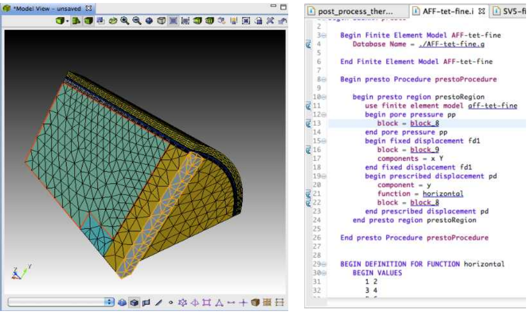
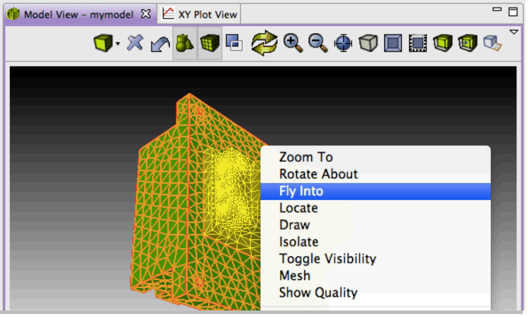
SAND2012-9091C



```
Begin Finite Element Model AFF-tet-fine
   Database Name = ./AFF-tet-fine.g

End Finite Element Model AFF-tet-fine

Begin presto Procedure prestoProcedure

   begin presto region prestoRegion
      use finite element model aff-tet-fine
      begin pore pressure pp
         block = block_8
      end pore pressure pp
      begin fixed displacement fd1
         block = block_9
         components = x Y
      end fixed displacement fd1
      begin prescribed displacement pd
         component = y
         function = horizontal
         block = block_8
      end prescribed displacement pd
   end presto region prestoRegion

End presto Procedure prestoProcedure


BEGIN DEFINITION FOR FUNCTION horizontal
   BEGIN VALUES
      1 2
      3 4
```



Sandia National Laboratories

Exceptional service in the national interest

The Sandia Analysis Workbench

Leveraging a COTS Framework To Provide Integrated Engineering Analysis Workflows On HPC Systems

Ernest J. Friedman-Hill
Edward L. Hoffman
Robert L. Clay

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

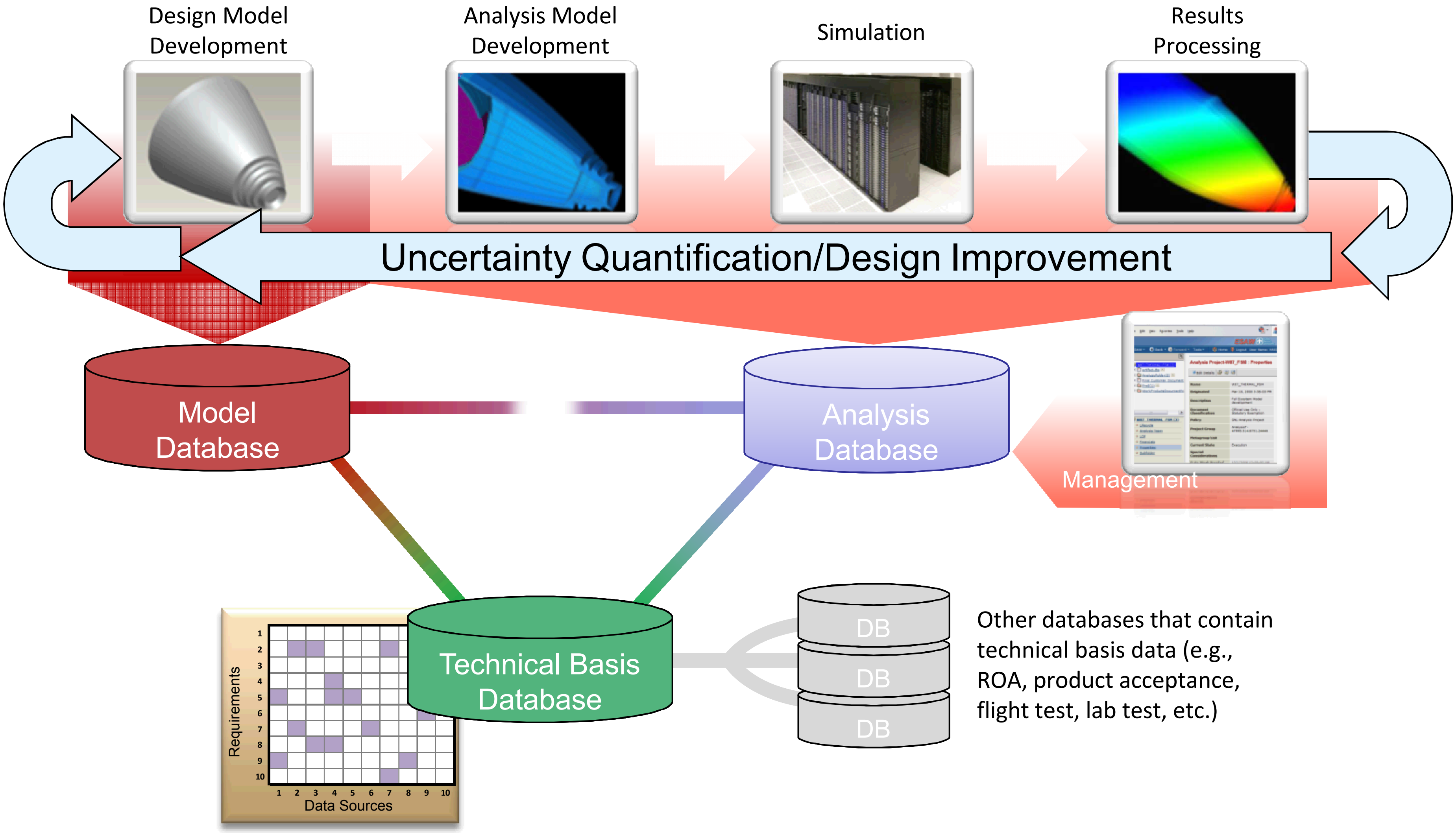
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2011-XXXXP

SAND #2012-9091 C

Outline

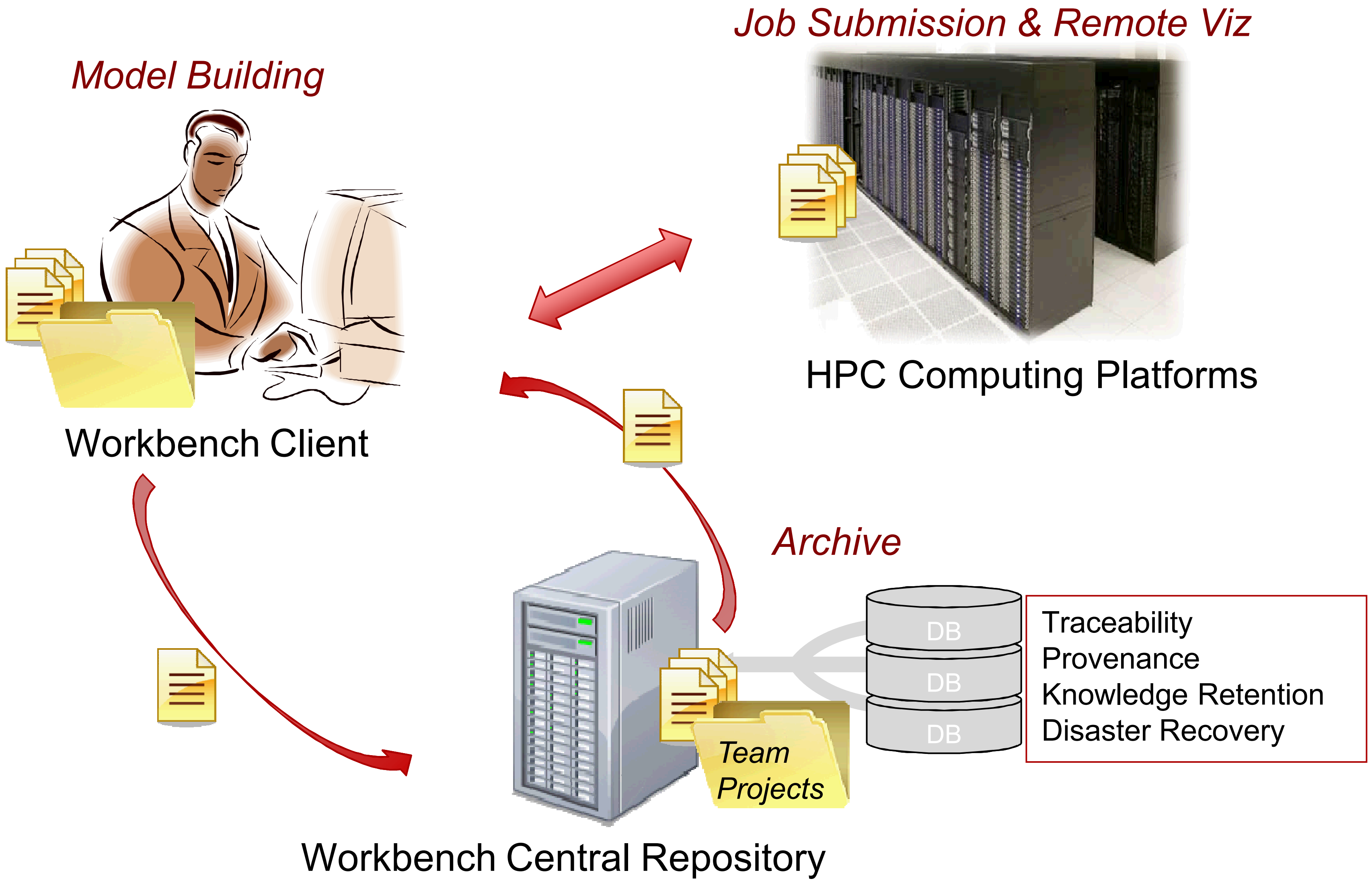
- Problem Space
- The Eclipse Framework
- Tool Case Studies

Support the Design-To-Analysis process, capturing data in context



Other databases that contain technical basis data (e.g., ROA, product acceptance, flight test, lab test, etc.)

Integrating Analysis Systems



Job Submission & Remote Viz

Model Building

HPC Computing Platforms

Workbench Client

Archive

Traceability
Provenance
Knowledge Retention
Disaster Recovery

Team Projects

Workbench Central Repository

Sandia Laboratories

- Scientists
- Engineers
- Developers

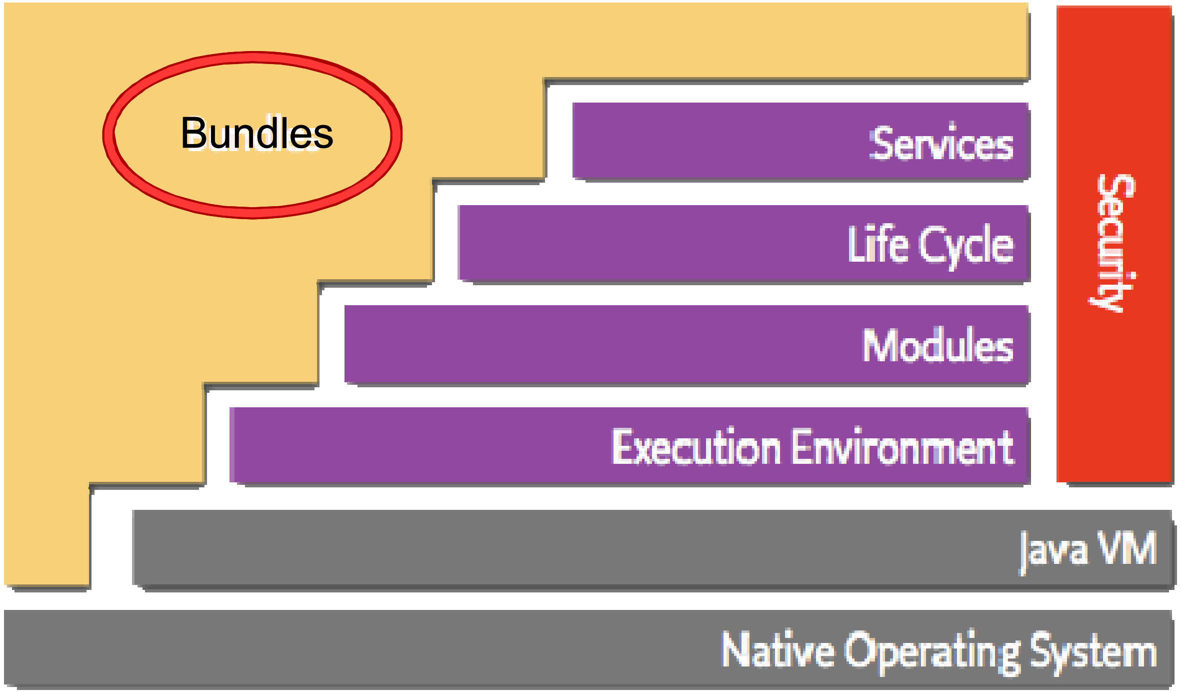
} All working together

- Wide variety of software in use
  - Commercial
  - In-house
- Corporate services available
- Change is a given

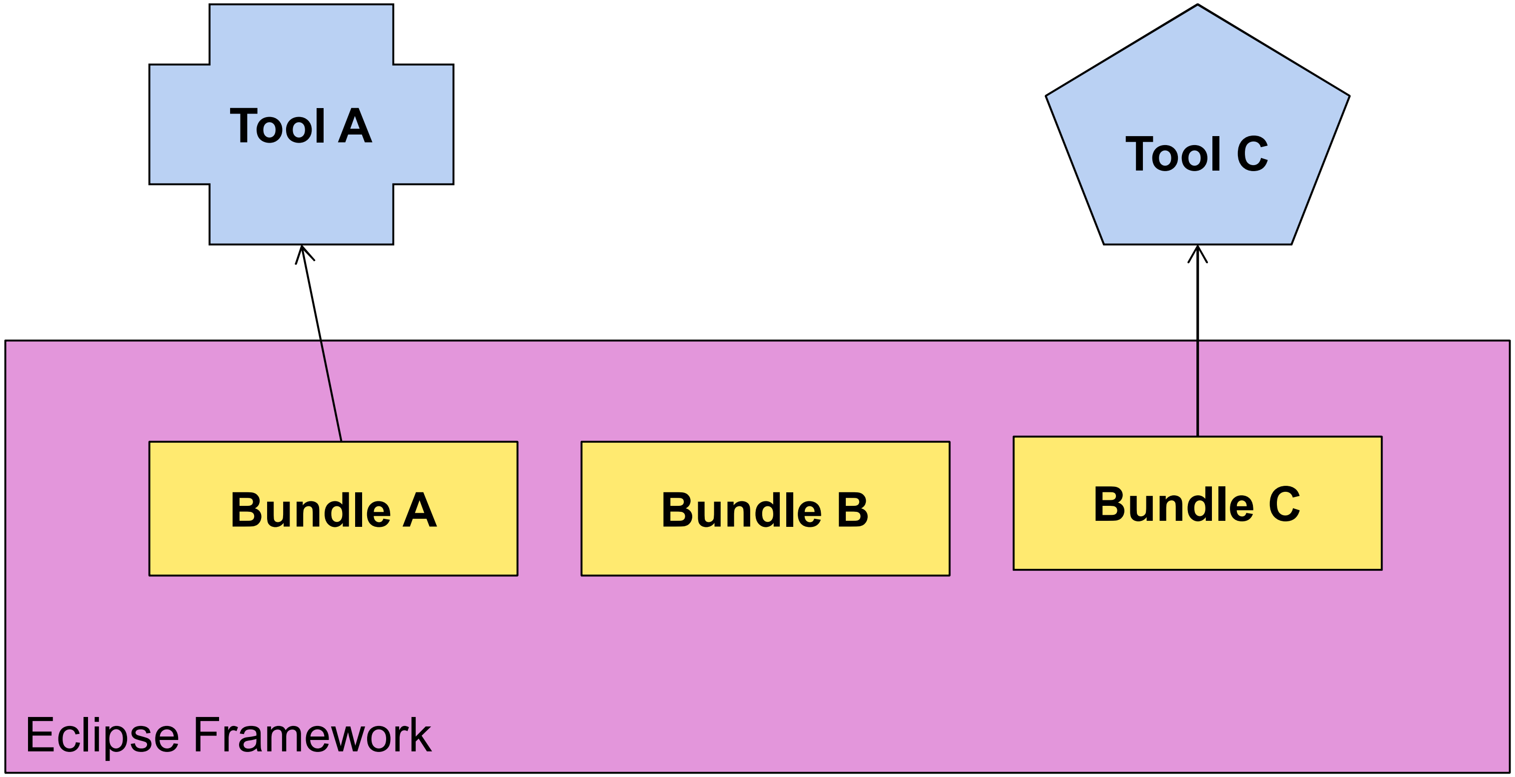
- How to make everything work together?

Eclipse

OSGi Architecture

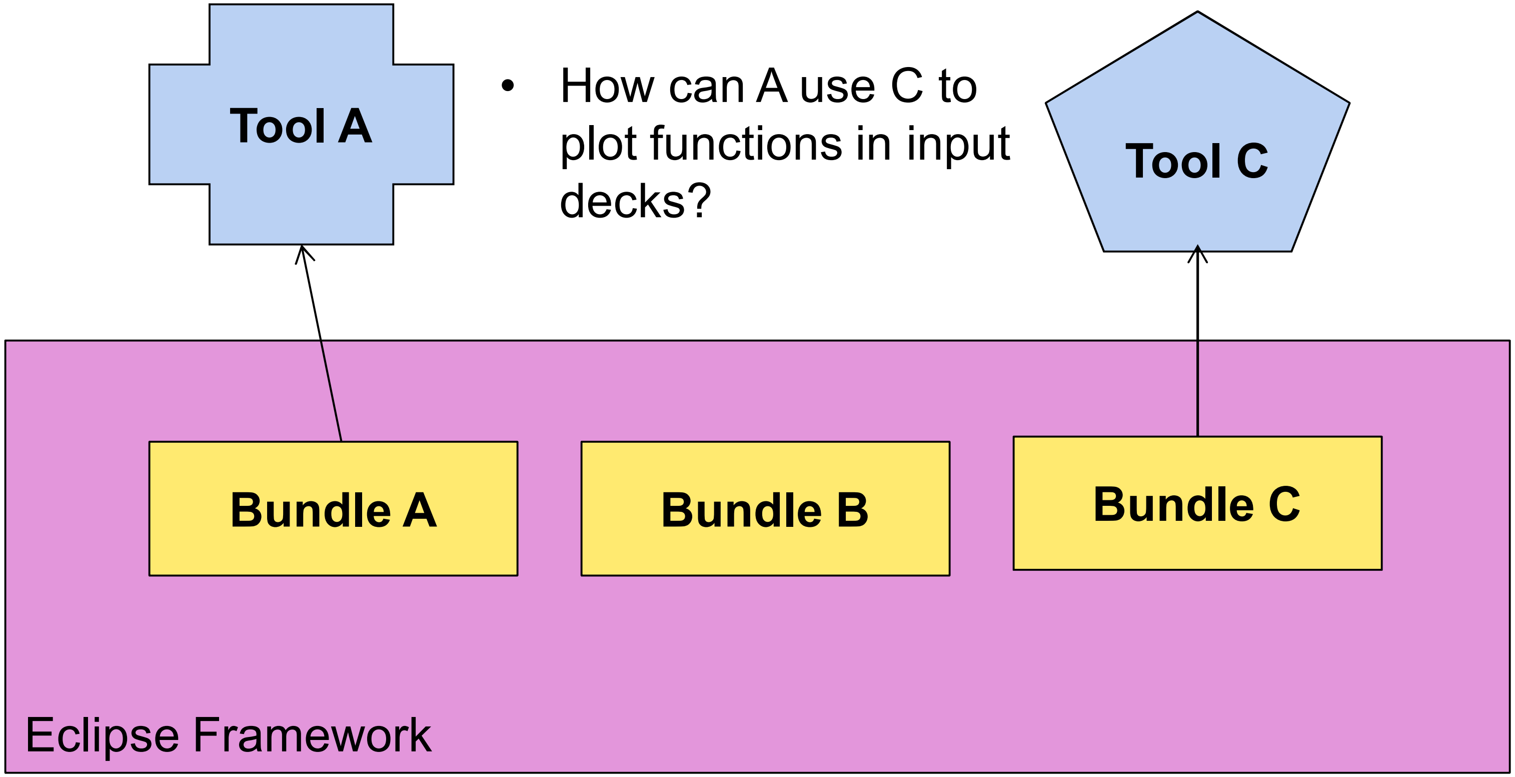


Bundles

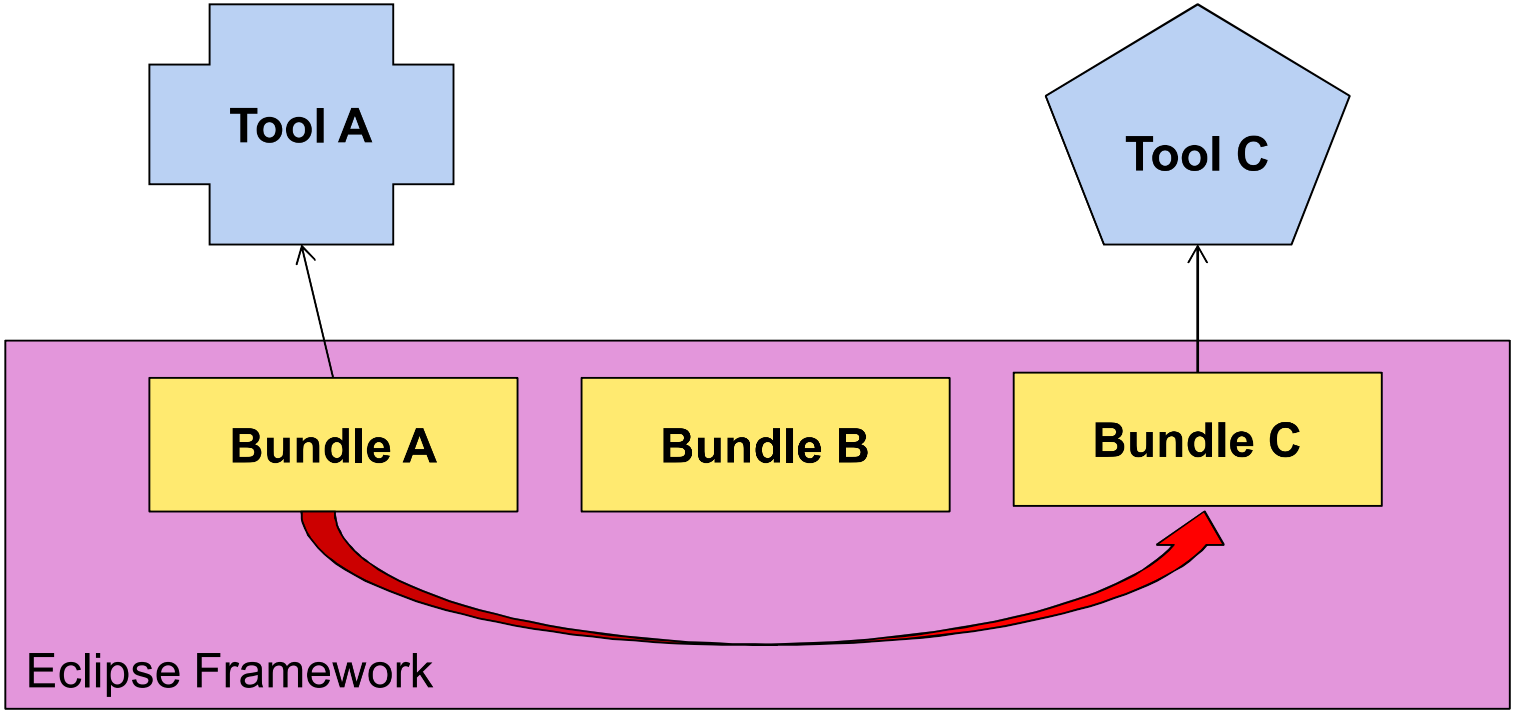


Tool Interactions

- A is an input deck editor
- C is a plotting package
- How can A use C to plot functions in input decks?



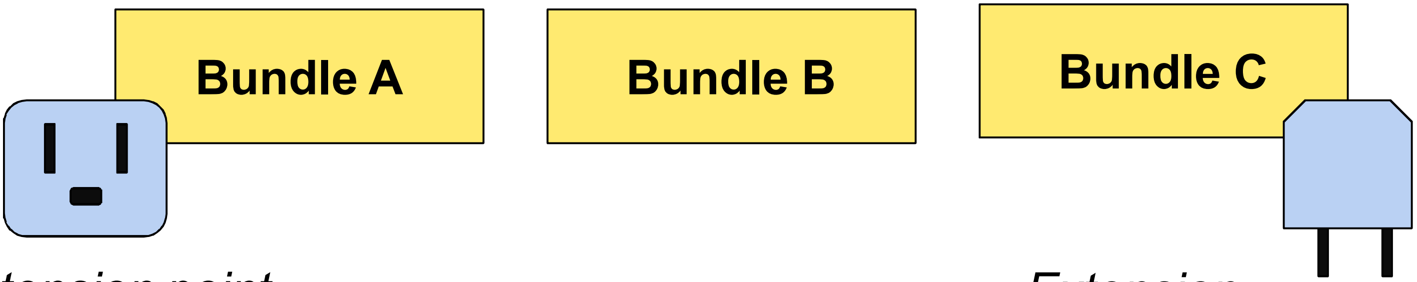
Direct Dependencies



- Hard-wired dependency
- No user choice

Extension Points

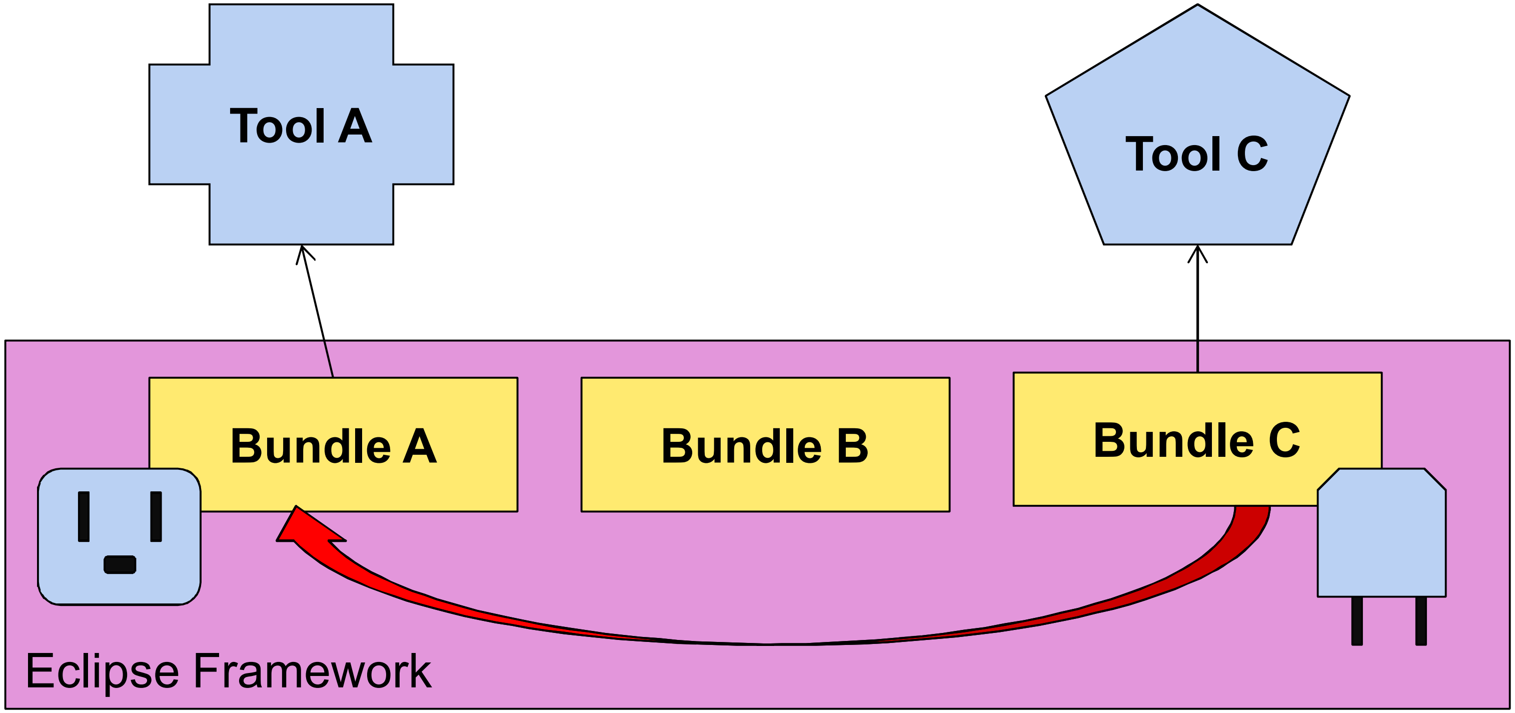
- “Inversion of Control”
- Framework gives A a list of extensions at runtime



Extension point (Interface plus property list)

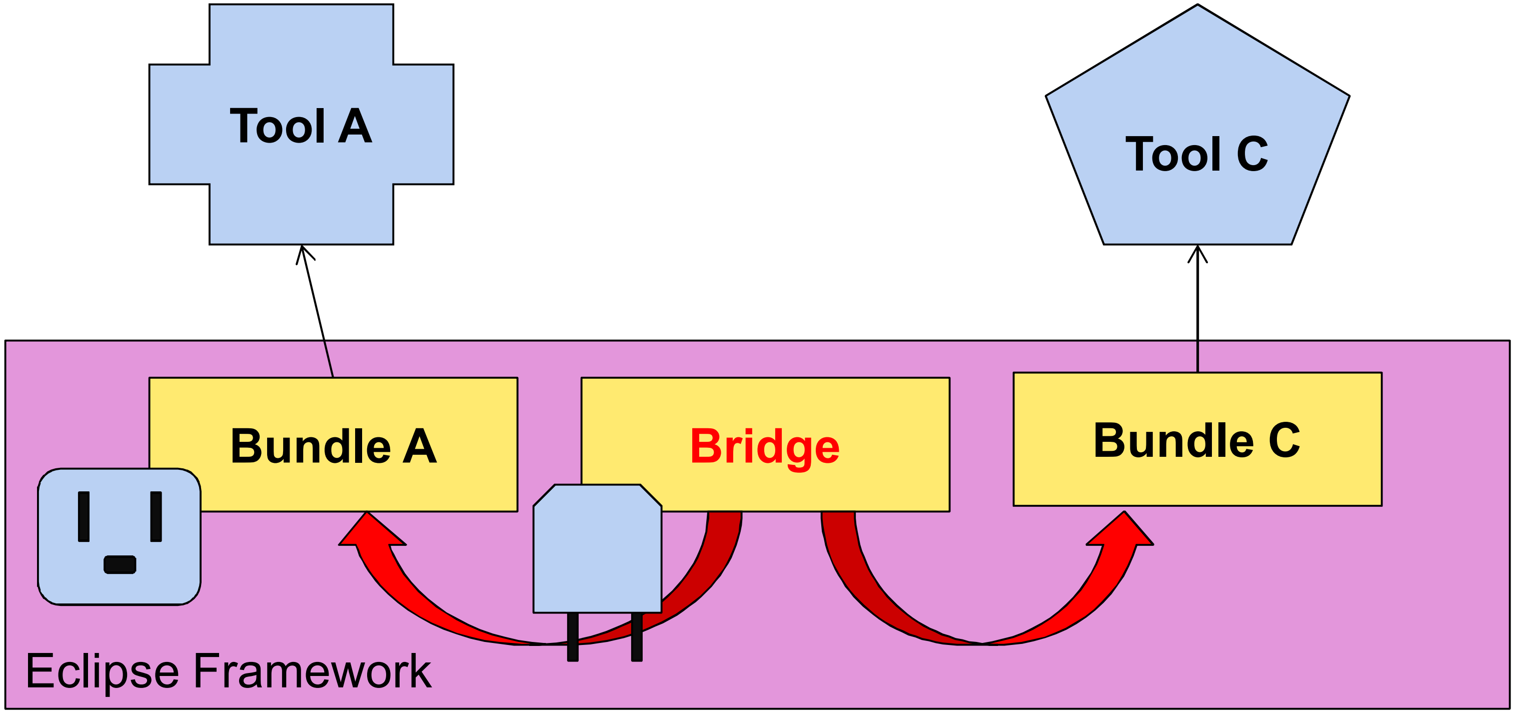
Extension (Implementation plus property values)

Extension Points



- Compile-time dependencies
- User choice enabled

Bridge Plugins



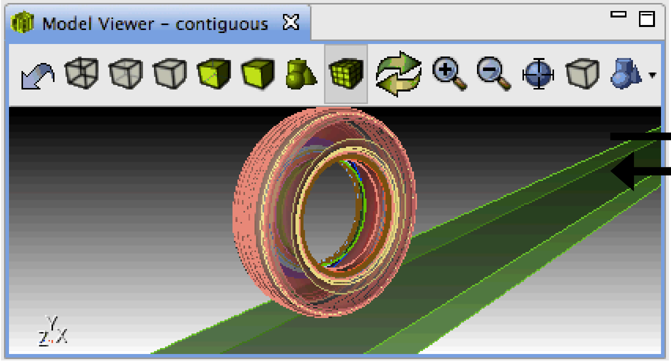
- Tools are independent
- User choice enabled

Object Adapters

- Adapt one object type to another
- IAdaptable interface
- AdapterManager
    - Any bundle can provide adapters
- No need to use common interfaces!

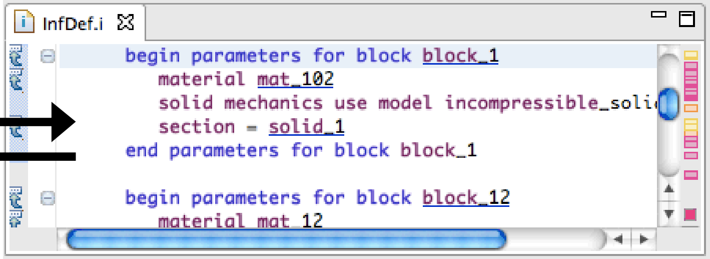
Eclipse platform selection service

Cubit VTK Viewer



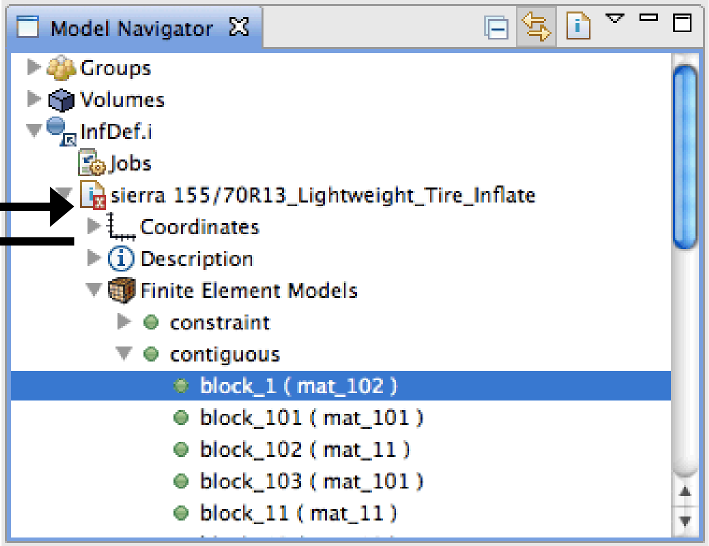
Eclipse Selection Service

Sierra Editor



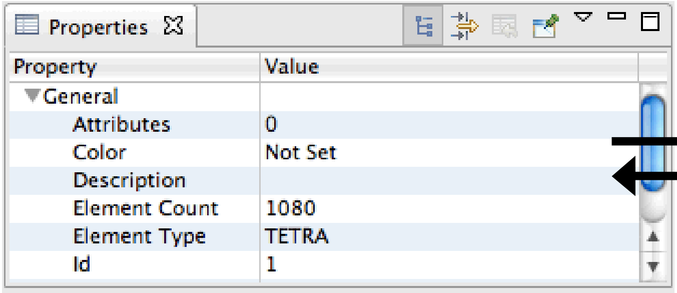
```
begin parameters for block block_1
   material mat_102
   solid mechanics use model incompressible_soli
   section = solid_1
end parameters for block block_1

begin parameters for block block_12
   material mat_12
```

Common Model Navigator



- Groups
- Volumes
- InfDef.i
  - Jobs
  - sierra 155/70R13_Lightweight_Tire_Inflate
    - Coordinates
    - Description
    - Finite Element Models
      - constraint
      - contiguous
        - block_1 (mat_102)
        - block_101 (mat_101)
        - block_102 (mat_11)
        - block_103 (mat_101)
        - block_11 (mat_11)

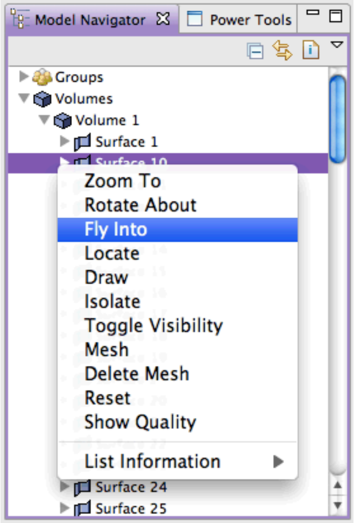
Properties View



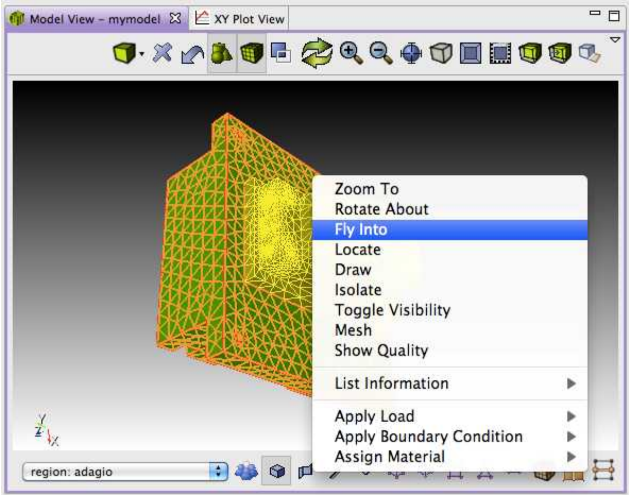
Property	Value
General	
Attributes	0
Color	Not Set
Description	
Element Count	1080
Element Type	TETRA
Id	1

Object Action Contributions

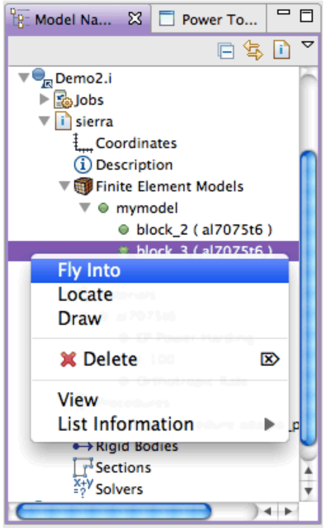
- Eclipse Command/Handler/Menu framework
- Action enablement based on selected object type
- Implemented once, available in many places



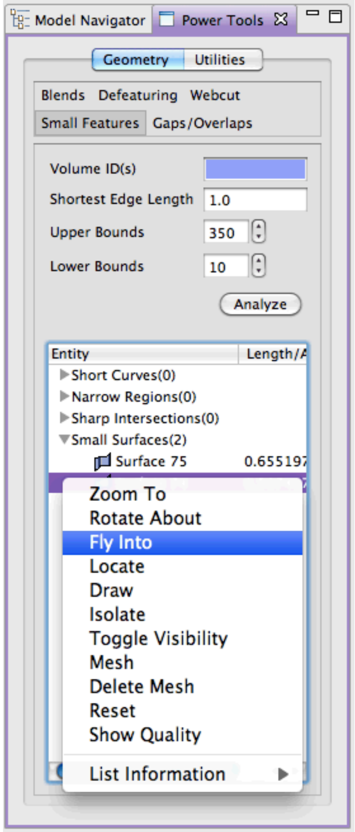
Model Tree



Model Viewer



Sierra Editor Tree (via Object Adapter)

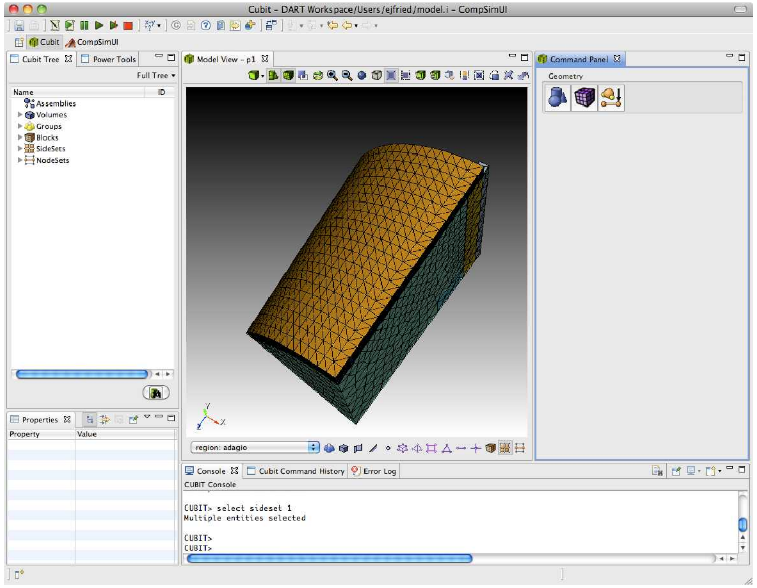


Volume ID(s)
Shortest Edge Length 1.0
Upper Bounds 350
Lower Bounds 10

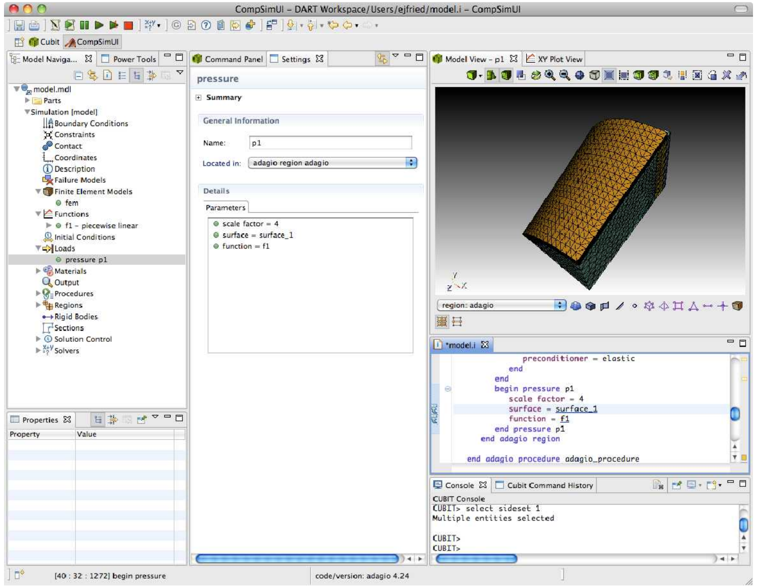
Cubit Model Tree

Eclipse “Perspectives”

- An arrangement of views, buttons, menus
- One button push separates these two screens



```
CUBIT> select sideset 1
Multiple entities selected

CUBIT>
CUBIT>
```



pressure

⊞ Summary

General Information

Name: p1

Located in: adagio region adagio

Details

Parameters

- scale factor = 4
- surface = surface_1
- function = f1

```
                preconditioner = elastic
              end
            end
            begin pressure p1
              scale factor = 4
              surface = surface_1
              function = f1
            end pressure p1
          end adagio region

        end adagio procedure adagio_procedure
```

```
CUBIT> select sideset 1
Multiple entities selected

CUBIT>
CUBIT>
```

[40 : 32 : 1272] begin pressure

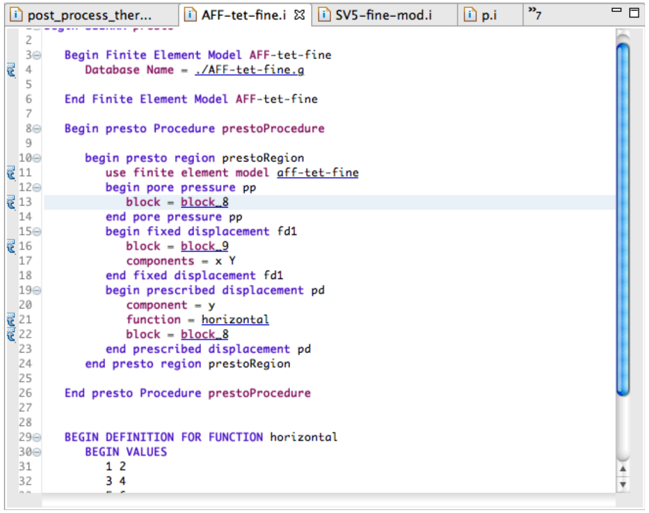
code/version: adagio 4.24

Sierra Analysis Codes

- Single framework
- Many different physics codes (Thermal, Structural)
- Used separately or coupled
- Available commands described in XML

Sierra Editor

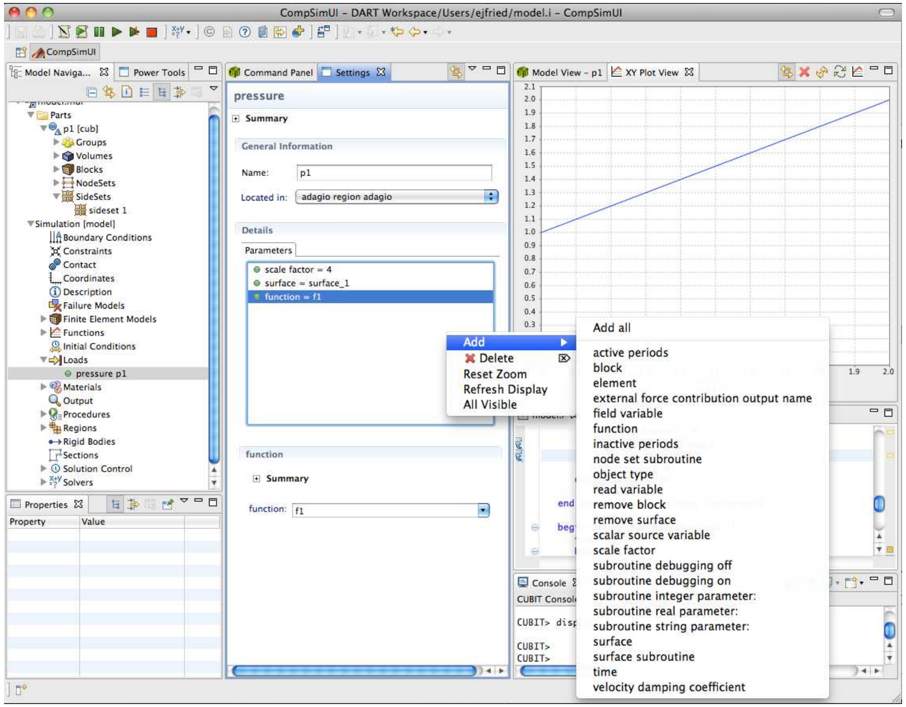
- Reads XML and provides
  - Syntax highlighting
  - Validation
  - Completion
  - Content assist
  - Hyperlinking
- Supporting other codes
  - Same XML format for commands
  - Syntax implemented with code module



```

  Begin Finite Element Model AFF-tet-fine
     Database Name = ./AFF-tet-fine.g

  End Finite Element Model AFF-tet-fine

  Begin presto Procedure prestoProcedure

     begin presto region prestoRegion
        use finite element model aff-tet-fine
        begin pore pressure pp
           block = block_8
        end pore pressure pp
        begin fixed displacement fd1
           block = block_9
           components = x Y
        end fixed displacement fd1
        begin prescribed displacement pd
           component = y
           function = horizontal
           block = block_8
        end prescribed displacement pd
     end presto region prestoRegion

  End presto Procedure prestoProcedure


  BEGIN DEFINITION FOR FUNCTION horizontal
     BEGIN VALUES
        1 2
        3 4
```

Sierra Builder

- Builds on editor to provide
  - Fully-graphical model building
  - Generated dialogs
  - Custom dialogs (via extension point)
  - Tree-based navigation



Name: p1

Located in: adagio region adagio

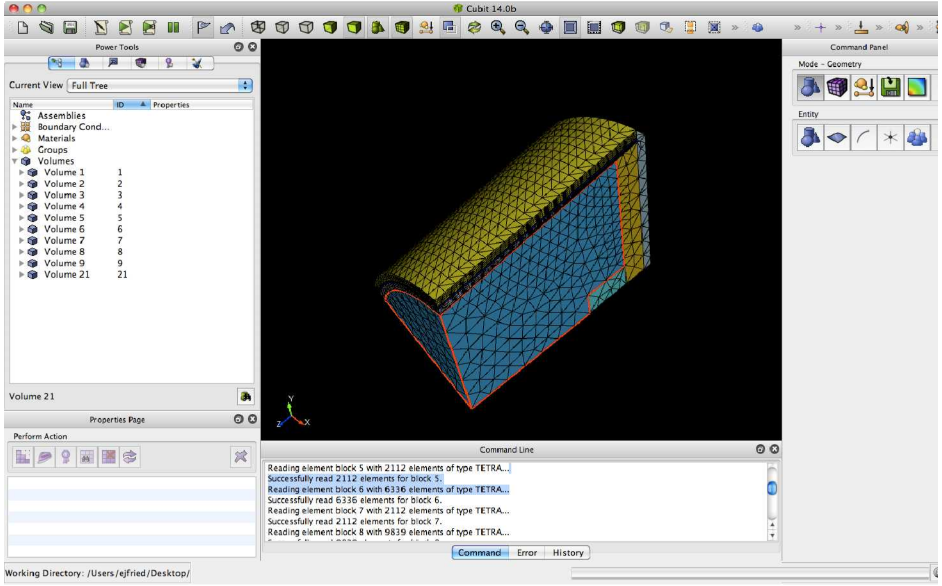
- scale factor = 4
- surface = surface_1
- function = f1

function: f1

```
CUBIT> disp

CUBIT>
CUBIT>
```

CUBIT Mesh Generator

- C++ library
- Interactive application
- Existing Qt GUI
  - Imperative command panels
  - Properties view
  - VTK-based viewer
  - Console
- Our approach: keep mesh viewer, recreate the rest of the GUI



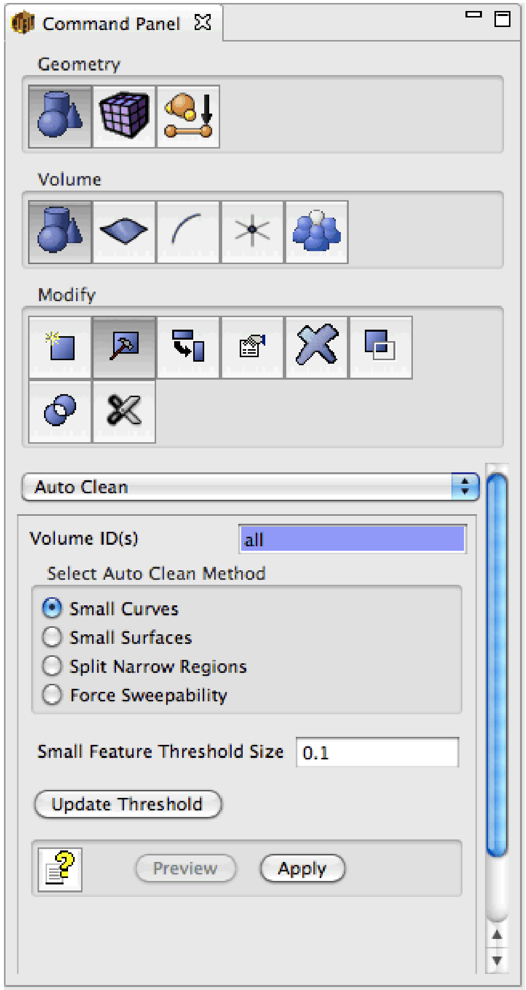
Name	ID	Properties
Assemblies		
Boundary Cond...		
Materials		
Groups		
Volumes		
Volume 1	1	
Volume 2	2	
Volume 3	3	
Volume 4	4	
Volume 5	5	
Volume 6	6	
Volume 7	7	
Volume 8	8	
Volume 9	9	
Volume 21	21	

```
Reading element block 5 with 2112 elements of type TETRA...
Successfully read 2112 elements for block 5.
Reading element block 6 with 6336 elements of type TETRA...
Successfully read 6336 elements for block 6.
Reading element block 7 with 2112 elements of type TETRA...
Successfully read 2112 elements for block 7.
Reading element block 8 with 9839 elements of type TETRA...
```

Working Directory: /Users/ejfried/Desktop/

CUBIT: Command Panel Builder

- Novel XML format
- Describe command, not GUI
  - "Hints" for GUI implementation
- Testing for panel generator



Auto Clean

Volume ID(s): all

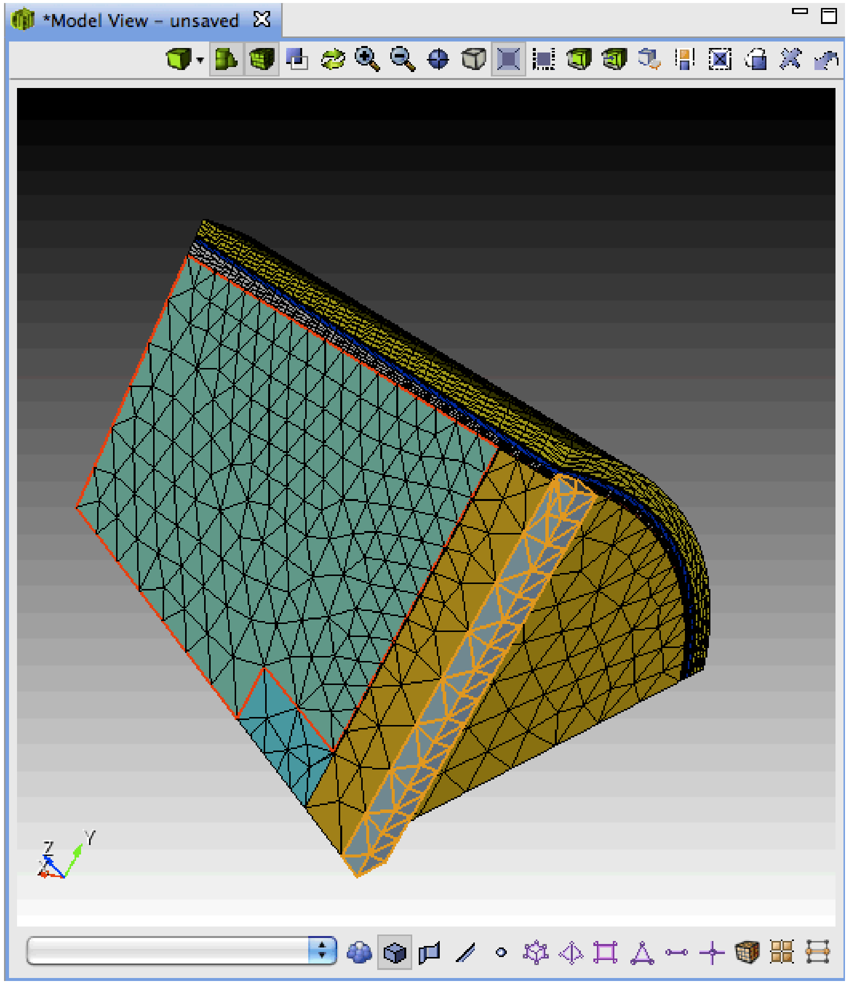
Select Auto Clean Method

● Small Curves
○ Small Surfaces
○ Split Narrow Regions
○ Force Sweepability

Small Feature Threshold Size: 0.1

CUBIT: Native Code Integration

- Generate glue code with SWIG
- Less than 500 lines of handwritten C++
- Platform-specific fragments



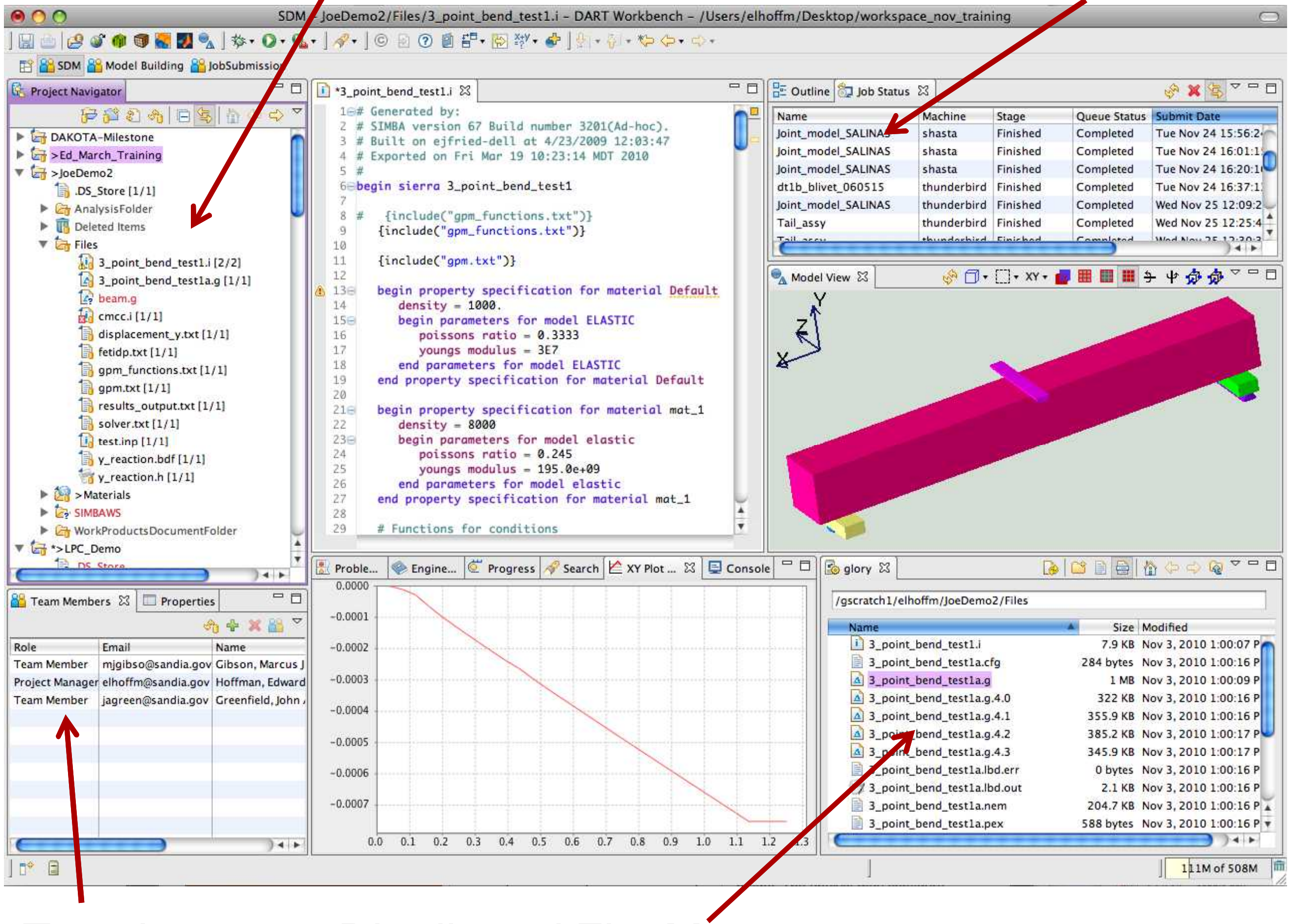
Data Management

- Teams
- NTK
- Metagroups

- Web services

Simulation Data Management

Job Management



```
▶ DAKOTA-Milestone
▶ >Ed_March_Training
▼ >JoeDemo2
    .DS_Store [1/1]
  ▶ AnalysisFolder
  ▶ Deleted Items
  ▼ Files
      3_point_bend_test1.i [2/2]
      3_point_bend_test1a.g [1/1]
      beam.g
      cmcc.i [1/1]
      displacement_y.txt [1/1]
      fetidp.txt [1/1]
      gpm_functions.txt [1/1]
      gpm.txt [1/1]
      results_output.txt [1/1]
      solver.txt [1/1]
      test.inp [1/1]
      y_reaction.bdf [1/1]
      y_reaction.h [1/1]
  ▶ >Materials
  ▶ SIMBAWS
  ▶ WorkProductsDocumentFolder
▼ *>LPC_Demo
```

```
# Generated by:
# SIMBA version 67 Build number 3201(Ad-hoc).
# Built on ejfried-dell at 4/23/2009 12:03:47
# Exported on Fri Mar 19 10:23:14 MDT 2010
#
begin sierra 3_point_bend_test1

#   {include("gpm_functions.txt")}
   {include("gpm_functions.txt")}

   {include("gpm.txt")}

   begin property specification for material Default
      density = 1000.
      begin parameters for model ELASTIC
         poissons ratio = 0.3333
         youngs modulus = 3E7
      end parameters for model ELASTIC
   end property specification for material Default

   begin property specification for material mat_1
      density = 8000
      begin parameters for model elastic
         poissons ratio = 0.245
         youngs modulus = 195.0e+09
      end parameters for model elastic
   end property specification for material mat_1

   # Functions for conditions
```

Name	Machine	Stage	Queue Status	Submit Date
Joint_model_SALINAS	shasta	Finished	Completed	Tue Nov 24 15:56:2
Joint_model_SALINAS	shasta	Finished	Completed	Tue Nov 24 16:01:1
Joint_model_SALINAS	shasta	Finished	Completed	Tue Nov 24 16:20:1
dt1b_blivet_060515	thunderbird	Finished	Completed	Tue Nov 24 16:37:1
Joint_model_SALINAS	thunderbird	Finished	Completed	Wed Nov 25 12:09:2
Tail_assy	thunderbird	Finished	Completed	Wed Nov 25 12:25:4

Role	Email	Name
Team Member	mjgibso@sandia.gov	Gibson, Marcus J
Project Manager	elhoffm@sandia.gov	Hoffman, Edward
Team Member	jagreen@sandia.gov	Greenfield, John

/gscratch1/elhoffm/JoeDemo2/Files

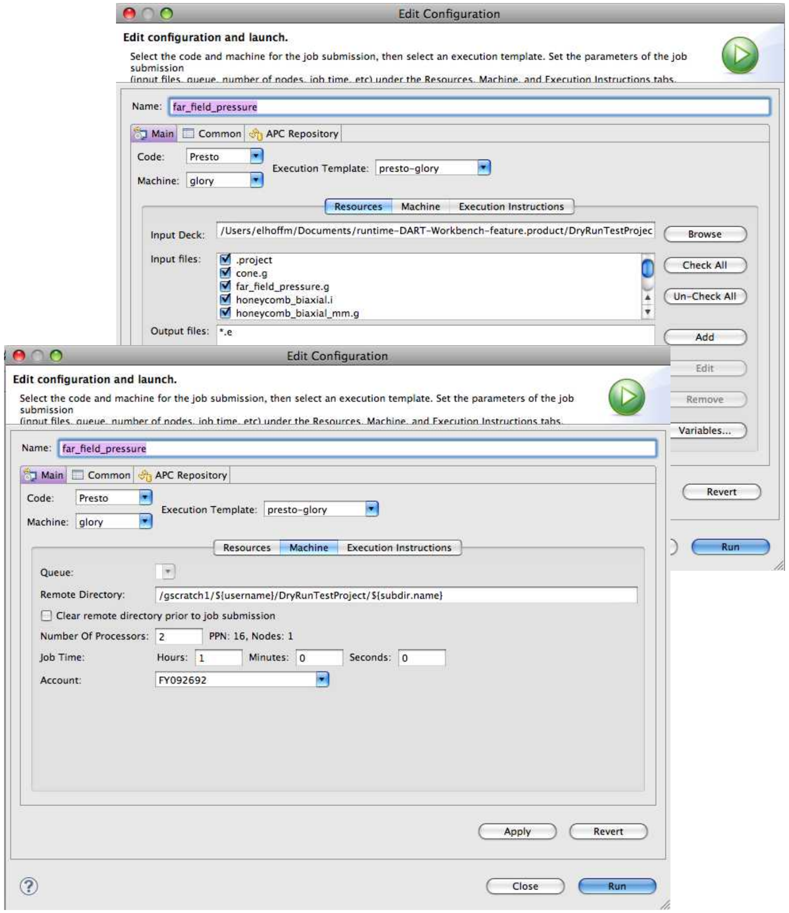
Name	Size	Modified
3_point_bend_test1.i	7.9 KB	Nov 3, 2010 1:00:07 P
3_point_bend_test1a.cfg	284 bytes	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.g	1 MB	Nov 3, 2010 1:00:09 P
3_point_bend_test1a.g.4.0	322 KB	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.g.4.1	355.9 KB	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.g.4.2	385.2 KB	Nov 3, 2010 1:00:17 P
3_point_bend_test1a.g.4.3	345.9 KB	Nov 3, 2010 1:00:17 P
3_point_bend_test1a.lbd.err	0 bytes	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.lbd.out	2.1 KB	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.nem	204.7 KB	Nov 3, 2010 1:00:16 P
3_point_bend_test1a.pex	588 bytes	Nov 3, 2010 1:00:16 P

Teaming

Distributed File Management

Job Submission

- Modular architecture
  - Machine templates
  - Code templates
  - Defaults
  - Custom templates
- Remote access
  - Heterogeneous machines
- Local access



Edit configuration and launch.

Select the code and machine for the job submission, then select an execution template. Set the parameters of the job submission (input files, queue, number of nodes, job time, etc) under the Resources, Machine, and Execution Instructions tabs.

Name: far_field_pressure

Code: Presto

Machine: glory

Execution Template: presto-glory

Input Deck: /Users/elhoffm/Documents/runtime-DART-Workbench-feature.product/DryRunTestProjec

Input files:
☑ .project
☑ cone.g
☑ far_field_pressure.g
☑ honeycomb_biaxial.i
☑ honeycomb_biaxial_mm.g

Output files: *.e

Edit configuration and launch.

Select the code and machine for the job submission, then select an execution template. Set the parameters of the job submission (input files, queue, number of nodes, job time, etc) under the Resources, Machine, and Execution Instructions tabs.

Name: far_field_pressure

Code: Presto

Machine: glory

Execution Template: presto-glory

Queue:

Remote Directory: /gscratch1/${username}/DryRunTestProject/${subdir.name}

□ Clear remote directory prior to job submission

Number Of Processors: 2 PPN: 16, Nodes: 1

Job Time: Hours: 1 Minutes: 0 Seconds: 0

Account: FY092692

Multiple Configurations

- Workbench
  - Everything
- CompSimUI
  - Model Building
  - Meshing
  - Job Submission
- Sierra Editor
  - Model Building
  - Job Submission

Eclipse allows us to build multiple application distributions by choosing from among our set of components

Conclusions

- Eclipse and the OSGi architecture let us
  - … reduce dependencies between integrated software projects
  - … integrate diverse components smoothly and robustly
  - … create and deploy customized solutions easily

Acknowledgements

- The DART Team
    - Douglas Clay, Marcus Gibson, John Greenfield, Stephen Mueller, Kevin Olson, Edward Walsh
- The CUBIT Team
    - Randy Morris, Matt Staten
- The SIERRA Team
    - Mike Glass, Martin Heinstein, Garth Reese, Brett Robertson

This work is supported by the Advanced Strategic Computing program of the NNSA.

Questions

Technical contact:

Ernest Friedman-Hill

925-294-2154

ejfried@sandia.gov

Programmatic contact:

Robert Clay

925-294-3114

rlclay@sandia.gov