Synopsys Users Group
CANADA 2012

UVM Sequence Item Based Error Injection

Jeff Montesano
Verilab, Canada

Agenda

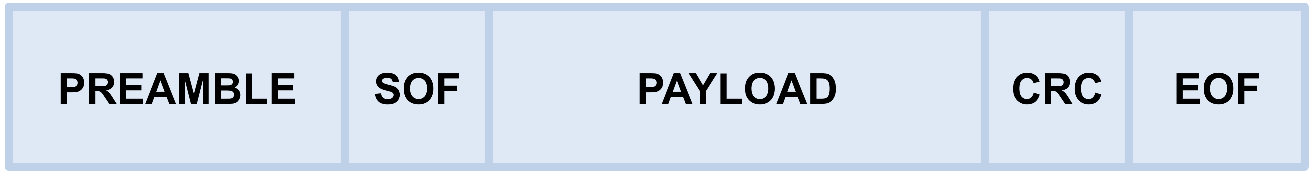
Synopsys Users Group
CANADA 2012

- Introduction
- When to Implement Error Injection
- Types of Error Injection
- Types of Error Detection
- Planning for Error Injection
- A UVM Error Injection Strategy
  - Proactive Masters
  - Reactive Slaves
- Conclusion and Questions

Jeff Montesano

Introduction

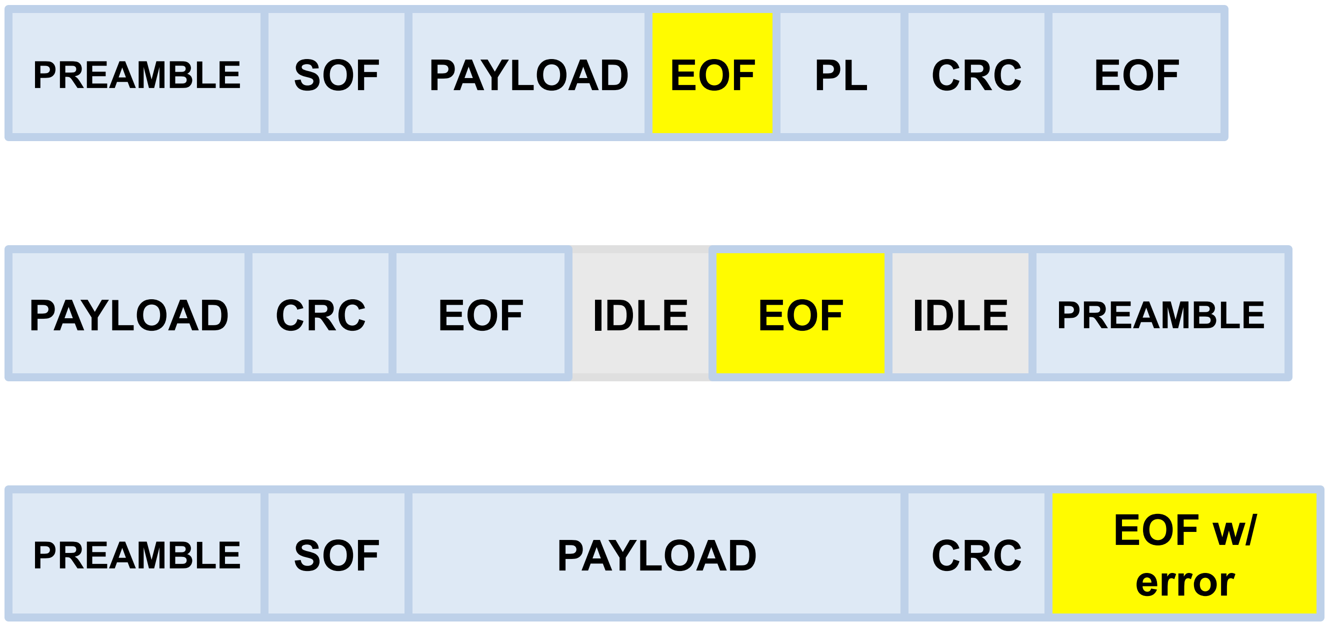
- Generic communications protocol example:



- Errors in Preamble/SOF/Payload/CRC/EOF/
- What exactly should an “EOF” error be?

Introduction

- Examples of EOF Errors



When to Implement Error Injection

- Planning should start early
  - Verification plan
  - Code hooks/comments (e.g. “TBD”)

- Implementation should start later
  - After basic functionality is verified
  - Before comprehensive testing is finished

Types of Error Injection

- Protocol errors
  - Important for interoperability
  - Violate each protocol rule in at least one way
- Physical errors
  - Important for certain designs
  - Only emulate likely operating scenarios

Types of Error Detection

Synopsys Users Group
CANADA 2012

- Stimulus monitors do error detection
  - Publish transactions to scoreboards and coverage
- Classifiable errors
  - Individual error flags in transaction
- Unclassifiable errors
  - “Aggregate” error flag in transaction
  - Stimulus coverage is appropriate

Planning for Error Injection

- For the approach outlined in this presentation:

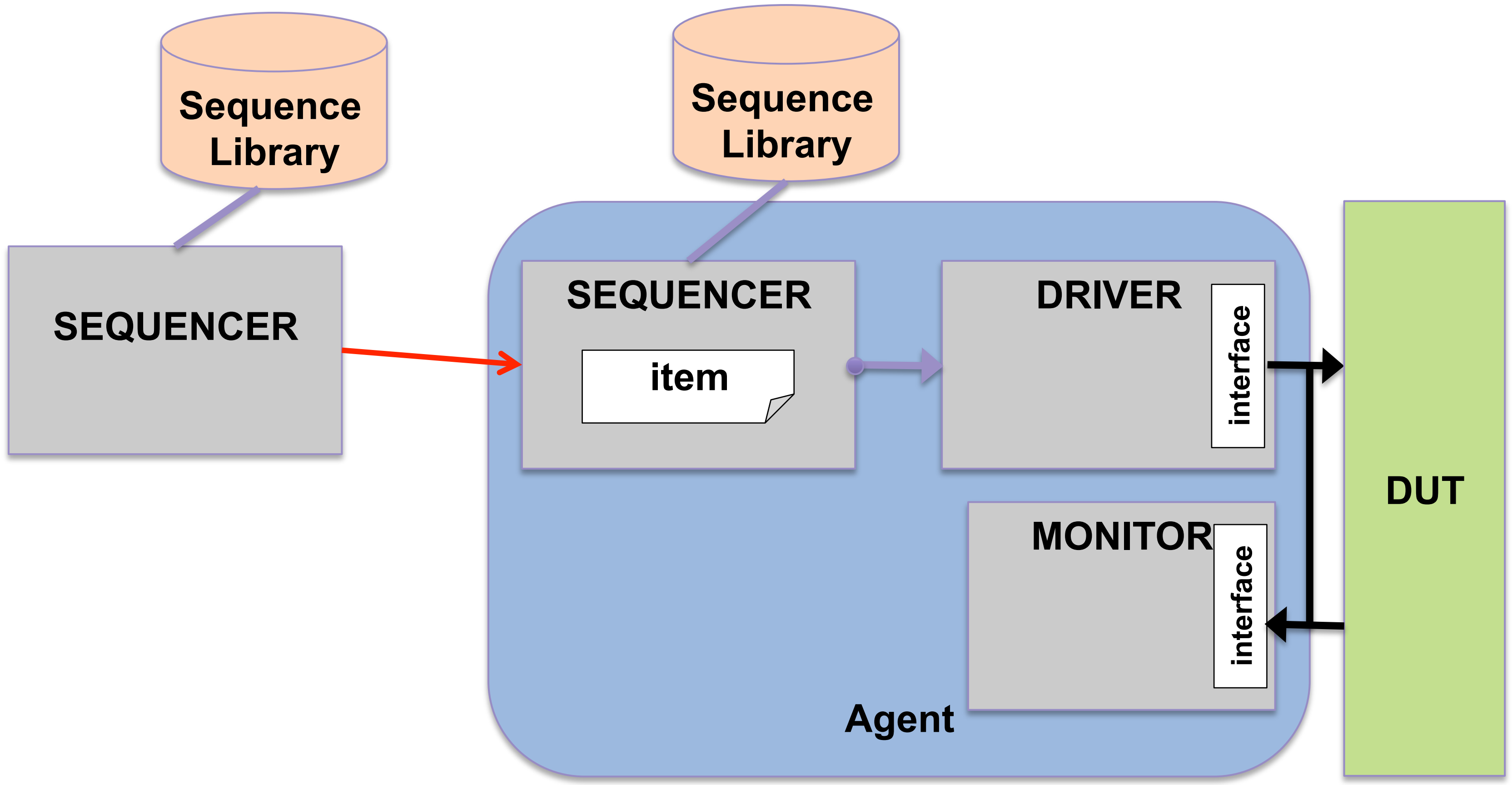
1. Sequence item modifications
   - `add error fields`
2. Sequence modifications
   - `add error sequence`
3. Driver modifications
   - `inject the errors`
4. Transaction modifications
   - `flag the errors`
5. Monitor Modifications
   - `detect the errors`

Jeff Montesano

A UVM Error Injection Strategy Proactive Masters

Synopsys Users Group
CANADA 2012

- What is a proactive master?



Jeff Montesano

Planning for Error Injection

Synopsys Users Group
CANADA 2012

- For the approach outlined in this presentation:

1. Sequence item modifications
   - `add error fields`
2. Sequence modifications
   - `add error sequence`
3. Driver modifications
   - `inject the errors`
4. Transaction modifications
   - `add error field`
5. Monitor modifications
   - `detect the errors`

Jeff Montesano

A UVM Error Injection Strategy
Proactive Masters

Synopsys Users Group
CANADA 2012

- Error injection fields added to sequence items

```
class protocol_seq_item extends uvm_seq_item;
  bit [7:0]  payload[];
  bit [15:0] crc;
  ...
  rand bit transmission_err;
  rand bit latency_err;
  rand bit crc_err;
  rand bit eof_err;
  ...
  constraint c_errors {
    transmission_err == 0;
    latency_err      == 0;
    crc_err          == 0;
    eof_err          == 0;
  }
  ...
endclass
```

Jeff Montesano

Planning for Error Injection

- For the approach outlined in this presentation:

1. Sequence item modifications
   - `add error fields`
2. Sequence modifications
   - `add error sequence`
3. Driver modifications
   - `inject the errors`
4. Transaction modifications
   - `add error field`
5. Monitor modifications
   - `detect the errors`

Jeff Montesano

A UVM Error Injection Strategy Proactive Masters

Synopsys Users Group
CANADA 2012

```
class reg_seq extends
uvm_sequence;
  bit [7:0]
ss_payload[];
  ...



  `uvm_do(s_item


endclass
```

```
class error_seq extends uvm_sequence;
  bit [7:0] ss_payload[];
  ...
  bit ss_crc_err;
  bit ss_eof_err;
  ...
  `uvm_create(s_item)
  if (!randomize(s_item)) `uvm_warning
("", "")

  s_item.crc_err          = ss_crc_err;
  s_item.eof_err          = ss_eof_err;

  `uvm_send(s_item)
endclass
```

Jeff Montesano

Planning for Error Injection

- For the approach outlined in this presentation:

1. Sequence item modifications
   - `add error fields`
2. Sequence library modifications
   - `add error sequence`
3. Driver modifications
   - `inject the errors`
4. Transaction modifications
   - `add error field`
5. Monitor modifications
   - `detect the errors`

A UVM Error Injection Strategy Proactive Masters

Synopsys Users Group
CANADA 2012

- Driver reacts to error flags

```
class protocol_driver extends uvm_driver;
  ...
  task run();
    forever begin
      seq_item_port.get(s_item);
      drive(s_item);
    end
  endtask
  ...
  task drive();
  ...
    if (s_item.transmission_err) begin
      // flip a payload bit
           ...
    end
  ...
  endtask
endclass
```

Jeff Montesano

Planning for Error Injection

- For the approach outlined in this presentation:

  1. Sequence item modifications
     - `add error fields`
  2. Sequence modifications
     - `add error sequence`
  3. Driver modifications
     - `inject the errors`
  4. Transaction modifications
     - `add error field`
  5. Monitor modifications
     - `detect the errors`

A UVM Error Injection Strategy
Proactive Master

Synopsys Users Group
CANADA 2012

- Aggregated error field added to transaction

```
class protocol_trans extends uvm_transaction;
 bit [7:0]  payload[];
 bit [15:0] crc;
 ...
 bit error_detected;
 ...
}
endclass
```

Jeff Montesano

Planning for Error Injection

- For the approach outlined in this presentation:

1. Sequence item modifications
   - `add error fields`
2. Sequence modifications
   - `add error sequence`
3. Driver modifications
   - `inject the errors`
4. Transaction modifications
   - `add error field`
5. Monitor modifications
   - `detect the errors`

Jeff Montesano

A UVM Error Injection Strategy
Proactive Masters

Synopsys Users Group
CANADA 2012

- Monitor detects errors and publishes flag

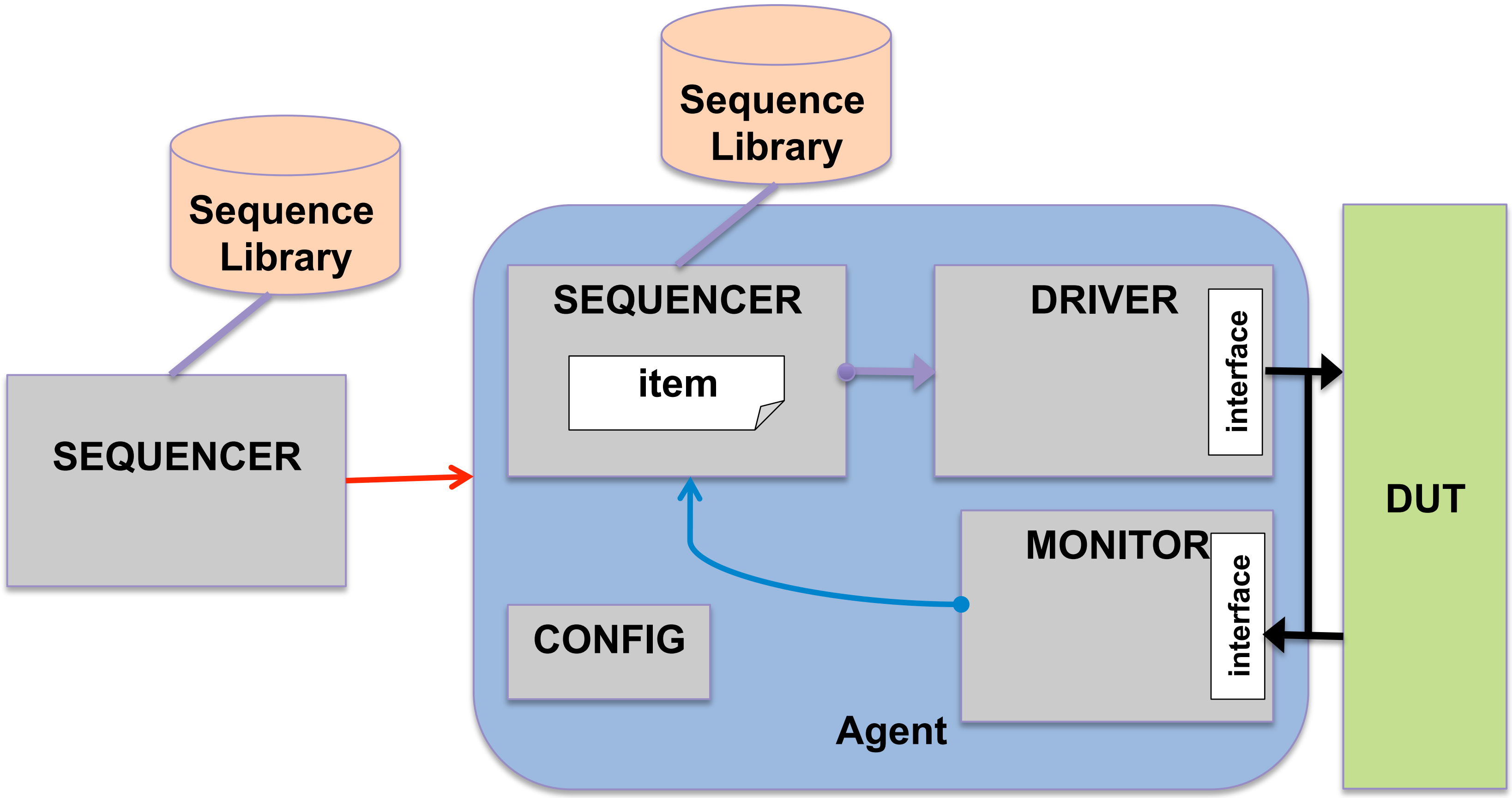
```
class protocol_monitor extends uvm_monitor;
  analysis_port #(protocol_trans) ap;
  protocol_trans trans;
  ...
  task run();
    trans = new();
    bit eof_err, crc_err;
    ...
    if (eof_err | crc_err) `uvm_warning("", "detected error");

    trans.payload         = observed_payload;
    trans.crc             = observed_crc;
    trans.error_detected  = eof_err | crc_err;
    ap.write(trans)
    ...
  endtask
endclass
```

Jeff Montesano

A UVM Error Injection Strategy Reactive Slaves

- What is a reactive slave?



Jeff Montesano

A UVM Error Injection Strategy Reactive Slaves

Synopsys Users Group
CANADA 2012

- Error injection counters added to configuration

```
class agent_config extends uvm_object;
   ...
   int latency_err_cnt;
   int eof_err_cnt;
   ...

endclass
```

Jeff Montesano

A UVM Error Injection Strategy
Reactive Slaves

Synopsys Users Group
CANADA 2012

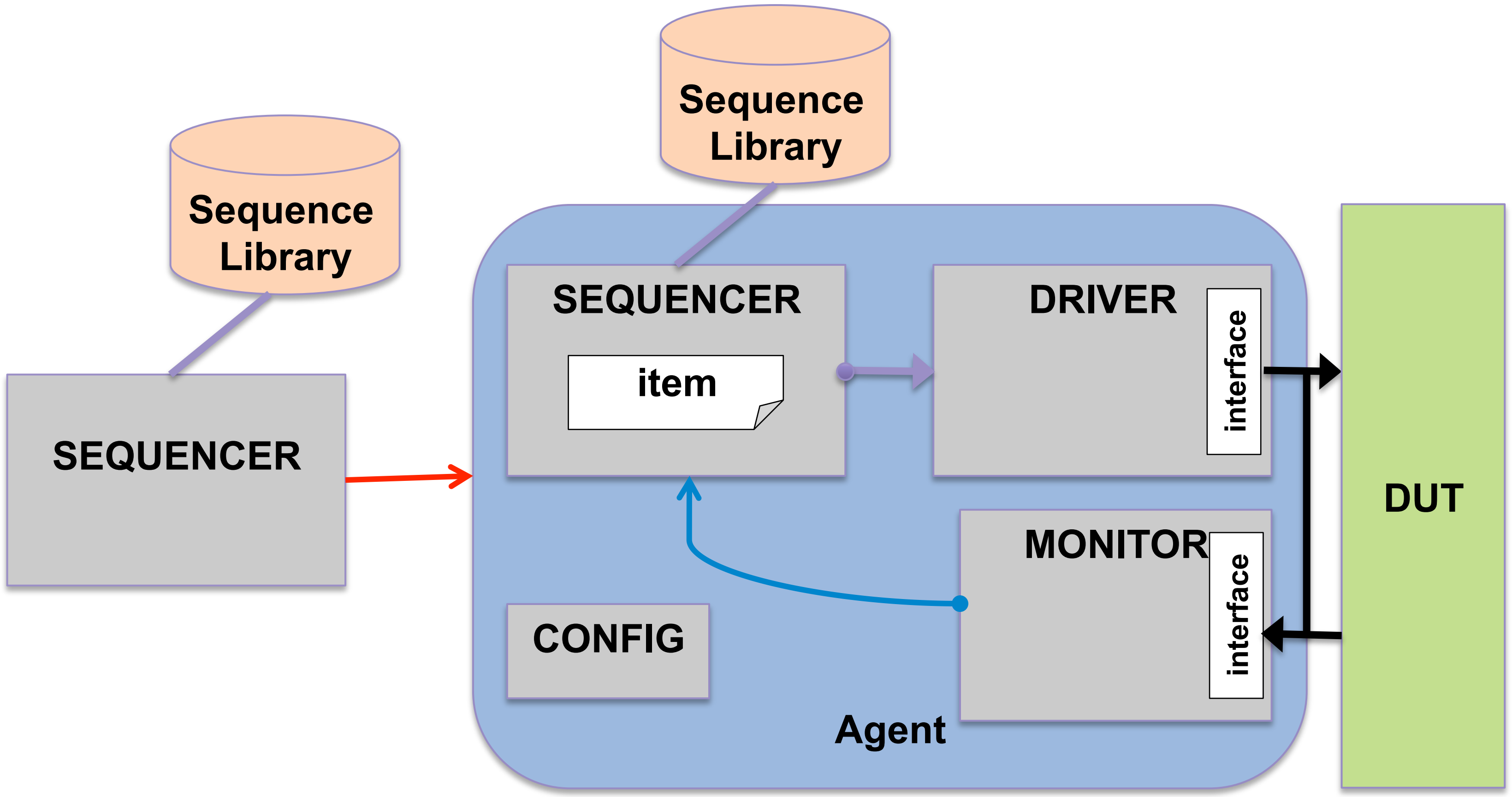
- Error sequence added to virtual sequencer to increment counters

```
class incr_err_seq extends uvm_sequence;
  ...
  bit incr_latency_err;
  bit incr_eof_err;
  ...
  task body();
    if (incr_latency_err)
      p_sequencer.cfg.latency_err_cnt++;
    if (incr_eof_err)
      p_sequencer.cfg.eof_err_cnt++;
        ...
  endtask
...
endclass
```

Jeff Montesano

A UVM Error Injection Strategy
Reactive Slaves

- What is a reactive slave?



Jeff Montesano

A UVM Error Injection Strategy Reactive Slaves

Synopsys Users Group CANADA 2012

- Error sequence added to agent sequencer

```
class agent_err_seq extends uvm_sequence;
 ...
  task body();
    forever begin
      ...
      `uvm_create(s_item)
      if (!randomize(s_item)) `uvm_warning ("","")

      if (p_sequencer.cfg.latency_err_cnt > 0) begin
        s_item.latency_err = 1;
        p_sequencer.cfg.latency_err_cnt--;
      end
      ...
      `uvm_send(s_item)
      ...
```

Jeff Montesano

A UVM Error Injection Strategy Reactive Slaves

- Base test overrides default sequence

```
class error_test extends uvm_test;
  ...
  task build();
  ...
  set_config_string("agent.sequencer","default_sequence",
    "agent_err_seq");
  ...
  endtask
...
endclass
```

Jeff Montesano
verilab

Conclusion and Questions

- Error injection
  - Opens up meaningful discussion
  - Stresses the design
  - Is a necessary part of any environment
- A sequence item approach
  - Straightforward to implement and understand
  - Applies to both proactive masters and reactive slaves