Coven
a Framework for High Performance Problem Solving Environments

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Problem Solving Environments in HPC

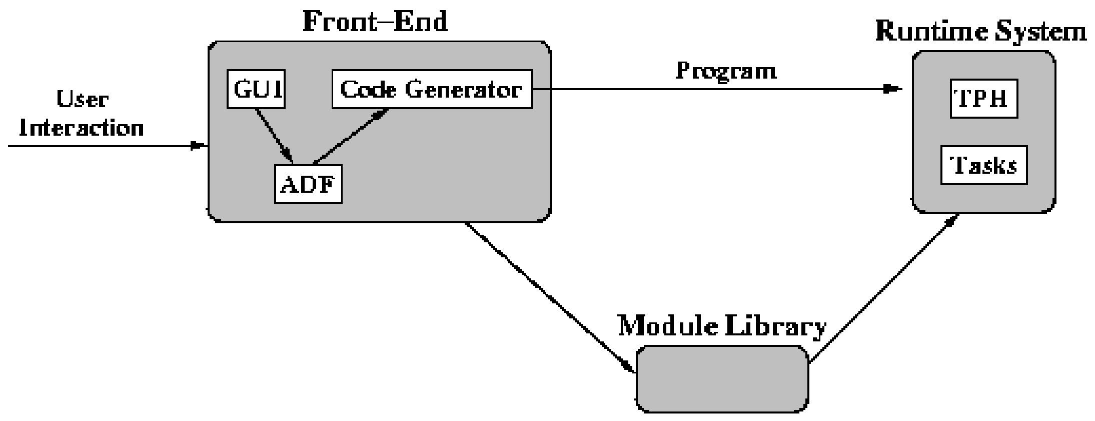
- PSEs are integral parts of modern HPC
- Help manage complexity of modern scientific computing
- Good PSE hides many details of the system, application, or both
- Good PSE flexible enough to solve the problem yet powerful enough to provide reasonably high performance

PSE Construction

- Some good examples of PSEs for HPCs, but specific to an application domain
- Little work has been done in creating a reusable framework for PSE construction
- Two important characteristics of a good PSE framework:
  - Flexibility
    - The ability to support a wide range of computational models that various domains may require
  - Abstraction
    - Carefully hide the details of both the underlying computer system and the problem domain, where appropriate

Coven

- Framework for building PSEs for parallel computers
- Three main components: runtime system, front-end, and module library



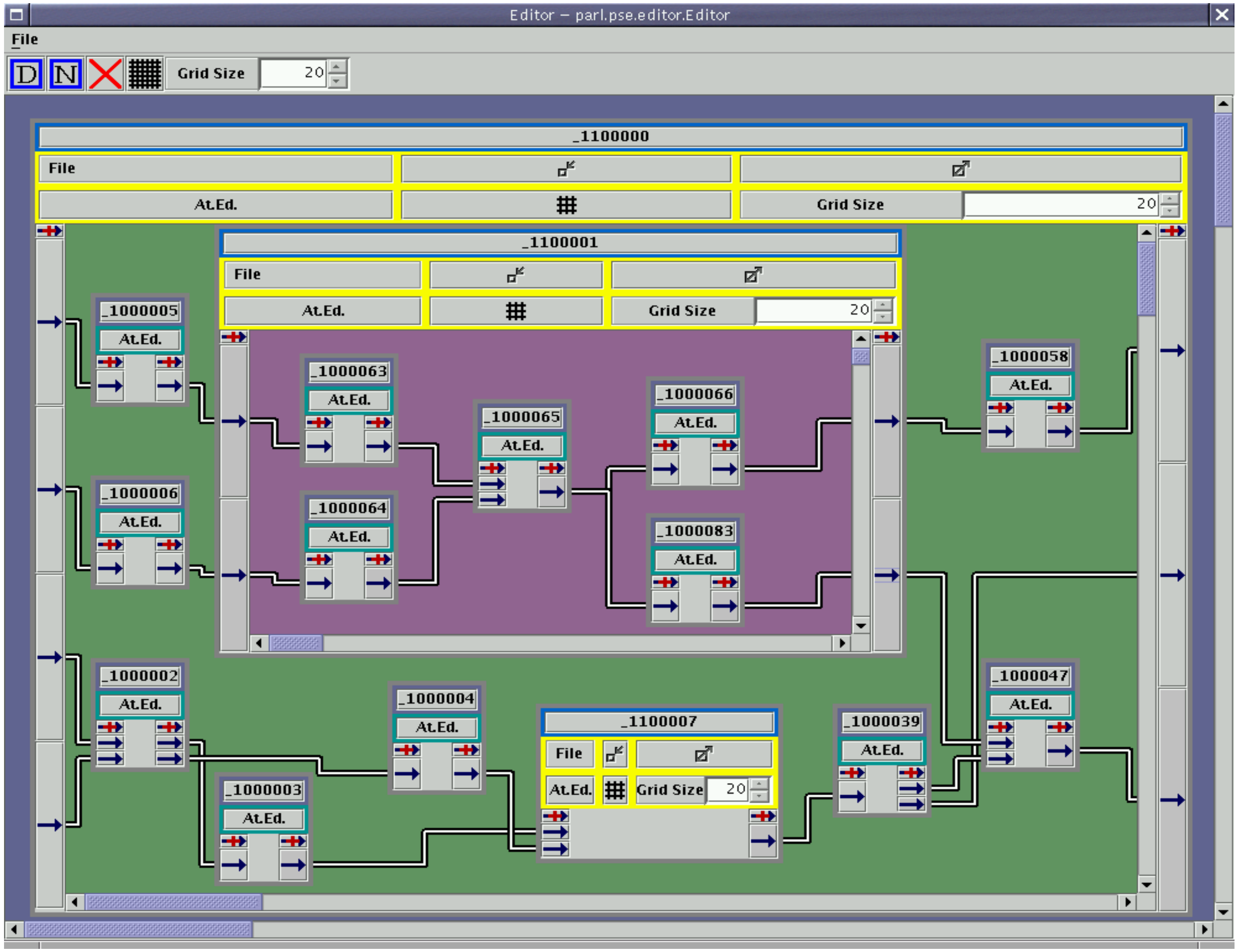
Runtime Driver

- Multi-threaded parallel runtime system
- Targets Beowulf clusters
- Uses a runtime generated data structure (TPH) to manage partitioning data sets among cluster nodes
- Executes applications capable of supporting most parallel programming constructs

Agent Based Front End

- Allows multiple custom interfaces to be constructed
- Stores information about the specification, implementation, and performance of the application in an attributed graph format
- Facilitates ways for agents to provide suitable abstractions for a particular class of user

GUI Screenshot



Module Library

- Collaborative repository
- Many pre-defined modules
- Users can add their own modules
- Holds both system and application modules
- Transfers modules from the front-end (GUI) machine to the back-end (parallel) machine

Tagged Partition Handle

- Internal data structure within Coven
- Hold buffers of data and provide means for creating, accessing, modifying, and destroying these buffers
- Handles all inputs to and outputs from modules
- Since TPHs pass from machine to machine, module programmers describe the data to access through a tag

Tagged Partition Handle

- Parallel task
  - Module
    - Piece of code which operates on some data
  - Tagged Partition Handle
    - Data structure containing related data
- Goal is to schedule execution of modules and TPHs to perform tasks in parallel
- Coven runtime driver provides means for this which allows overlapping of I/O, computation, and communication

Modules

- Reside in the module library on front-end machine
- Transferred to parallel computer upon execution
- Two classes of modules:
  - Application modules
  - System modules

Application Modules

- Written by an application designer
- Examples:
  - Compute resultant of vector multiplication
  - Compute partial force between two bodies
  - Calculate lat / long of a buffer of grid points
  - Update a temperature matrix based on values of neighboring cells

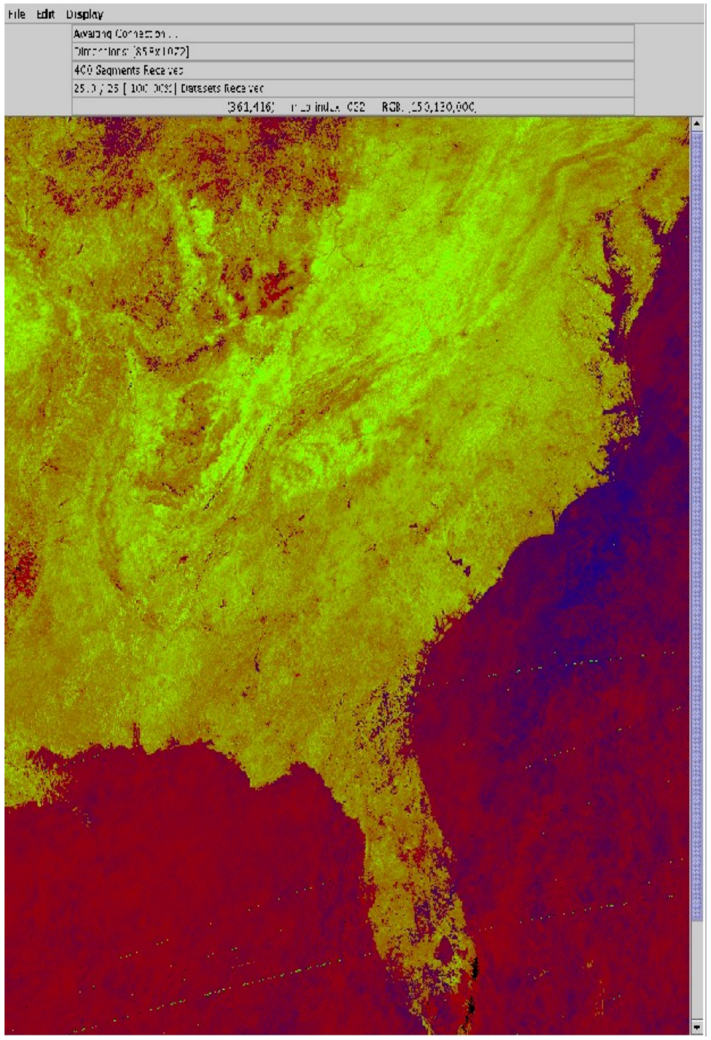
System Modules

- Written by someone familiar with parallel computing, load balancing, etc.
- Allows for steering of computation
- Examples:
  - Perform parallel communication such as shifting data to neighbor in a parallel stage (such as with MPI)
  - Partition data
  - Create TPHs
  - Consume TPHs

Prototype PSEs

- CERSe
  - Remotely sensed satellite data
  - Legacy NASA remote sensing code
- Medea
  - N-Body simulations
- Still in development
  - Molecular dynamics
  - CFD / Heat transfer

CERSe



Awaiting Connection . . .

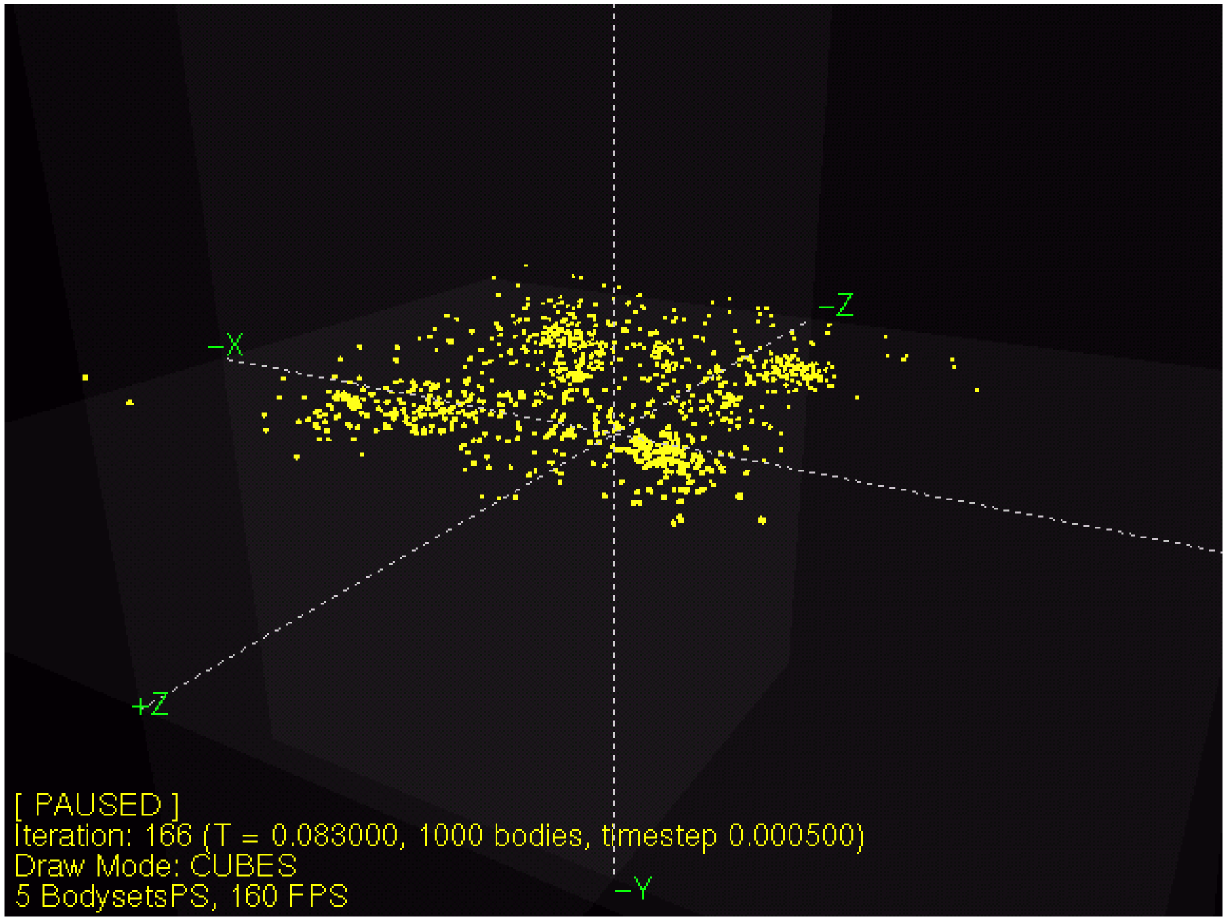
Dimensions: [859x1072]

400 Segments Received

25.0 / 25 [100.00%] Datasets Received

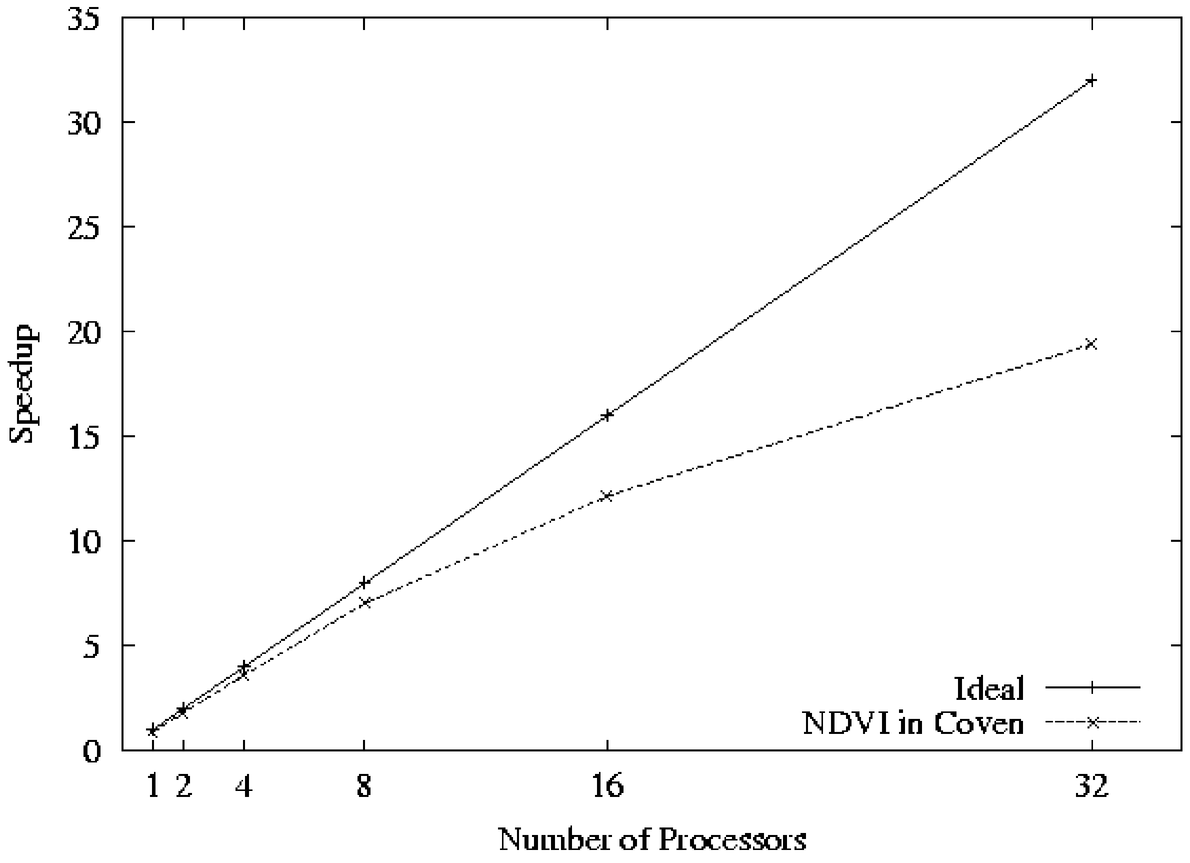
(361,416) map index: 032 RGB: (150,130,000)

Medea

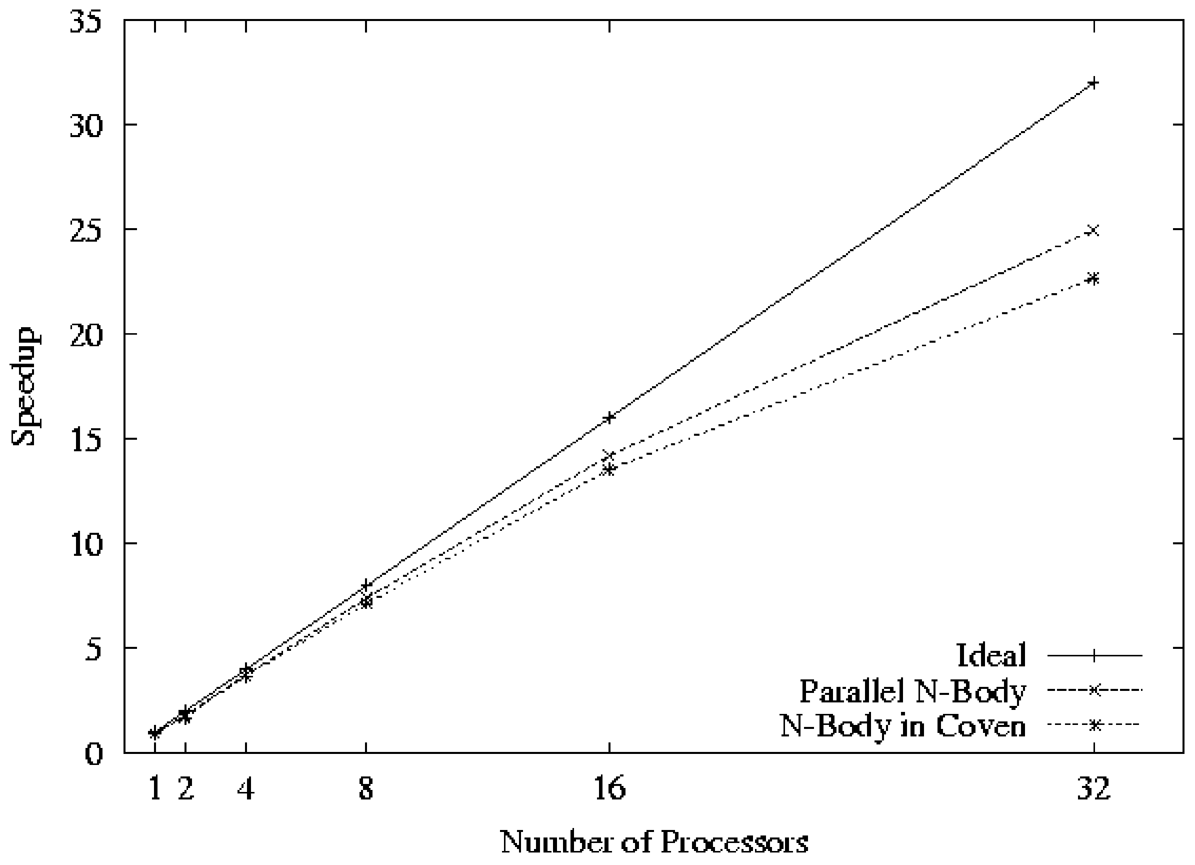


[PAUSED]
Iteration: 166 (T = 0.083000, 1000 bodies, timestep 0.000500)
Draw Mode: CUBES
5 BodysetsPS, 160 FPS

NDVI Performance



N-Body Performance



Conclusions and Future Work

- Presented a customizable framework for the creation of PSEs for HPCs
- Prototype PSEs have been demonstrated
- Applications built using these PSEs have achieved promising performance
- Coven can speed up the PSE construction process
- Create additional prototype PSEs to evaluate the flexibility of the framework
- Study performance tuning with the framework

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