



OpenCPI - Open Component Portability Infrastructure

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

OpenCPI RCC Development

- RCC Development Overview
- Advanced RCC Features and Functionality

- RCC – Resource-constrained C/C++
- C and C++ language workers
- Focus on C++ moving forward
- “Supported Systems and Platforms” in the *OpenCPI Installation Guide* and *OpenCPI User Guide* lists development hosts, embedded systems platforms

Application Worker Build Steps

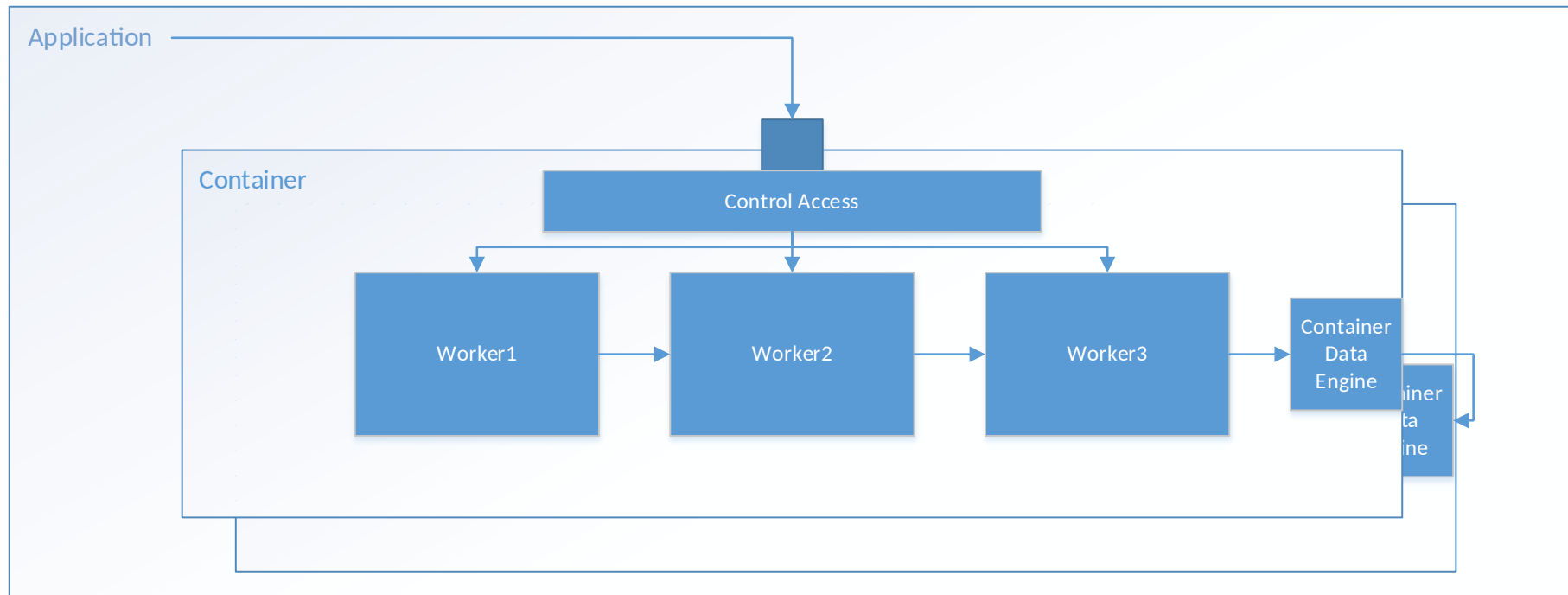
- 1. OPS: Use a pre-existing OPS or create a new one.**
- 2. OCS: Use a pre-existing OCS or create a new one.**
- 3. Create a new worker (modify OWD and source code).**
- 4. Build the worker for the target device(s).**
- 5. Create the unit test (<component>-test.xml, generate, verify and view scripts).**
- 6. Build the unit test.**
- 7. Run the unit test.**

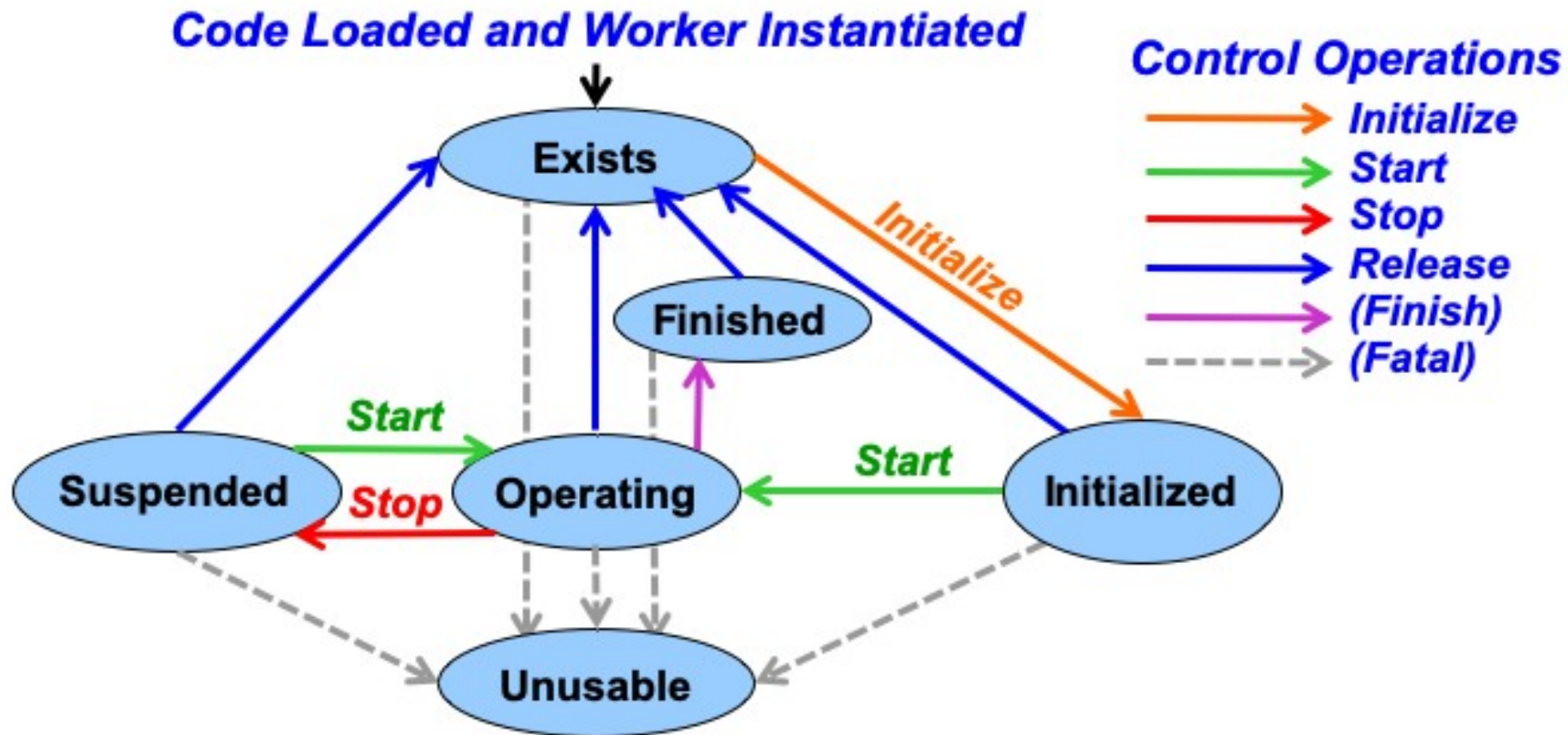
OpenCPI Tutorial 3 demonstrates this process.

- *Software containers* provide the execution environment for workers
 - Load, execute, control, and configure workers
 - Move data between workers
- Provide interfaces for local services
 - Including software watchdog timer
- Evaluate data availability
 - Consumer's buffer has data
 - Producer's buffer has space
- Each RCC container is a single *thread*

Execution Model (cont.)

- Shared buffers between workers that are in the same container





*(Fatal): fatal error from control operation, other transitions based on success:
non-fatal errors do not change states.*

(Finish): is self initiated, not controlled from outside

Run Method

- Called by container when all ports are ready (input ports have data and output ports have a free buffer)
- Other advanced use cases; for example, timeouts if run condition changed from default
- Return values to container
 - `RCC_ADVANCE` (good state + advance all ports)
 - `RCC_OK` (good state)
 - `RCC_FINISHED` (finished state)
 - `RCC_ADVANCE_FINISHED` (finished + advance all ports)
 - `RCC_ERROR` (bad state: recoverable; still operating)
 - `RCC_FATAL` (bad state: **unrecoverable**)

Start/Initialize/Stop/Release

OWD XML:

```
<RCCWorker language="c++"  
spec="myname_spec.xml"  
ControlOperations="start,  
stop, initialize,  
release"/>
```

C++:

```
RCCResult start() // others  
are  
//  
initialize(),  
// stop(),  
and  
//  
release()  
{  
    //your code goes here  
    return RCC_OK;  
}
```

OCS XML:

```
<property name="myprop"  
type="bool"  
writeable="true"  
volatile="true"/>
```

C++:

```
if (properties().myprop ==  
true)  
{  
    //do something  
}  
  
properties().myprop = false;
```

Port Access: Scalar Length

OCS XML:

```
<Port Name="myin"  
  Producer="false"  
  Protocol="my_protocol"/>  
<Port Name="myout"  
  Producer="true"  
  Protocol="my_protocol"/>
```

OPS XML:

```
<Protocol>  
  <Operation name="myOp">  
    <Argument name="myArg1"  
      type="bool"/>  
  </Operation>  
</Protocol>
```

Input ports can be assumed based on the protocol, because there is no variable length data. Output port lengths do not need to be set as long as all arguments are scalar:

C++:

//Nothing to do

Port Access: Scalar Data

OCS XML:

```
<Port Name="myin"  
  Producer="false"  
  Protocol="my_protocol"/>  
<Port Name="myout"  
  Producer="true"  
  Protocol="my_protocol"/>
```

C++:

```
const bool inArg1 =  
myin.myOp().myArg1();  
const bool inArg2 =  
myin.myOp().myArg2();  
myout.myOp().myArg1() = false;  
myout.myOp().myArg2() = true;
```

OPS XML:

```
<Protocol>  
  <Operation name="myOp">  
    <Argument name="myArg1"  
type="bool"/>  
    <Argument name="myArg2"  
type="bool"/>  
  </Operation>  
</Protocol>
```

Port Access: Sequence Length

OCS XML:

```
<Port Name="myin"  
  Producer="false"  
  Protocol="my_protocol"/>  
<Port Name="myout"  
  Producer="true"  
  Protocol="my_protocol"/>
```

C++:

```
//length in elements  
const size_t length =  
    myin.myOp().myArg1().size();  
  
myout.myOp().myArg1().resize(length);  
  
//length in bytes  
myout.setDefaultLength(2*sizeof(bool));
```

OPS XML:

```
<Protocol>  
<Operation name="myOp">  
  <Argument name="myArg1"  
    type="bool"  
    SequenceLength="2048"/>  
</Operation>  
</Protocol>
```

OCS XML:

```
<Port Name="myin"  
  Producer="false"  
  Protocol="my_protocol"/>  
<Port Name="myout"  
  Producer="true"  
  Protocol="my_protocol"/>
```

OPS XML:

```
<Protocol>  
<Operation name="myOp">  
  <Argument name="myArg1"  
    type="bool"  
    SequenceLength="2048"/>  
  </Operation>  
</Protocol>
```

C++:

```
const bool* inData =  
    myin.myOp().myArg1().data();  
  
bool*      outData =  
    myout.myOp().myArg1().data();  
  
for (int i = 0; length > i; i++)  
{  
    //do something with the data  
    inData++;  
    outData++;  
}
```

Port Access: OpCode

OCS XML:

```
<Port Name="myin"
Producer="false"
Protocol="my_protocol"/>
<Port Name="myout"
Producer="true"
Protocol="my_protocol"/>
```

OPS XML:

```
<Protocol>
  <Operation name="MyOp1">
    <Argument name="myArg1"
type="bool"/>
    <Argument name="myArg2"
type="bool"/>
  </Operation>
  <Operation name="MyOp2">
    <Argument name="otherArg1"
type="bool"
SequenceLength="2048"/>
  </Operation>
</Protocol>
```

C++:

```
//for all outputs on this port
myout.setDefaultOpCode(My_protocolMyOp1_OPE
RATION);
//for the current output on this port
myout.setOpCode(My_protocolMyOp1_OPERATION
);

switch(myin.opCode())
{
  case My_protocolMyOp1_OPERATION:
  {
    //do something
    break;
  }
  case My_protocolMyOp2_OPERATION:
  {
    //do something different
    break;
  }
  default:
  {
    cout << "bad Opcode" << endl;
    break;
  }
}
```

Port Access: Manually Advancing

OCS XML:

```
<Port Name="myin" Producer="false"  
Protocol="my_protocol"/>  
<Port Name="myout" Producer="true"  
Protocol="my_protocol"/>
```

C++ advance all:

```
return RCC_ADVANCE;
```

C++ advance manually:

```
myin.advance();  
myout.advance();  
  
return RCC_OK;
```

Define any local variables that you need as class variables.

OWD XML:

```
<RccWorker spec="myworker-  
spec.xml" language="C++">  
</RccWorker>
```

C++:

```
class My_workerWorker :  
    public My_workerWorker base  
{  
  
    bool myLocalVar1;  
    bool myLocalVar2;  
  
    ...  
  
    RCCResult run()  
    {  
        //use local variables  
    }
```

OWD XML:

```
<RCCWorker language="c++"  
spec="myname_spec.xml"  
version="2"/>
```

We recommend that all newly created workers use the latest interface version.

version 1:
interprets a zero length message(ZLM) with opcode 0 as end of file(eof) on both input and output ports

version 2:
eof is received on an input port:
`myin.eof()`

eof is set on an ouput port:
`myout.setEOF()`

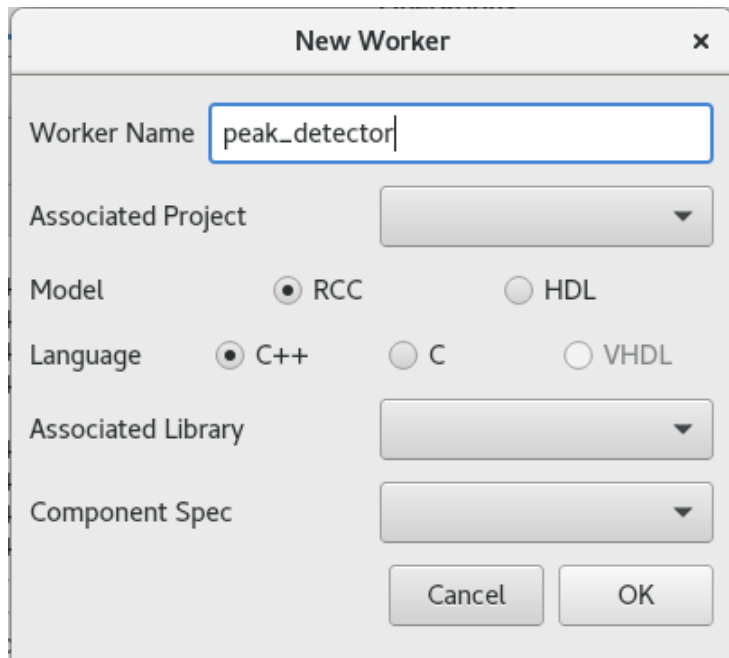
Creating RCC Workers

With

ocpidev:

```
ocpidev create worker peak_detector.rcc
```

With OpenCPI GUI:



Files

created:

```
peak_detector.rcc/  
|-- gen  
|   |-- peak_detector_map.h  
|   |-- peak_detector-build.xml  
|   |-- peak_detector-skel.cc  
|   |-- peak_detector-skel.cc.deps  
|   |-- peak_detector-worker.hh  
|   |-- peak_detector-worker.hh.deps  
|-- peak_detector.cc  
|-- peak_detector.xml
```

Cross Building

- An example of a cross-building target is Zynq-arm, the CPU inside the Zynq system-on-chip (SoC).

- To enable cross build:

```
ocpidev build --rcc --rcc-platform xilinx19_2_aarch32
```

- To enable build for x86:

```
ocpidev build --rcc
```

Or use the OpenCPI GUI

- A built RCC worker is a Linux shared object file
 - Dynamically loadable on the platform that it is built for
- Info about the worker (XML) embedded in .so
 - `ocpixml get myworker.so`

Advanced RCC Features and Functionality

- RCC Development Overview
- Advanced RCC Features and Functionality

OWD XML:

```
<RccWorker spec="myworker-  
spec.xml"  
  language="C++">  
  <property name="myparam"  
type="bool"  
  parameter="true">  
</RccWorker>
```

C++:

```
if (MYWORKER_MYPARAM == true)  
{  
  //do something  
}
```

Property Write Notification

OWD XML:

```
<SpecProperty  
name="myprop" type="bool"  
writeSync="true"/>
```

C++:

```
RCCResult myprop_written()  
{  
    //your code  
    return RCC_OK;  
}
```

Property Read Notification

OWD XML:

```
<SpecProperty  
name="myprop" type="bool"  
readSync="true"/>
```

C++:

```
RCCResult myprop_read()  
{  
    //your code  
    return RCC_OK;  
}
```

OCS XML:

```
<Port Name="myout"  
  Producer="true"  
    optional="true"  
Protocol="rstream_protocol"/>
```

C++:

```
if (myout.isConnected())  
{  
    //output the data to the  
    port  
}
```

- A C++ worker that can manipulate other workers' properties
 - Slave worker can be HDL or another RCC
 - Can be 1:1 or 1:many (workers and/or properties)
- Main use case is for platform development to simplify the user interface when developing a Board Support Package (BSP)

- Described in the *RCC Development Guide* :
 - Gives directions on how to break gdb in your worker when trying to debug
 - Can be used in a standalone graphical debugger such as DDD
 - gdb is available native on remote systems (e310); remote debugging with gdbserver is not required