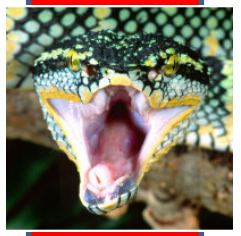
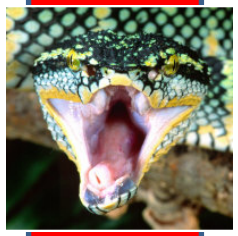


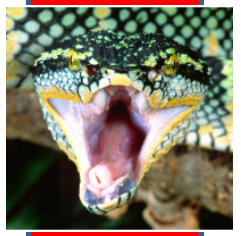
Lab 1
OpenCPI Application Development

Objectives



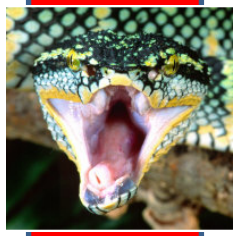
1. Create FSK loopback (FPGA internal) OpenCPI Application XML (OAS) using the IDE
2. Run application on Matchstiq Z1 hardware

Overview

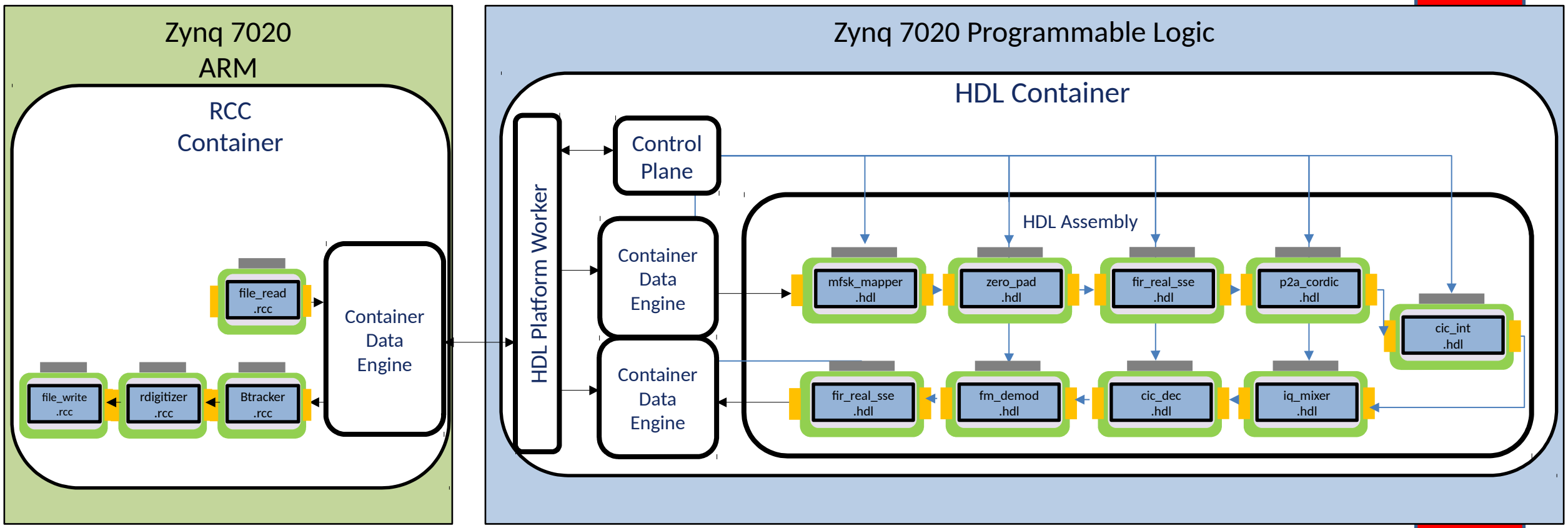


- A common use case for OpenCPI is the reuse of components from multiple libraries to construct applications for heterogeneous systems
- An OpenCPI Application Specification (OAS) XML describes the connections and initial property settings of the components
  - The ANGRYVIPER (AV) IDE helps generate this XML file graphically
- The generated XML is used by the `ocpirun` utility program during the execution of the application on a platform

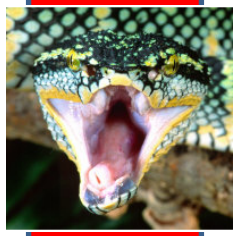
Overview



- The reference application performs FSK modulation/demodulation
  - Modulation
    - Read Input File → FSK Symbol Mapper → Zero-pad → Pulse Shape → FM Modulate → Interpolate
  - Demodulation
    - Decimate → Demodulate → Filter → Baud Track → Digitize → Write Output File



Using the ocpirun utility

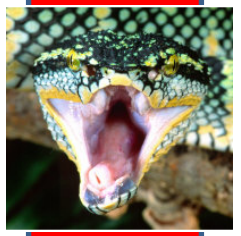


- The utility program ocpirun provides a simple way to execute applications
- Usage is: ocpirun app.xml
  - app.xml is a OAS file like the one which will be generated with the IDE in this lab
- The arguments passed to ocpirun can specify how the application is run

Option	Letter	Description
Dump	d	Dump all readable properties after initialization, and again after execution, to stderr.
Verbose	v	Be verbose in describing what is happening.
Log Level	l	For this execution, set the OpenCPI log level to the given level. 8 and 10 are commonly used.
Time	t	Stop execution after this many seconds. This is useful when there is no definition of “done” for the application.

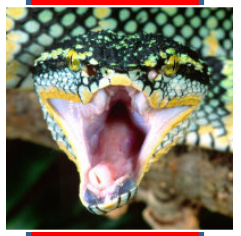
More detail on ocpirun can be found in the **OpenCPI Application Development Guide** document

Application Development Flow

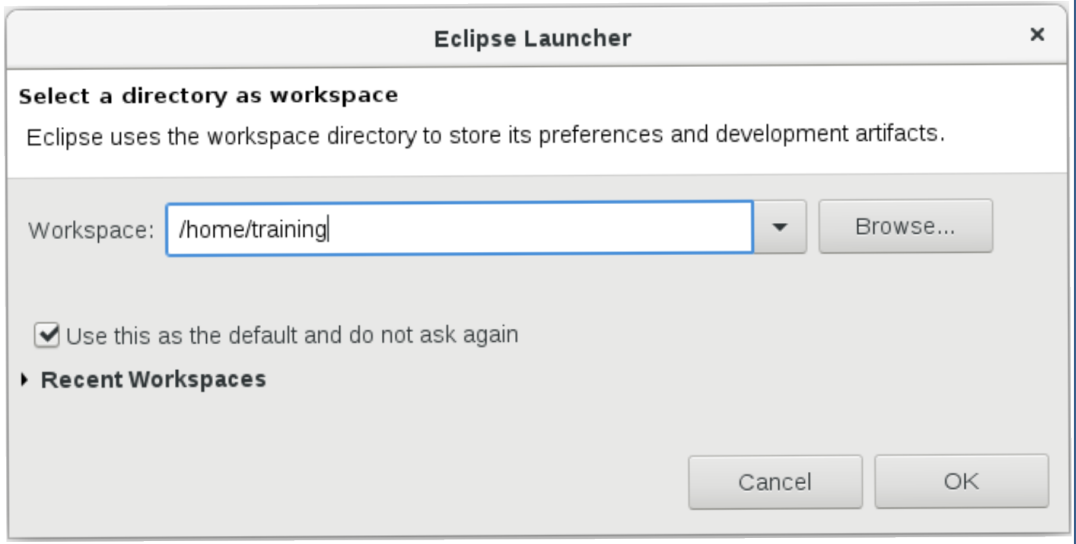


1. Add components to the OAS
2. Specify non-default properties for the components
3. Make connections between the components
4. Setup deployment platform
5. Run and test the application

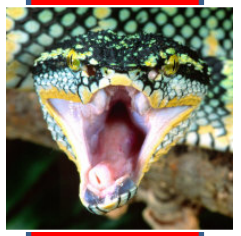
Step 1



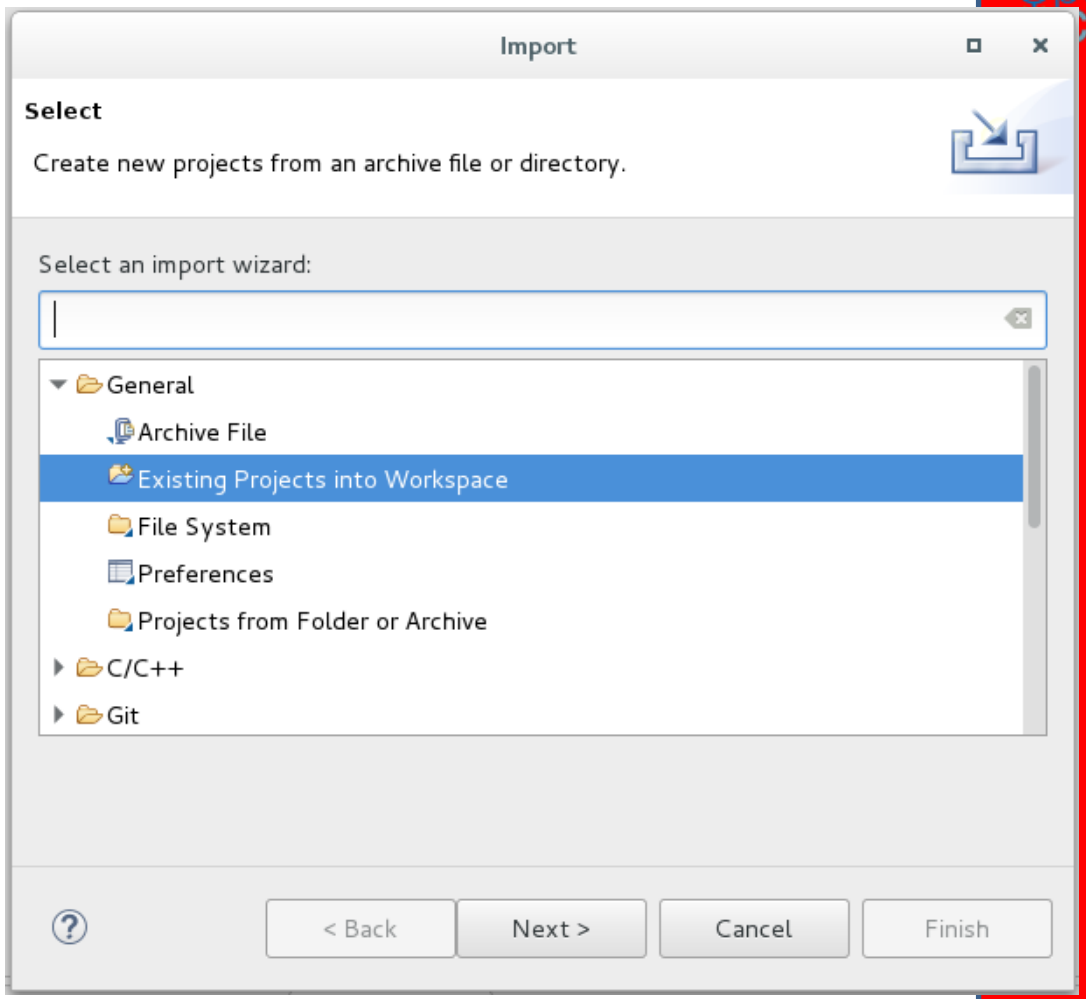
- Start AV IDE and set the default workspace to:
  - /home/training/
  - Note: Don’ t deviate from this path, this will be used in the remainder of the labs.
- Exit the welcome screen
- Launch the “perspective”
  - Window → Perspective → Open Perspective → Other…
  - Choose “ANGRYVIPER Perspective”



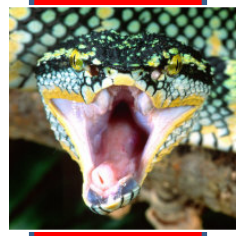
Step 2



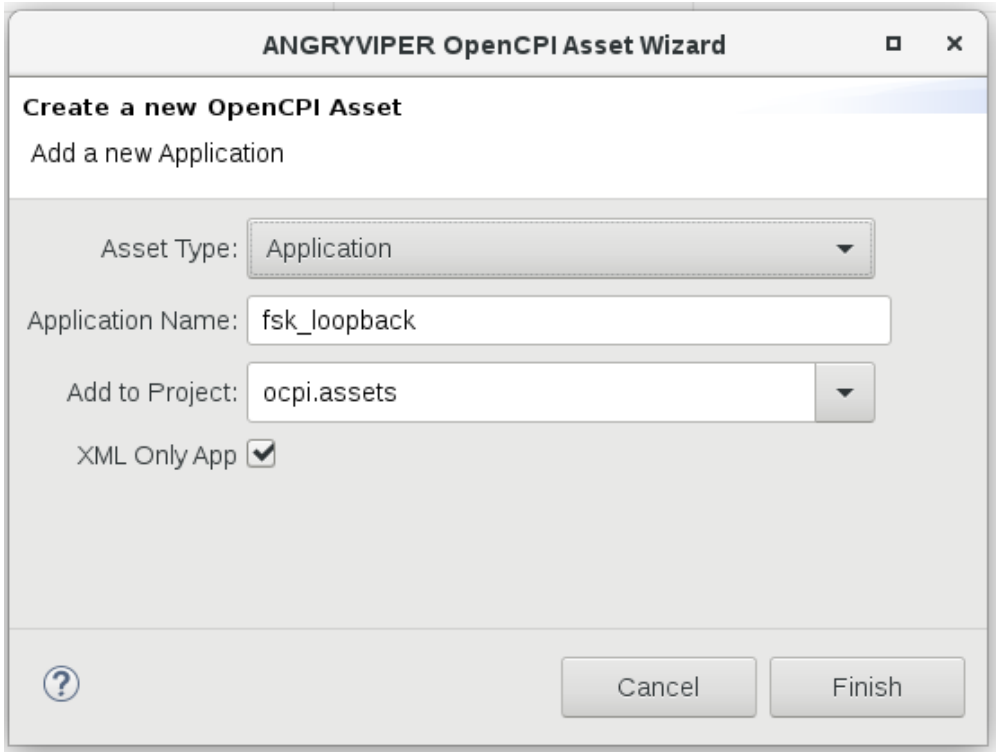
- Import pre-built projects: core and assets
  - The **core** project contains some basic components, including workers to read and write files.
  - Another project called **assets** is included. It contains a number of components used in this lab.
  - Pre-built projects are located at:
    - ~/core
    - ~/assets
- To import project into eclipse:
  - File → Import…
    - "Existing Projects into Workspace"



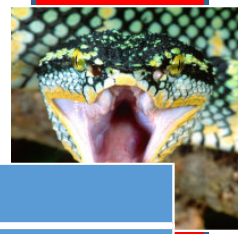
Step 3



- Create new application in an existing project
- To create an application
  - In OpenCPI Projects, right click assets:
    - Asset Wizard
  - Asset Type: Application
  - Application Name: fsk_loopback
  - Add to Project: ocpi.assets
  - XML only: Yes



Step 4



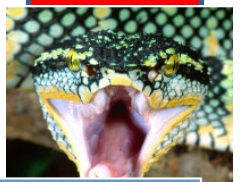
- Delete the ocpi.core.nothing component
  - This worker is automatically placed by the framework to ensure the generated OAS can be executed without editing the generated file
- To add a component
  1. Within the Project Explorer tab and using the provided table, navigate into the 'specs' directory of the appropriate Project:Library
  2. Drag spec file onto Application Editor
  3. Recommended: Name component
     - **There are 2 instances of fir_real_sse-spec.xml. To distinguish the instances, name one ‘tx_fir’ and the other ‘rx_fir’**

Component Specs Required	
Name	**Project : Library**
file_read_spec.xml	Core Project : components
mfsk_mapper-spec.xml	Assets : components/comms_comps
zero_pad-spec.xml	Assets : components/util_comps
fir_real_sse-spec.xml	Assets : components/dsp_comps
phase_to_amp_cordic-spec.xml	Assets : components/dsp_comps
cic_int-spec.xml	Assets : components/dsp_comps
complex_mixer-spec.xml	Assets : components/dsp_comps
cic_dec-spec.xml	Assets : components/dsp_comps
rp_cordic-spec.xml	Assets : components/dsp_comps
fir_real_sse-spec.xml	Assets : components/dsp_comps
baudTracking-spec.xml	Assets : components/dsp_comps
real_digitizer-spec.xml	Assets : components/dsp_comps
file_write_spec.xml	Core Project : components

Step 5

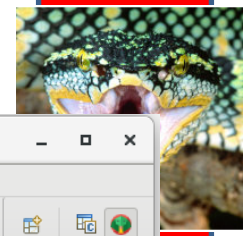
- Set property values
  - To specify a property value **(diagram on next slide)**

1) Right click on instance → 'Show in Properties View'
2) Click Properties Tab → Properties
3) Click green plus sign on right side of tab → Instance Property
4) Add ‘Name’ and ‘Value’



Property Values Required		
Component	**Property Name**	**Value**
file_read	fileName	FSK/idata/Os.jpeg
file_read	messageSize	2048
mfsk_mapper	symbols	-32768, 32767
zero_pad	num_zeros	38
phase_to_amp_cordic	magnitude	20000
phase_to_amp_cordic	STAGES	16
cic_int	R	16
cic_int	ACC_WIDTH	28
complex_mixer	enable	False
cic_dec	R	16
cic_dec	ACC_WIDTH	28
baudTracking	SPB	39
baudTracking	BaudAvrCount	10
file_write	fileName	out.out

Specifying Property Values



training - ANGRYVIPER Perspective - ocpi.assets/applications/fsk_loopback.xml - Eclipse

File Edit Navigate Search Project Run Window Help

Quick Access

OpenCPI Projects

Refresh

ocpi.core

ocpi.assets

Project Operations

ANGRYVIPER Operations Panel

RCC Platforms

xilinx13_3
centos6
xilinx13_4
centos7
macos10_13

HDL Targets

HDL Platforms

e3xx
alst4
modelsim
picoflexor_s1t6a
matchstiq_z1
xsim
zed

Assets Tests

Build Label (optional):

Build Assemblies

Build

Clean

Build Status

Project Explorer

tx_event_test
zipper_i2c_test
bias.xml
copy.xml
devbias.xml.hold
file-bias-capture.xml
fsk_loopback.xml
hello.xml
Makefile
nothing.xml
out.out
pattern-bias-file.xml

fsk_loopback.xml

App...n OAS Diagram

1

file_read
fileName FSK/idata/Os.jpeg
messageSize 2048

mfsk_mapper
symbols -32768,32767

Palette
Connections
Advanced Connection
Simple Connection
Objects
Instance

Application Details Source

2

Properties

Instance Properties

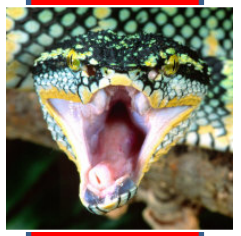
4

Properties:

Name	Value	ValueFile	DumpFile
fileName	FSK/idata/Os.jpe		
messageSize	2048		

3

Step 6

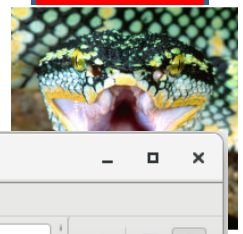


- Set property ValueFiles
- The fir_real_sse components used in this application have a property called 'taps' which are arrays of 64
- Instead of specifying all 64 values in the IDE, we can set an attribute called **ValueFile** which points to a file which contains the values
- To specify a property **ValueFile** **(diagram on next slide)**

1) Right click on instance → 'Show in Properties View'
2) Click Properties Tab → Properties
3) Click green plus sign on right side of tab → Instance Property
4) Add ‘Name’ and ‘ValueFile’

Property Values Required		
Component	**Property Name**	**ValueFile**
rx_fir	taps	FSK/idata/rx_rrcos_taps.dat
tx_fir	taps	FSK/idata/tx_rrcos_taps.dat

Specifying Property ValueFiles



training - ANGRYVIPER Perspective - ocpi.assets/applications/fsk_loopback.xml - Eclipse

File Edit Navigate Search Project Run Window Help

Quick Access

OpenCPI Projects

Refresh

ocpi.core

ocpi.assets

Project Operations

ANGRYVIPER Operations Panel

RCC Platforms

xilinx13_3

centos6

xilinx13_4

centos7

HDL Targets

HDL Platforms

e3xx

alst4

modelsim

picoflexor_s1t6a

matchstiq_z1

xsim

>

<

clr

Assets Tests

Build Label (optional):

Build Assemblies

Build

Clean

Build Status

Project Explorer

tx_event_test

zipper_i2c_test

bias.xml

copy.xml

devbias.xml.hold

file-bias-capture.xml

fsk_loopback.xml

hello.xml

Makefile

nothing.xml

out.out

fsk_loopback.xml

Application OAS Diagram

1

zero_pad

num_zeros 38

tx_fir

taps FSK/idata/tx_rrcos_taps.dat

Palette

Connections

Advanced Connection

Simple Connection

Objects

Instance

Application Details Source

2

Instance

Properties

Properties

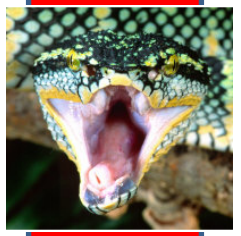
Instance Properties

4

3

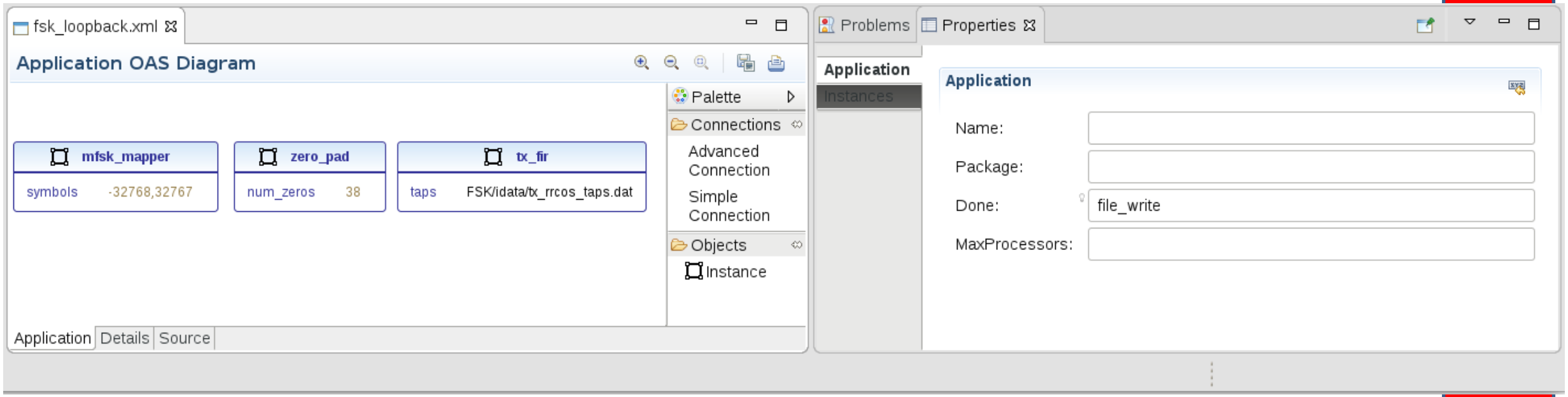
Properties:

Name	Value	ValueFile	DumpFile
taps		FSK/idata/tx_rrcos_taps.dat	

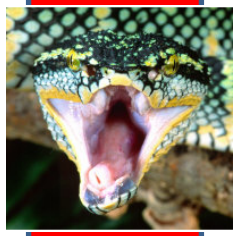


Step 7

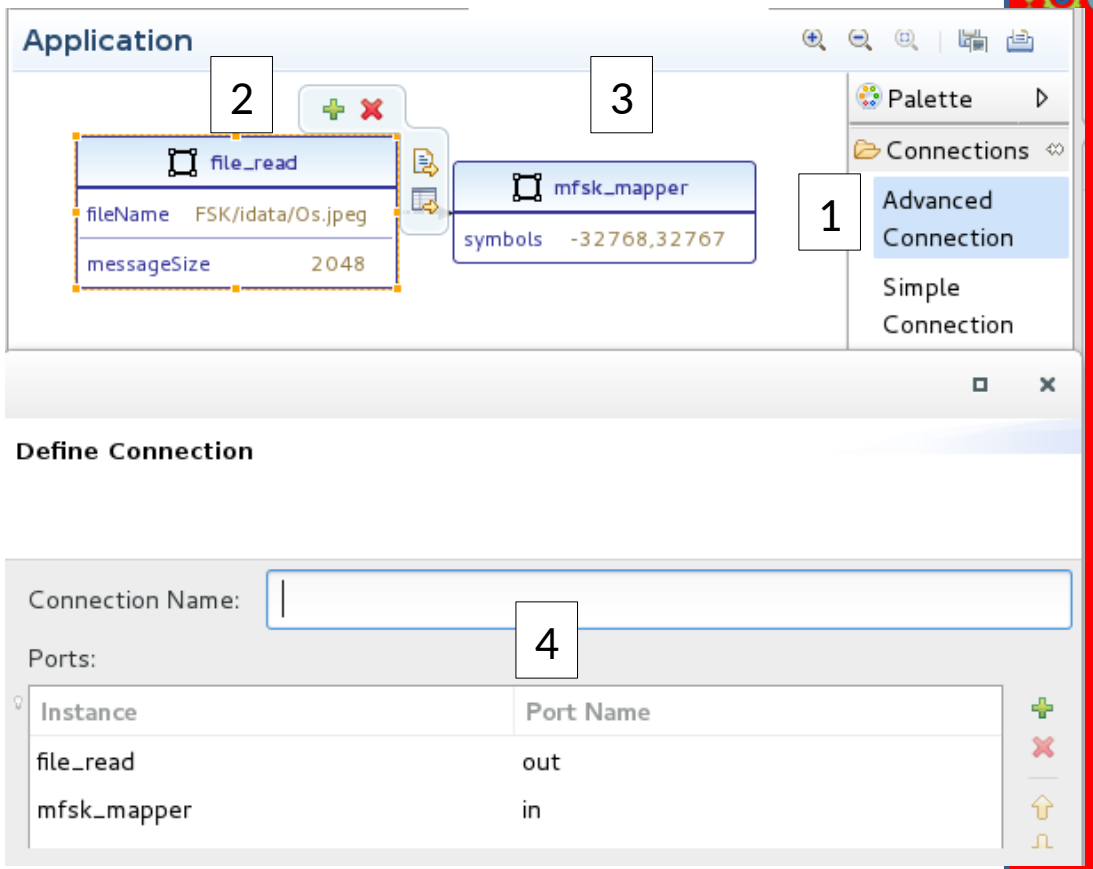
- Specifying Top Level Attributes in OAS
  - Configure the OAS to ‘be done’ when the file_write component received End-of-File. There is a “top-level” attribute for OAS XML called “Done” used for this purpose
- To set top level OAS attribute:
  1. Click on the white space in between instances so none are selected
  2. In the property tab, fill in the “Done” field with the desired worker name



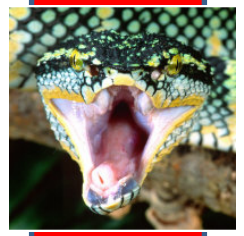
Step 8

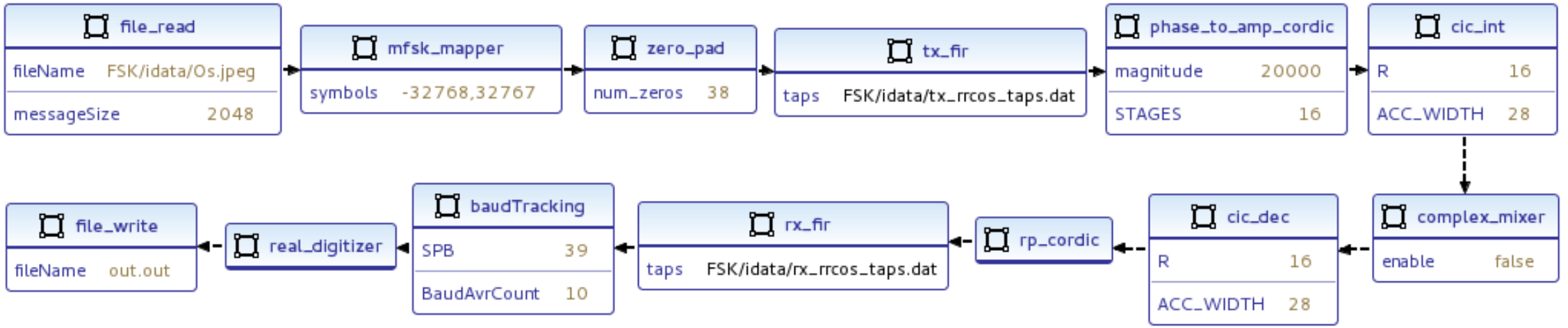


- Make connections
  - See next slide for diagram of required connections
  - Maximizing OAS pane helps
- To make a connection
  1. Click “Advanced Connection” on Palette Menu
  2. Click originating instance
  3. Click destination instance
  4. Populate “Port Name” fields
     - All workers in this lab use the default ‘out’ and ‘in’ Port Names
- **Save your work!**



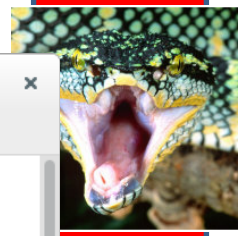
End Result

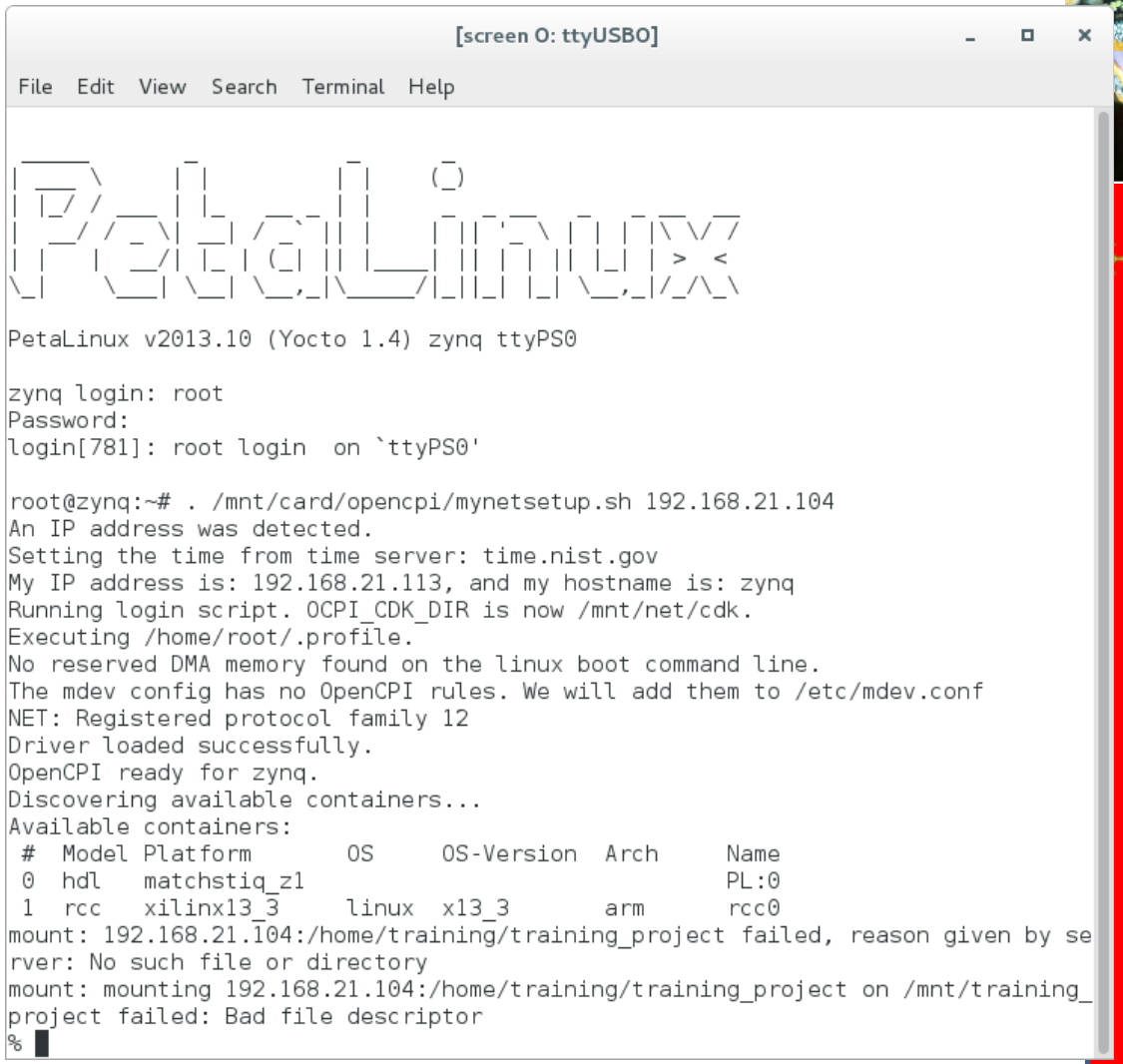



file_read
fileName FSK/idata/Os.jpeg
messageSize 2048
mfsk_mapper
symbols -32768,32767
zero_pad
num_zeros 38
tx_fir
taps FSK/idata/tx_rrcos_taps.dat
phase_to_amp_cordic
magnitude 20000
STAGES 16
cic_int
R 16
ACC_WIDTH 28
complex_mixer
enable false
cic_dec
R 16
ACC_WIDTH 28
rp_cordic
rx_fir
taps FSK/idata/rx_rrcos_taps.dat
baudTracking
SPB 39
BaudAvrCount 10
real_digitizer
file_write
fileName out.out

Step 9

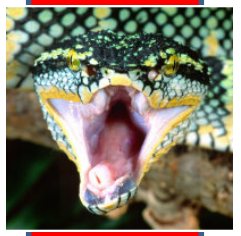
- Setup deployment platform
  1. Connect to serial port via USB on rear of Matchstiq Z1 using Host
     - ‘screen /dev/matchstiq_z1_0 115200’
  2. Boot and login into PetaLinux
     - User/Password = root:root
  3. Verify Host and Matchstiq Z1 have valid IP addresses
     - For training, they should both be on the same subnet
  4. Run setup script on Matchstiq Z1
     - ‘source /mnt/card/opencpi/mynetsetup.sh <Host IP address>’





More detail on this process can be found in the **Matchstiq_Z1 Getting Started Guide** document

Step 10



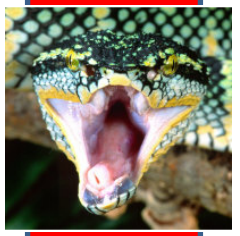
- Setup environment on Matchstiq Z1 using OCPI_LIBRARY_PATH
  - The OCPI_LIBRARY_PATH environment variable is used to locate deployable artifacts
    - To deploy this application, 5 artifacts are needed
      - 4 software worker .so files
        1. file_read.so
        2. file_write.so
        3. Baudtracking_simple.so
        4. real_digitizer.so
      - 1 HDL container .bitz
        1. fsk_filerw_matchstiq_base.bitz
- To set OCPI_LIBRARY_PATH on Matchstiq Z1
  - 'export OCPI_LIBRARY_PATH=/mnt/ocpi_core/exports:/mnt/ocpi_assets/exports'
    - These component instances were added from these component libraries.
    - The directories in this path are searched recursively, so this variable can be as specific or as broad as needed as long as the artifacts are in the path. Broader paths lead to longer search times when running an application
    - The exports directory at the top level of project contains links to artifacts contained in the project

Step 11

- Run application on Matchstiq Z1 using ocpirun
  - ocpirun is a utility program provided with the Component Development Kit (CDK) for running applications described by OAS XML
- To run application on Matchstiq Z1:
  1. Navigate to OAS XML:
     - ‘cd /mnt/ocpi_assets/applications’
  2. Pass OAS XML to ocpirun:
     - ‘ocpirun -v fsk_loopback.xml’
     - ocpirun is a utility program provided with the CDK for running the application
       - Optional arguments on previous slides
     - Problems? See next slide
  3. View output image on Host
     - ‘cd /home/training/assets/applications’
     - ‘eog out.out’


```
File  Edit  View  Search  Terminal  Help
% cd /mnt/ocpi_assets/applications/
% ocpirun -v fsk_loopback.xml
Available containers are:  0: PL:0 [model: hdl os:  platform: matchstiq_z1], 1: rcc
0 [model: rcc os: linux platform: xilinx13_3]
Actual deployment is:
  Instance  0 file_read (spec ocpi.core.file_read) on rcc container 1: rcc0, using
file_read in /mnt/ocpi_core/exports/lib/components/rcc/linux-x13_3-arm/file_read_s.
so dated Wed Feb 14 09:38:37 2018
  Instance  1 mfsk_mapper (spec ocpi.assets.comms_comps.mfsk_mapper) on hdl contain
er 0: PL:0, using mfsk_mapper/a/mfsk_mapper in /mnt/ocpi_assets/exports/lib/hdl/ass
emblies/fsk_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  2 zero_pad (spec ocpi.assets.util_comps.zero_pad) on hdl container 0: P
L:0, using zero_pad-1/a/zero_pad in /mnt/ocpi_assets/exports/lib/hdl/assemblies/fsk
_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  3 tx_fir (spec ocpi.assets.dsp_comps.fir_real_sse) on hdl container 0:
PL:0, using fir_real_sse/a/tx_fir_real in /mnt/ocpi_assets/exports/lib/hdl/assembli
es/fsk_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  4 phase_to_amp_cordic (spec ocpi.assets.dsp_comps.phase_to_amp_cordic)
on hdl container 0: PL:0, using phase_to_amp_cordic-1/a/phase_to_amp_cordic in /mnt
/ocpi_assets/exports/lib/hdl/assemblies/fsk_filerw_matchstiq_z1_base.bitz dated Tue
 Feb 13 16:44:59 2018
  Instance  5 cic_int (spec ocpi.assets.dsp_comps.cic_int) on hdl container 0: PL:0
, using cic_int-5/a/cic_int in /mnt/ocpi_assets/exports/lib/hdl/assemblies/fsk_file
rw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  6 complex_mixer (spec ocpi.assets.dsp_comps.complex_mixer) on hdl conta
iner 0: PL:0, using complex_mixer/a/complex_mixer in /mnt/ocpi_assets/exports/lib/h
dl/assemblies/fsk_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  7 cic_dec (spec ocpi.assets.dsp_comps.cic_dec) on hdl container 0: PL:0
, using cic_dec-5/a/cic_dec in /mnt/ocpi_assets/exports/lib/hdl/assemblies/fsk_file
rw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  8 rp_cordic (spec ocpi.assets.dsp_comps.rp_cordic) on hdl container 0:
PL:0, using rp_cordic/a/rp_cordic in /mnt/ocpi_assets/exports/lib/hdl/assemblies/fs
k_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance  9 rx_fir (spec ocpi.assets.dsp_comps.fir_real_sse) on hdl container 0:
PL:0, using fir_real_sse/a/rx_fir_real in /mnt/ocpi_assets/exports/lib/hdl/assembli
es/fsk_filerw_matchstiq_z1_base.bitz dated Tue Feb 13 16:44:59 2018
  Instance 10 baudTracking (spec ocpi.assets.dsp_comps.baudTracking) on rcc contain
er 1: rcc0, using Baudtracking_simple in /mnt/ocpi_assets/exports/lib/dsp_comps/rcc
/linux-x13_3-arm/Baudtracking_simple_s.so dated Tue Feb 13 15:16:23 2018
  Instance 11 real_digitizer (spec ocpi.assets.dsp_comps.real_digitizer) on rcc con
tainer 1: rcc0, using real_digitizer in /mnt/ocpi_assets/exports/lib/dsp_comps/rcc/
linux-x13_3-arm/real_digitizer_s.so dated Tue Feb 13 15:16:24 2018
  Instance 12 file_write (spec ocpi.core.file_write) on rcc container 1: rcc0, usin
g file_write in /mnt/ocpi_core/exports/lib/components/rcc/linux-x13_3-arm/file_writ
e_s.so dated Wed Feb 14 09:38:40 2018
Application XML parsed and deployments (containers and implementations) chosen
Application established: containers, workers, connections all created
Communication with the application established
Application started/running
Waiting for application to finish (no time limit)
Application finished
%
```

Common Errors / Debugging



1. “No acceptable implementations found”
   - OCPI_LIBRARY_PATH incorrect; try “-l 8”
   - Typo in OAS; check “Source” Tab and check spelling
     - Log 8 would say something like: Rejected: initial property "your_typo" not found
2. “No containers were found for deploying instance”
   - OCPI_LIBRARY_PATH incorrect
   - Have instructor check project exports
3. “…produced an error during the "start" control operation”
   - Follow diagnostics given, *e.g.* mistyped fileName entry
4. “Can't process file…”
   - Follow diagnostics given, *e.g.* mistyped ValueFile entry