Coupling ALEGRA and COYOTE under IMPRESARIO

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Objective

Proof of Concept:

Determine whether independently developed physics codes on a heterogeneous network can be successfully coupled with tools complying with the CORBA standard and applied to problems of interest to Defense Programs

Motivation:

- need for coupled physics capability (ASCI goal)
- existing codes written in several different languages and run on many different platforms
- desire to make minimal code modifications
- capitalize on investment already made in these codes

Strategy

Couple a solid dynamics code running on one machine with a heat transfer code running on another machine under a CORBA-based framework

- ALEGRA, a solid dynamics code written in C++
- COYOTE, a thermal analysis code written in Fortran
- IMPRESARIO, a software system based on XShell

Run a prototype 2D impact/heat transfer problem

Efforts were begun in mid-June, are now summarized on the World Wide Web:

- http://www.sandia.gov/1431/projectsw.html

CORBA

Common Object Request Broker Architecture

- http://www.acl.lanl.gov/sunrise/DistComp/Objects/corba.html

Emerging standard for distributed object computing sponsored by the Object Management Group, a large software consortium

- http://www.omg.org

Concrete specification of the interfaces and services that must be provided by compliant ORBs

Object Request Broker (ORB)

- delivers requests to objects and returns output to client
- provides transparency of object location, activation, and communication on a heterogeneous network

ALEGRA Arbitrary-Lagrangian-Eulerian (ALE) Code

Capabilities

Shock Waves
Low Amplitude Stress Waves
Detailed Material Models
Fracture
Sliding
Explosives

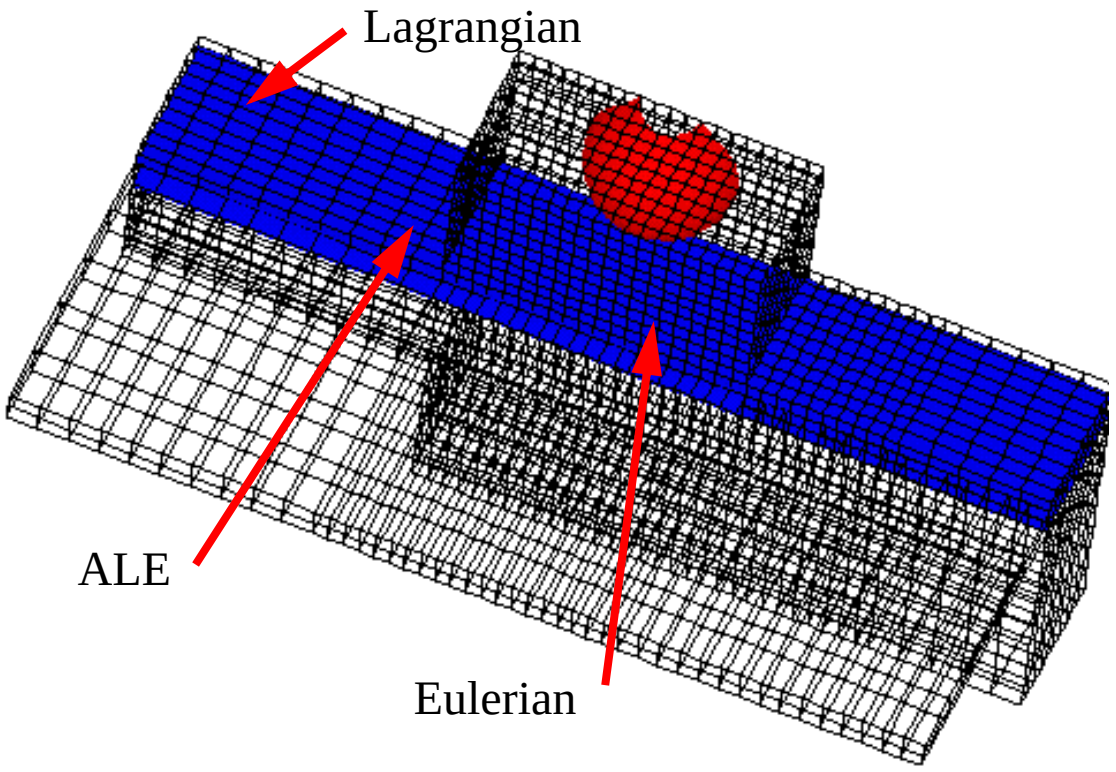
Adaptive Algorithms

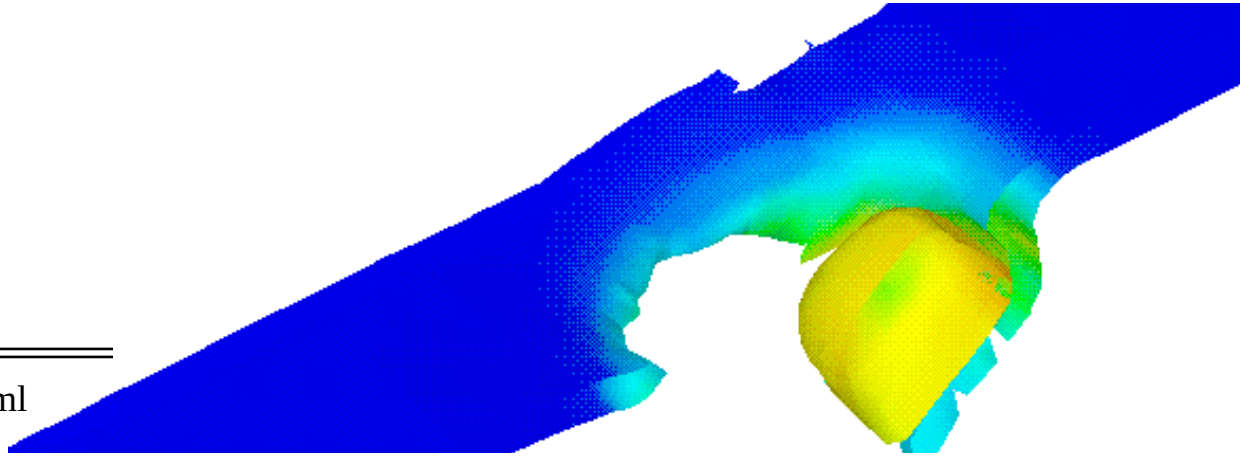
Arbitrary Connectivity Mesh
Adaptive Mesh
Adaptive Solution Algorithm

Runs on

Intel Paragon
IBM SP2
Clustered Workstations
Workstations

http://www.sandia.gov/1431/ALEGRAw.html

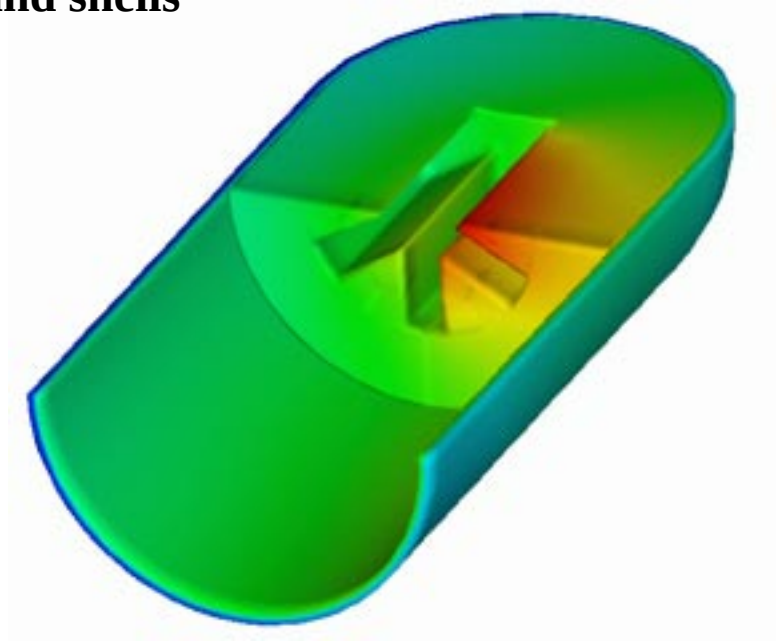




COYOTE II -- Galerkin Finite Element Code For Non-Linear Heat Conduction Problems

Summary of Coyote II Capabilities:

- **Heat conduction with chemical kinetics and enclosure radiation**
- **Multi-dimensional: 2-d planar/axisymmetric and fully 3-d**
- **Steady or transient: explicit and implicit temporal integration**
- **Fixed time steps or adaptive time step algorithm**
- **Extensive 2-d and 3-d element library, including bars and shells**
- **Material motion: Eulerian and/or Lagrangian**
- **Material addition/removal**
- **Anisotropic material properties: f(x,t,T)**
- **General boundary conditions: f(x,t,T)**
- **Phase change**
- **Contact/slide-line capabilities**
- **http://cfd.sandia.gov/docs/coyote/coyote-welcome.html**



IMPRESARIO

Integrated Multiple Platform for Remote-sensing Simulation and Real-time Interactive Operation

Software system developed by Sandia's Information Systems Engineering Center for integrated modeling, simulation and data visualization

Facilitates interoperability among independent models of different physical processes across multiple platforms

- provides standard interfaces for data sharing
- enhanced input/output interface

Based on CORBA-compliant commercial software, XShell

XShell

Open, object-oriented programming environment for distributed systems marketed by Expersoft

- http://www.expersoft.com

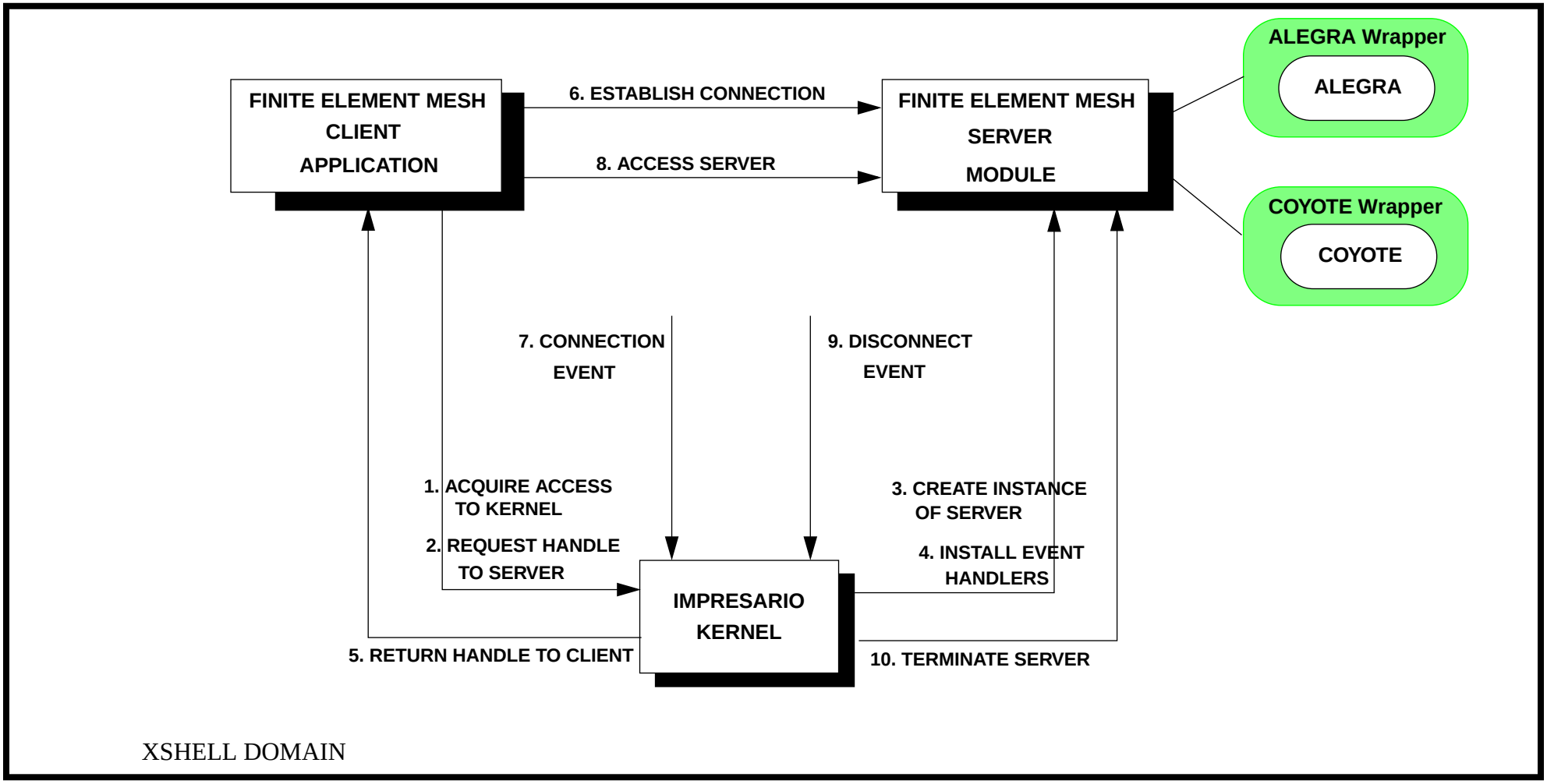
Transparently takes care of network and communication protocols and differences between machine architectures on a heterogeneous network

Allows developer to focus on application functionality

Complies with CORBA standard

IMPRESARIO Framework for DP Models

Coupling of ALEGRA and COYOTE under IMPRESARIO



Modifications to ALEGRA and COYOTE

Minor top-level restructuring:

- modules for ALEGRA and COYOTE interfaced to IMPRESARIO
- distributed member functions (DMFs) for execution stages
- capability to advance one cycle at a time

Abstract data types (ADTs) developed for physics data passing

- Temperatures, Coordinates, Mech_Work
- module DMFs to send and receive ADT objects
- code to extract data to send to other applications
- code to utilize data from other applications

Physics Coupling

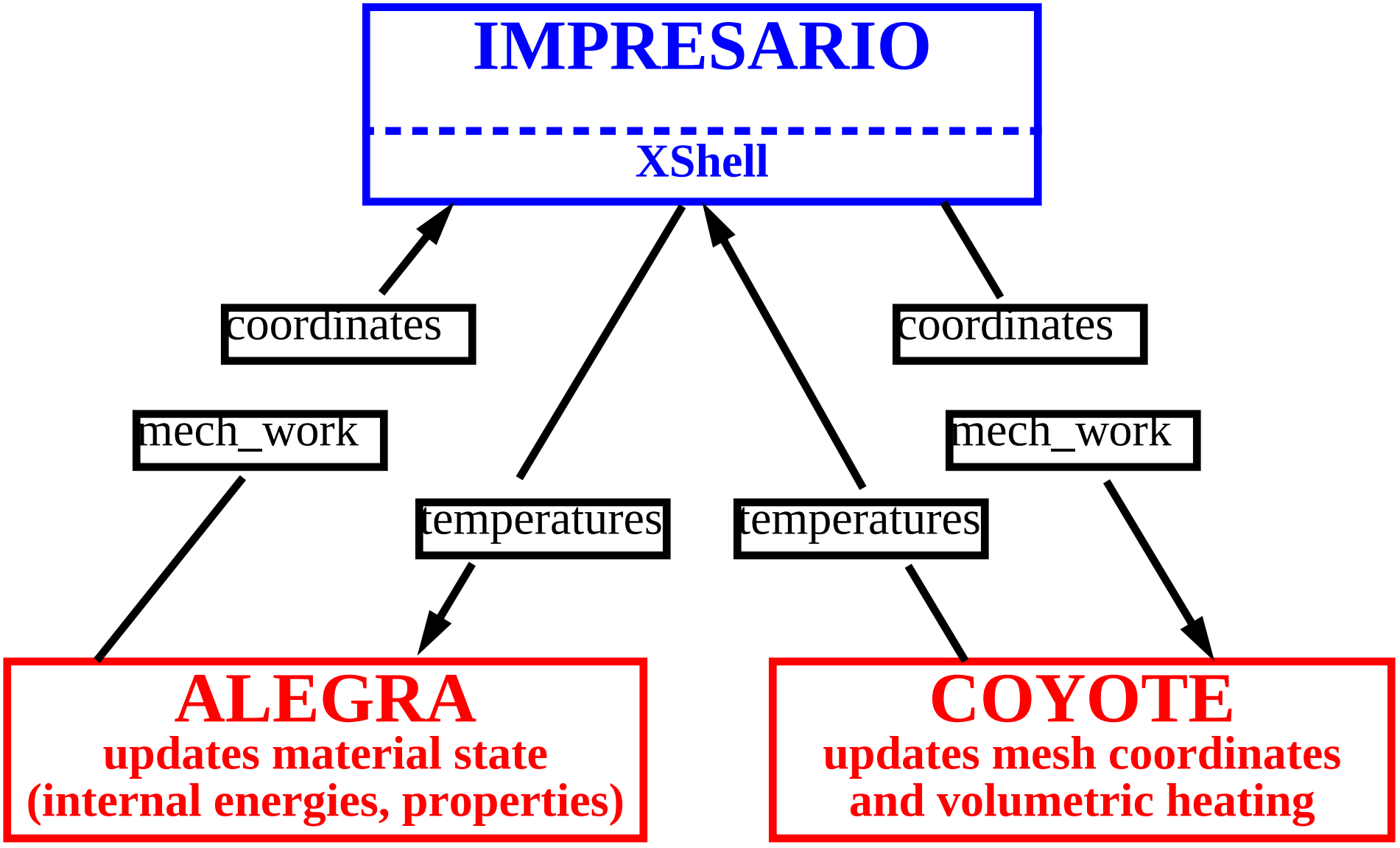
ALEGRA and COYOTE run on their own copy of the same mesh using their own input files

Time step selected from requests by COYOTE and ALEGRA

IMPRESARIO then advances each code one cycle

Data exchanged at the beginning of each cycle through the IMPRESARIO interface

Physics Coupling



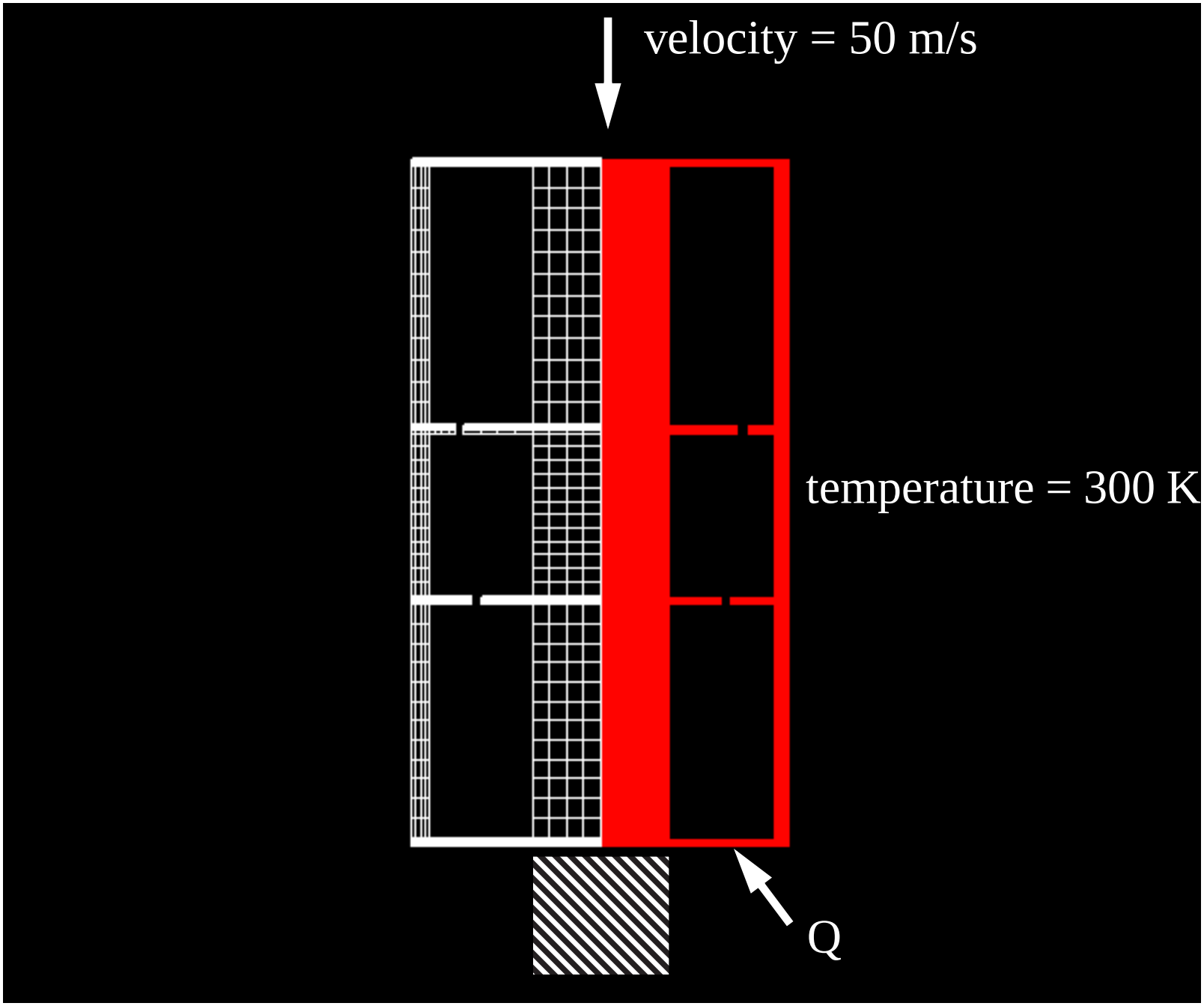
Demonstration Calculation

- ALEGRA and COYOTE run coupled
  - ALEGRA on HP workstation
  - COYOTE on an IBM SP-2 node

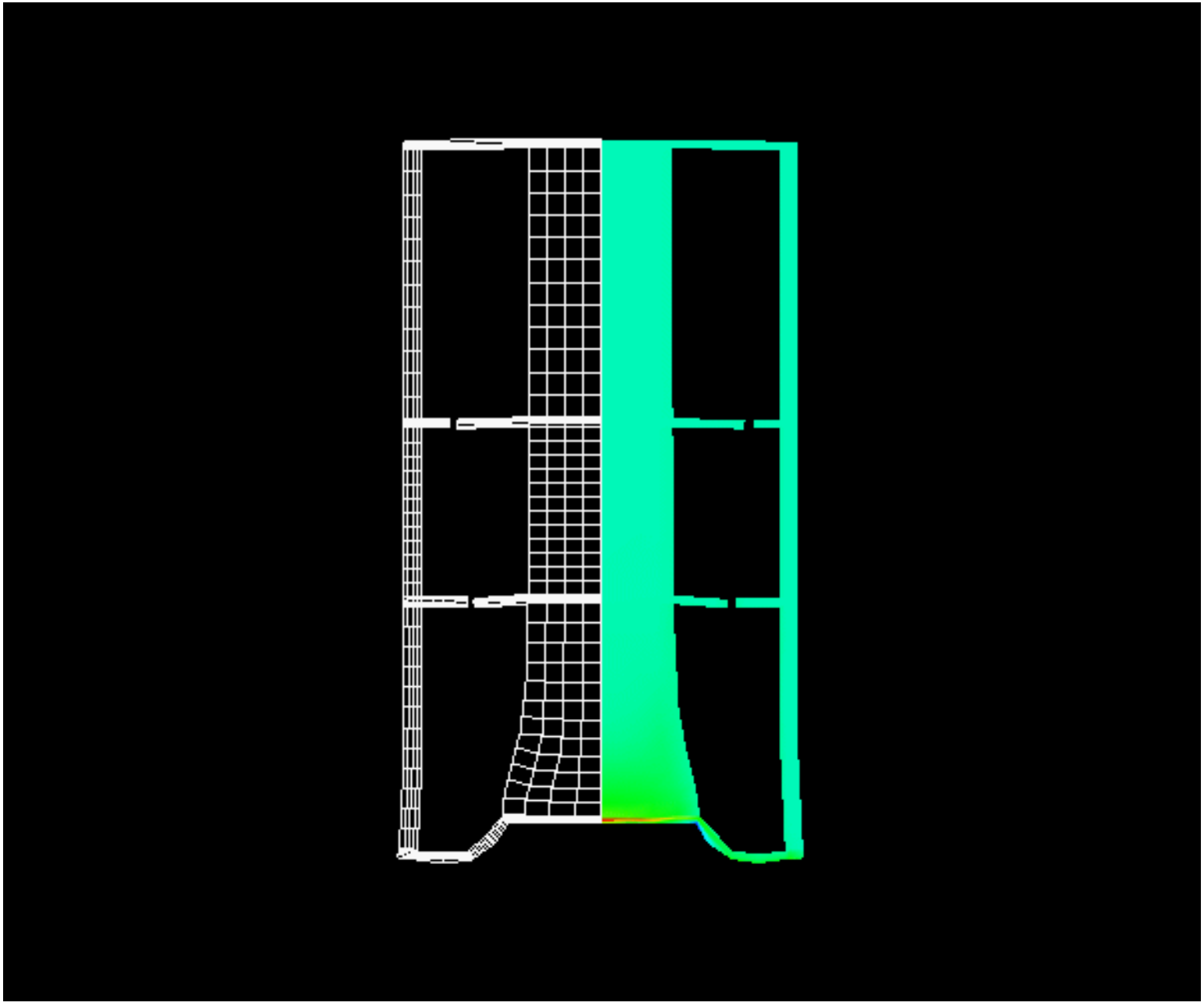
- Prototype 2D impact/heat transfer problem
  - axisymmetric canister
  - impact on center axis
  - heat flux imposed on bottom surface

- Modified properties to match physical time scales

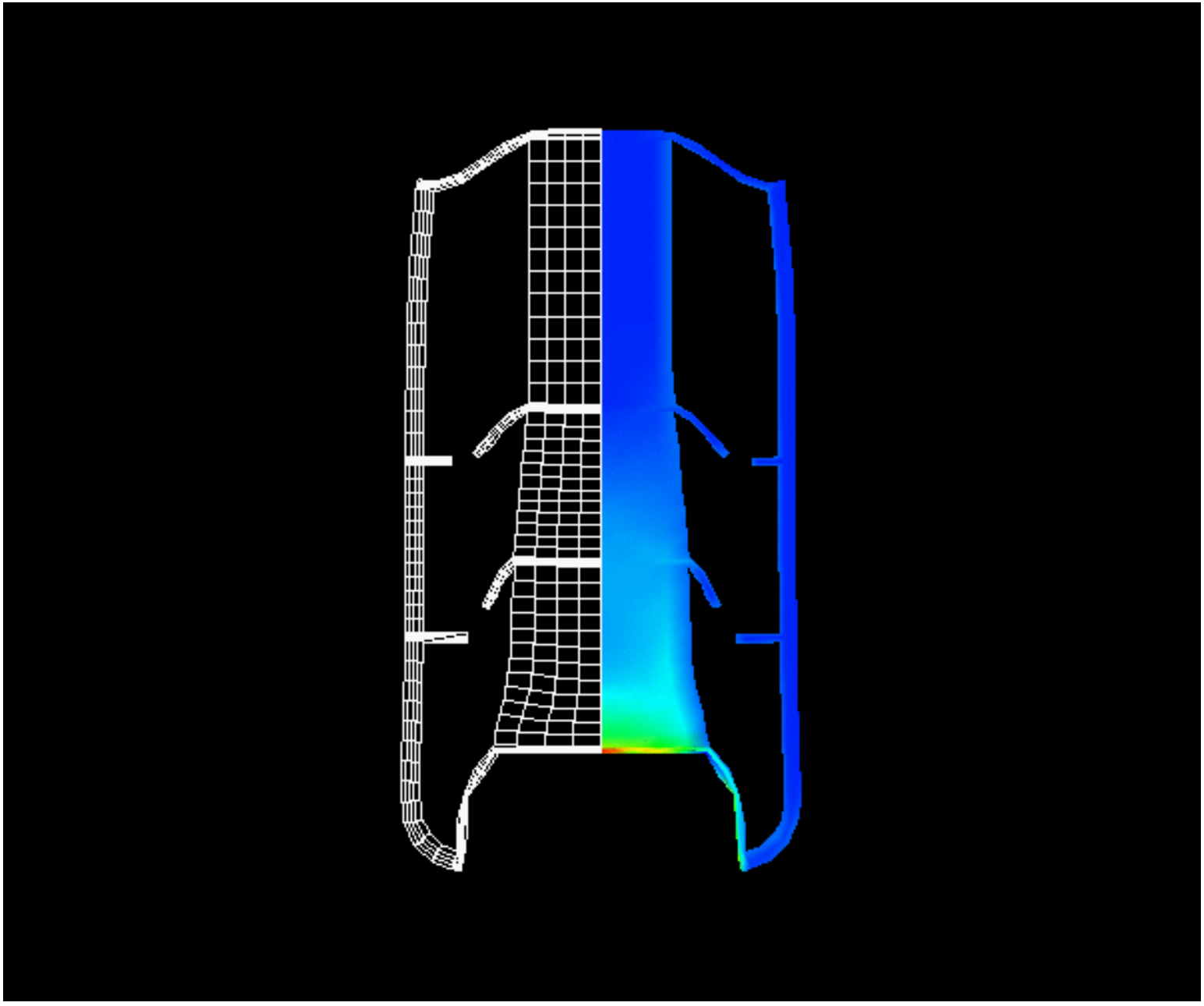
Initial and Boundary Conditions



Shortly after Impact



End Time (1 ms)



Conclusion

CORBA-based frameworks such as IMPRESARIO are very promising for coupling physics codes in a heterogeneous environment

Issues for further investigation:

- extension to massively parallel environments
- efficiency of data communication through CORBA tools
- coupling requirements of additional physics codes

Vision: An integrated toolbox containing a wide variety of physics packages running on single or networked MP machines that can be readily applied in a coupled manner to solve challenging problems of national importance