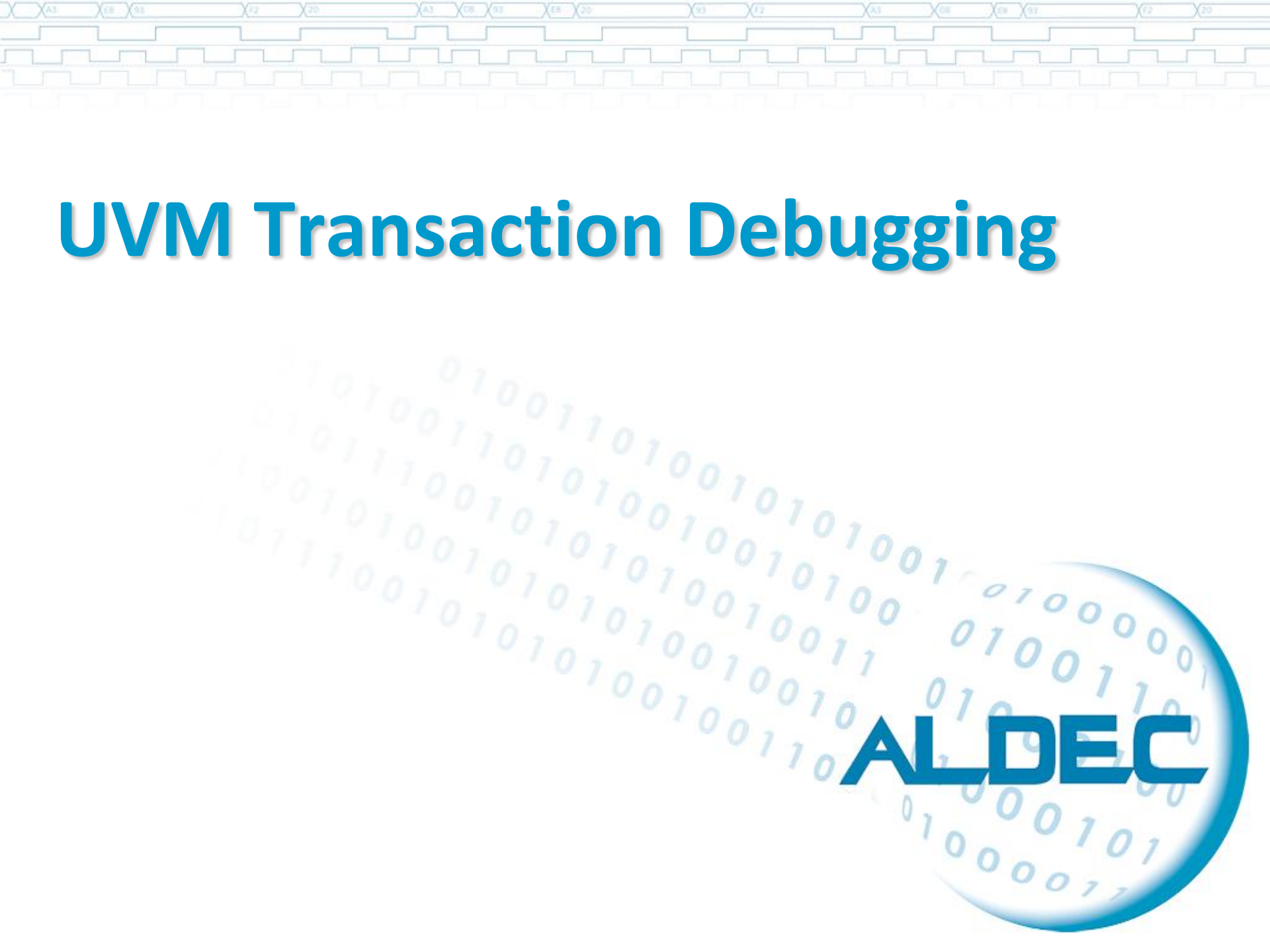
UVM Transaction Debugging

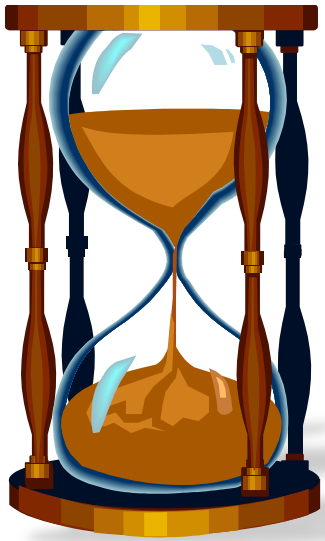


Agenda

- TLM Introduction
- Transaction visualization in Riviera-PRO
- Transaction recording in UVM
- Graphical Debugging for TLM and UVM in Riviera-PRO
- UVM-TLM simulation example demo

Introduction

- As size of typical digital design grows, you have to raise ***abstraction level*** while creating it.
- Higher abstraction levels can be achieved in different areas:
  - When handling individual bits is no longer feasible, you can use arrays, records/structures or even associative arrays.



  - When simple functions/tasks/procedures are not enough to manage your code, you can switch to ***Object Oriented Programming*** (OOP).
  - When data transferred in your design gets too diverse and too complicated, you should consider raising data transfer abstraction to ***Transaction Level***…

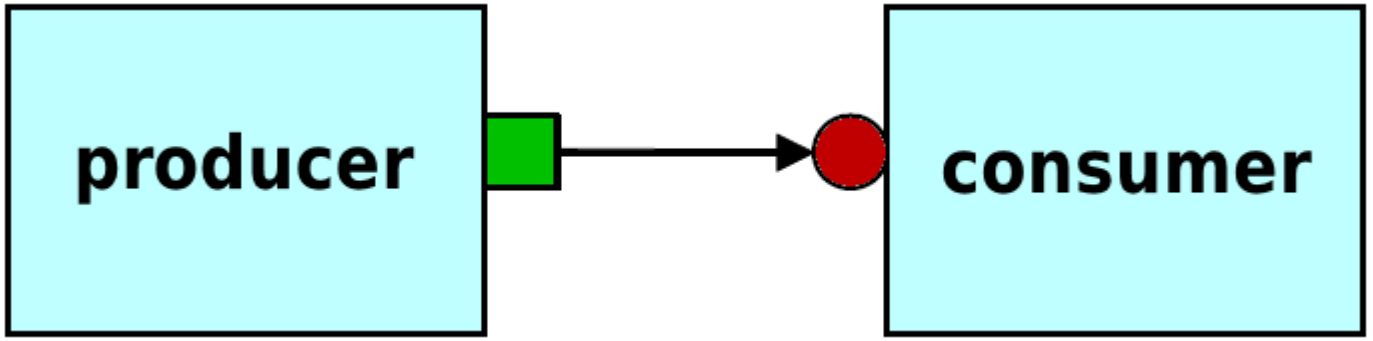
Transactions Overview

- ***Transaction*** is an abstraction of information transfer.
- If you have a problem with the term ***transaction***, try to replace it with ***message***.
- In languages supporting OOP transaction is typically executed by calling method of some design object.
  In other languages it can be a procedure/function call.

- In UVM a transaction is a class object (*uvm_transaction*), that includes whatever information is needed to model the communication between two components.
- The amount and detail of the information encapsulated in a transaction is an indication of the abstraction level of the model.

Basic TLM Communication

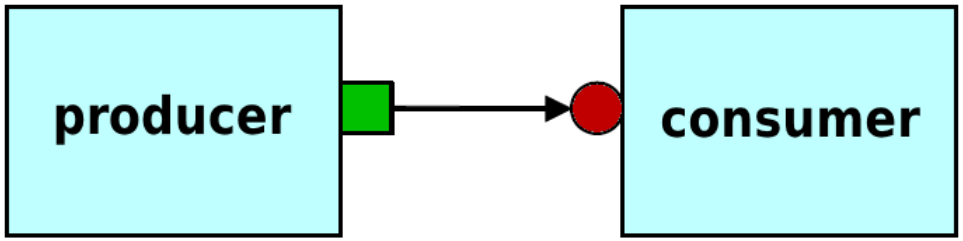
- The most basic transaction-level operation allows one component to put a transaction to another
- The producer generates transactions and sends them out through its ***port*** (**green square**).



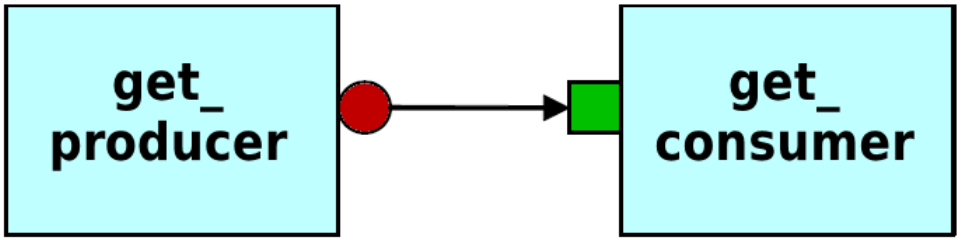
- The actual implementation of the transaction is supplied by the consumer.
- The transaction implementation (in consumer) connects with requester via ***export*** (**red circle**).

Put vs. Get

- If directions of data and control flow agree, ***producer puts transaction into consumer***:



- If directions of data and control flow disagree, ***consumer gets transaction from the producer***:



- No matter if it is ***put*** or ***get*** situation, the process with ***export*** (the executor) is responsible for implementation of the transaction; requester is using its *port* to call services of the executor.

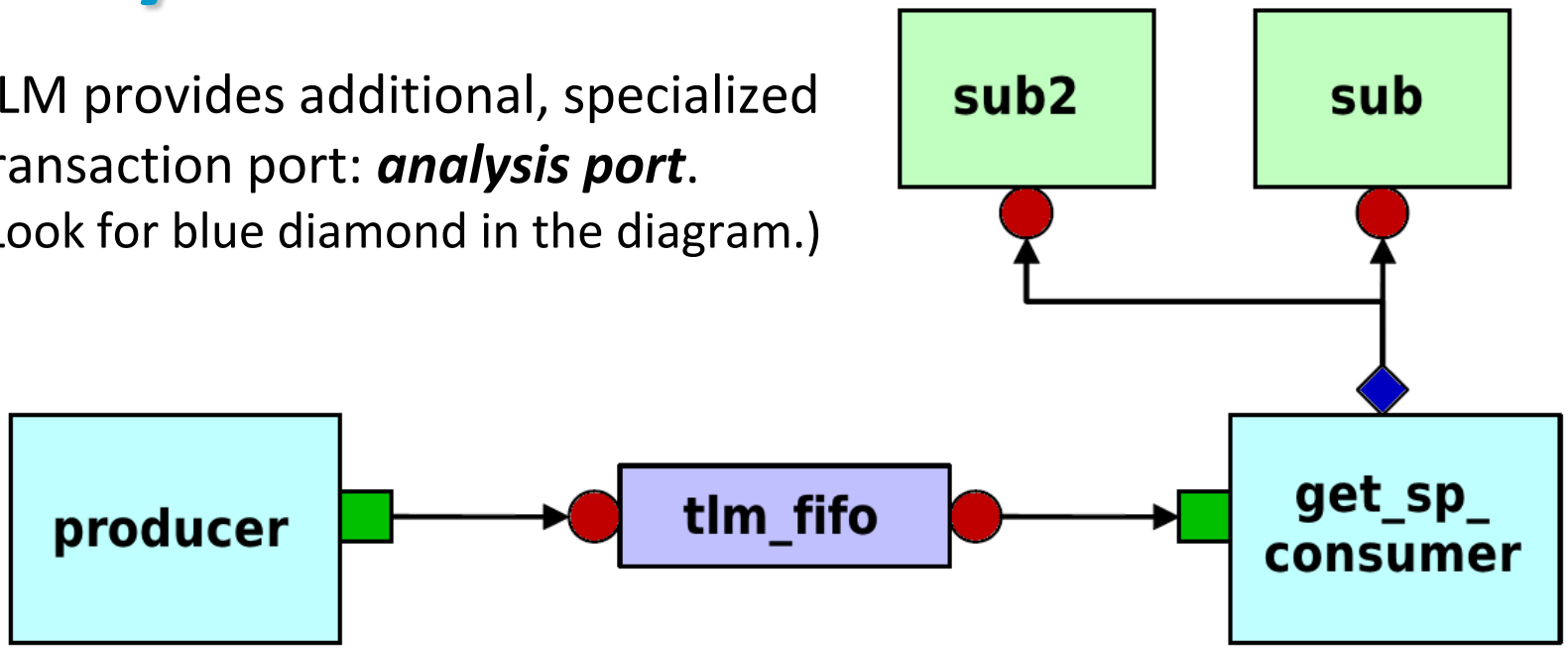
FIFOs

- Simple transaction models (direct consumer to producer connection) work OK only when data traffic is slow.
- It may be necessary for components to operate independently, where the producer is creating transactions in one process while the consumer needs to operate on those transactions in another.

- TLM ***FIFO*** is used to synchronize data flow between producer and consumer.
- So, the producer puts the transaction into the TLM FIFO fifo, while the consumer independently gets the transaction from the FIFO.

Analysis Ports

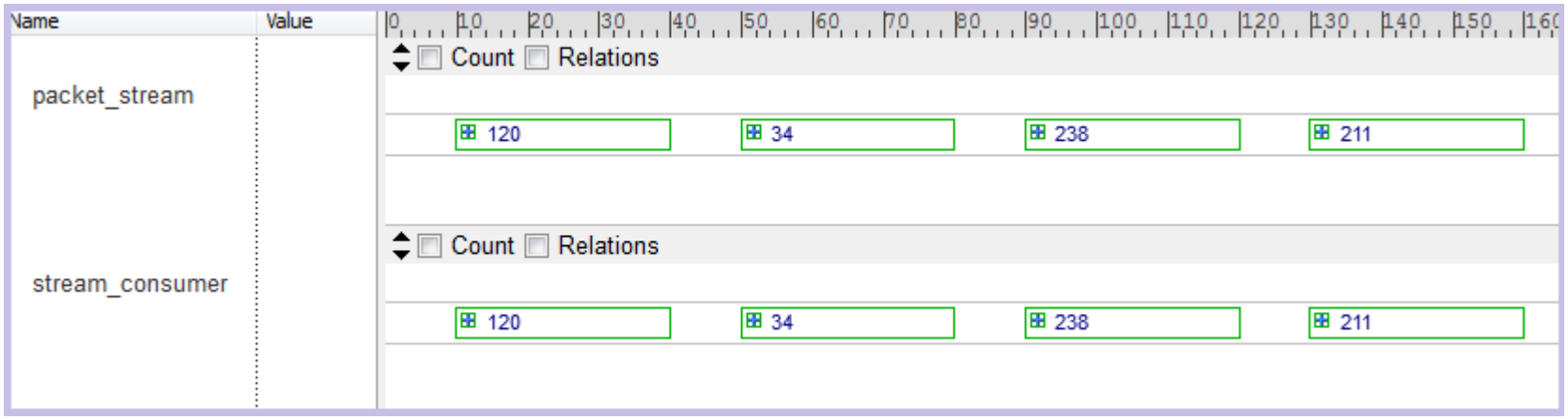
- TLM provides additional, specialized transaction port: ***analysis port***.
  (Look for blue diamond in the diagram.)



- `tlm_analysis_port` has just one interface method `write` (void function) and can be connected to analysis exports of multiple data-collecting components (scoreboards, coverage collectors, etc.)

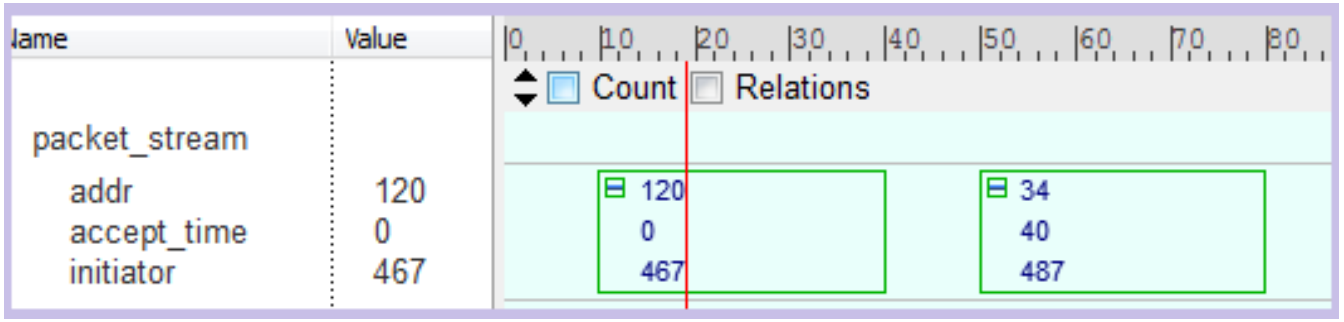
Transaction Recording in Riviera-PRO

- The transaction defined in the source code can be recorded in the simulation database in Riviera-PRO.
- The transaction happens on a transaction stream.
- Transactions have both their beginning and end times and can overlap one another.



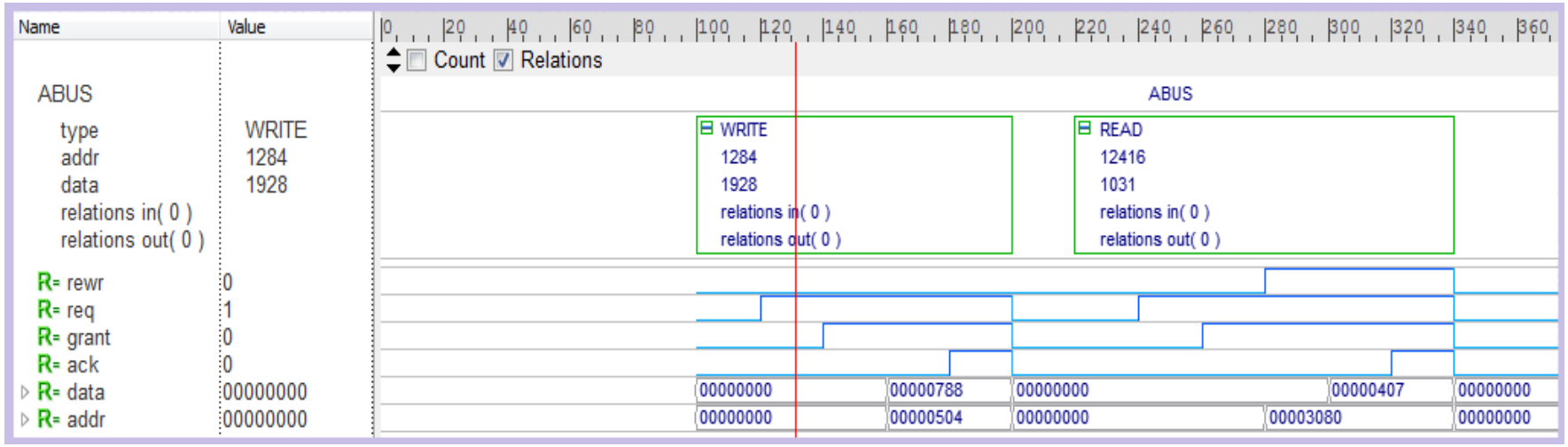
Transaction Attributes

- The transaction attribute is a user-defined property assigned to a transaction.
- An attribute has a name and a value.
- Attributes can be assigned any arbitrary meaning.



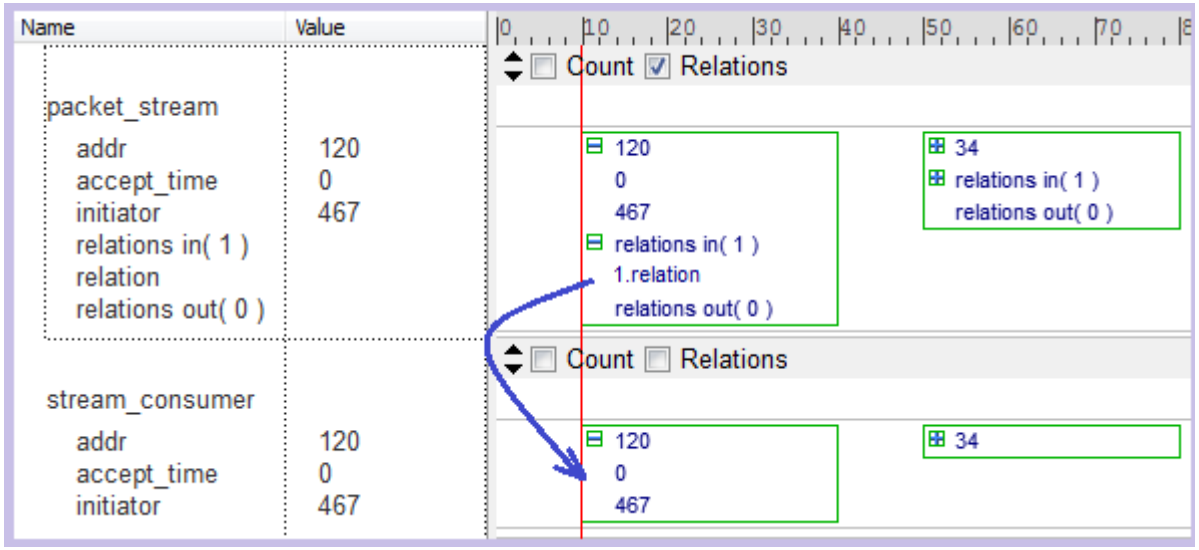
Linking Signals to a Transaction

- Signals could be linked to a transaction stream.
- Easy association between the transactions and the signals.
- Linked signals are automatically traced in asdb.



Linking Transactions

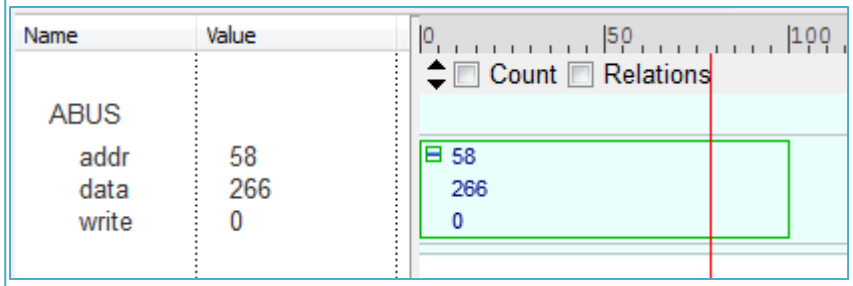
- Two transactions can be related as source transaction and target transaction.
- Helps with better understanding of the data flow in the design.
- The relation interpretation is abstract and up to the user.



Using Transaction Recording

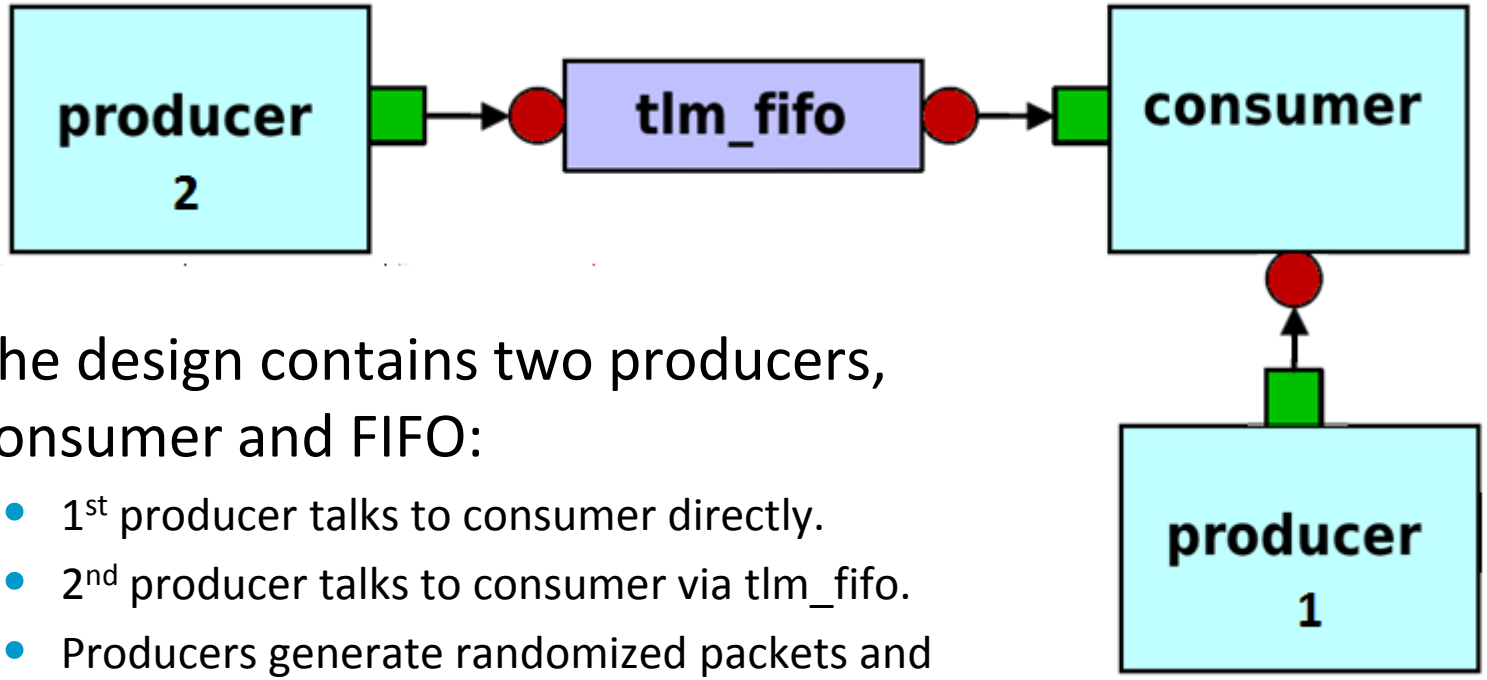
- Simple case using Riviera-PRO's transaction recording functions.

```
task doXaction (abus ibus);
    trans1 = $beginTransaction ( my_stream, $time);
    tmp = ibus.addr;
    $addAttribute( trans1, "addr", tmp );
    tmp = ibus.data;
    $addAttribute( trans1, "data",  tmp );
    tmp = ibus.write;
    $addAttribute( trans1, "write", tmp );
    #100
    $endTransaction ( trans1, $time );
endtask

initial begin
    abus t;
    my_stream = $createStream ("ABUS");
    t = new;
    t.randomize();
    doXaction(t);
end
```



Transaction Recording in UVM

- Let's take a look at UVM's sample design: 'Hello World'.



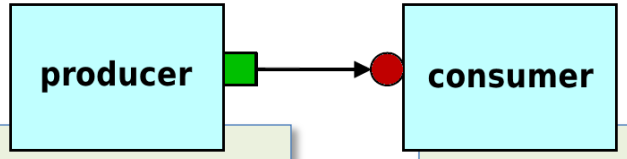
- The design contains two producers, consumer and FIFO:
  - 1st producer talks to consumer directly.
  - 2nd producer talks to consumer via tlm_fifo.
  - Producers generate randomized packets and sends them via ports.
  - Consumer receives packets and generates transactions .

‘Hello World’- Top level connections

```
class top extends uvm_component;

  producer #(packet) p1;
  producer #(packet) p2;
  uvm_tlm_fifo #(packet) f;
  consumer #(packet) c;

  `uvm_component_utils(top)

  function new (string name, uvm_component parent=null);
    super.new(name,parent);

    p1 = new("producer1",this);
    p2 = new("producer2",this);
    f  = new("fifo",this);
    c  = new("consumer",this);

    p1.out.connect( c.in );
    p2.out.connect( f.blocking_put_export );
    c.out.connect( f.get_export );
  endfunction

endclass
```

Direct Port/Export Connection

- Producer 1 connects to Consumer directly: port to export.
- Producer 1 makes call to **put()** function.
- Consumer provides implementation for **put()** function.




```
uvm_blocking_put_port #(T) out;
 ...
 task run();
    T p;
    for (count =0; count < num_packets; count++)
    begin
      ...
      void'(p.randomize());
      out.put(p);
      #10;
    end
  endtask
```

```
uvm_blocking_put_imp #(T,consumer #(T)) in;
...
task put (T p);
    lock.get();
    count++;
    accept_tr(p);
    #10;
    void'(begin_tr(p));
    #30;
    end_tr(p);
endtask
```

Connection via TLM-FIFO

- Producer 2 connects to Consumer vial TLM FIFO.
- Producer and consumer operate independently.


```
uvm_blocking_put_port #(T) out;
 ...
 task run();
    T p;
    for (count =0; count < num_packets; count++)
    begin
      ...
      void'(p.randomize());
      out.put(p);
      #10;
    end
  endtask
```

```
uvm_get_port #(T) out;
...
task run ();
    T p;
    while(out.size()) begin
      out.get(p);
      put(p);
    end
  endtask
...
```

‘Hello World’ - Consumer

- Let’s have a closer look at the transaction implementation in UVM starting with the Consumer.

```
class consumer #(type T=packet)
extends uvm_component;
  ...

  task put (T p);
    lock.get();
    count++;
    accept_tr(p);
    #10;
    void'(begin_tr(p));
    #30;
    end_tr(p);
    ...
   endtask
endclass
```

Call stack

consumer :: begin_tr(p)

uvm_component :: begin_tr (uvm_transaction tr)

uvm_transaction :: begin_tr

uvm_recorder_aldec :: begin_tr
(overrides default uvm_recorder)

uvm_recorder_aldec Class

- Default **uvm_recorder** class provides methods (functions) with basic recording functionality for the transactions
  - simple output to a text file.
- **uvm_recorder_aldec** extends **uvm_recorder** with
  - Transaction recording to Aldec's simulation database.
  - This enables visualization of transactions on the waveform.
- Using uvm_recorder_aldec
  - If no recorder object is instantiated in Consumer *uvm_default_recorder* will be used
  - To override instantiate *global_recorder_aldec* in Consumer:

```
task run_phase(uvm_phase phase);
    . . .
    this.recorder = global_recorder_aldec;
     . . .
```

Attributes Recording

- A user does not have to worry about specifying each property of the transaction object he/she wants to be recorded.
- The following UVM techniques take care of it:
  1. Register object properties with **`uvm_field_int** macro.

```
class packet extends uvm_transaction;
rand int addr;
endclass

class consumer #(type T=packet) extends uvm_component;
…
`uvm_component_utils_begin(consumer #(T))
   `uvm_field_int(count,UVM_ALL_ON + UVM_READONLY + UVM_DEC)
 `uvm_component_utils_end      . . .
```

Attributes Recording – cont.

2. Consumer calls end_tr()

uvm_transaction::end_tr()

uvm_object ::record -

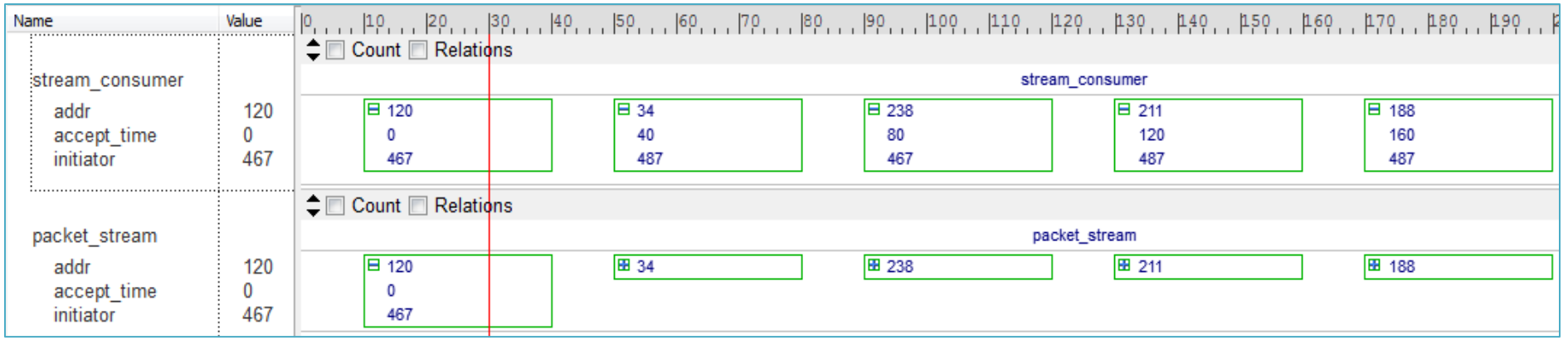
__m_uvm_field_automation () – automatically extracts all the fields

uvm_recorder_aldec :: record_field

uvm_recorder_aldec :: set_attribute

$addAttribute(…); - Aldec's PLI function to record the transaction attribute in the simulation database (asdb)

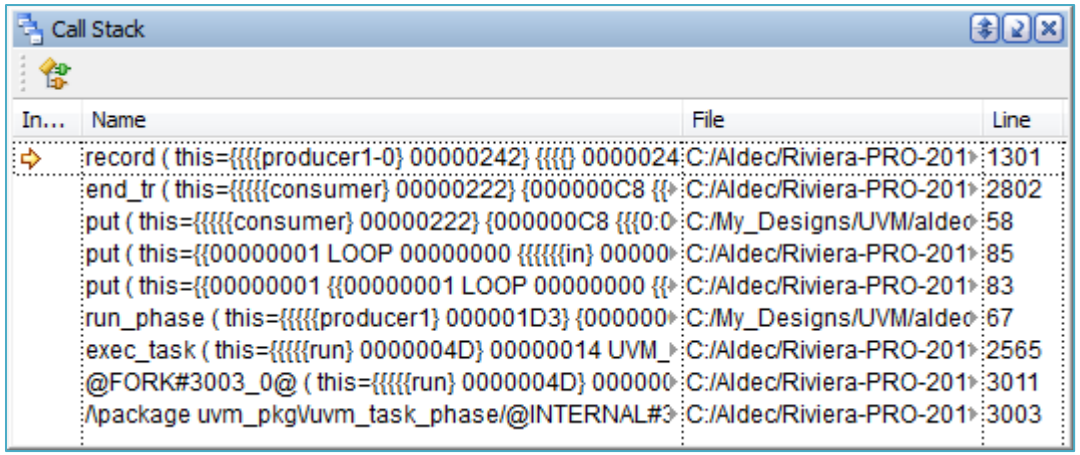
‘Hello World’ Example – output



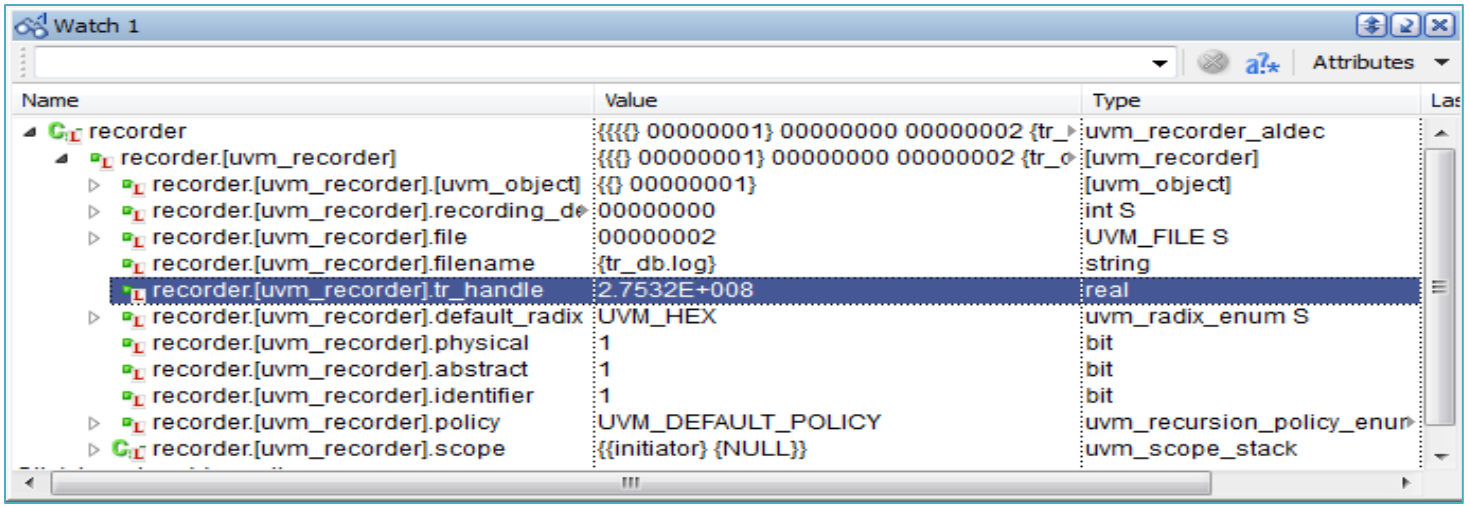

```
{INFO}/producer.sv(46) @ 0 ns: top.producer2 [producer] Starting.
{INFO}/producer.sv(62) @ 0 ns: top.producer2 [producer] Sending producer2-0
{INFO}/producer.sv(46) @ 0 ns: top.producer1 [producer] Starting.
{INFO}/producer.sv(62) @ 0 ns: top.producer1 [producer] Sending producer1-0
{INFO}/producer.sv(62) @ 10 ns: top.producer2 [producer] Sending producer2-1
{INFO}/producer.sv(62) @ 20 ns: top.producer2 [producer] Sending producer2-2
{INFO}/consumer.sv(57) @ 40 ns: top.consumer [consumer] Received producer1-0 local_count=1
{INFO}/producer.sv(62) @ 50 ns: top.producer1 [producer] Sending producer1-1
{INFO}/consumer.sv(57) @ 80 ns: top.consumer [consumer] Received producer2-0 local_count=2
{INFO}/producer.sv(62) @ 90 ns: top.producer2 [producer] Sending producer2-3
...
```

Graphical Debugging in Riviera-PRO

1. Call Stack window



2. Watch window



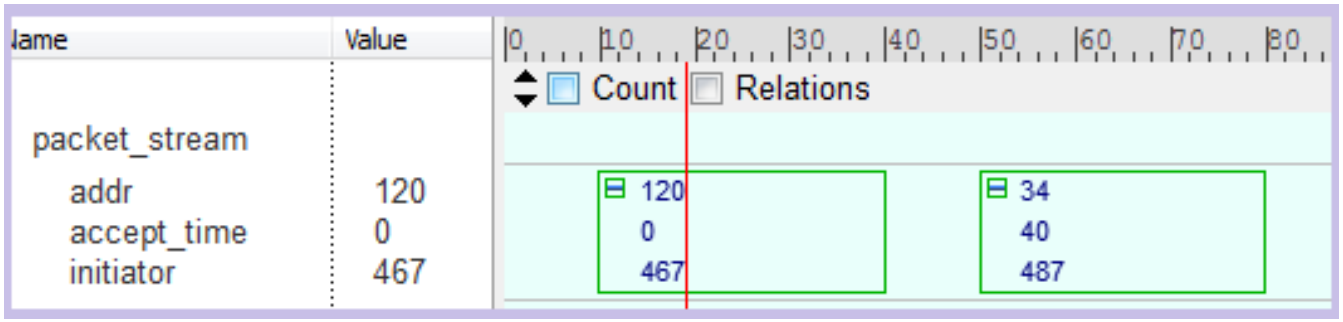
Graphical Debugging – cont.

3. Transaction Data Viewer

Begin Time

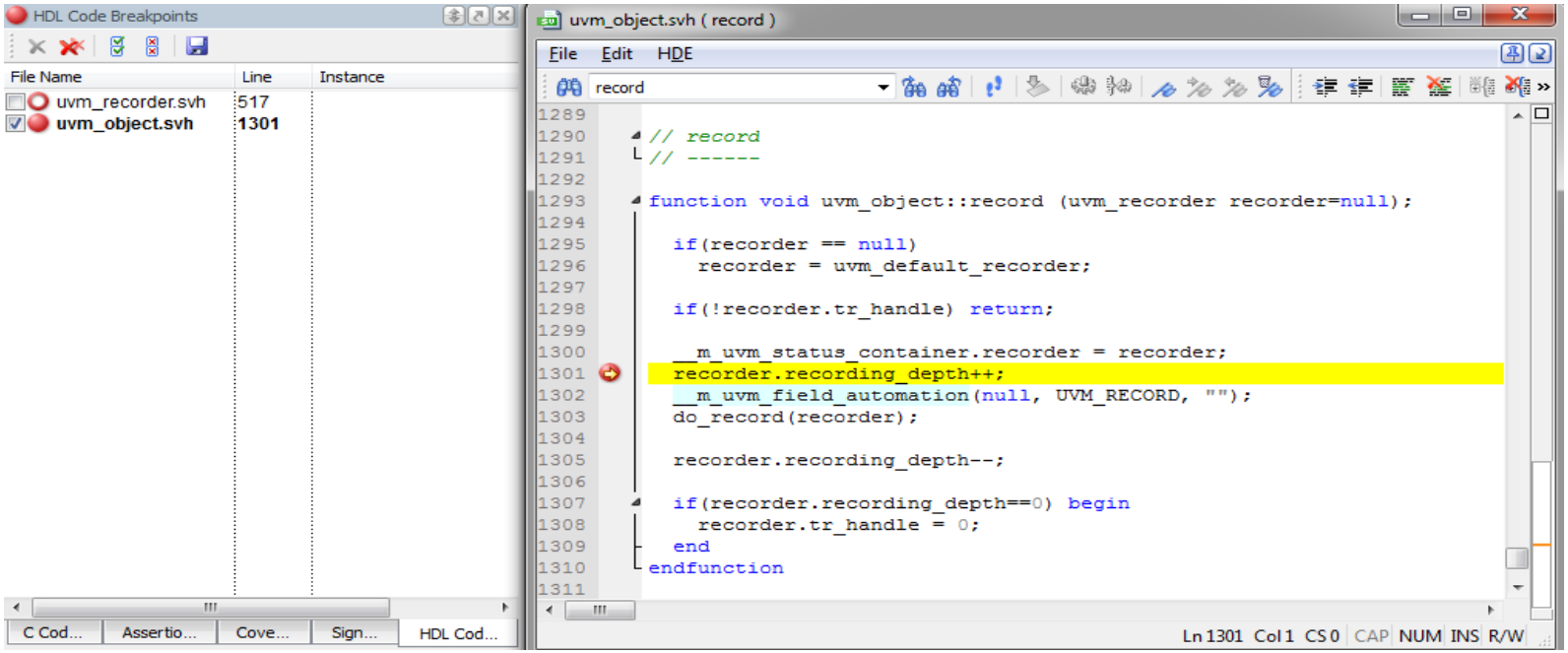
	Begin Time	End Time	addr	accept_time	initiator	relation
1	10ns	40ns	120	0	468	1
2	50ns	80ns	34	40	488	1
3	90ns	120ns	238	80	468	1
4	130ns	160ns	211	120	488	1
5	170ns	200ns	188	160	488	1
6	210ns	240ns	72	200	488	1

4. Waveform



Graphical Debugging –cont.

5. Breakpoints and single stepping



6. Class Viewer is coming soon…

Summary

- Start using UVM in your Testbench
- UVM provides mechanism for doing many things automatically, recording transactions is one of them
- Aldec enhances UVM recording function with graphical visualization of transactions

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US Patent#4,791,357: Electronic circuit board testing system and method

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