Virtual Earthquake and seismology Research Community e-science environment in Europe
Project 283543 – FP7-INFRASTRUCTURES-2011-2 – www.verce.eu – info@verce.eu

dispel4py: A Python Framework for Data-Intensive Scientific Computing

(dispel4py training)
day 3

3 July 2015, Liverpool

Outline

- What is dispel4py
- What is a stream
- What is a processing element (PE)
- What is a instance
- What is a graph
- What I need for constructing a dispel4py workflow
- Extra material

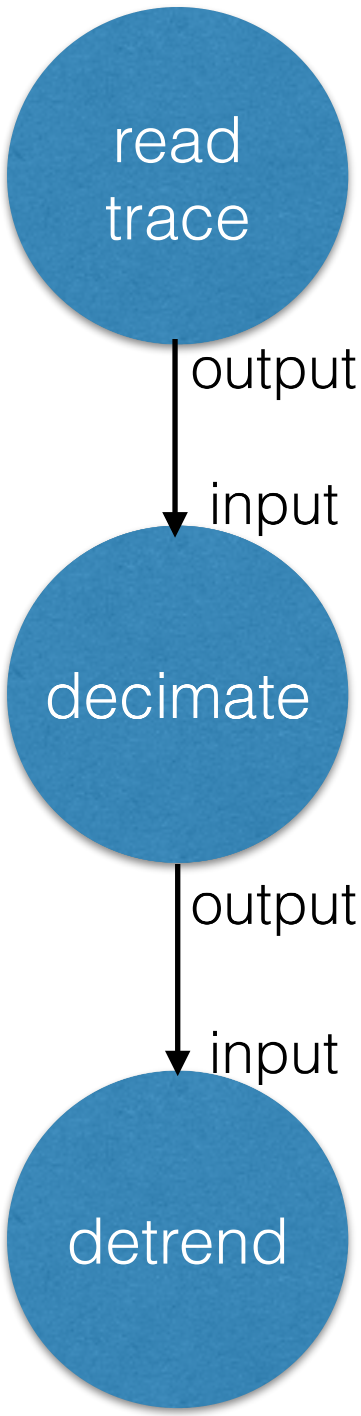
What is dispel4py

- dispel4py for **distributed data-intensive applications**
- Describes data-flow and processing elements using **Python**
- It enables abstract description of methods
- dispel4py **maps** to multiple enactment systems
- Applications **scale** automatically
  - exploiting parallel processing, clusters, grids and clouds
- dispel4py is **dataflow-oriented**
  - rather than control-oriented
  - no explicit specification of data movement
  - light-weight composition of data operations

What is a data stream

- A **stream** is a sequence of data units:
  - from external source
  - between data operations - Processing Elements (PEs)
  - to external destination
- Flow of input or output data between PEs
- Processes data from a source and delivers data to one or more destinations

What is a processing element (PE)



- Computational activity encapsulates
  - algorithm
  - services
  - data transformation processes
- Basic computational elements of dispel4py workflows
- PEs have:
  - inputs & outputs
  - computational activity.
- PEs are connected by streams
  - saves computational costs

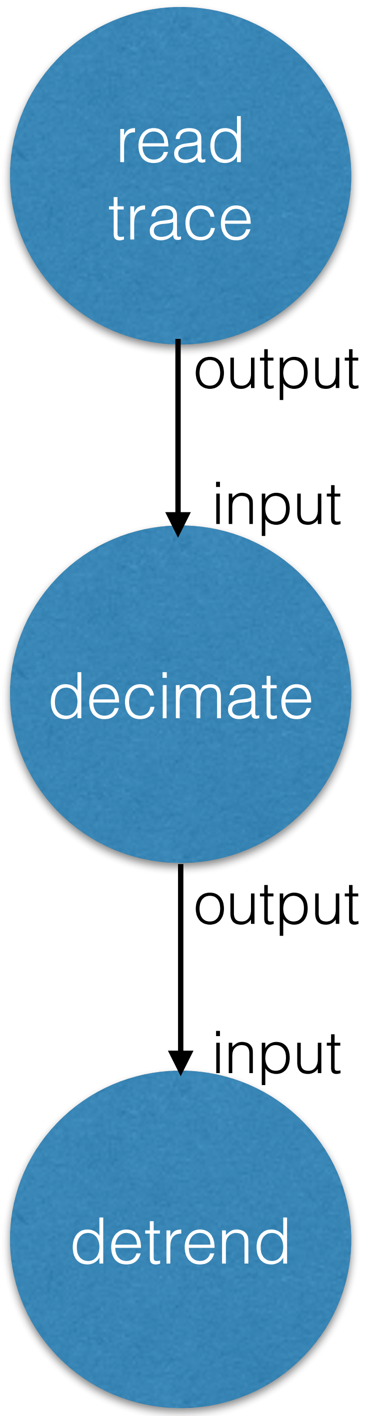
What is a graph

- How the PEs are connected
- How data is streamed
- The topology of the data flow
- No limitations on the type of graphs

What I need for constructing a dispel4py workflow

- You **only** have to **implement PEs** (in Python) and connect them:
    - Learn how to implement PEs.
    - Learn how to connect them.

Learning dispel4py by an example



- dispel4py workflow that reads a trace
- decimate the trace
- detrend the trace

How to implement a PE

- Each PE specifies:
  - input & output connections
  - computational activity for processing data units
    - implement the "_process" method.

Types of PEs

Type	Inputs	Outputs	When to use it
GenericPE	*n* inputs	*m* outputs	many inputs and/or many outputs
IterativePE	1 input named 'input'	1 output named 'output'	process one and produce one data unit in each iteration
Consumer PE	1 input named 'input'	no output	no output and one input
ProducerPE	no input	1 input named 'output'	no inputs and one output; usually the root in a graph
Simple FunctionPE	1 input named 'input'	1 output named 'output'	only implement _process method; it can not store state between calls
create_itera tive_chain	1 input named 'input'	1 output named 'output'	pipeline of functions processing sequentially; creates a composite PE

IterativePE example

```
from dispel4py.base import IterativePE
from obspy.core import read

class ReadTrace(IterativePE):
    def __init__(self):
        IterativePE.__init__(self)
    def _process(self, data):
        filename = data
        st = read(filename)
        return st
```

This PE receives a filename ('input'), reads the obspy trace from the file, and writes it to the output ('output')

What we have learnt:

- We don't need to specify the input and output
- The parameter to the _process method is the data (the filename)
- _process returns the value that is written to the output stream

SimpleFunctionPE example

```
from dispel4py.base import SimpleFunctionPE

def decimate(st, sps):
    st.decimate(int(st[0].stats.sampling_rate/sps))
    return st

decimate = SimpleFunctionPE(decimate, {‘sps’: 4})
```

This PE will emit a decimated trace.

What we have learnt:

- Only implement the processing function
- The easiest but the most restrictive way
- 1 input called ‘input’, 1 output called ‘output’.

ConsumerPE example

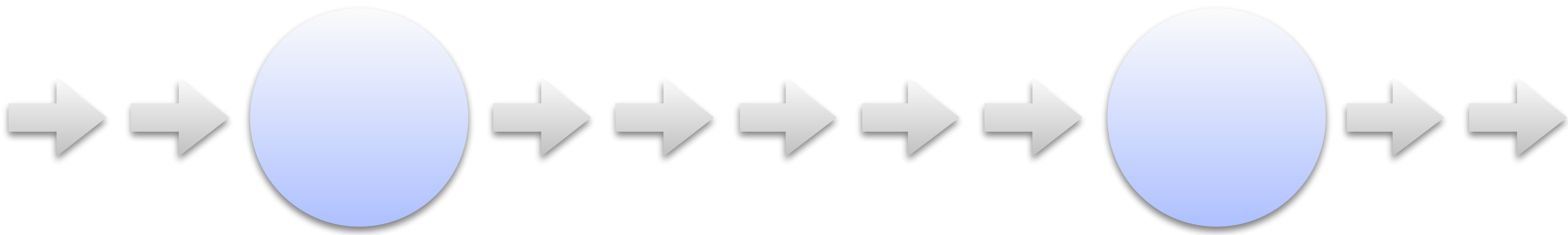
```
from dispel4py.base import ConsumerPE

class Detrend(ConsumerPE):
    def __init__(self):
        ConsumerPE.__init__(self)
    def _process(self, st):
        st.detrend('simple')
        st.write(st[0].getId() + '.mseed', 'MSEED')
```

This PE receives one decimated trace, applies detrend and writes it to a MSEED file.

What we have learnt:

- We don't need to specify the input
- It does not return any output.

How to connect PEs
What does it mean



- PEs process a small amount of data at a time
- Data need not be explicitly stored
- PEs may store a small amount of result data (e.g. stacking) or big amount (if you have the resources)

How to connect PEs: Create a graph

- **Create the PEs**

```
readtrace = ReadTrace()
decimate = SimpleFunctionPE(decimate, {‘sps’: 4})
detrend = Detrend()
```

- **Create the graph and connect the PEs**

```
from dispel4py.workflow_graph import WorkflowGraph

graph = WorkflowGraph()
graph.connect(readtrace, 'output', decimate, ‘input')
graph.connect(decimate, 'output', detrend, 'input')
```

Example- Summary

```
from dispel4py.base import IterativePE, ConsumerPE, SimpleFunctionPE
from dispel4py.workflow_graph import WorkflowGraph
from obspy.core import read

class ReadTrace(IterativePE):
    def __init__(self):
        IterativePE.__init__(self)
    def _process(self, data):
        filename = data
        st = read(filename)
        return st

def decimate(st, sps):
    st.decimate(int(st[0].stats.sampling_rate/sps))
    return st

class Detrend(ConsumerPE):
    def __init__(self):
        ConsumerPE.__init__(self)
    def _process(self, st):
        st.detrend('simple')
        st.write(st[0].getId() + '.mseed', 'MSEED')

readtrace = ReadTrace()
decimate = SimpleFunctionPE(decimate, {'sps': 4})
detrend = Detrend()

graph = WorkflowGraph()
graph.connect(readtrace, 'output', decimate, 'input')
graph.connect(decimate, 'output', detrend, 'input')
```

Extra Material

- GenericPE example
- ProducerPE example
- creative_iterative_chain
- How to create those three new PE types
- What does connecting PEs really mean?

GenericPE example

```
from dispel4py.core import GenericPE

class StreamAndStatsProducer(GenericPE):
    def __init__(self):
        GenericPE.__init__(self)
        self._add_input('input')
        self._add_output('output')
        self._add_output('output_stats')
    def process(self, inputs):
        data = inputs['input']
        filename = data
        st = read(filename)
       return {'output': st, 'output_stats': st[0].stats}
```

This PE also reads a file that contains seismological traces and returns two outputs: obspy stream and metadata.

What we have learnt:

- We can add several outputs with different names
- The process method gets values from the input streams
- The process method returns both streams

create_iterative_chain

```
def decimate(data, sps):
    st = data[0]
    st.decimate(int(st[0].stats.sampling_rate/sps))
    return st
def detrend(data):
    st = data[0]
    st.detrend('simple')
    return st
def demean(data):
    st = data[0]
    st.detrend('demean')
    return st
# For using this function as a PE we need to use ‘creative_iterative_chain’ before defining the graph.
preprocess_trace = create_iterative_chain([(decimate, {'sps':4}), detrend, demean])
```

What we have learnt:

- We can create a *composite* PE which processes several function in a sequence
- Creates a pipeline of SimpleFunctionPEs
- It’s the easiest way to create a pipeline but the most restrictive
- 1 input called ‘input’, 1 output called ‘output’.

How to connect PEs: Create a PE object

- Create a PE (could be GenericPE, IterativePE, ConsumerPE, ProducerPE)

```
readTrace = ReadTrace()
```

- Create a function wrapped in a simple PE

```
detrend = SimpleFunctionPE(detrend)
```

- Create a composite PE with a pipeline

```
preprocessData =
    create_iterative_chain([(decimate,{'sps':4}), detrend, demean])
```