
# OpenCPI - Open Component Portability Infrastructure

## An Open Source Infrastructure for Heterogeneous/Embedded Component-Based Systems and Applications

## OpenCPI Unit Test Framework: Details

# OpenCPI Unit Test Framework Details: Topics

- Configuring file I/O handling
  - Using embedded opcodes
  - Calculating the best buffer size for the protocols in use
- Understanding the *two* HDL assemblies used for testing
  - When to use each one (simulators vs. hardware)
  - Test XML attributes for data flow configuration
- Debugging your failed tests
  - "Where did my overnight simulation go?"
- Understanding test cases: two examples of cases.xml

# Unit Test Framework File I/O Basics

- OpenCPI unit test framework uses the OpenCPI utilities **`ocpi.core.file_read`** and **`ocpi.core.file_write`** for file I/O.
- These utilities have two modes of operation:
  - Data Streaming
    - **`file_read`**: input file contents are copied to payload of a stream of messages. Fixed number of bytes of data (defaults to 4KB), all with the same opcode.
    - **`file_write`**: output file contents become the payloads of a stream of messages. No message lengths of opcodes are recorded.
  - Messaging
    - **`file_read`**: input file contents are interpreted as a sequence of defined messages. An 8-byte header precedes payload data of each messages. Four-byte length (in bytes, little-endian): one byte opcode, three padding bytes.
    - **`file_write`**: output file contents are written as a sequence of defined messages. Uses same 8-byte header and 4-byte format as **`file_read`**.
- For messaging mode, use the **messageInFile** test XML attribute to select it and follow the input data format
- For data streaming mode, use the **messageSize** test XML attribute to define buffer size
- For details as to how file I/O is typically performed in OpenCPI applications, see the ocpi.core.file_read and ocpi.core.file_write data sheets

# Using *messagesInFile*

- The test XML attribute **messagesInFile** enables messaging mode for `file_read` workers
- If more than one opcode is needed, set `messagesInFile="true"`
- Input data needs to have:
  - Length of message (in bytes)
  - Opcode number to transmit
  - Message (if non-zero length)
- Example with four operations:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0 | short scalar mesg. | 4 | 1 | short sequence(0) mesg. | short sequence(1) mesg. | 4 | 2 | long scalar mesg. | 1 | 3 | char scalar mesg. |

# Calculating *messageSize*

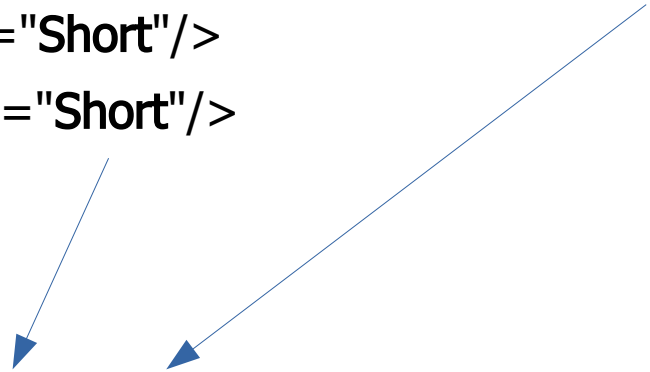
- The test XML attribute **messageSize** specifies the buffer size, which also determines the size of messages read from test input
- In general, bigger the buffer, higher the throughput
- Determine a **messageSize** that best uses the protocol buffer size
  - Protocol buffer size is the largest of all the operations in a protocol
  - This is needed because **`file_read`** doesn't "know" the protocol within
- How to calculate the protocol buffer size?
  - Protocol buffer size = max operation size × *length* of the max operation size
    - max operation size - the operation in the protocol with largest number of bytes
    - *length* of the max operation size - either the StringLength, SequenceLength, ArrayDimensions, or size of the type

# Protocol Buffer Size

protocol buffer size = max operation size × length of the max operation size

Example 1

```
<Protocol>
   <Operation Name="demo">
      <Argument Name="data" Type="Struct" SequenceLength="2048">
        <Member Name="I" Type="Short"/>
        <Member Name="Q" Type="Short"/>
      </Argument>
    </Operation>
 </Protocol>
```



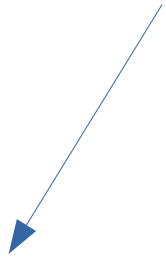
Solution: Protocol Buffer Size is 4 Bytes x 2K = **8K Bytes**

# Protocol Buffer Size (Continued)

protocol buffer size = max operation size × length of the max operation size

Example 2

```
<Protocol>
   <Operation Name="demo">
      <Argument Name="data" Type="Short"></Argument>
    </Operation>
 </Protocol>
```



Solution: Protocol Buffer Size is 2 Bytes x 1 Scalar = **2 Bytes**

# Protocol Buffer Size (Continued)

protocol buffer size = max operation size × length of the max operation size

Example 2

```
<Protocol>
  <Operation Name="demo1">
    <Argument Name="data" Type="longlong" ArrayDimensions="2048"> </Argument>
 </Operation>
 <Operation Name="demo2">
    <Argument Name="data" Type="Struct" SequenceLength="2048">
<Member Name="I" Type="Short"/>
<Member Name="Q" Type="Short"/>
    </Argument>
  </Operation>
</Protocol>
```

Solution: Protocol Buffer Size is 8B x 2K = **16KB**, 4B x 2K = 8KB

# Two HDL Test Assemblies

- Both built around "core" of

  (data in) ⇨ metadata_stressor ⇨ UUT ⇨ backpressure ⇨ (data out)

- One test assembly uses file I/O in an RCC worker
  - Can be built for *any* HDL platform, including simulators ("co-simulation")
  - Uses the simulatable portions of the data plane
  - No DMA engine
  - (data in) and (data out) above are the assembly's external ports
  - This test assembly is used by default
- The other test assembly uses HDL file I/O workers
  - Can *only* be used on simulator platforms
  - Generally much faster simulations than co-simulation
  - (data in) and (data out) above are **`file_read`** and **`file_write`** HDL workers
  - To use, set test XML attribute **`UseHdlFileIO="true"`**

# Test XML Attributes for Data Flow Configuration

- Data flow as noted on previous slide:

  (data in) ⇨ metadata_stressor ⇨ UUT ⇨ backpressure ⇨ (data out)

- By default, "backpressure" is applied to ensure an HDL worker properly respects flow control on its output
  - Can be disabled with test XML attribute **disableBackpressure**
- "metadata_stressor" can ensure worker's input properly handles intra-worker protocols and data starvation
  - Configured with test XML attribute **stressorMode**
    - bypass – disabled (default configuration)
    - throttle – randomly holds back data (starvation)
    - metadata – manipulates metadata randomly (*e.g.* som) (edge conditions)
    - full – above two plus random idle cycles between messages (full compliance)

# Unit Test Suite Debug

- Log files are located in:
  <component>.test/run/<platform>/case##.##.<component>.<implementation>.log
- The **`ocpirun`** command that was executed can be found in the log file. For example:

```
$ OCPI_LIBRARY_PATH=../../../lib/rcc:../../gen/assemblies:$OCPI_CDK_DIR/lib/components/rcc ocpirun -d -v
-mcomplex_mixer=hdl -wcomplex_mixer=complex_mixer -Pcomplex_mixer=modelsim --sim-
dir=case00.00.complex_mixer.hdl.simulation --dump-file=case00.00.complex_mixer.hdl.props
-pfile_write=fileName=case00.00.complex_mixer.hdl.out.out ../../gen/applications/case00.00.xml
```

- You can copy & paste (or modify) the above command, but it must be run from the run/<platform> directory

# Unit Test Suite Simulation

- Execute the **`ocpiview`** command from the <component>.test/ directory

  ocpiview run/xsim/case##.##.<component>.simulation/ &

- The **sim.out** simulator log file can be found at

run/xsim/case##.##.<component>.simulation/<component>_0_frw.xsim.<datestamp>/sim.out

# Two Examples of cases.xml

- First is simple **`ocpi.tutorial`** example with Xilinx-provided cores
- Second is **`ocpi.assets`** copy (complicated, CORDIC-based)

# complex_mixer cases.txt Example 1

```
Values common to all property combinations:
==========================================
    ocpi_debug = false
    ocpi_endian = little
    phs_inc = -8192

Descriptions of the 1 case and its subcases:
==========================================
Case case00:
  Summary of subcases
  Subcase #   enable    data_select
  ------------  --------  ---------------
     0:          false         false
     1:                        true
     2:          true          false
     3:                        true

Subcase 00:
  ocpi_debug = false
  ocpi_endian = little
  enable = false
  phs_inc = -8192
  data_select = false
Subcase 01:
  ocpi_debug = false
  ocpi_endian = little
  enable = false
  phs_inc = -8192
  data_select = true
Subcase 02:
  ocpi_debug = false
  ocpi_endian = little
  enable = true
  phs_inc = -8192
  data_select = false
Subcase 03:
  ocpi_debug = false
  ocpi_endian = little
  enable = true
  phs_inc = -8192
  data_select = true
```

# Unit Test Suite cases.xml Example 1

```
<cases spec='ocpi.tutorial.complex_mixer'>
  <case name='case00'>
    <subcase id='0'>
      <worker name='complex_mixer' model='hdl' outputs='out'/>
      <worker name='complex_mixer' model='rcc' outputs='out'/>
    </subcase>
    <subcase id='1'>
      <worker name='complex_mixer' model='hdl' outputs='out'/>
    </subcase>
    <subcase id='2'>
      <worker name='complex_mixer' model='hdl' outputs='out'/>
      <worker name='complex_mixer' model='rcc' outputs='out'/>
    </subcase>
    <subcase id='3'>
      <worker name='complex_mixer' model='hdl' outputs='out'/>
    </subcase>
  </case>
</cases>
```

# complex_mixer cases.txt Example 2

Values common to all property combinations:
==========
ocpi_debug = false
ocpi_endian = little
CHIPSCOPE_p = false (specific to worker complex_mixer.hdl)
CORDIC_STAGES_p = 16 (specific to worker complex_mixer.hdl)
PEAK_MONITOR_p = true (specific to worker complex_mixer.hdl)
phs_inc = -8192
phs_init = 0 (specific to worker complex_mixer.hdl)
mag = 1024 (specific to worker complex_mixer.hdl)
messageSize = 8192 (specific to worker complex_mixer.hdl)

Descriptions of the 1 case and its subcases:
==========
Case case00:
Summary of subcases

| Subcase # | NCO_DATA_WIDTH_p | INPUT_DATA_WIDTH_p | enable | data_select |
|---|---|---|---|---|
| 0: | 12 | 12 | false | false |
| 1: | | | | true |
| 2: | | | true | false |
| 3: | | | | true |
| 4: | 16 | 16 | false | false |
| 5: | | | | true |
| 6: | | | true | false |
| 7: | | | | true |

Subcase 00:
ocpi_debug = false
ocpi_endian = little
CHIPSCOPE_p = false
NCO_DATA_WIDTH_p = 12
INPUT_DATA_WIDTH_p = 12
CORDIC_STAGES_p = 16
PEAK_MONITOR_p = true
enable = false
phs_inc = -8192
phs_init = 0
mag = 1024
messageSize = 8192
data_select = false
Subcase 01:
ocpi_debug = false
ocpi_endian = little
CHIPSCOPE_p = false
NCO_DATA_WIDTH_p = 12
INPUT_DATA_WIDTH_p = 12
CORDIC_STAGES_p = 16
PEAK_MONITOR_p = true
enable = false
phs_inc = -8192
phs_init = 0
mag = 1024
messageSize = 8192
data_select = true

# Unit Test Suite cases.xml Example 2

```
<cases spec='ocpi.assets.dsp_comps.complex_mixer'>
 <case name='case00'>
  <subcase id='0'>
   <worker name='complex_mixer' model='hdl' outputs='out'/>
   <worker name='complex_mixer' model='rcc' outputs='out'/>
  </subcase>
  <subcase id='1'>
   <worker name='complex_mixer' model='hdl' outputs='out'/>
  </subcase>
  <subcase id='2'>
   <worker name='complex_mixer' model='hdl' outputs='out'/>
   <worker name='complex_mixer' model='rcc' outputs='out'/>
  </subcase>
  <subcase id='3'>
   <worker name='complex_mixer' model='hdl' outputs='out'/>
  </subcase>
  <subcase id='4'>
   <worker name='complex_mixer-1' model='hdl' outputs='out'/>
  </subcase>
  <subcase id='5'>
   <worker name='complex_mixer-1' model='hdl' outputs='out'/>
  </subcase>
  <subcase id='6'>
   <worker name='complex_mixer-1' model='hdl' outputs='out'/>
  </subcase>
  <subcase id='7'>
   <worker name='complex_mixer-1' model='hdl' outputs='out'/>
  </subcase>
 </case>
</cases>
```