

PyLith Modeling Tutorial

Debugging PyLith Simulations

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What parameters are available?

Parameters are specified as a hierarchy of components and properties

- Components (Facilities) are the object building blocks
Appendix B of the PyLith manual lists all of the components
 - Problem `TimeDependent`
 - Boundary conditions `DirichletBC`
 - Faults `FaultCohesiveKin`
 - Materials `MaxwellViscoelastic3D`
 - Output managers `OutputSolnSubset`
 - Readers `MeshIOCubit`
- Properties are the basic types
 - String `mat.viscoelastic.spatialdb`
 - Integer `4`
 - Float `2.3`
 - Dimensioned quantity `2.5*year`
 - Array of Strings, Integers, or Floats `[0, 0, 1]`

How do I show the values of the current parameters?

Case study: `examples/3d/hex8/step01`

- All current parameters and their values

```
pylithinfo [--verbose] [-o pylith.parameters.txt] [-h] [PyLith args]
```

```
pylithinfo --verbose step01.cfg
```

- Components and properties for given component `--help`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help
```

- Current components of a given component `--help-components`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help-components
```

- Current properties of a given component `--help-properties`

```
step01.cfg [pylithapp.timedependent.bc.z_neg]
```

```
shell pylith step01.cfg --timedependent.bc.z_neg.help-properties
```

What about a GUI?

Browser-based GUI under development

- Use web browser as GUI to parameters
 - See all parameters with descriptions
 - See possible choices for components and properties
- Basic validation of parameters
- Export parameters to single file
Facilitate archiving parameters used in given simulation

Started in Oct 2013 but v2.0 and v3.0 releases have higher priority

Debugging Examples

See `examples/debugging`

Step01 Simple shear using Dirichlet BC in static simulation

Step02 Prescribed fault slip with Dirichlet BC

- Static simulation
- Fault is embedded within the domain

Step03 Spontaneous rupture with Dirichlet BC

- Static simulation
- Static friction ($\mu_f = 0.6$)
- Slip driven by simple shear

Correct files are provided for reference

Step01: Error 1

Error found while doing very basic validation of parameters

```
$ pylith step01.cfg
```

Python stacktrace

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith", line 27, in <module>
```

```
    start(applicationClass=PyLithApp)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg  
shell.run(**kwds)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg  
app.applyConfiguration(context)
```

```
File "/Volumes/Tools/unix/cig/gcc-4.7.3/lib/python2.7/site-packages/pythia-0.8.1.15-py2.7.egg  
    raise ValueError("%s\nBacktrace - Component %s" % (err.message, aliases))
```

Error message

ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):

Error while configuring boundary condition (dirichletbc , x_pos):

Label for group/nodeset/pset in mesh not specified.

Component hierarchy

Backtrace - Component dirichletbc , x_pos

Backtrace - Component bc

Backtrace - Component timedependent , problem

Backtrace - Component pylithapp

Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

Debug: Examine parameters for `pylithapp.problem.bc.x_pos`

Step01: Error 1 Resolution

Error found while doing very basic validation of parameters

Error message

```
ValueError: Error while configuring Dirichlet boundary condition (dirichletbc , x_pos):  
Error while configuring boundary condition (dirichletbc , x_pos):  
Label for group/nodeset/pset in mesh not specified.
```

Component hierarchy

```
Backtrace – Component dirichletbc , x_pos  
Backtrace – Component bc  
Backtrace – Component timedependent , problem  
Backtrace – Component pylithapp
```

Debug: Examine parameters for `pylithapp.problem.bc.x_pos` Resolution

```
[pylithapp.timedependent.bc.x_pos]
```

Step01: Error 2

Error found in parsing .cfg file

```
$ pylith step01.cfg
```

.cfg file with line number

```
>> step01.cfg:100:
```

Error message

```
— pyre.inventory (error)
— pylithapp.timedependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'
— unknown component
'pylithapp.timedependent.implicit.output.outputsoln.write'
```

Usage information

```
usage: pylith [--<property><value>] [--<facility ><property><value>] [FILE.cfg] ...
component 'pylithapp'
  properties: help, help-components, help-persistence, help-properties, initialize-only, job,
  facilities: job, launcher, mesh_generator, perf_logger, petsc, problem, scheduler, weaver
```

For more information:

```
—help-properties: prints details about user settable properties
—help-components: prints details about user settable facilities and components
pylithapp: configuration error(s)
```

Step01: Error 2 Resolution

Error found in parsing .cfg file

Error message

```
— pyre.inventory(error)
— pylithapp.time-dependent.implicit.output.outputsoln.write.filename ← 'output/step01.vtk'
— unknown component
'pylithapp.time-dependent.implicit.output.outputsoln.write'
```

Step01: Error 2 Resolution

Error found in parsing .cfg file

Error message

```
— pyre.inventory(error)
— pylithapp.timedependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'
— unknown component
'pylithapp.timedependent.implicit.output.outputsoln.write'
```

Debug: Look up the properties of the OutputSoln object

Step01: Error 2 Resolution

Error found in parsing .cfg file

Error message

```
— pyre.inventory (error)
— pylithapp.time-dependent.implicit.output.outputsoln.write.filename <- 'output/step01.vtk'
— unknown component
'pylithapp.time-dependent.implicit.output.outputsoln.write'
```

Debug: Look up the properties of the OutputSoln object

Resolution

```
[pylithapp.problem.formulation.output.domain]
writer.filename = output/step01.vtk
```

Step01: Error 3

Error found when initializing integrators

```
$ pylith step01.cfg
```

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what():  Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

Debug: Look at `mat_elastic.spatialdb` for errors in data

Step01: Error 3 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
I/O error while reading SimpleDB data.
```

Debug: Look at `mat_elastic.spatialdb` for errors in data

Resolution

```
num-locs = 1 // number of locations
```

Step01: Error 4

Error found when initializing integrators

```
$ pylith step01.cfg
```

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimensions
```

Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'
```

```
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.
```

```
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimens
```

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimens
```

Debug: Look at coordinate system in `mat_elastic.spatialdb` header

Step01: Error 4 Resolution

Error found when initializing integrators

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Error occurred while reading spatial database file 'mat_elastic.spatialdb'.  
Number of dimensions in coordinates of spatial distribution (2) does not match number of dimens
```

Debug: Look at coordinate system in `mat_elastic.spatialdb` header
Resolution

```
space-dim = 3
```

Step01: Error 5

Error found when setting up solution field

```
$ pylith step01.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  constraint.setConstraintSizes(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/bc/bc.py",
  def setConstraintSizes(self, *args): return _bc.DirichletBC.setConstraintSizes(self, *args)
```

Error message

```
RuntimeError: Found overly constrained point while setting up constraints for
DirichletBC boundary condition 'face_zneg'. Number of DOF at point 503 is 3
and number of attempted constraints is 4.
```

Abort information

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

Step01: Error 5 Resolution

Error found when setting up solution field

Error message

```
RuntimeError: Found overly constrained point while setting up constraints for  
DirichletBC boundary condition 'face-zneg'. Number of DOF at point 503 is 3  
and number of attempted constraints is 4.
```

Step01: Error 5 Resolution

Error found when setting up solution field

Error message

```
RuntimeError: Found overly constrained point while setting up constraints for  
DirichletBC boundary condition 'face-zneg'. Number of DOF at point 503 is 3  
and number of attempted constraints is 4.
```

Debug: Look at overlap of constraints in Dirichlet BC

Step01: Error 5 Resolution

Error found when setting up solution field

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face.zneg'. Number of DOF at point 503 is 3 and number of attempted constraints is 4.

Debug: Look at overlap of constraints in Dirichlet BC Resolution

```
[pylithapp.timedependent.bc.y_pos]
bc_dof = [0]
...
[pylithapp.timedependent.bc.y_neg]
bc_dof = [0]
```

Step02: Error 1

Error found in parsing .cfg file

```
$ pylith step02.cfg
```

Configuration error

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

Step02: Error 1 Resolution

Error found in parsing .cfg file

Error message

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

Step02: Error 1 Resolution

Error found in parsing .cfg file

Error message

```
>> step02.cfg:30:  
— pyre.inventory (error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

Debug: Pyre is poorly documented. Look for example. :(

Step02: Error 1 Resolution

Error found in parsing .cfg file

Error message

```
>>> step02.cfg:30:  
— pyre.inventory(error)  
— timedependent.nondimelasticquasistatic.relaxation_time ← '2.0*years'  
— name 'years' is not defined  
pylithapp: configuration error(s)
```

Debug: Pyre is poorly documented. Look for example. :(

```
$ python
```

```
>>> from pyre.units.time import *  
>>> dir()  
['__builtins__', '__doc__', '__name__', '__package__', 'day', 'hour', 'micro', 'microsecond',  
'milli', 'millisecond', 'minute', 'ms', 'nano', 'nanosecond', 'ns', 'pico',  
'picosecond', 'ps', 's', 'second', 'us', 'year']
```

Resolution

```
relaxation_time = 2.0*year
```

Step02: Error 2

Error doing some basic validation of input

```
$ pylith step02.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.verifyConfiguration()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  ModuleFaultCohesiveKin.verifyConfiguration(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def verifyConfiguration(self, *args): return
_faults.FaultCohesiveLagrange.verifyConfiguration(self, *args)
```

Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

Abort info

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

Step02: Error 2 Resolution

Error doing some basic validation of input

Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible  
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

Step02: Error 2 Resolution

Error doing some basic validation of input

Error message

RuntimeError: Number of dofs in reference cell (3) is not compatible with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.

Debug: Turn on journal for quadrature

```
$ pylith step02.cfg --problem.interfaces.fault.quadrature.help-components
```

facilities of 'quadrature':

```
cell=<component name>: Reference cell with basis fns and quadrature rules.  
  current value: 'fiatsimplex', from {default}  
  configurable as: fiatsimplex, cell
```


Step02: Error 2 Resolution

Error doing some basic validation of input

Error message

```
RuntimeError: Number of dofs in reference cell (3) is not compatible  
with number of edges (4) in cohesive cell 256 for fault 'fault_ext'.
```

Debug: Turn on journal for quadrature

```
$ pylith step02.cfg --problem.interfaces.fault.quadrature.help-components
```

```
facilities of 'quadrature':  
  cell=<component name>: Reference cell with basis fns and quadrature rules.  
    current value: 'fiatsimplex', from {default}  
    configurable as: fiatsimplex, cell
```

```
[pylithapp.journal.info]  
fiatlagrange = 1  
fiatsimplex = 1
```

Resolution

```
[pylithapp.timedependent.interfaces.fault]  
quadrature.cell = pylith.feassemble.FIATLagrange
```

Step02: Error 3

Error found when initializing integrators

```
$ pylith step02.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/feassemble/
  ModuleElasticityImplicit.initialize(self, self.mesh())
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/feassemble/
  def initialize(self, *args): return _feassemble.IntegratorElasticity_initialize(self, *args)
```

Error message

RuntimeError: Determinant of Jacobian (1.25e-07) for cell 0 is smaller than minimum permissible value (1e-06)! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

Abort info

Step02: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Determinant of Jacobian ($1.25e-07$) for cell 0 is smaller than minimum permissible value ($1e-06$)! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

Step02: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Determinant of Jacobian ($1.25e-07$) for cell 0 is smaller than minimum permissible value ($1e-06$)! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

Debug: Look at nondimensional scales relative to the parameters

```
$ pylith step02.cfg --problem.normalizer.help-properties
```

```
properties of 'nondimelasticquasistatic':
```

```
  length_scale=<dimensional>: Value to nondimensionalize length scale.
```

```
    default value: 1000*m
```

```
    current value: 1e+06*m, from {file='step02.cfg', line=28, column=-1}
```

```
    validator: (greater than 0*m)
```

```
  relaxation_time=<dimensional>: Relaxation time to nondimensionalize time.
```

```
    default value: 3.15576e+07*s
```

```
    current value: 6.31152e+07*s, from {file='step02.cfg', line=30, column=-1}
```

```
    validator: (greater than 0*s)
```

```
  shear_modulus=<dimensional>: Shear modulus to nondimensionalize pressure.
```

```
    default value: 3e+10*m**-1*kg*s**-2
```

```
    current value: 3e+10*m**-1*kg*s**-2, from {file='step02.cfg', line=29, column=-1}
```

```
    validator: (greater than 0*m**-1*kg*s**-2)
```

Step02: Error 3 Resolution

Error found when initializing integrators

Error message

RuntimeError: Determinant of Jacobian ($1.25e-07$) for cell 0 is smaller than minimum permissible value ($1e-06$)! The two most likely causes of this are highly distorted cells and nondimensionalization with a length scale that is much larger than the dimensions of the cells.

Debug: Look at nondimensional scales relative to the parameters

```
$ pylith step02.cfg --problem.normalizer.help-properties
```

```
properties of 'nondimelasticquasistatic':
```

```
  length_scale=<dimensional>: Value to nondimensionalize length scale.
```

```
    default value: 1000*m
```

```
    current value: 1e+06*m, from {file='step02.cfg', line=28, column=-1}
```

```
    validator: (greater than 0*m)
```

```
  relaxation_time=<dimensional>: Relaxation time to nondimensionalize time.
```

```
    default value: 3.15576e+07*s
```

```
    current value: 6.31152e+07*s, from {file='step02.cfg', line=30, column=-1}
```

```
    validator: (greater than 0*s)
```

```
  shear_modulus=<dimensional>: Shear modulus to nondimensionalize pressure.
```

```
    default value: 3e+10*m**-1*kg*s**-2
```

```
    current value: 3e+10*m**-1*kg*s**-2, from {file='step02.cfg', line=29, column=-1}
```

```
    validator: (greater than 0*m**-1*kg*s**-2)
```

Resolution

```
[pylithapp.problem.normalizer]
```

```
length_scale = 1.0*m
```

Step02: Error 4

Error found when initializing fault

```
$ pylith step02.cfg
```

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

Abort message

```
[0]0:Return code = 0, signaled with Abort trap: 6
```

Step02: Error 4 Resolution

Error found when initializing fault

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

Step02: Error 4 Resolution

Error found when initializing fault

Error message

```
terminate called after throwing an instance of 'std::runtime_error'  
  what(): Could not find value left-lateral-slip in spatial database  
Final slip. Available values are:  
  lateral-slip  
  reverse-slip  
  fault-opening
```

Resolution

```
slip.values = [left-lateral-slip , reverse-slip , fault-opening]
```


Step02: Error 5

Error found when setting up solution field

```
$ pylith step02.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscC...
  self.main(*args, **kwds)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLith...
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir...
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im...
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo...
  integrator.checkConstraints(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault...
  def checkConstraints(self, *args): return _faults.FaultCohesiveLagrange.checkConstraints(se
```

Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Abort info

```
application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith: /Volumes/Tools/unix/cig/gcc-4.7.3/bin/neme
```

Step02: Error 5 Resolution

Error found when setting up solution field

Error message

`RuntimeError: Vertex with label '396' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.`

Step02: Error 5 Resolution

Error found when setting up solution field

Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Debug: Oops. Didn't mean to use through-going fault!

Step02: Error 5 Resolution

Error found when setting up solution field

Error message

RuntimeError: Vertex with label '396' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Debug: Oops. Didn't mean to use through-going fault!

Resolution

```
[pylithapp.timedependent.interfaces.fault]  
label = fault
```

Step02: Error 6

Error when initializing fault

```
$ pylith step02.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.initialize(totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  FaultCohesive.initialize(self, totalTime, numTimeSteps, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  ModuleFault.initialize(self, self.mesh(), self.upDir)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def initialize(self, *args): return _faults.Fault.initialize(self, *args)
```

Error message

RuntimeError: Error computing orientation of cell face.

Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).

If the face is horizontal, adjust the up_dir parameter.

Abort info

Step02: Error 6 Resolution

Error found when initializing fault

Error message

RuntimeError: Error computing orientation of cell face.
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).
If the face is horizontal, adjust the up_dir parameter.

Step02: Error 6 Resolution

Error found when initializing fault

Error message

RuntimeError: Error computing orientation of cell face.
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).
If the face is horizontal, adjust the up_dir parameter.

Debug: Change up-dir

```
up_dir = [1,0,1]
```

Step02: Error 6 Resolution

Error found when initializing fault

Error message

RuntimeError: Error computing orientation of cell face.
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).
If the face is horizontal, adjust the up_dir parameter.

Debug: Change up-dir

```
up_dir = [1,0,1]
```

Debug: Look at fault surface

Step02: Error 6 Resolution

Error found when initializing fault

Error message

RuntimeError: Error computing orientation of cell face.
Up direction (0, 0, 1) cannot be parallel to the face normal (0, 0, 1).
If the face is horizontal, adjust the up_dir parameter.

Debug: Change up-dir

```
up_dir = [1,0,1]
```

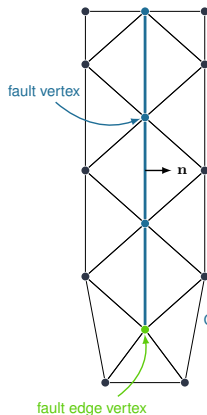
Debug: Look at fault surface

Resolution: Mark buried edges

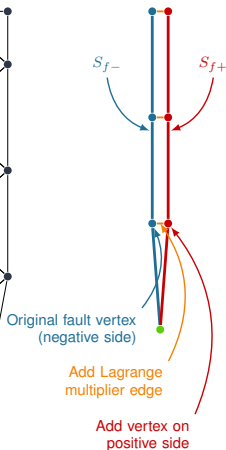
```
[pylithapp.timedependent.interfaces.fault]  
label = fault  
edge = fault_edge  
up_dir = [0,0,1]
```

Insertion of Cohesive Cells

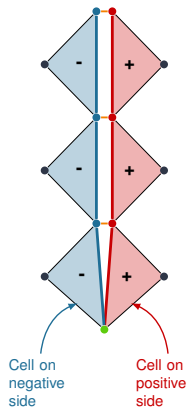
(a) Original mesh



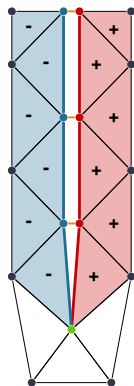
(b) Add collocated vertices



(c) Update cells with fault faces



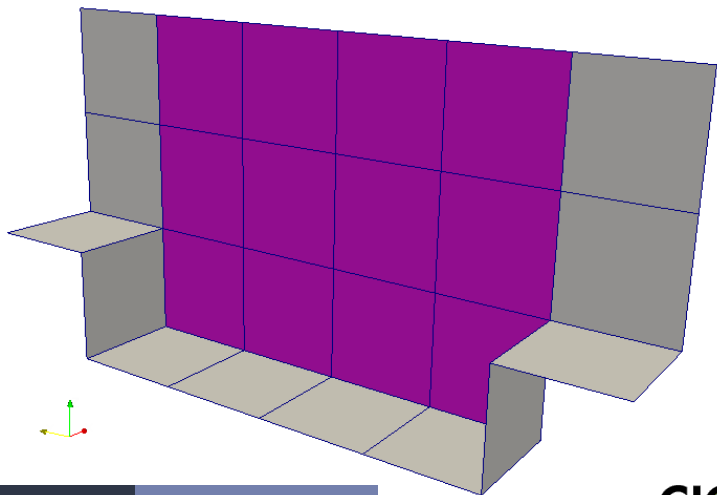
(d) Classify cells and update remaining cells



Forgetting to Mark Buried Edges

PyLith will extend the fault one cell in an arbitrary fashion

Purple region shows intended fault surface.



Step03: Error 1

Error doing basic validation on parameters

```
$ pylith step02.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwds)
```

```
...
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  FaultCohesive.verifyConfiguration(self)
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/Fault
  self.output.verifyConfiguration(self.mesh())
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/meshio/Output
  self._verifyFields(self.dataProvider().availableFields)
```

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/meshio/Output
  raise ValueError(msg)
```

Error message

ValueError: Requested fields not available for output.

Data provider: 'faultcohesivedyn'

Field type: 'vertex'

Data type: 'data'

Available fields: 'slip' 'slip_rate' 'traction'

Fields not available: 'initial_traction'

Abort info

application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0

: mpirun: exit 255

Step03: Error 1 Resolution

Error doing basic validation on parameters

Error message

```
ValueError: Requested fields not available for output.  
Data provider: 'faultcohesivedyn'  
Field type: 'vertex'  
Data type: 'data'  
Available fields: 'slip' 'slip_rate' 'traction'  
Fields not available: 'initial_traction'
```

Step03: Error 1 Resolution

Error doing basic validation on parameters

Error message

```
ValueError: Requested fields not available for output.  
Data provider: 'faultcohesivedyn'  
Field type: 'vertex'  
Data type: 'data'  
Available fields: 'slip' 'slip_rate' 'traction'  
Fields not available: 'initial_traction'
```

Resolution

```
vertex_data_fields = [slip, slip_rate, traction]
```

Step03: Error 2

Error creating solution field

```
$ pylith step03.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwargs)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  constraint.setConstraintSizes(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/bc/bc.py",
  def setConstraintSizes(self, *args): return _bc.DirichletBC.setConstraintSizes(self, *args)
```

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

Abort info

```
application called MPI_Abort(MPI_COMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith:
: exit 1
```

Step03: Error 2 Resolution

Error creating solution field

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

Step03: Error 2 Resolution

Error creating solution field

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

Debug: Look for overlap of constraints in Dirichlet BC

Step03: Error 2 Resolution

Error creating solution field

Error message

RuntimeError: Found overly constrained point while setting up constraints for DirichletBC boundary condition 'face_zneg'. Number of DOF at point 535 is 3 and number of attempted constraints is 4.

Debug: Look for overlap of constraints in Dirichlet BC Resolution

```
[pylithapp.timedependent.bc.x_pos]  
bc_dof = [0, 1]  
...  
[pylithapp.timedependent.bc.x_neg]  
bc_dof = [0, 1]
```

Step03: Error 3

Error creating solution field

```
$ pylith step03.cfg
```

Python stacktrace

Fatal error. Calling MPI_Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA
  self.main(*args, **kwds)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA
  self.problem.initialize()
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir
  self.formulation.initialize(self.dimension, self.normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im
  self._initialize(dimension, normalizer)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Fo
  integrator.checkConstraints(solution)
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/faults/fault
  def checkConstraints(self, *args): return _faults.FaultCohesiveLagrange.checkConstraints(se
```

Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Abort info

```
application called MPI_Abort(MPLCOMM_WORLD, -1) - process 0
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: mpirun: exit 255
/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/bin/pylith :
/Volumes/Tools/unix/cig/gcc-4.7.3/bin/nemesis: exit 1
```

Step03: Error 3 Resolution

Error creating solution field

Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Step03: Error 3 Resolution

Error creating solution field

Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Debug: Look for overlap in fault and BC nodesets

Step03: Error 3 Resolution

Error creating solution field

Error message

RuntimeError: Vertex with label '605' on negative side of fault 'fault_ext' is constrained.
Fault vertices cannot be constrained.

Debug: Look for overlap in fault and BC nodesets Resolution

```
[pylithapp.timedependent.bc.z.neg]  
...  
label = face_zneg_nofault
```

Step03: Error 4

No error but funky results

Step03: Error 4 Resolution

No error but funky results

Debug: Did the solver converge?

Step03: Error 4 Resolution

No error but funky results

Debug: Did the solver converge?

Resolution

```
[pylithapp.petsc]  
ksp_monitor = true  
ksp_converged_reason = true  
ksp_error_if_not_converged = true
```

```
snes_converged_reason = true  
snes_error_if_not_converged = true  
snes_monitor = true
```

Step03: Error 5

Nonlinear solver diverges

PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/librs
```

Debugging

Examine KSP and SNES residuals

Fatal error. Calling MPI.Abort() to abort PyLith application.

Traceback (most recent call last):

```
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PetscA  
self.main(*args, **kwds)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/apps/PyLithA  
self.problem.run(self)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Tir  
self.formulation.step(t, dt)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/Im  
self.solver.solve(displncr, self.jacobian, residual)  
File "/Volumes/Tools/unix/pylith-dev/gcc-4.7.3/lib/python2.7/site-packages/pylith/problems/pr  
def solve(self, *args): return _problems.SolverNonlinear.solve(self, *args)
```

Abort info

RuntimeError: Error detected while in PETSc function.

```
... -1) - process 0  
: mpirun: exit 255
```

Step03: Error 5 Resolution

Nonlinear solver diverges

PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

Step03: Error 5 Resolution

Nonlinear solver diverges

PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____
[0]PETSC ERROR: SNESolve has not converged
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0
...
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

Debug: Examine KSP and SNES residuals using log file

```
$ pylith step03.cfg >& step03.log
```

```
$ grep " norm" step03.log
```

Step03: Error 5 Resolution

Nonlinear solver diverges

PETSc error message

```
[0]PETSC ERROR: _____ Error Message _____  
[0]PETSC ERROR: SNESolve has not converged  
[0]PETSC ERROR: See http://www.mcs.anl.gov/petsc/documentation/faq.html for trouble shooting.  
[0]PETSC ERROR: Petsc Development GIT revision: v3.4.4-4559-g852d360 GIT Date: 2014-05-19 15:0  
...  
[0]PETSC ERROR: #1 SNESolve() line 3765 in /Volumes/Tools/unix/petsc-dev/src/snes/interface/sn  
[0]PETSC ERROR: #2 SNESLogConvergenceHistory() line 150 in /Users/baagaard/src/cig/pylith/libsrc
```

Debug: Examine KSP and SNES residuals using log file

```
$ pylith step03.cfg >& step03.log
```

```
$ grep " norm" step03.log
```

Resoluton

```
[pylithapp.timedependent.interfaces.fault]  
zero_tolerance = 1.0e-10
```

```
[pylithapp.petsc]  
ksp_rtol = 1.0e-20  
ksp_atol = 1.0e-12
```

```
snes_rtol = 1.0e-20  
snes_atol = 1.0e-8
```

Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Compare T_{shear} / T_{normal} against μ_f

Step03: Error 6

Intended shear to drive fault slip

Debug: Check fault tractions

Compare T_{shear} / T_{normal} against μ_f

Resolution

```
[pylithapp.timedependent.bc.x_pos]
...
db_initial.data = [-1.0*m, 3.0*m, 0.0*m]

[pylithapp.timedependent.bc.x_neg]
...
db_initial.data = [1.0*m, -3.0*m, 0.0*m]
```


Asking For Help

Send email to cig-short@geodynamics.org

- Try to debug on your own first
- Describe what you are trying to do
 - Overview of problem, BC (**diagrams/sketches are very helpful**)
 - 2-D or 3-D
 - Cell type (tri, quad, hex, tet)
 - Prescribed slip or spontaneous rupture
- Specify which version you are using AND your operating system (**PyLith v2.1.2 binary on Linux x86_64**)
- Send the **entire** error message, not just what you think is important (**entire log of output is best**)