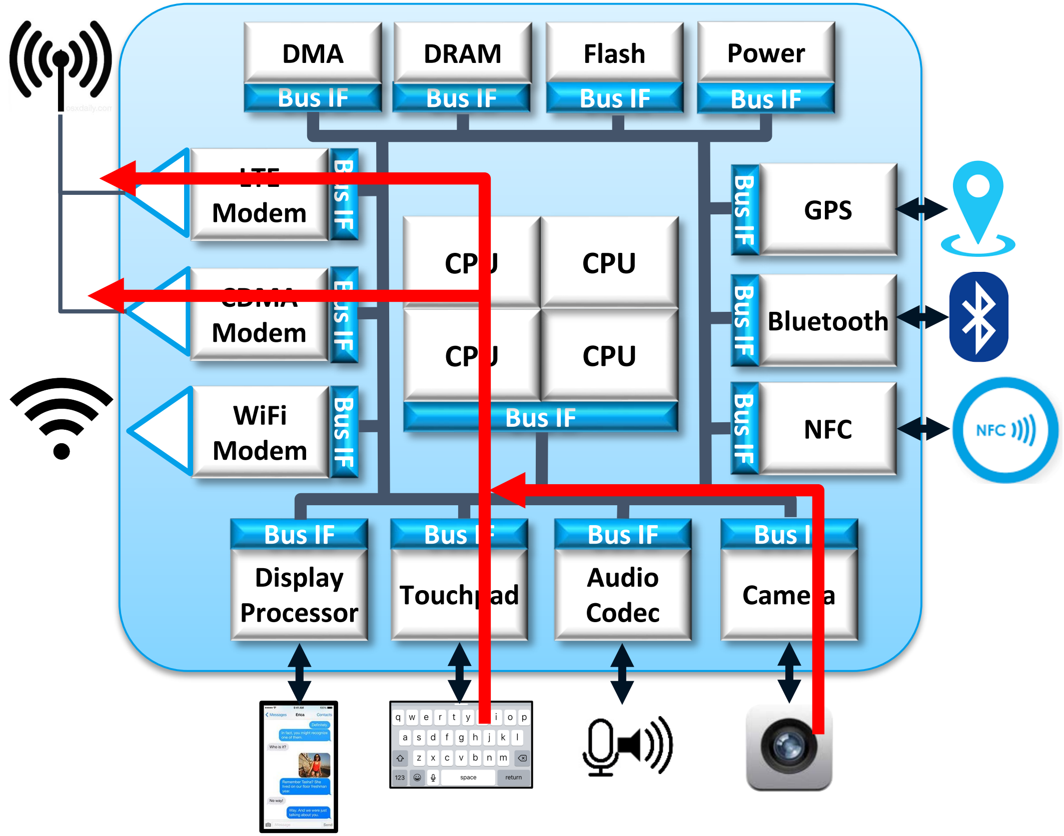
Text Message with Photo

```
component touchpad_c {
  action enter_a {
    output message msg;
    lock screen lk;
    …
  }
}
```



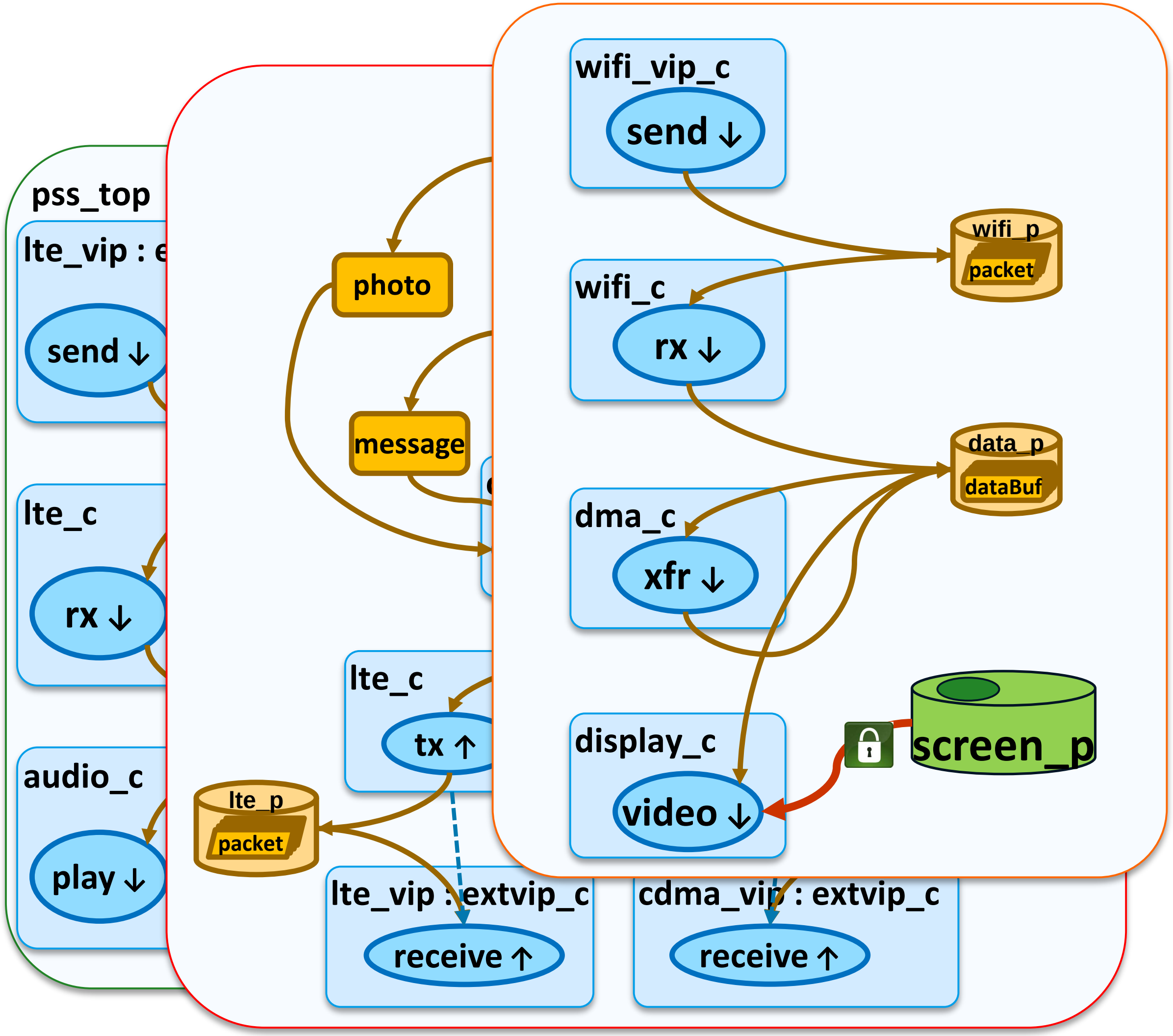
Text Message with Photo

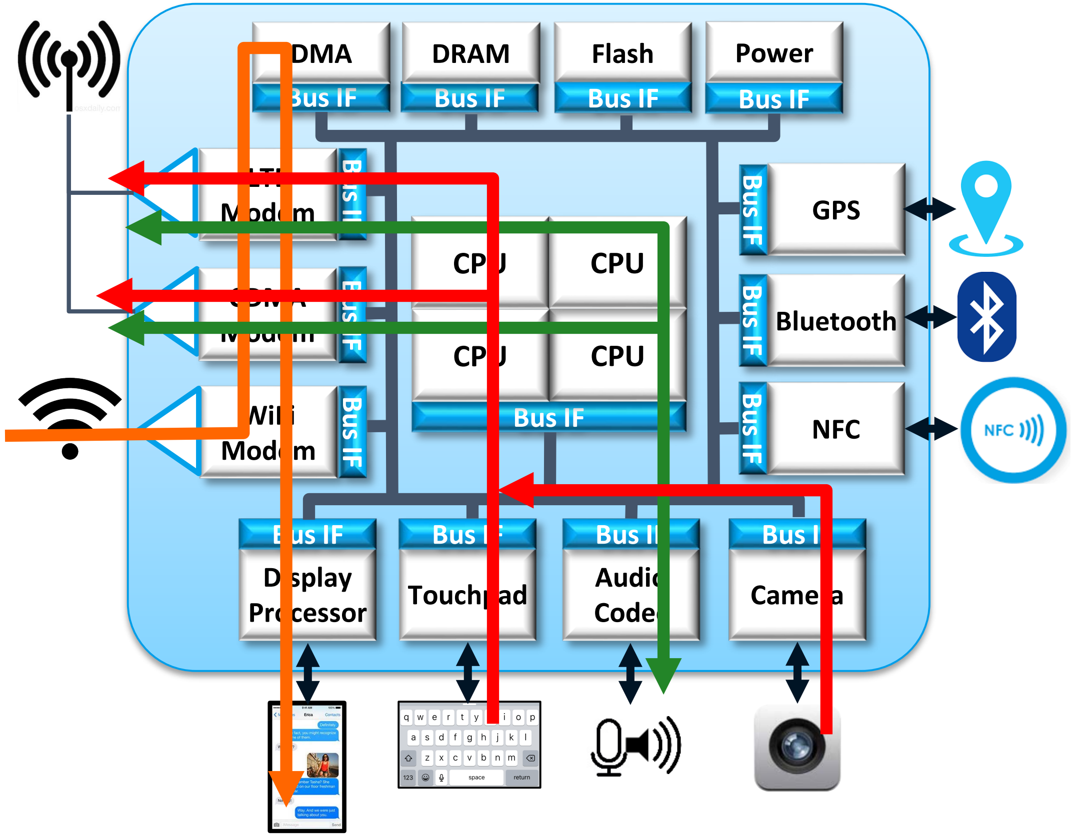
```
component pss_top {

  action txt_msg_a {
    camera_c::capture_a capture;
    touchpad_c::enter_a enter
    cpu_c::send_msg send;

    bind capture.out_photo send.in_photo;
    bind enter.out_msg send.in_msg;

    activity {
      capture;
      enter;
      send;
    }
  }
}
```



System

Putting it All Together

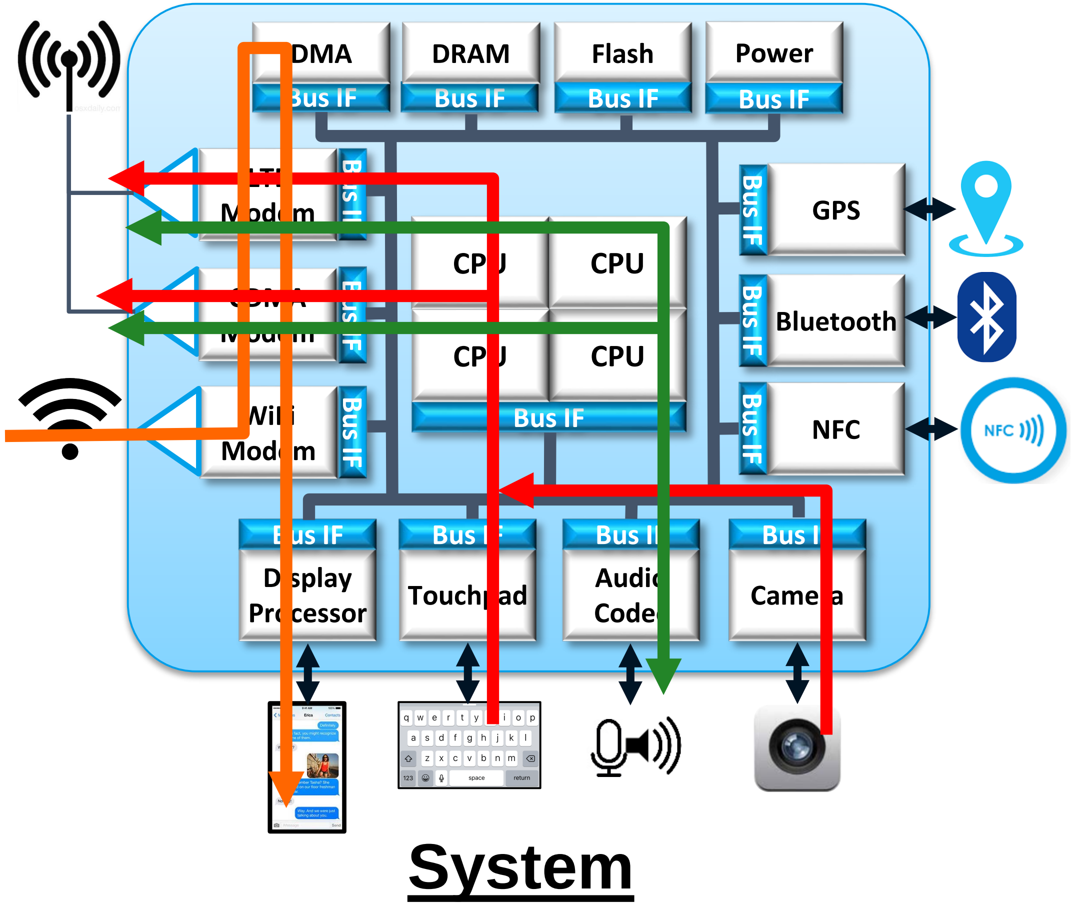




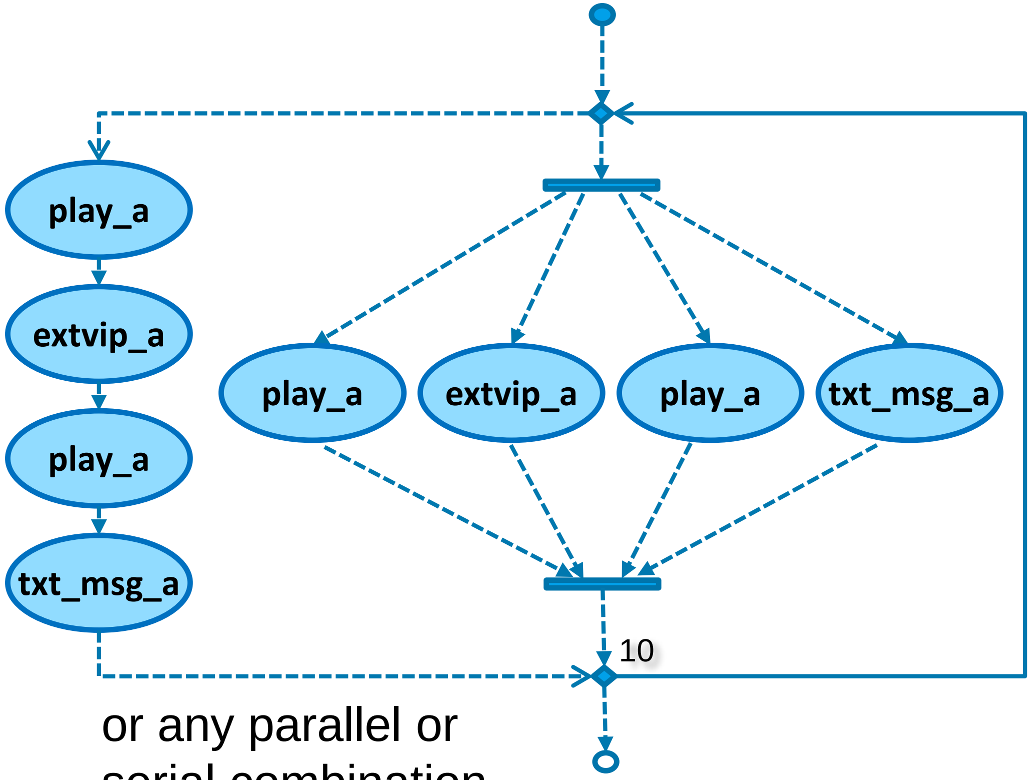
System

Putting it All Together

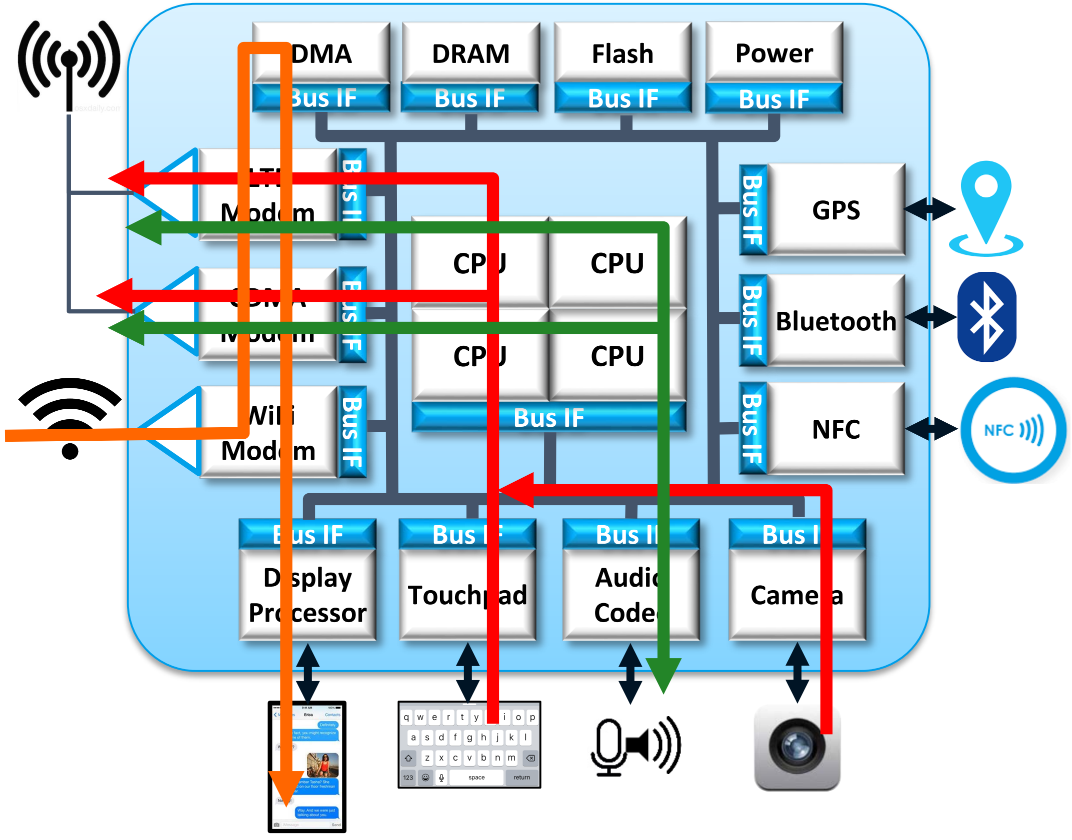
```
component pss_top {
  // imports
  // instantiations
  // pools & binds

  action test {
    activity {
      repeat (10) {
        schedule {
          do audio_c::play_a;
          do extvip_c::receive;
          do diplay_c::play_a;
          do txt_msg_a;
        }
      }
    }
  }
}
```



Putting it All Together



or any parallel or
serial combination



System

Thank You!

Portable Test and Stimulus: The Next Level of Verification Productivity is Here

Part 3: Panel Discussion

Accellera Portable Stimulus Working Group

Introducing the Panel

- Faris Khundakjie, Intel, PSWG Chair
- Sharon Rosenberg, Cadence
- Srivatsa Vasudevan, Synopsys
- Karthick Gururaj, Vayavya
- Tom Fitzpatrick, Mentor
- Adnan Hamid, Breker

Moderator: Larry Melling, Cadence

Enhancements Being Worked For 1.0

- Enhanced control of random selection and scheduling of actions
- Enhanced coverage constructs for coverage of flows, action scheduling, and resource utilization
- Enhanced features to handle hardware-software interface and product-configurable features
- Enhanced modeling of memory management
- Enhanced type system to include additional array types and parameterization by type and value
- Enhanced reactivity of model to environment
- Enhanced conditional code processing

Thank You!