Introduction to the Cactus Framework

The Cactus team

Mar 30 2011

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- Computational problem
- Too large for single machine
- Distributed development
- Multiple programming languages

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Cactus is

- a framework for developing portable, modular applications
- focusing, although not exclusively, on high-performance simulation codes
- designed to allow experts in different fields to develop modules based upon their experience and to use modules developed by experts in other fields with minimal knowledge of the internals or operation of the other modules

Cactus Goals

- Portable
  - Different development machines
  - Different production machines

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  - Interchangeable modules with same functionality

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- Portable
  - Different development machines
  - Different production machines
- Modular
  - Standard interfaces for module interaction for easier code interaction, writing and debugging
  - Interchangeable modules with same functionality
- Easy to use
  - Good documentation
  - Try to let users program the way they are used to
  - Support all major (HPC) programming languages

Philosophy

- Open code base to encourage community contributions
- Strict quality control for base framework
- Development always driven by real user requirements
- Support and develop for a wide range of application domains

Cactus History

- Direct descendant of many years of code development in Ed Seidel's group of researchers at NCSA
- 1995, Paul Walker, Joan Masso, Ed Seidel, and John Shalf: Cactus 1.0
- Originally for numerical relativity
- Over the years generalized for use by scientists in other domains

Current Users and Developers

Community

- Web: `http://www.cactuscode.org/`
- Email lists
  - `users@cactuscode.org`
  - `developers@cactuscode.org`
- Download: Subversion (`https://svn.cactuscode.org/`)
- Bug tracker

Covers


COMMUNICATIONS
HIGH-PERFORMANCE NETWORKING
The Future of Theoretical Physics and Cosmology
MaxPlanckResearch
Sun, Man and Climate
Invisible U
National Science Foundation
National Science Board
Science and Engineering Indicators 2006
Volume 1
Visualization and Processing of Tensor Fields
Chapman & Hall/CRC
Computational Science Series
Petascale Computing
Algorithms and Applications
EDITED BY
DAVID A. BADER
Chapman & Hall/CRC
Naturwissenschaftliche Rundschau
NR 689

Cactus Funding

- Organizations:
  - Max-Planck-Gesellschaft
  - Center for Computation & Technology at LSU
  - National Center for Supercomputing Applications
  - Lawrence Berkeley National Laboratory
  - Washington University
  - University of Tübingen
- Grants:
  - NSF (PHY-9979985, 0540374, 0653303, 0701491, 0701566, PIF-0904015, 0903973, 0903782)
  - Europ. Commission (HPRN-CT-2000-00137, IST-2001-32133)
  - DFN-Verein (TK 6-2-AN 200)
  - DFG (TiKSL)
  - ONR (COMI)
  - DOE/BOR (OE DE-FG02-04ER46136, BOR DOE/LEQSF)

The Cactus Computational Toolkit

Core modules (thorns) providing many basic utilities:

- I/O methods
- Boundary conditions
- Parallel unigrid driver
- Reduction and Interpolation operators
- Interface to external elliptic solvers
- Web-based interaction and monitoring interface
- Simple example thorns (wavetoy)

Many arrangements with many modules...

CactusBase	Basic utility and interface thorns
CactusBench	Benchmark utility thorns
CactusConnect	Network utility thorns
CactusElliptic	Elliptic solvers / interface thorns
CactusExamples	Example thorns
CactusExternal	External library interface thorns
CactusIO	General I/O thorns
CactusNumerical	General numerical methods
CactusPUGH	Cactus Unigrid Driver thorn
CactusPUGHIO	I/O thorns specifix for PUGH driver
CactusTest	Thorns for Cactus testing
CactusUtils	Misc. utility thorns
CactusWave	Wave example thorns

I/O Capabilities

Usual I/O and checkpointing in different formats:

- Screen output
- ASCII file output
- HDF5 file in-/output
- Online Jpeg rendering
- Online VisIt visualization

More Capabilities: Grids, Boundaries, Symmetries

- Grids
  - Only structured meshes (at the moment)
  - Unigrid (PUGH)
  - Adaptive Mesh Refinement (Carpet)
- Boundaries / Symmetries
  - Periodic
  - Static
  - Mirror symmetries
  - Rotational symmetries
  - Problemspecific boundaries

Visualization

Visualization is important, because

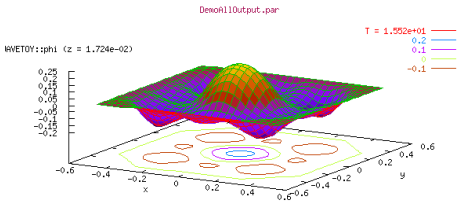
- can give essential insight into dynamics
- can detect errors much better than just looking at numbers
- necessary for publications
- can be good advertisement (cover pages ...)

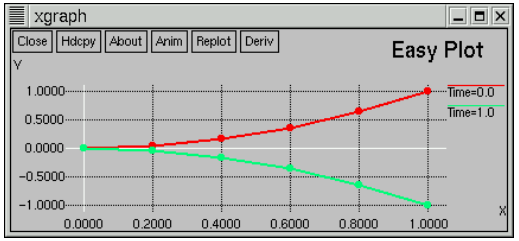
Different visualization types:

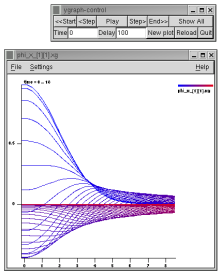
- 1D/2D: most of published pictures
- 3D: usually done for movies

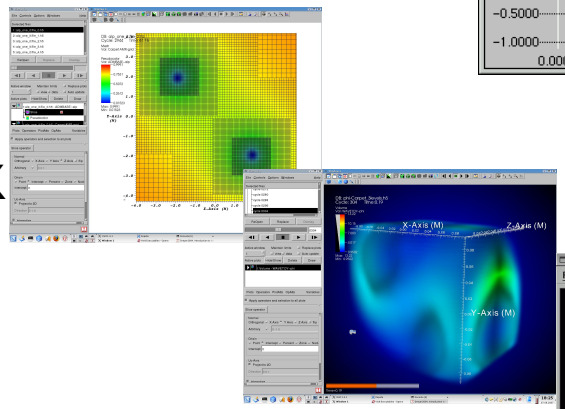
Visualization Clients

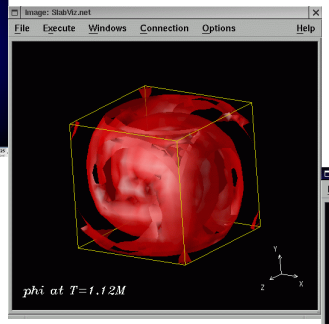
- Output can be visualized by many clients, e.g.:
  - 1D/2D
    - gnuplot
    - xgraph
    - ygraph
  - 3D
    - VisIt
    - OpenDX
    - Amira
    - Vish

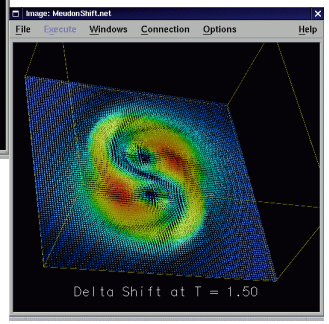




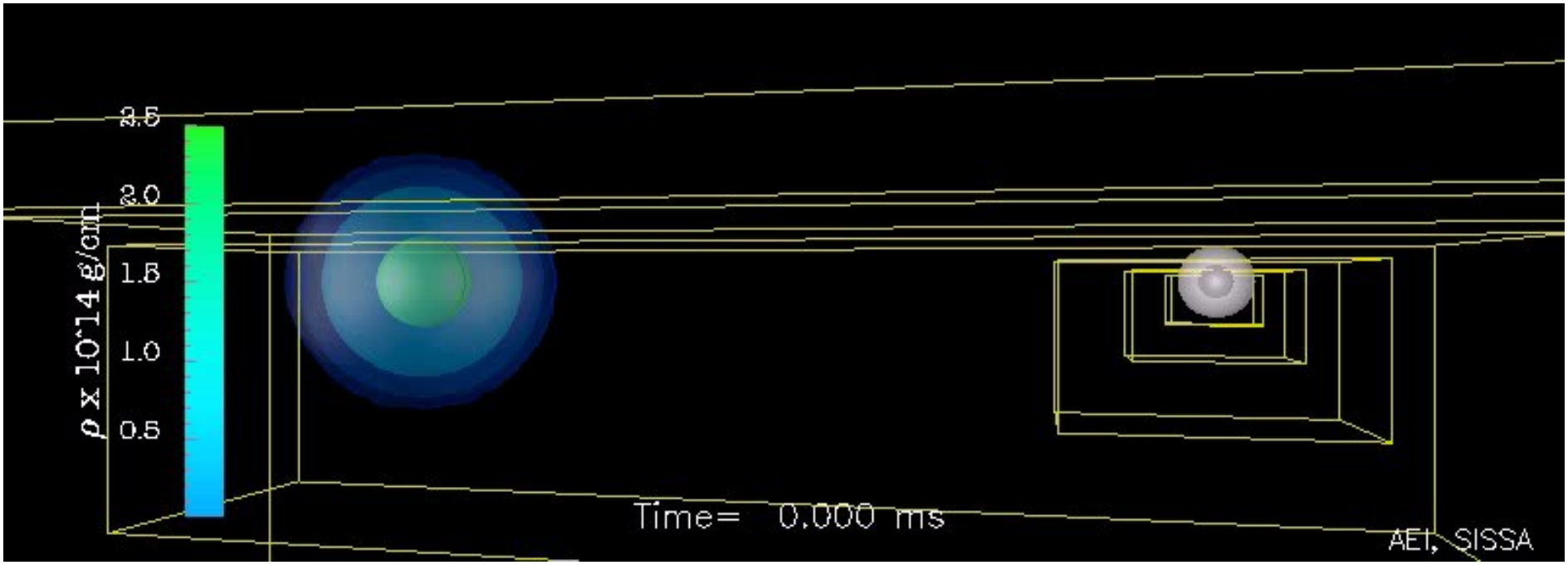








Example Movie I



Merger of neutron star and black hole

Example Movie II

Binary black hole inspiral, merger and ringdown

Cactus Structure

Cactus Structure

Framework - no prebuild executable

Cactus

- does not provide executable files
- provides infrastructure to create executables

Why?

- Problemspecific code not part of Cactus
- System libraries different on different systems
- Cactus is free software, but often problemspecific codes are not → non-distributable binary

Structure Overview

Two fundamental parts:

- The Flesh
  - The core part of Cactus
  - Independent of other parts of Cactus
  - Acts as utility and service library

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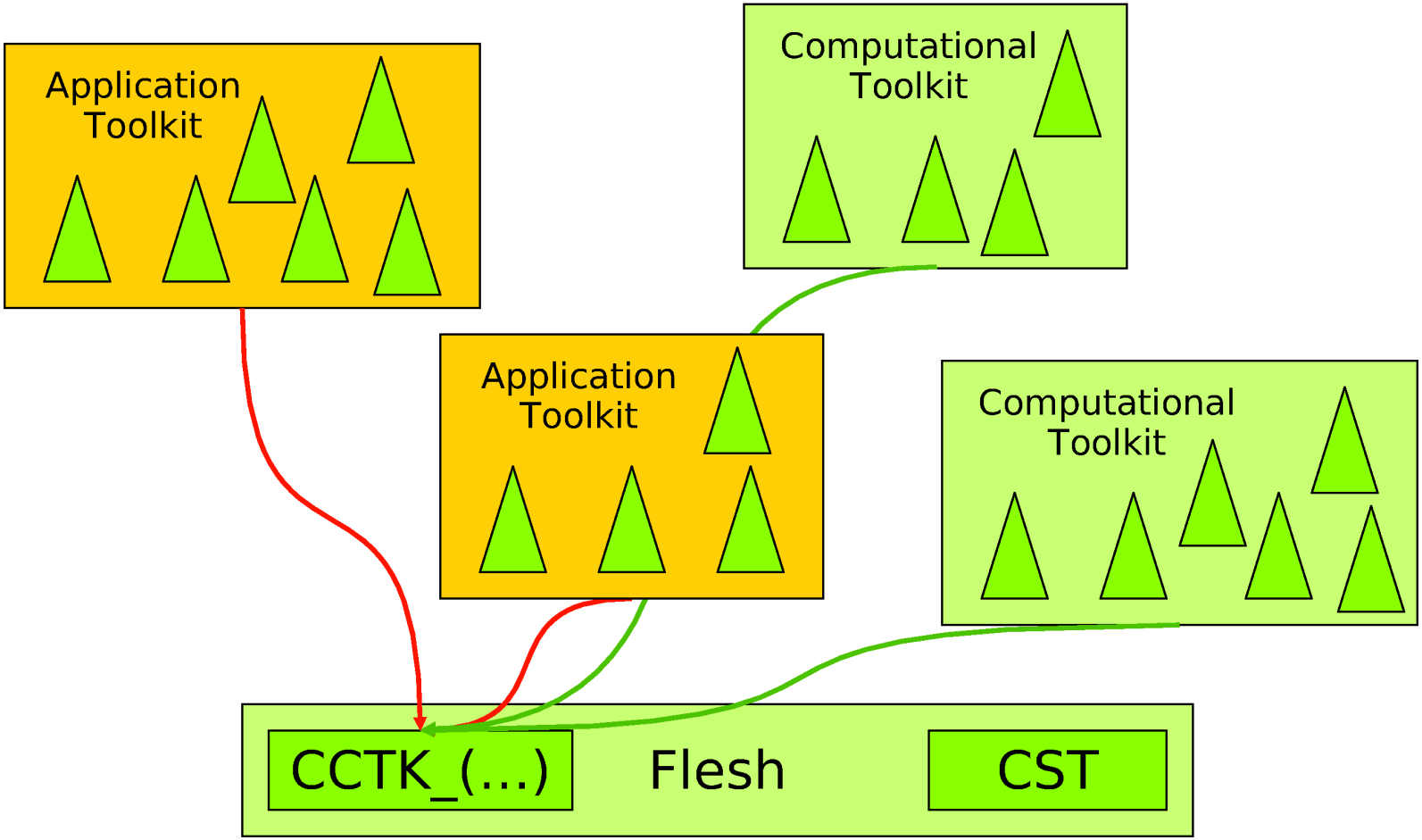
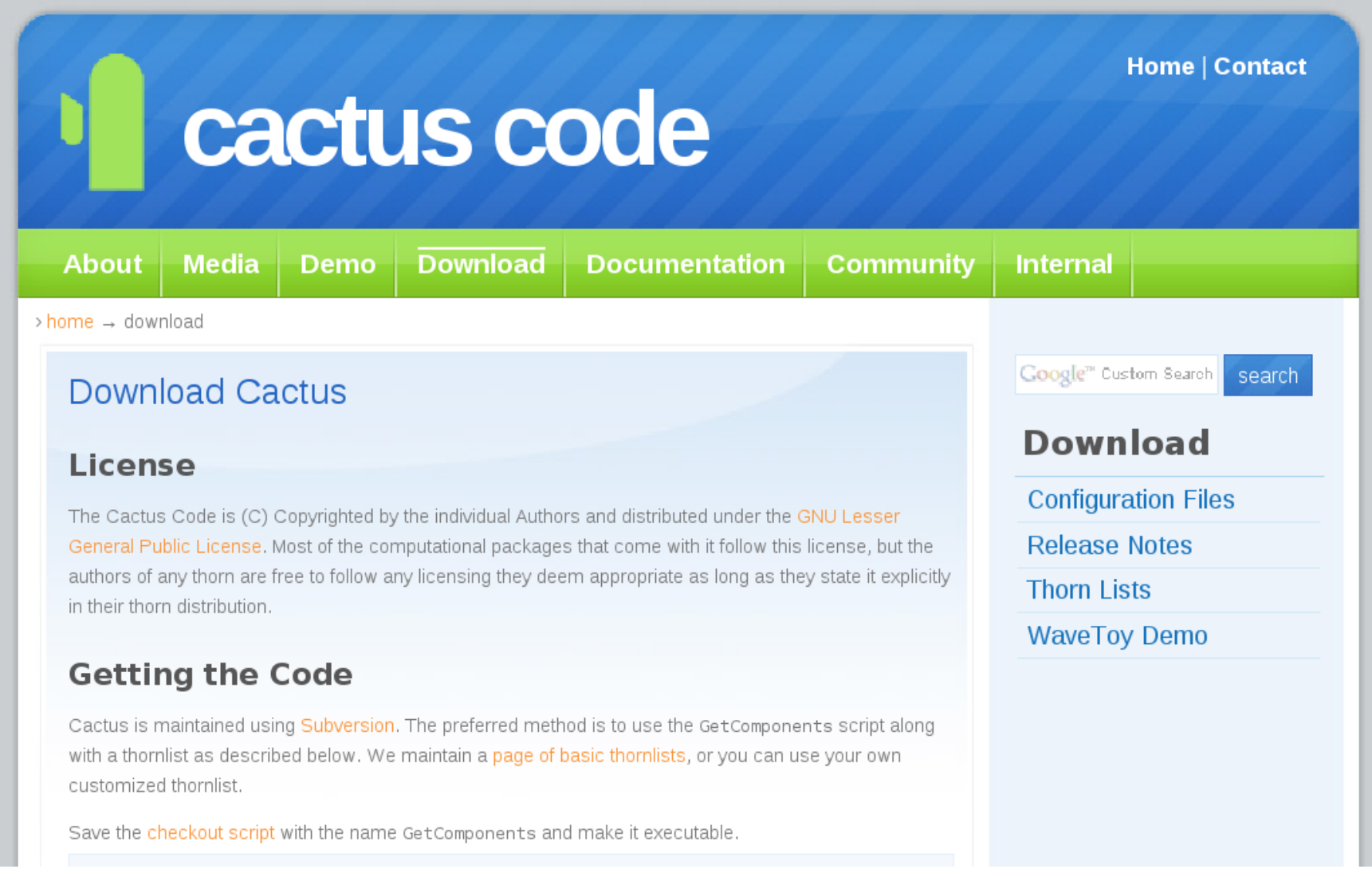
- The Flesh
  - The core part of Cactus
  - Independent of other parts of Cactus
  - Acts as utility and service library
- The Thorns
  - Separate libraries (modules) which encapsulate the implementation of some functionality
  - Can specify dependencies on other implementations

Application View

The structure of an application that is built upon the Cactus computational framework

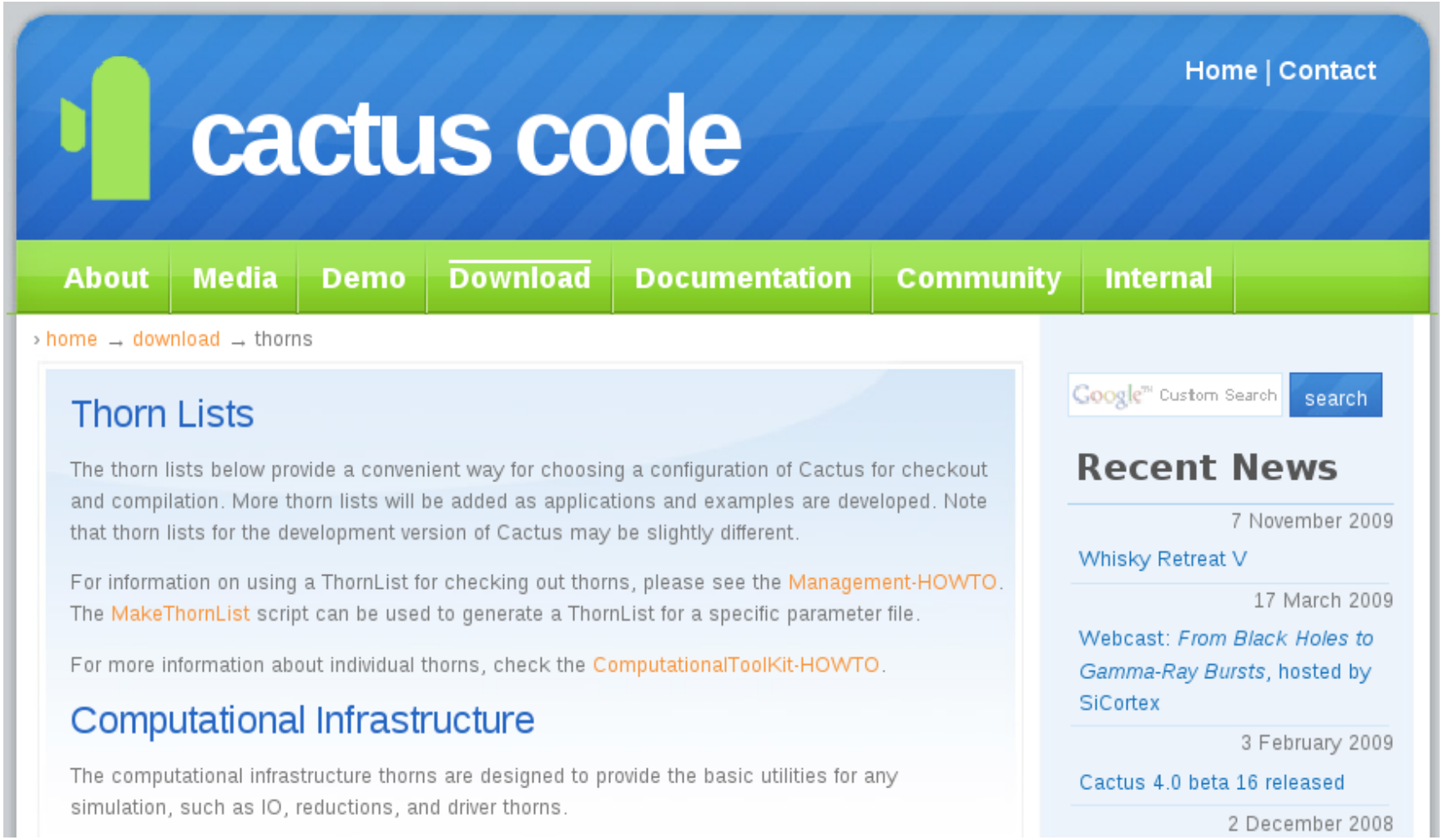


Download 'GetComponents'



http://www.cactuscode.org/download/GetComponents

Download Thornlist



http://www.cactuscode.org/download/thorns/

Download basic Cactus configuration

./GetComponents <thornlist file>

```
$ wget http://www.cactuscode.org/download/thorns/computationalToolkit.th
$ GetComponents -a computationalToolkit_new.th
-----------------------------------------------------------------
  Checking out module: Cactus
      from repository: :pserver:cvs_anon:anon@cvs.cactuscode.org/cactusdevcvs
                 into: Cactus
                   as: .
-----------------------------------------------------------------
  Checking out module: CactusBase/Boundary
      from repository: :pserver:cvs_anon:anon@cvs.cactuscode.org/cactusdevcvs
                 into: Cactus/arrangements
-----------------------------------------------------------------
  Checking out module: CactusBase/CoordBase
      from repository: :pserver:cvs_anon:anon@cvs.cactuscode.org/cactusdevcvs
                 into: Cactus/arrangements
-----------------------------------------------------------------
  Checking out module: CactusBase/CartGrid3D
      from repository: :pserver:cvs_anon:anon@cvs.cactuscode.org/cactusdevcvs
                 into: Cactus/arrangements
-----------------------------------------------------------------
...
-----------------------------------------------------------------
  33 components checked out successfully.
  0 components updated successfully.

  Time Elapsed: 0 minutes, 32 seconds
```

Thornlists

- List of thorn names
- Corresponding download methods and locations (optional)
- Supported download methods:
  - CVS / Subversion / Git / Mercurial
  - http / https / ftp
- Example:

```
!CRL_VERSION = 1.0

# Cactus Flesh
!TARGET   = $ROOT
!TYPE     = svn
!URL      = http://svn.cactuscode.org/flesh/trunk
!CHECKOUT = Cactus
!NAME     = .

# Cactus thorns
!TARGET   = Cactus/arrangements
!TYPE     = svn
!URL      = http://svn.cactuscode.org/arrangements/$1/$2/trunk
!CHECKOUT =
CactusBase/Boundary
CactusBase/CartGrid3D
CactusBase/CoordBase
CactusBase/IOASCII
CactusBase/IOBasic
```

Cactus directory structure

```
.
`-- Cactus
    |-- CONTRIBUTORS
    |-- COPYRIGHT
    |-- Makefile
    |-- arrangements
    |   `-- CactusBase
    |       |--Boundary
    |       |--CartGrid3D
    |       |--CoordBase
    |       |--IOASCII
    |       `--IOBasic
    |-- doc
    |-- lib
    `-- src
```

Configuring Cactus

- Cactus knows about a lot of default system configurations
- However: often system specific configuration needed
- Example config file:

```
CC  = /usr/local/compilers/intel_cce_11.0.074.x86_64/bin/intel64/icc
CXX = /usr/local/compilers/intel_cce_11.0.074.x86_64/bin/intel64/icpc
F77 = /usr/local/compilers/intel_fce_11.0.074.x86_64/bin/intel64/ifort
F90 = /usr/local/compilers/intel_fce_11.0.074.x86_64/bin/intel64/ifort

CPPFLAGS = -openmp -DMPICH_IGNORE_CXX_SEEK
FPPFLAGS = -fopenmp -traditional
CFLAGS   = -openmp -g -debug all -align -std=c99 -U__STRICT_ANSI__
CXXFLAGS = -openmp -g -debug all -align -std=c++0x -restrict -D__builtin_isnan=::isnan
F77FLAGS = -openmp -g -debug all -align -pad -traceback -w95 -cm
F90FLAGS = -openmp -g -debug all -align -pad -traceback -w95 -cm

DEBUG          = yes
OPTIMISE       = yes
WARN           = yes

MPI       = MPICH
MPICH_DIR = /usr/local/packages/numrel/mpich-1.2.7p1

HDF5     = yes
HDF5_DIR = /usr/local/packages/numrel/hdf5-1.8.0
```

Creating a Configuration

- Configurations consist of
  - a particular list of thorns
  - particular configuration options
- Creating configuration:
  `make <NAME>-config`
- New source tree:

```
`-- Cactus
      :
      |-- Makefile
      |-- arrangements ...
      |-- doc
      |-- lib
      |-- src
      `-- configs
            `-- NAME
```

Building and Running a Cactus binary

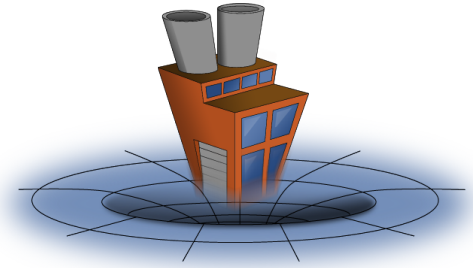
- Building new configuration:
  `make <NAME>`
- Executable in `Cactus/exe` subdirectory

```
`-- Cactus
    :
    |-- doc
    |-- lib
    |-- src
    |-- configs ...
    `-- exe
        |-- cactus_HelloWorld
        `-- cactus_wavetoy
```

- Execute Syntax: `<executable> [options] <parameter file>`
- Example: `./exe/cactus_HelloWorld HelloWorld.par`

The Simulation Factory

- Tool of choice for building and deploying Cactus simulations
- Supports many popular HPC machines such as
  - LONI - eric, queenbee, zeke, painter, etc
  - TeraGrid - abe, lincoln, ranger, kraken, etc
  - LSU HPC - tezpur, philip
- Provides many features
  - Building multiple Cactus configurations
  - Synchronizing Cactus source trees to many machines
  - Remote login
  - Submitting and managing Cactus jobs
- Available via svn at: `https://svn.cct.lsu.edu/repos/numrel/simfactory/branches/PYSIM_2010`



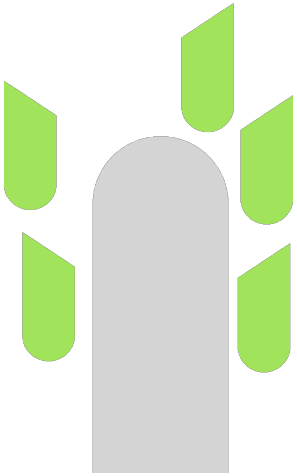
The Simulation Factory - Building Cactus

- The Simulation Factory lives in the `simfactory` folder inside Cactus source tree
- First, create a simple user configuration
  - `./simfactory/bin/sim setup`
- The Simulation Factory will determine correct machine configuration to use
- Creating a configuration and building the executable is one step
  - `./simfactory/bin/sim build <NAME>`
- The compiled executable is in the same `exe` folder.

Cactus Structure
The Flesh

The Flesh

- Make system
  - Organizes builds as 'configurations'
  - Can build various documentation documents
  - Can update Cactus flesh and thorns
- Scheduling: Sophisticated scheduler which calls thorn-provided functions as and when needed
- API: Interface for functions to be callable from one thorn by another
- CCL: Configuration language which describes necessary details about thorns to the flesh

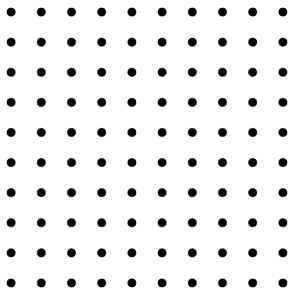


Cactus Structure
The Thorns

The Driver

- Special thorn
- Only one active for a run, choose at starttime
- The only code (almost) dealing with parallelism
- Other thorns access parallelism via API
- Underlying parallel layer transparent to application thorns
- Examples
  - PUGH: unigrid, part of the Cactus computational toolkit
  - Carpet: mesh refinement, `http://www.carpetcode.org`

Grid functions

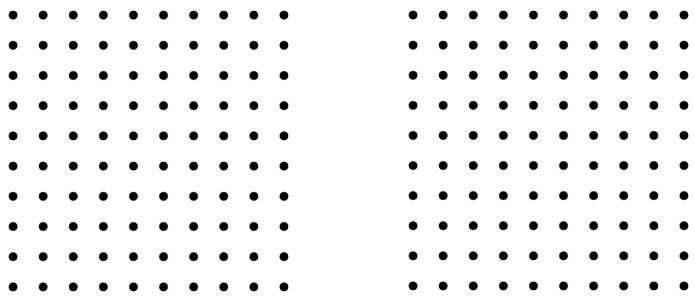


Cactus provides methods to

- Distribute variables across processes (grid function)
- Synchronize processor domain boundaries between processes
- Compute reductions across grid functions
- Actual implementation in driver thorn

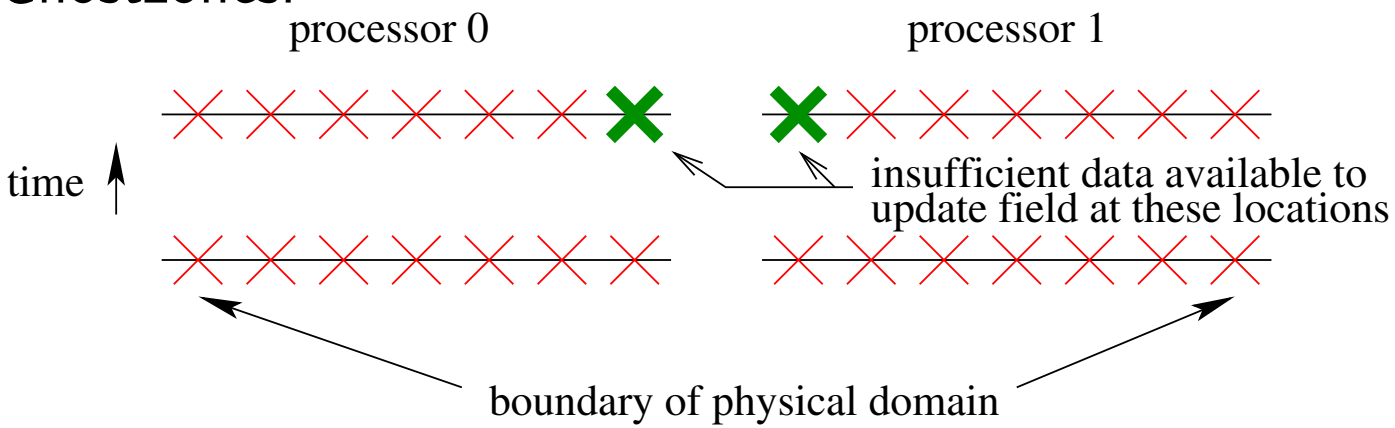
Ghost zones

- Grid variables: distributed across processes
- Assumption: Most work done (quasi-) locally: True for hyperbolic and parabolic problems
- Split of computational domain into blocks
- Only communication at the borders (faces)
- At least stencil size many ghostzones

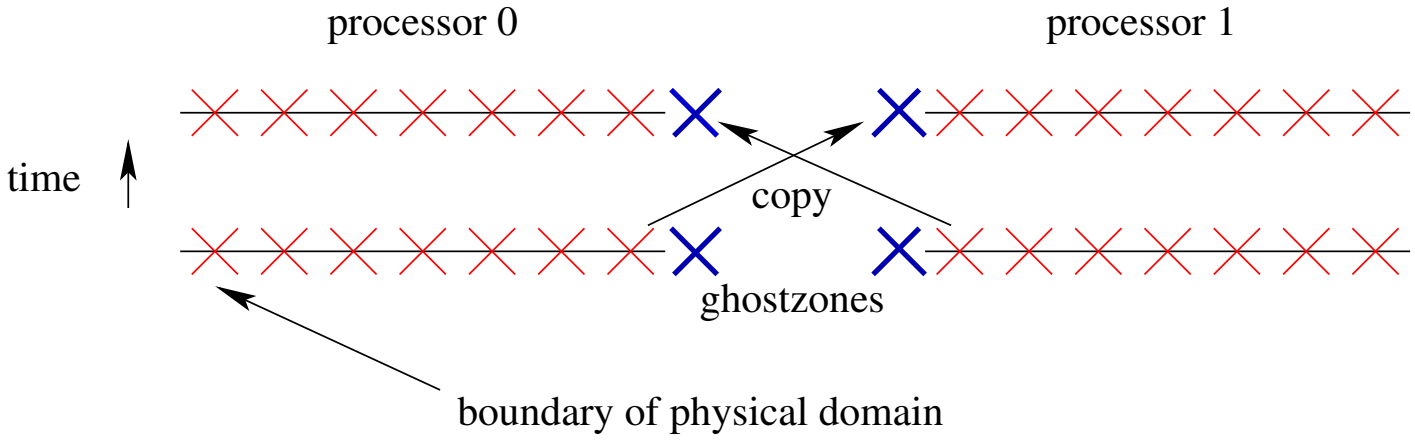


Ghost zone example

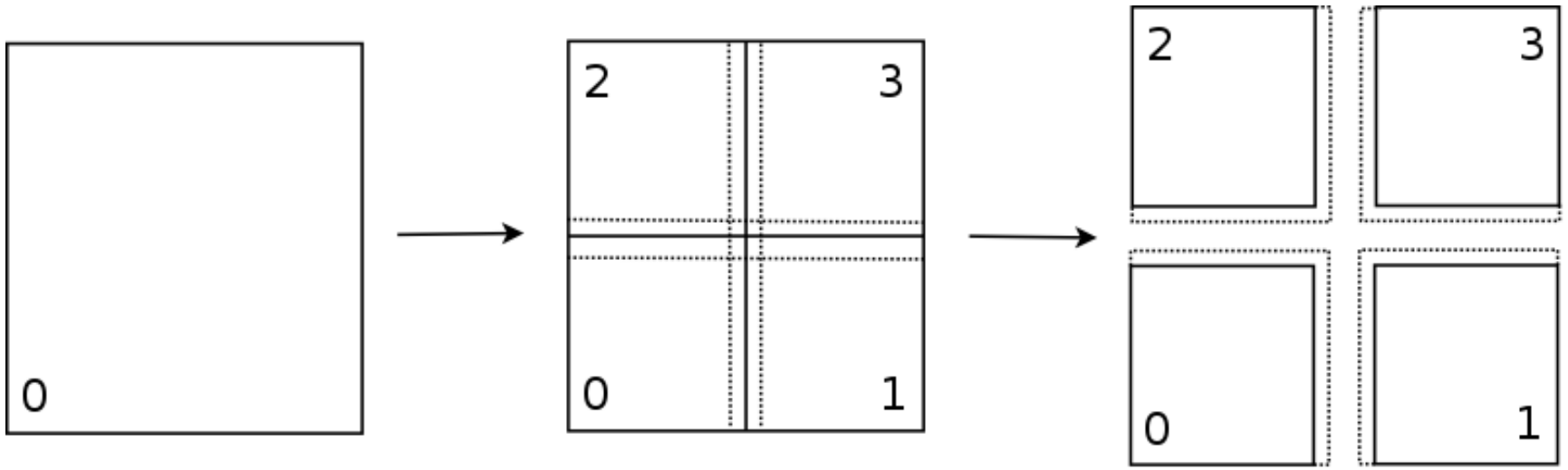
Without Ghostzones:



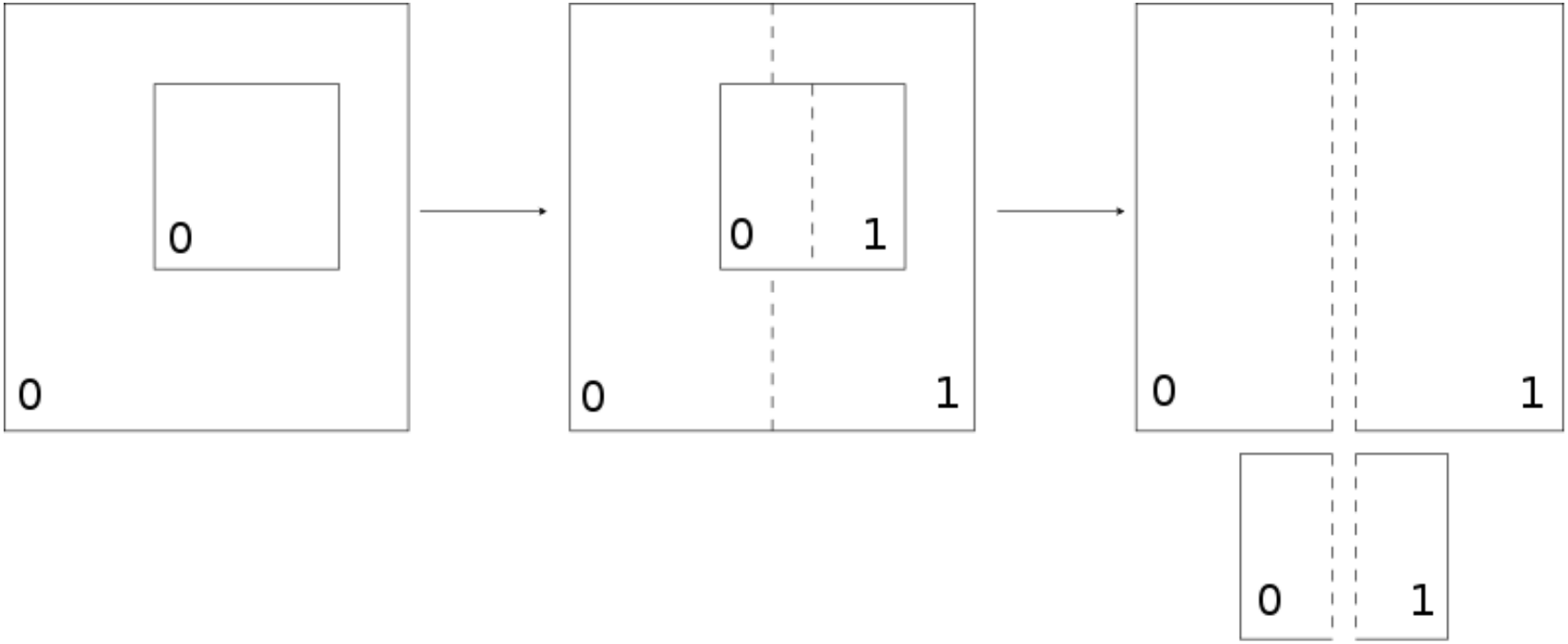
With Ghostzones:



Domain decomposition



Mesh refinement decomposition



Arrangements

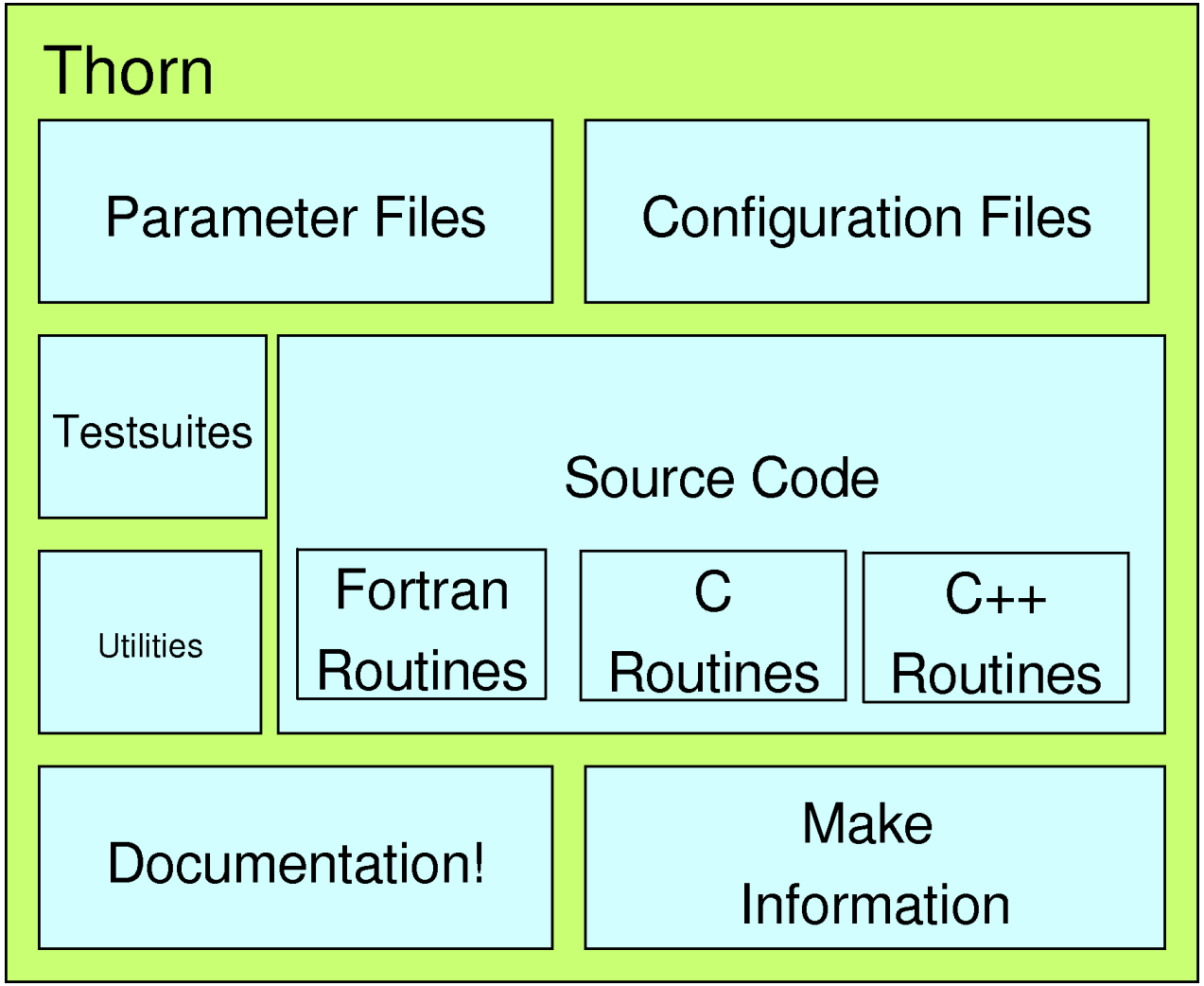
- Group of thorns
- Organizational convenience
- Something in common:
  - Related functionality
  - Same author(s), research group
- Toolkit: Collection of Arrangements

Directory structure:

```
Cactus
`-- arrangements
    |-- Arrangement-A
    |   |-- Thorn-A1
    |   `-- Thorn-A2
    `-- Arrangement-B
        |-- Thorn-B1
        `-- Thorn-B2
```

Thorn Structure

Inside view of a plug-in module, or thorn for Cactus



Thorn Structure

Directory structure:

```
Cactus
`-- arrangements
    `-- Introduction
        `-- HelloWorld
            |-- interface.ccl
            |-- param.ccl
            |-- schedule.ccl
            |-- README
            |-- doc
            |   `-- documentation.tex
            |-- src
            |   |-- HelloWorld.c
            |   `-- make.code.defn
            |-- test
            `-- utils
```

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Thorn Specification

Three configuration files per thorn:

- interface.ccl declares:
  - an 'implementation' name
  - inheritance relationships between thorns
  - Thorn variables
  - Global functions, both provided and used

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  - Which variables should be syncronized when

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- param.ccl declares:
  - Runtime parameters for the thorn
  - Use/extension of parameters of other thorns

interface.ccl

Variables:

- Flesh needs to know about thorn variables for which it has to care about allocation, parallelism, inter-thorn use
- Scopes: public, private
- Many different basic types (double, integer, string, ...
- Different 'group types' (grid functions, grid arrays, scalars, ...)
- Different 'tags' (not to be checkpointed, vector types, ...)

Example interface.ccl

```
IMPLEMENTS: wavetoy

INHERITS: grid

PUBLIC:

REAL scalarevolve TYPE=gf TIMELEVELS=3
{
  phi
} "The evolved scalar field"
```

Example interface.ccl cont.

```
CCTK_INT FUNCTION Boundary_SelectVarForBC (
        CCTK_POINTER_TO_CONST IN cctkGH,
        CCTK_INT IN faces,
        CCTK_INT IN boundary_width,
        CCTK_INT IN options_handle,
        CCTK_STRING IN var_name,
        CCTK_STRING IN bc_name
        )

REQUIRES FUNCTION Boundary_SelectVarForBC
```

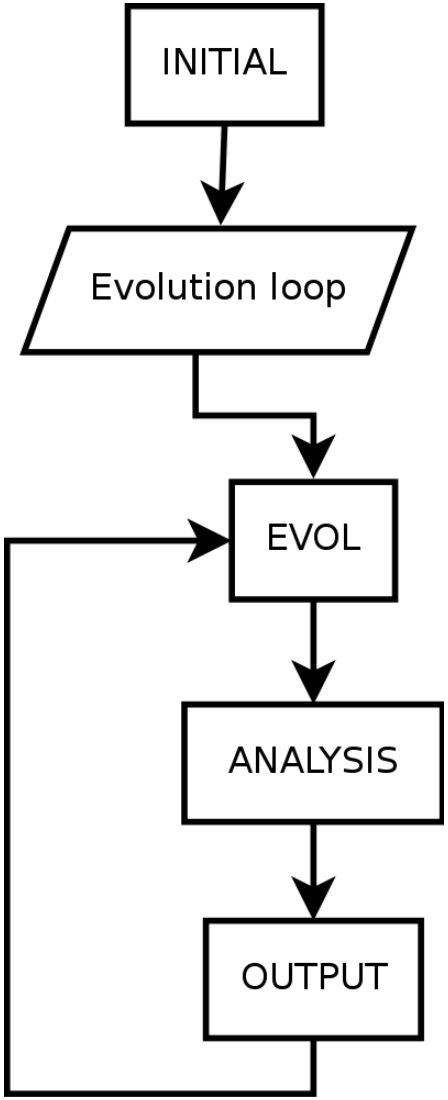
schedule.ccl

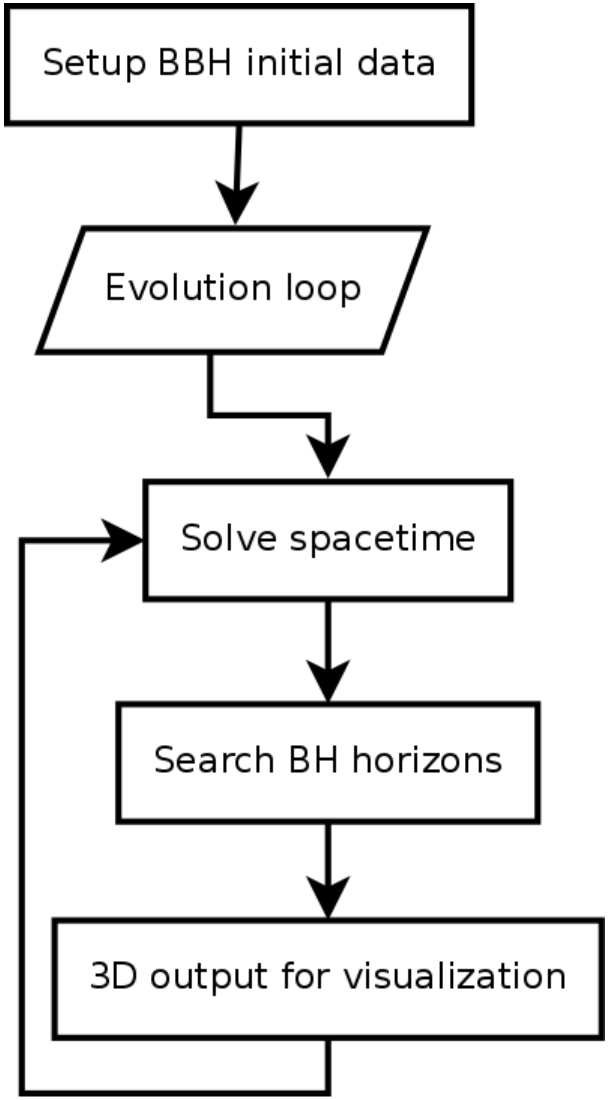
- Flesh contains a flexible rule based scheduler
- Order is prescribed in `schedule.ccl`
- Scheduler also handles when variables are allocated, freed or syncronized between parallel processes
- Functions or groups of functions can be
  - grouped and whole group scheduled
  - scheduled before or after each other
  - scheduled depending on parameters
  - scheduled while some condition is true
- Flesh scheduler sorts all rules and flags an error for inconsistent schedule requests.

`schedule.ccl` cont.

- Hierarchy: using schedule groups leads to a *schedule tree*
- Execution order: can schedule `BEFORE` or `AFTER` other items
  e.g.: take time step after calculating RHS
- Loops: can schedule `WHILE` a condition is true
  e.g.: loop while error is too large
- Conditions: can schedule `if` a parameter is set
  e.g.: choose between boundary conditions
- Perform analysis at run time: `TRIGGERS` statements: call routine only if result is needed for I/O

Example scheduling tree





Example schedule.ccl

```
SCHEDULE WaveToyC_Evolution AT evol
{
  LANG: C
} "Evolution of 3D wave equation"

SCHEDULE GROUP WaveToy_Boundaries AT evol \
               AFTER WaveToyC_Evolution
{
} "Boundaries of 3D wave equation"

STORAGE: scalarevolve[3]
```

param.ccl

- Definition of parameters
- Scopes: Global, Restricted, Private
- Thorns can use and extened each others parameters
- Different types (double, integer, string, keyword, . . .)
- Range checking and validation
- Steerablility at runtime

Example param.ccl

```
SHARES: grid
USES KEYWORD type

PRIVATE:
KEYWORD initial_data "Type of initial data"
{
    "plane"    :: "Plane wave"
    "gaussian" :: "Gaussian wave"
} "gaussian"

REAL radius "The radius of the gaussian wave"
{
    0:* :: "Positive"
} 0.0
```

Examples

Hello World, Standalone

Standalone in C:

```
#include <stdio.h>
int main(void)
{
  printf("Hello World!\n");
  return 0;
}
```

Hello World Thorn

- interface.ccl:

```
implements: HelloWorld
```

- schedule.ccl:

```
schedule HelloWorld at CCTK_EVOL
{
  LANG: C
} "Print Hello World message"
```

- param.ccl: empty
- REAME:

```
Cactus Code Thorn HelloWorld
Author(s)    : Frank Löffler <knarf@cct.lsu.edu>
Maintainer(s): Frank Löffler <knarf@cct.lsu.edu>
Licence      : GPL
--------------------------------------------------------------------------

1. Purpose

Example thorn for tutorial Introduction to Cactus
```

Hello World Thorn cont.

- src/HelloWorld.c:

```
#include "cctk.h"
#include "cctk_Arguments.h"

void HelloWorld(CCTK_ARGUMENTS)
{
  DECLARE_CCTK_ARGUMENTS
  CCTK_INFO("Hello World!");
  return;
}
```

- make.code.defn:

```
SRCS = HelloWorld.c
```

Hello World Thorn

- parameter file:

```
ActiveThorns = "HelloWorld"
Cactus::cctk_itlast = 10
```

- run: `[mpirun] <cactus executable> <parameter file>`

Hello World Thorn

- Screen output:

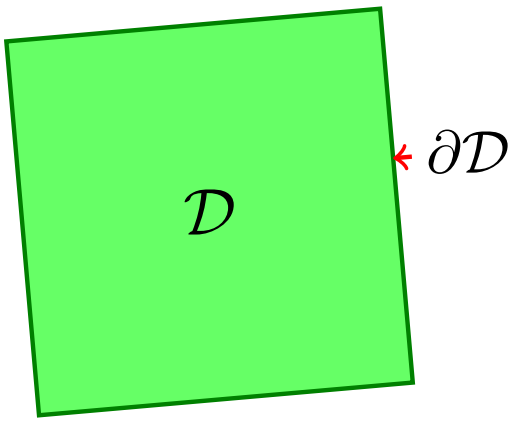
```
      10
  1   0101       ************************
  01  1010 10      The Cactus Code V4.0
 1010 1101 011      www.cactuscode.org
  1001 100101    ************************
    00010101
     100011     (c) Copyright The Authors
      0100      GNU Licensed. No Warranty
      0101

Cactus version:    4.0.b17
Compile date:      May 06 2009 (13:15:01)
Run date:          May 06 2009 (13:15:54-0500)
[...]

Activating thorn Cactus...Success -> active implementation Cactus
Activation requested for
--->HelloWorld<---
Activating thorn HelloWorld...Success -> active implementation HelloWorld
--------------------------------------------------------------------------------
INFO (HelloWorld): Hello World!
INFO (HelloWorld): Hello World!
[...] 8x
--------------------------------------------------------------------------------
Done.
```

WaveToy Thorn: Wave Equation

For a given source function $S(x, y, z, t)$ find a scalar wave field $\varphi(x, y, z, t)$ inside the domain $\mathcal{D}$ with a boundary condition:



- inside $\mathcal{D}$:

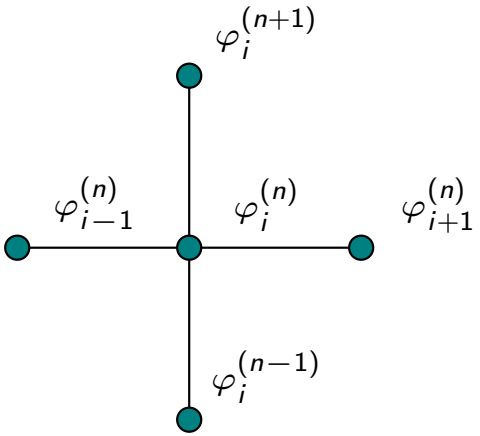
$$\frac{\partial^2 \varphi}{\partial t^2} = c^2 \Delta \varphi + S$$

- on the boundary $\partial\mathcal{D}$:

$$\varphi|_{\partial\mathcal{D}} = \varphi(t = 0)$$

WaveToy Thorn: Discretization

Discretization:
approximating continuous function $\varphi(x,t)$ with a grid function $\varphi_i^{(n)}$:



$$\frac{\partial^2\varphi}{\partial t^2} = c^2(\partial_x^2\varphi) + S$$

$$\Downarrow (c \equiv 1)$$

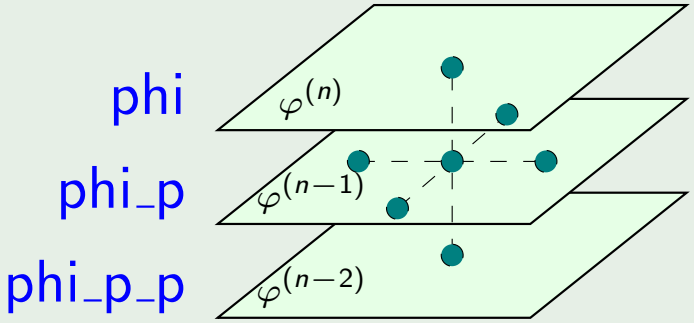
$$\frac{\varphi_i^{(n+1)} - 2\varphi_i^{(n)} + \varphi_i^{(n-1)}}{2\Delta t^2} = \frac{\varphi_{i+1}^{(n)} - 2\varphi_i^{(n)} + \varphi_{i-1}^{(n)}}{2\Delta x^2} + S_i^{(n)}$$

WaveToy Thorn

Thorn structure:

interface.ccl

- grid function phi[3]:



- Boundary_SelectVarForBC

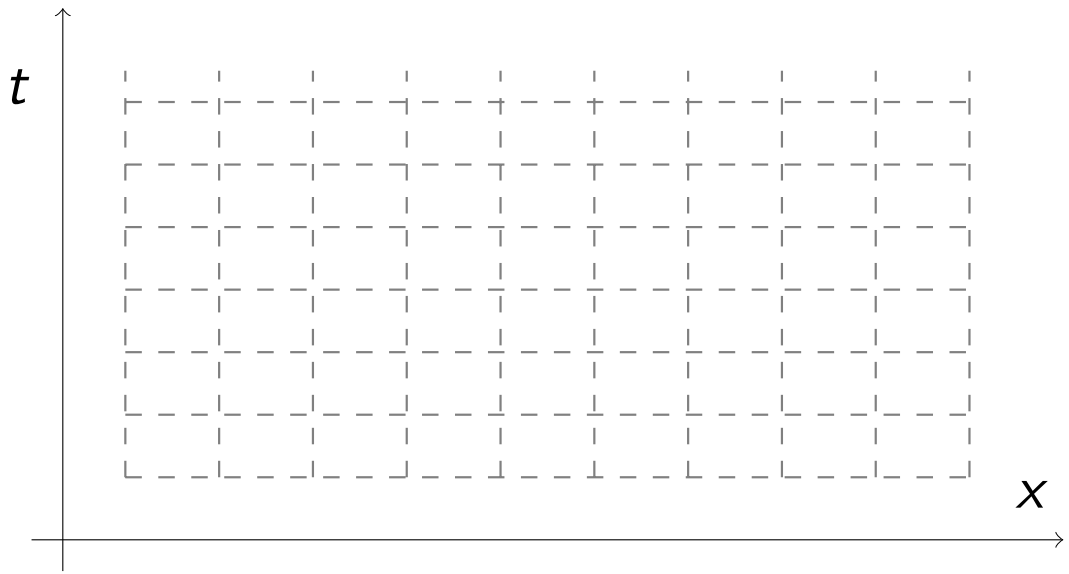
param.ccl

- Parameters of initial Gaussian pulse: amplitude A, radius R, width σ

schedule.ccl

- WaveToy_InitialData
- WaveToy_Evolution
- WaveToy_Boundaries

WaveToy Thorn: Algorithm Illustration



Grid structure
GF allocation

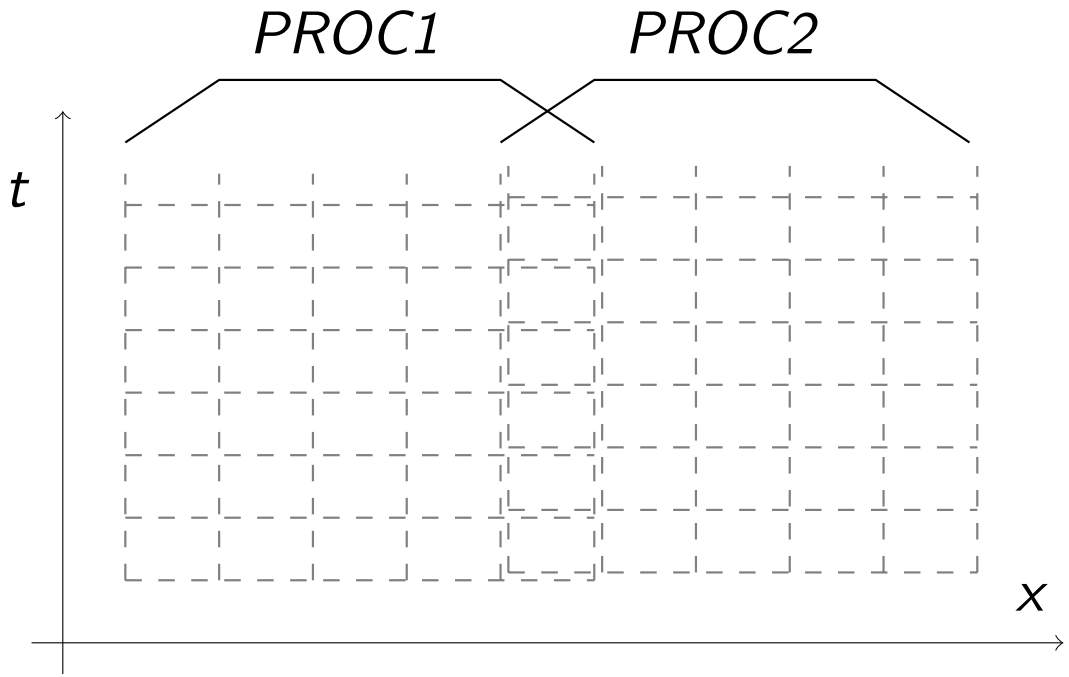
↓

Set up coords
Compute Δt
Initial data

↓

Rotate timelevels
Evolve GF, sync
Apply BCs
Output data

WaveToy Thorn: Algorithm Illustration



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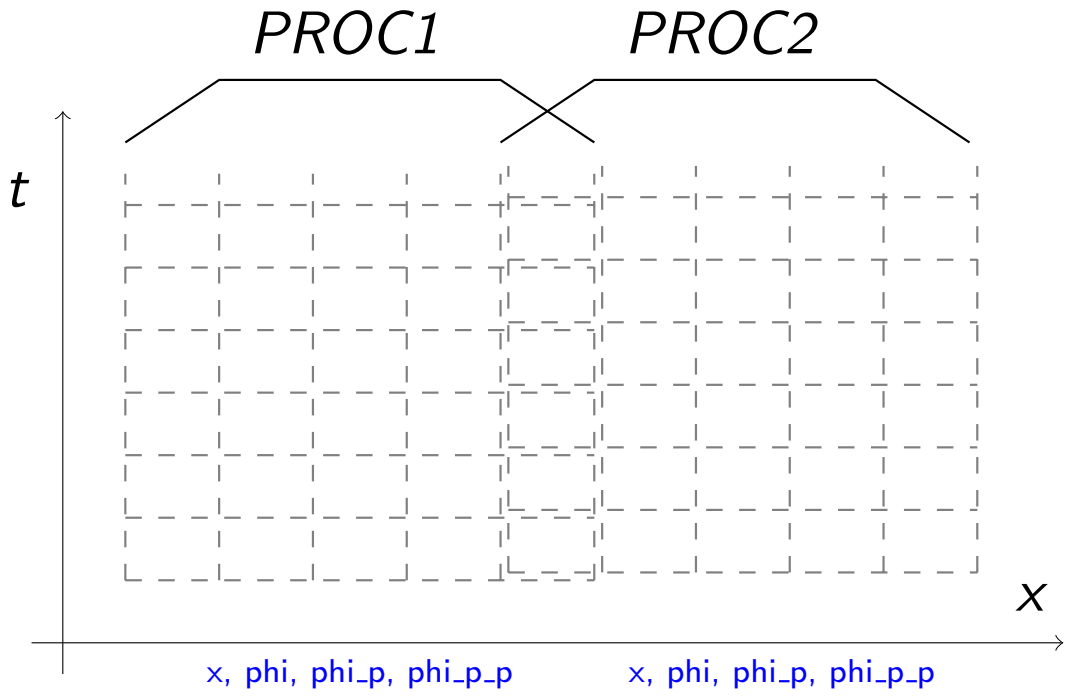

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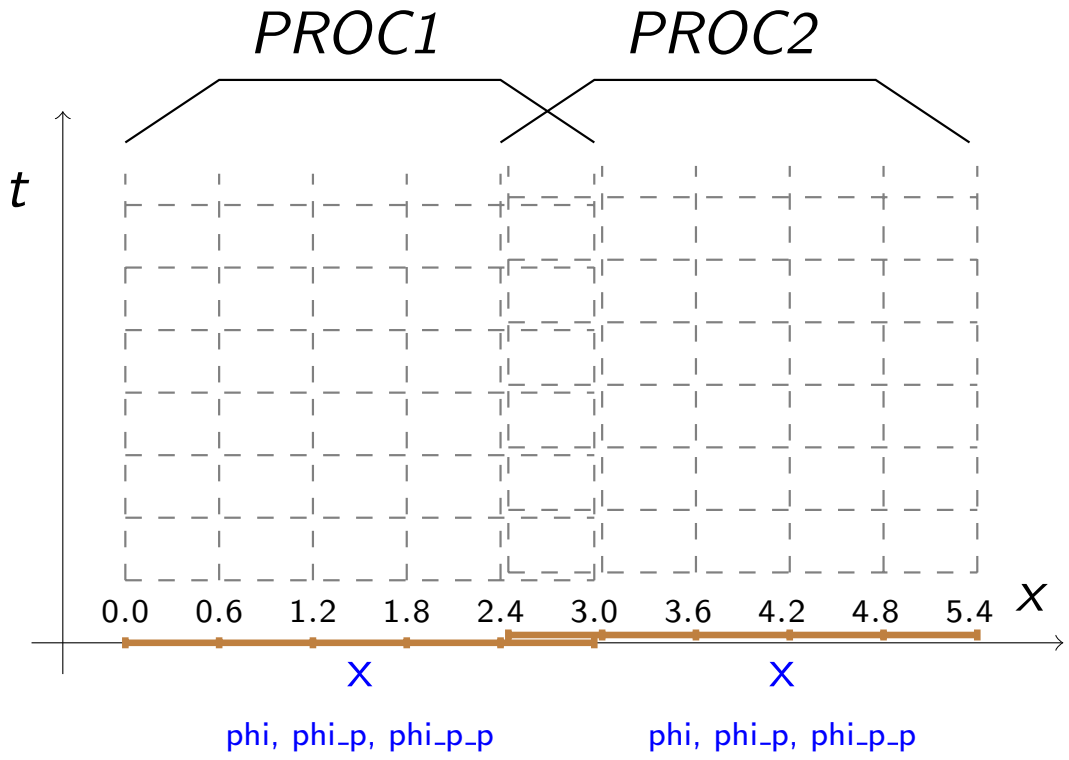

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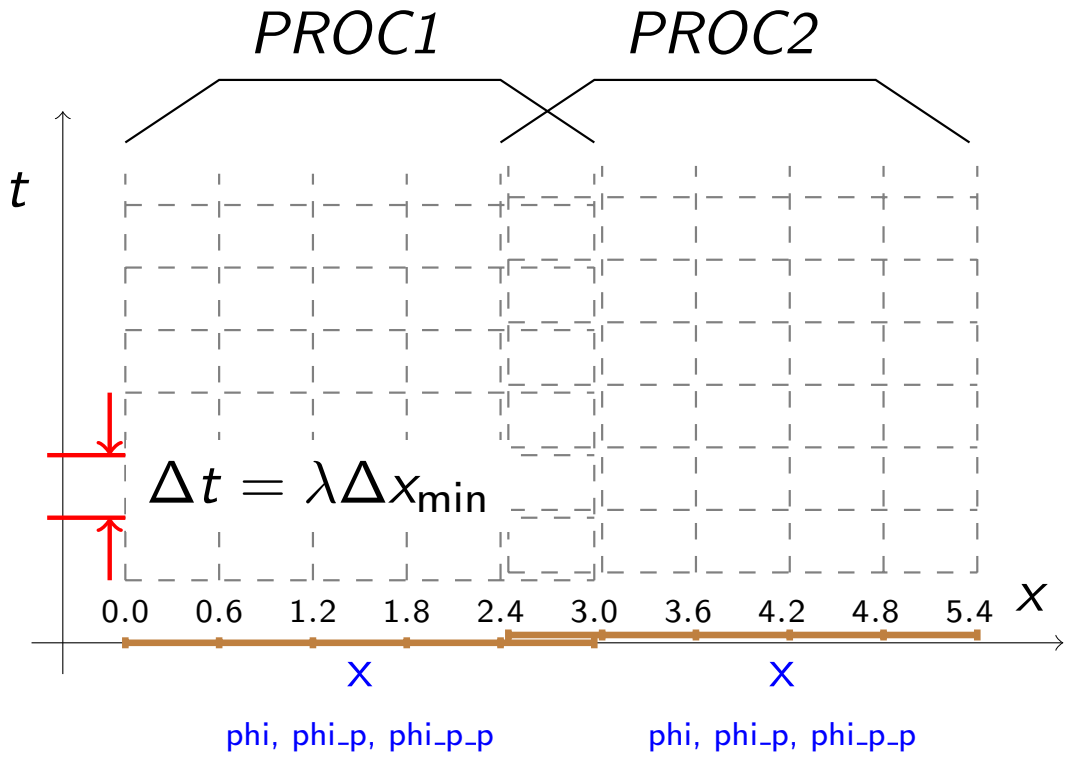

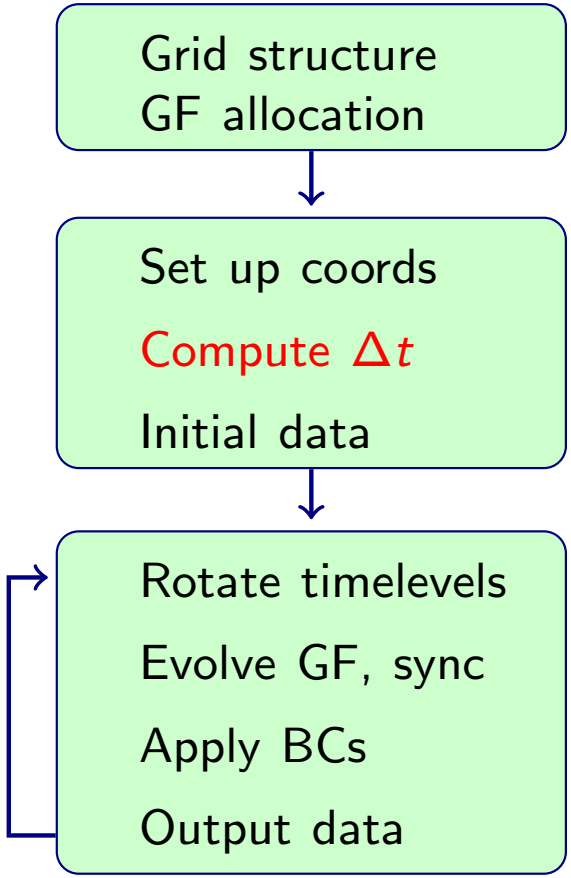

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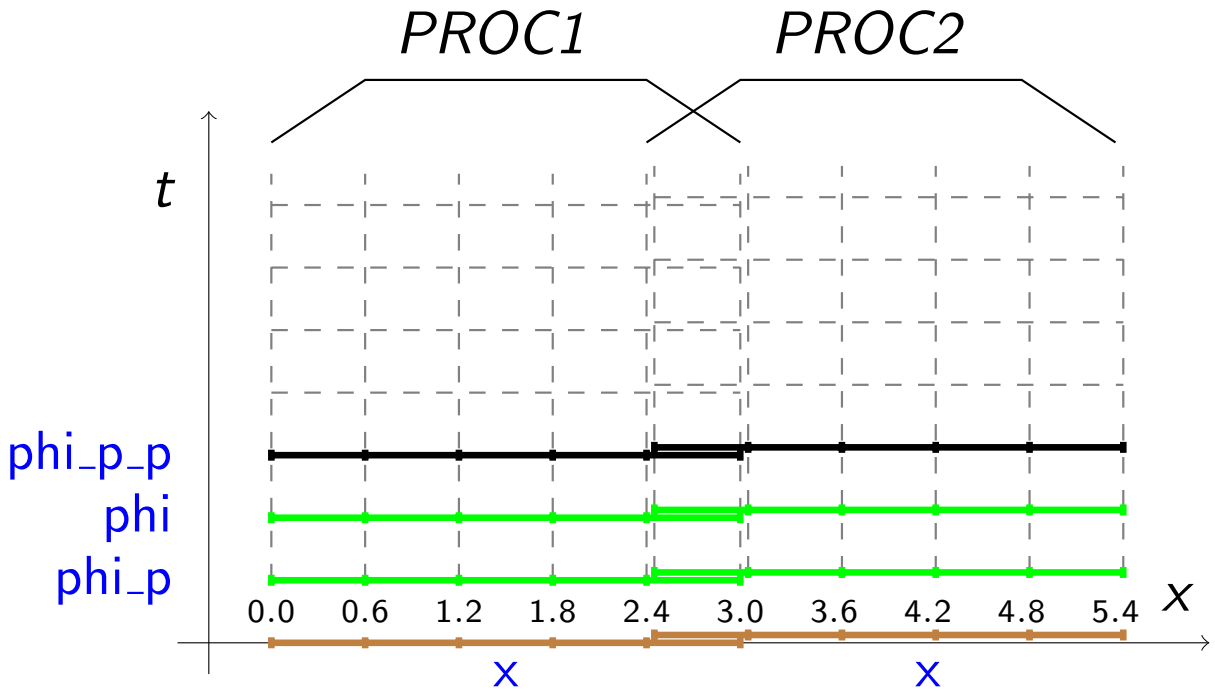

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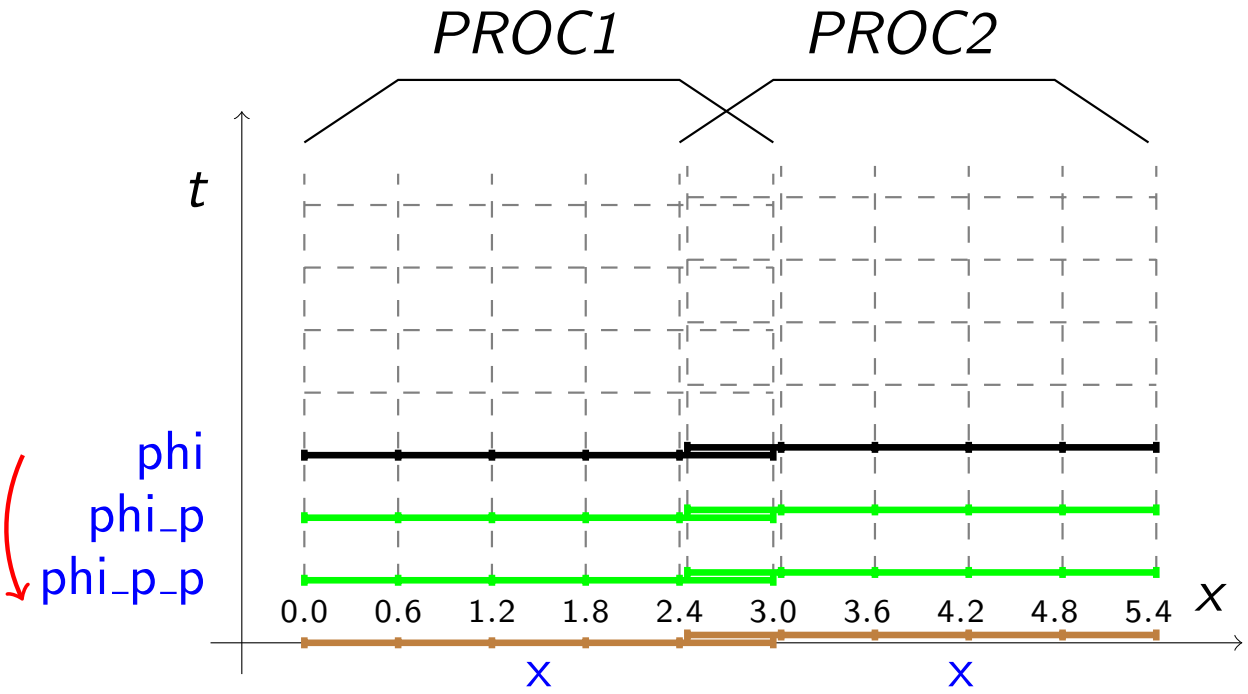

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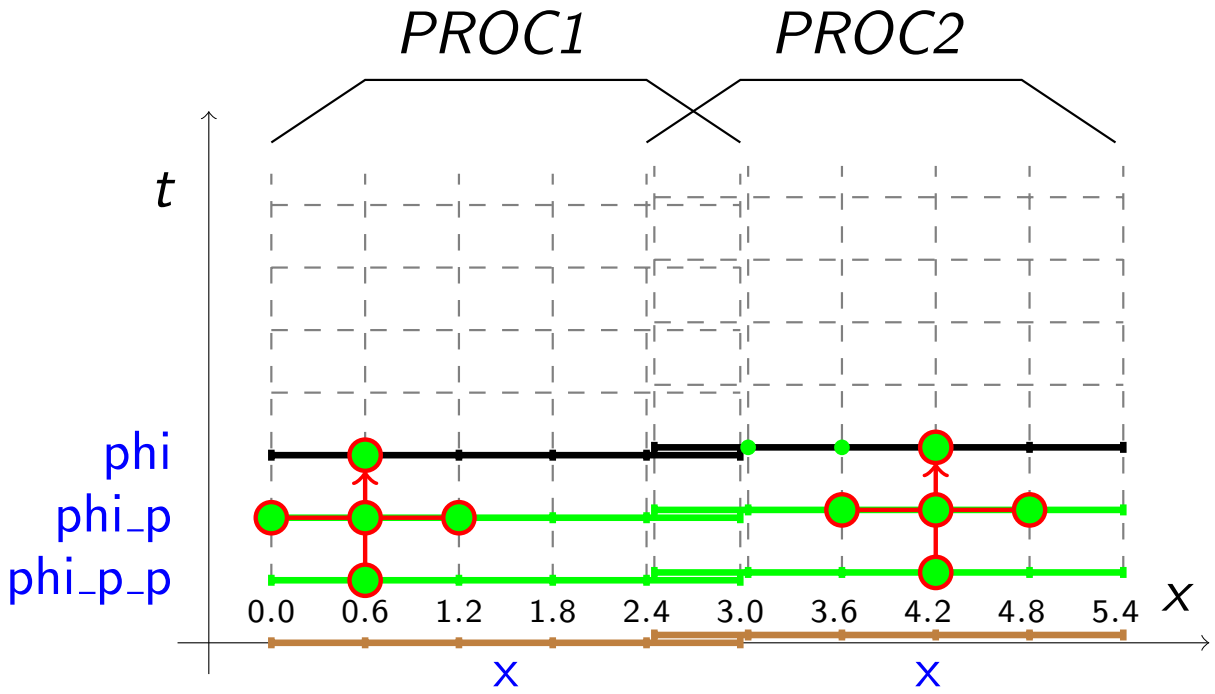

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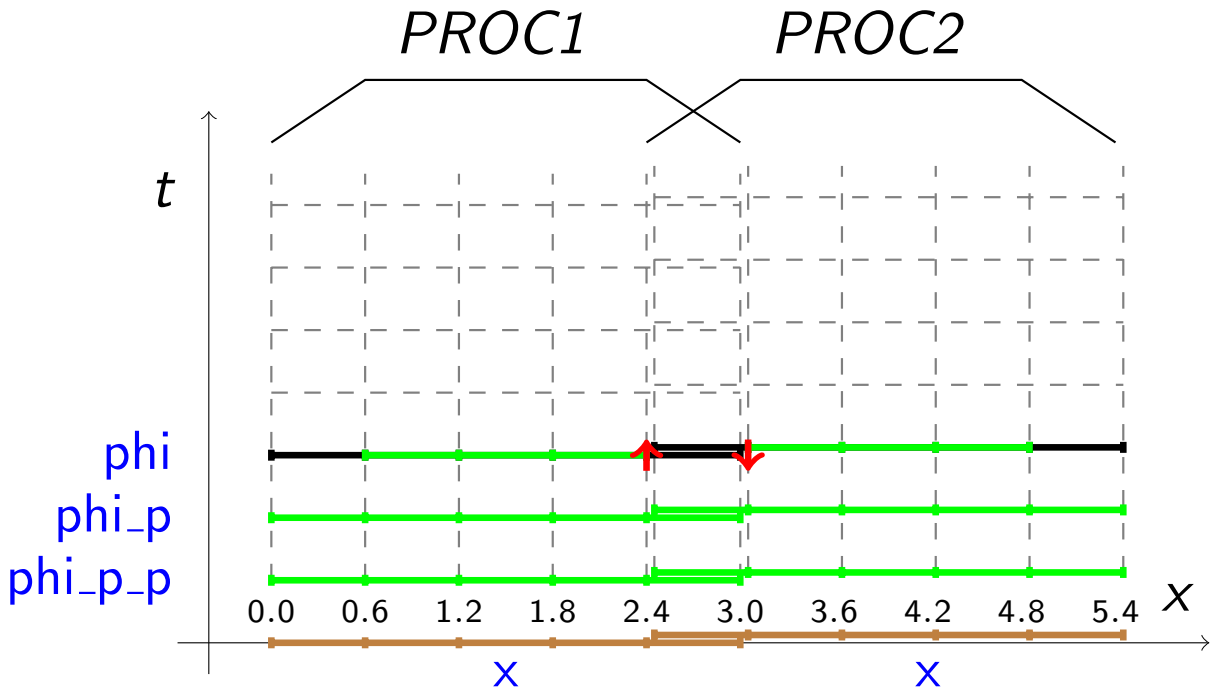

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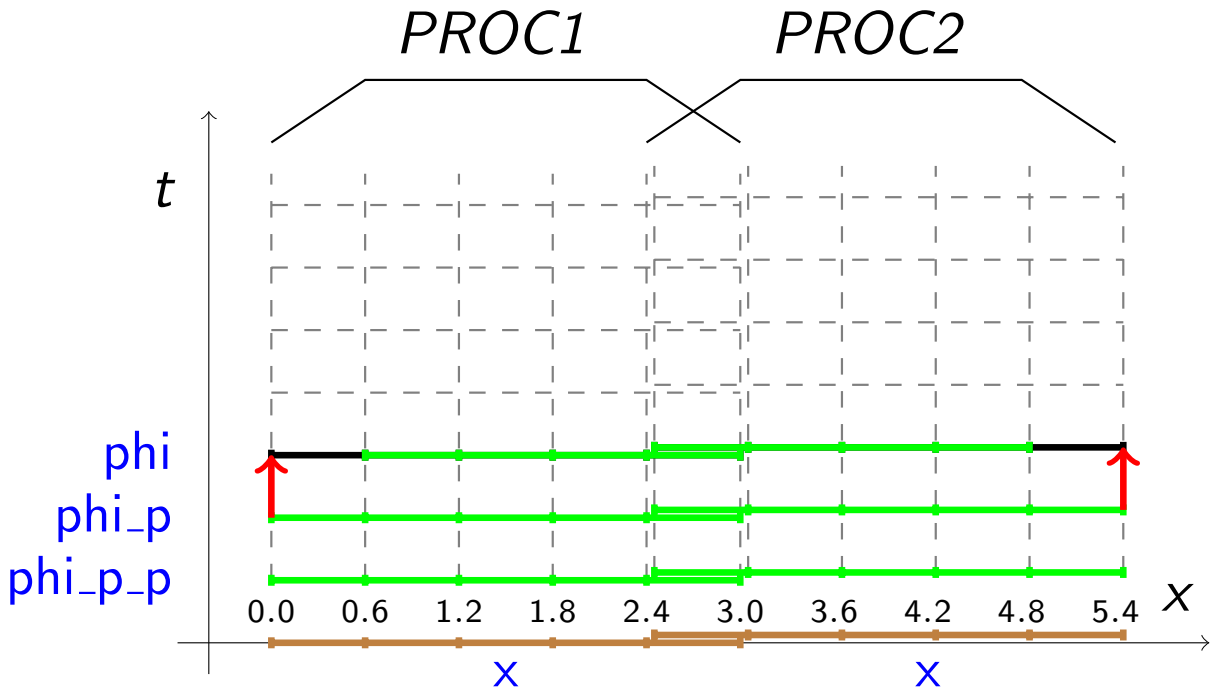

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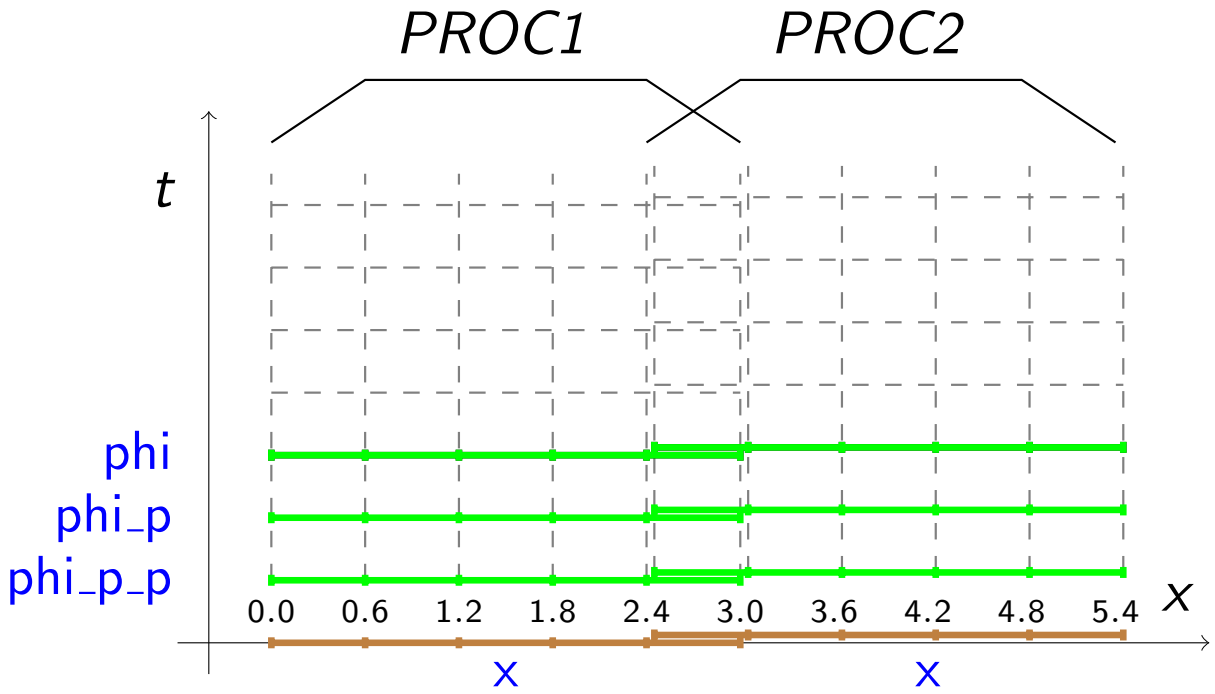

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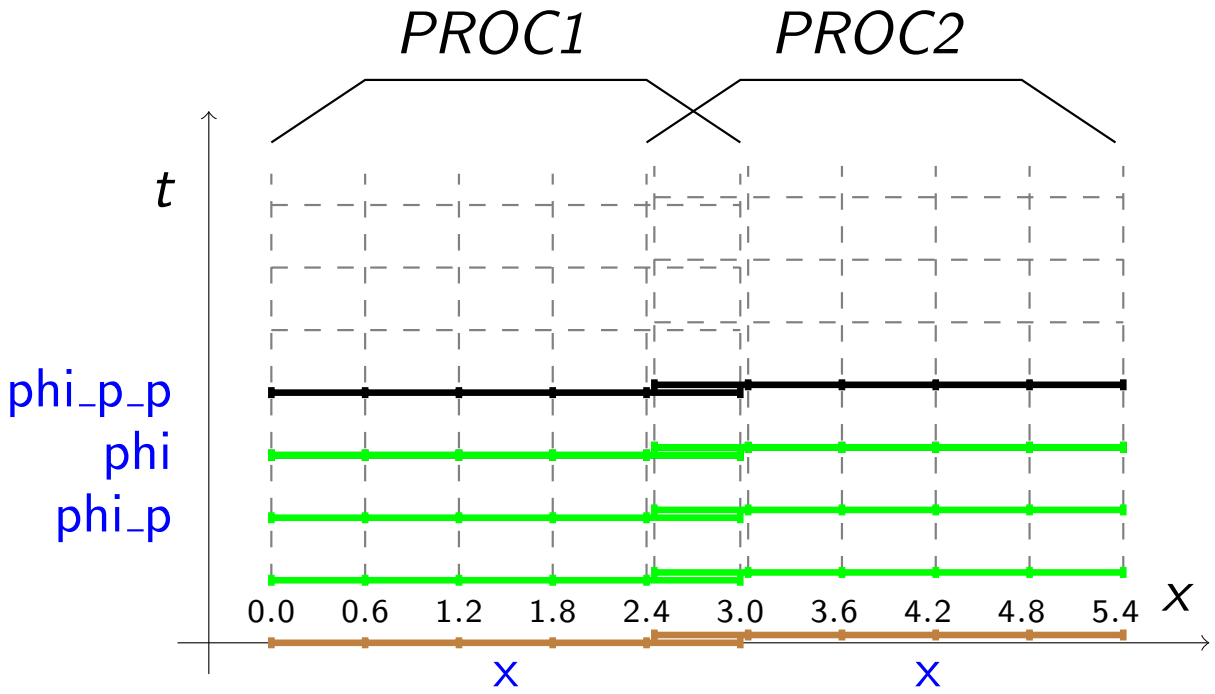

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WaveToy Thorn

Directory structure:

```
WaveToy/
|-- COPYRIGHT
|-- README
|-- configuration.ccl
|-- doc
|   `-- documentation.tex
|-- interface.ccl
|-- schedule.ccl
|-- param.ccl
`-- src
    |-- WaveToy.c
    `-- make.code.defn
```

WaveToy Thorn

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|-- param.ccl
`-- src
     |-- WaveToy.c
     `-- make.code.defn
```

WaveToy Thorn

- `interface.ccl`:

```
IMPLEMENTS: wavetoy_simple
INHERITS: grid

PUBLIC:

CCTK_REAL scalarevolve TYPE=gf TIMELEVELS=3
{
  phi
} "The evolved scalar field"

CCTK_INT FUNCTION Boundary_SelectVarForBC( \
  CCTK_POINTER_TO_CONST IN GH, CCTK_INT IN faces, \
  CCTK_INT IN boundary_width, CCTK_INT IN table_handle, \
  CCTK_STRING IN var_name, CCTK_STRING IN bc_name)

REQUIRES FUNCTION Boundary_SelectVarForBC
```

WaveToy Thorn cont.

- `schedule.ccl`:

```
STORAGE: scalarevolve[3]

SCHEDULE WaveToy_InitialData AT CCTK_INITIAL
{
  LANG: C
} "Initial data for 3D wave equation"

SCHEDULE WaveToy_Evolution AT CCTK_EVOL
{
  LANG: C
  SYNC: scalarevolve
} "Evolution of 3D wave equation"

SCHEDULE WaveToy_Boundaries AT CCTK_EVOL AFTER WaveToy_Evolution
{
  LANG: C
} "Select boundary conditions for the evolved scalar"

SCHEDULE GROUP ApplyBCs as WaveToy_ApplyBCs AT CCTK_EVOL AFTER WaveToy_Boundaries
{
} "Apply boundary conditions"
```

WaveToy Thorn cont.

- param.ccl:

```
CCTK_REAL amplitude "The amplitude of the waves"
{
 *:* :: "Anything"
} 1.0

CCTK_REAL radius "The radius of the gaussian wave"
{
 0:* :: "Positive"
} 0.0

CCTK_REAL sigma "The sigma for the gaussian wave"
{
 0:* :: "Positive"
} 0.1
```

WaveToy Thorn cont.

- Example parameter file:

```
Cactus::cctk_run_title = "Simple WaveToy"

ActiveThorns = "time boundary Carpet CarpetLib CartGrid3D"
ActiveThorns = "CoordBase ioutil CarpetIOBasic CarpetIOASCII"
ActiveThorns = "CarpetIOHDF5 SymBase wavetoy"

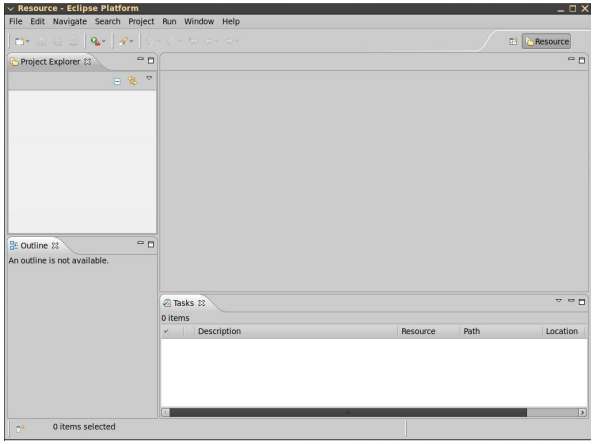
cactus::cctk_itlast = 10000
time::dtfac = 0.5

IO::out_dir             = $parfile
IOBasic::outInfo_every  = 1
IOASCII::out1D_every    = 1
IOASCII::out1D_vars     = "wavetoy_simple::phi"

iohdf5::out_every = 10
iohdf5::out_vars        = "grid::coordinates{out_every=10000000} wavetoy_simple::phi"
```

Mojave: Eclipse Plugin for Cactus

Mojave is an Eclipse plug-in for Cactus. Eclipse is an open-source multi-platform graphical IDE written in Java for development in Java, C/C++, COBOL, and PHP. More information about Eclipse, including downloads, can be found at http://www.eclipse.org.



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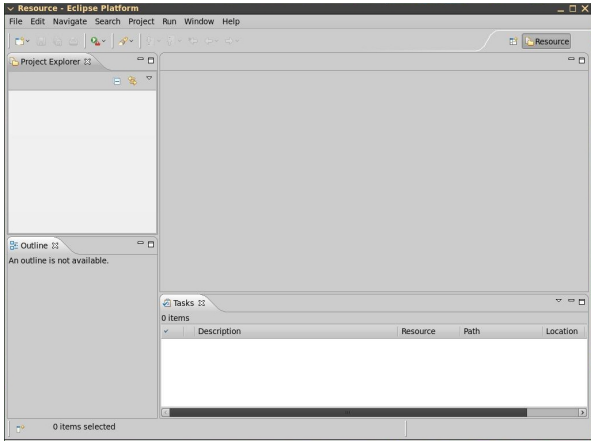

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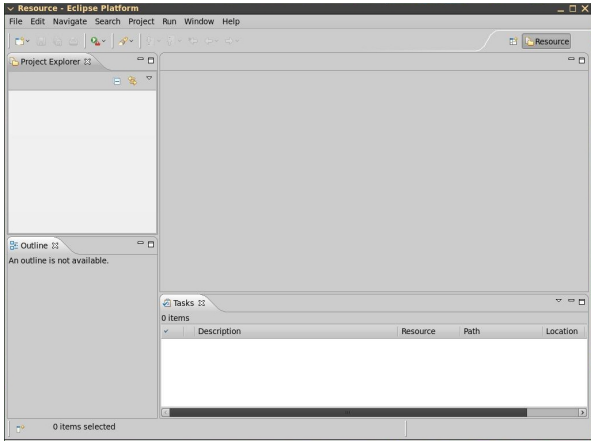

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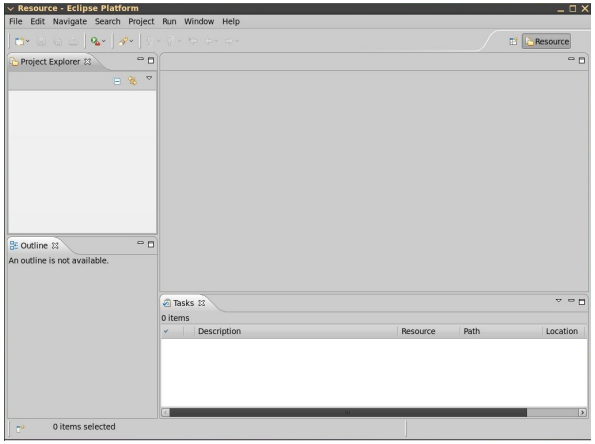

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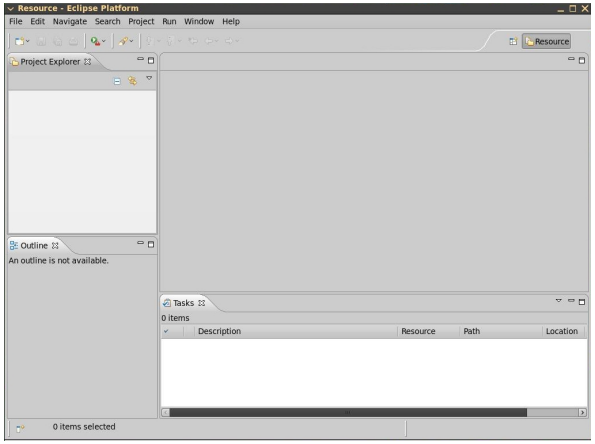

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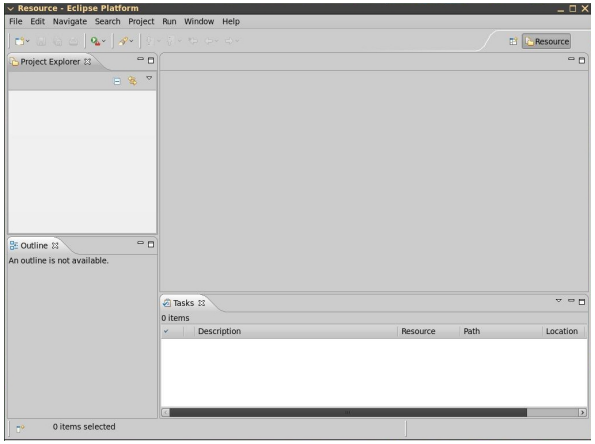

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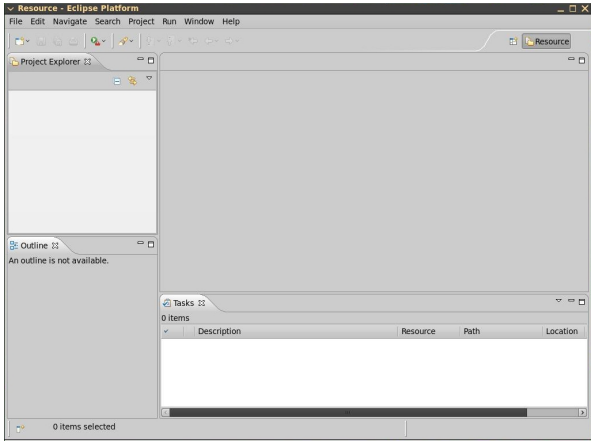

The Eclipse IDE.

- open-source
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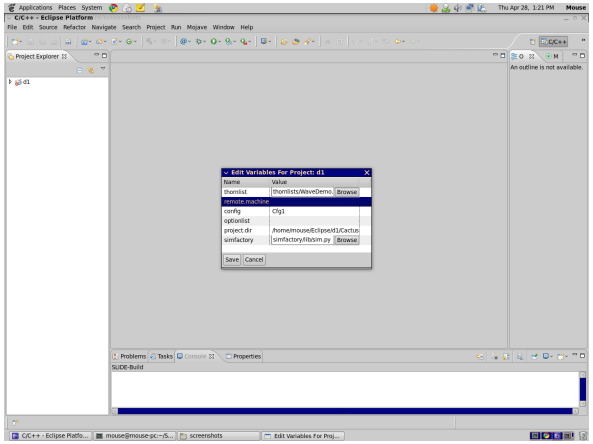
- extensible
- advanced editor
- multiple layouts
- **SVN interface**

Mojave: Features

Mojave automatically downloads Cactus thornlists and prepares an environment for development. Mojave options are available through an Eclipse menu button. Through the Mojave menu, one may edit variables, perform builds, and run projects.



Mojave.

- **edit variables**

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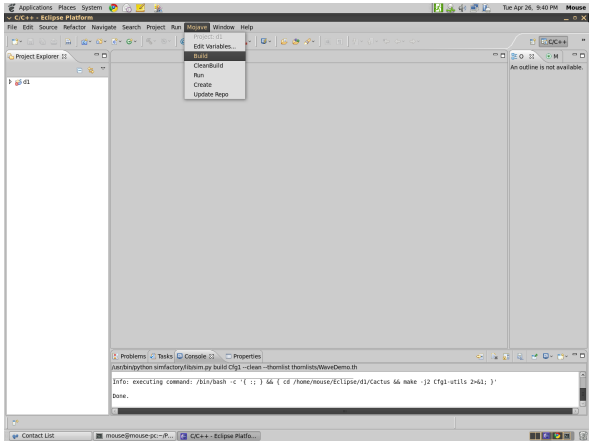

Mojave.

- edit variables
- **build** the project

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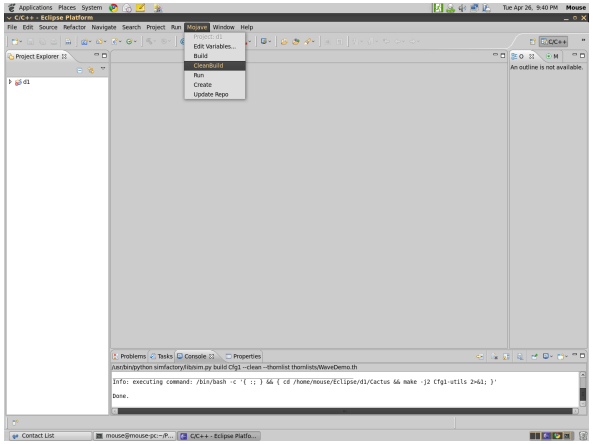

Mojave.

- edit variables
- build
- do a **clean build**

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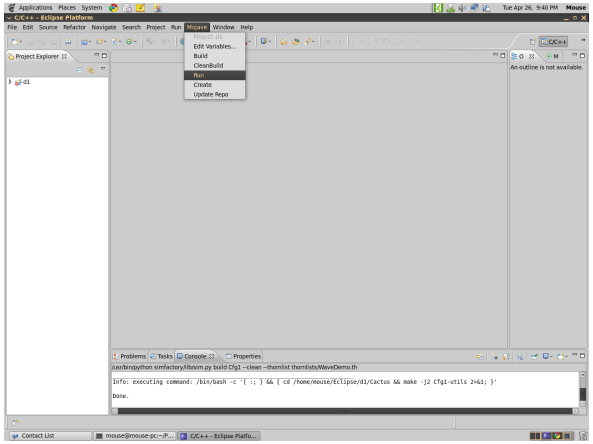

Mojave.

- edit variables
- build
- clean build
- **run** the executable

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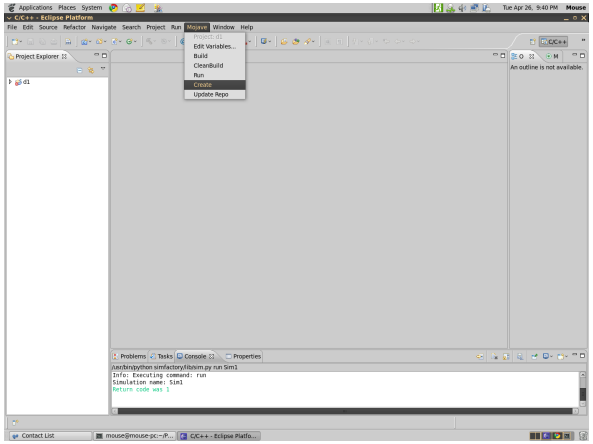

Mojave.

- edit variables
- build
- clean build
- run
- **create** a subfolder

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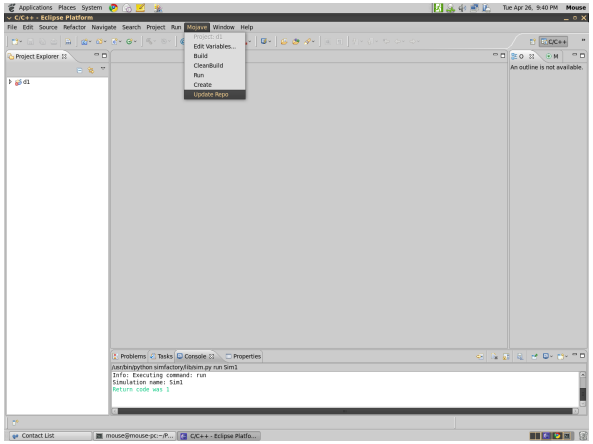
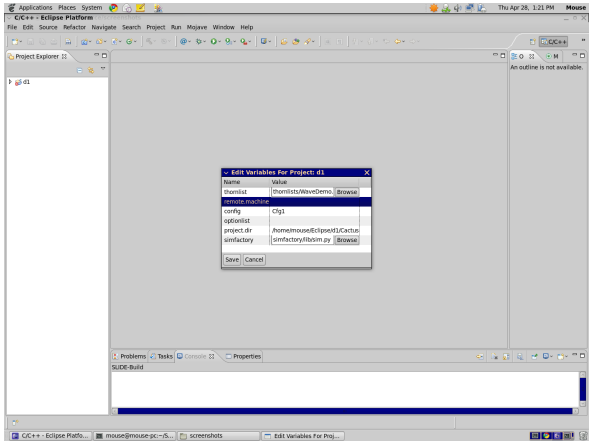


Mojave.

- edit variables
- build
- clean build
- run
- create
- **update** the repository

Mojave: Remote Build

Mojave automatically downloads Cactus thornlists and prepares an environment for development. Mojave options are available through an Eclipse menu button. Through the Mojave menu, one may edit variables, perform builds, and run projects. It can even build remotely!

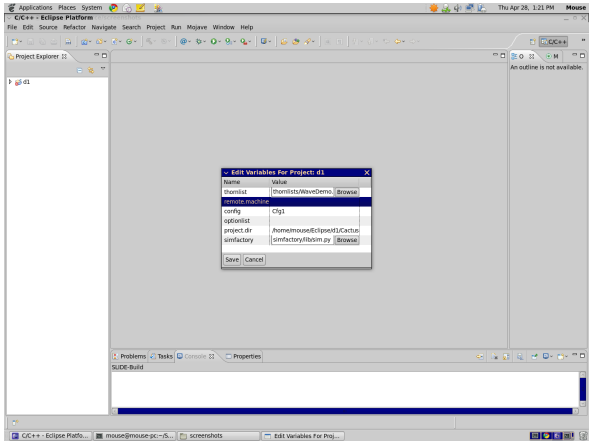


Mojave.

- edit variables
- **build** remotely
- clean build
- run
- create
- update

Mojave: Remote Build

To build remotely, under **Mojave - Edit Variables...**, simply set the variable remote.machine to the host name of the target machine, then click **Mojave - Build**. Eclipse will automatically build the project on the target machine, provided the target machine is configured to allow remote builds.



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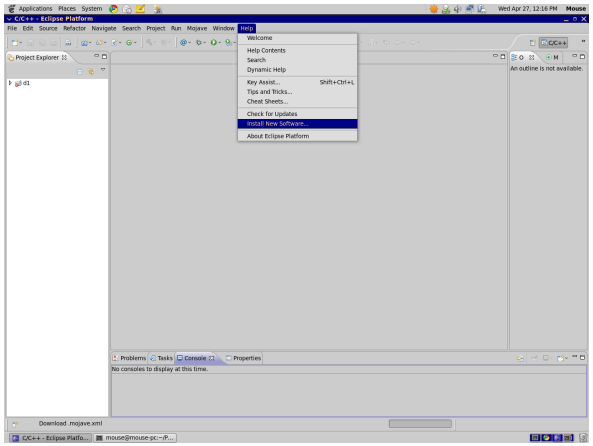
Mojave: Installation

The Mojave plugin is easy to install. Simply:



Step 1.

- Click **Help** → **Install New Software**.

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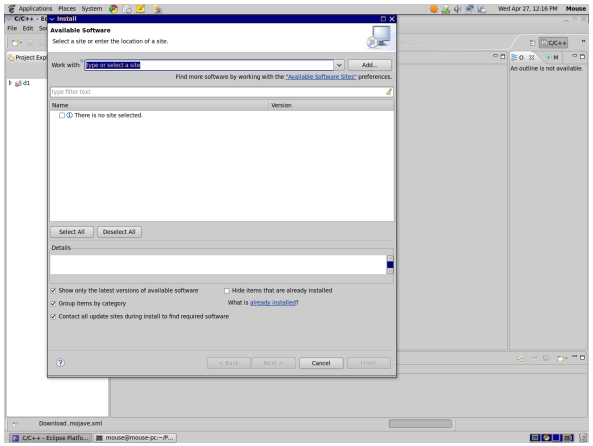

Step 2.

- Click **Help** → **Install New Software**.
- In the 'Install' dialogue, click the **Add** button.

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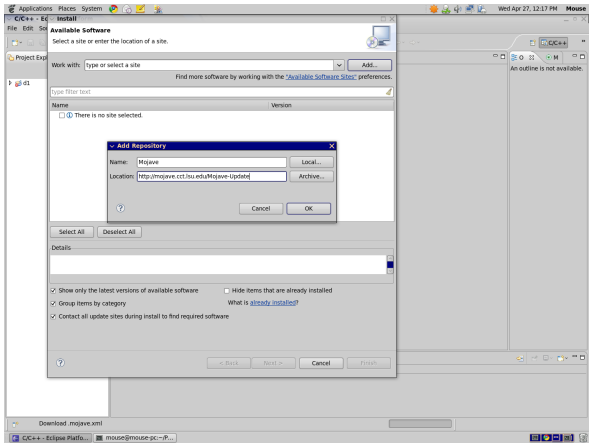

Step 3.

- Click **Help** → **Install New Software**.
- In the 'Install' dialogue, click the **Add** button.
- In the " dialogue, type *Mojave* for the Name field and for the URL, http://mojave.cct.lsu.edu/Mojave-Update.

Mojave: Installation

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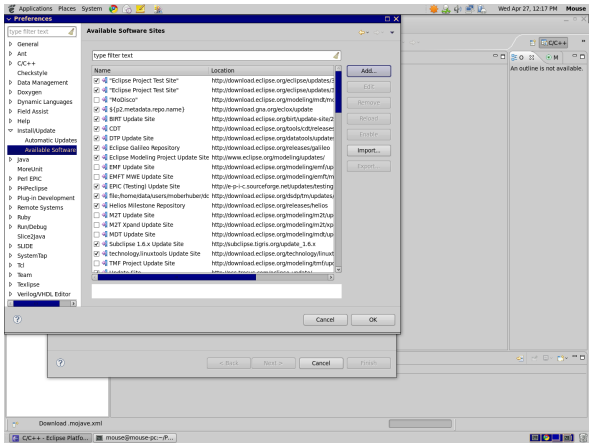

Step 4.

- Click the Available Software Sites link. In the dialogue window which opens, mark all checkboxes.

Mojave: Installation

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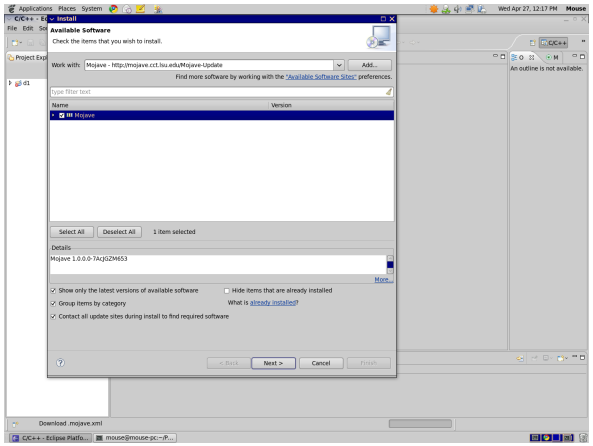

Step 5.

- Click the Available Software Sites link. In the dialogue window which opens, mark all checkboxes.
- Select the Mojave site from the drop-down list of sites, then mark the checkbox for 'Mojave' in the list of software packages. Click **Next**.

Mojave: Installation

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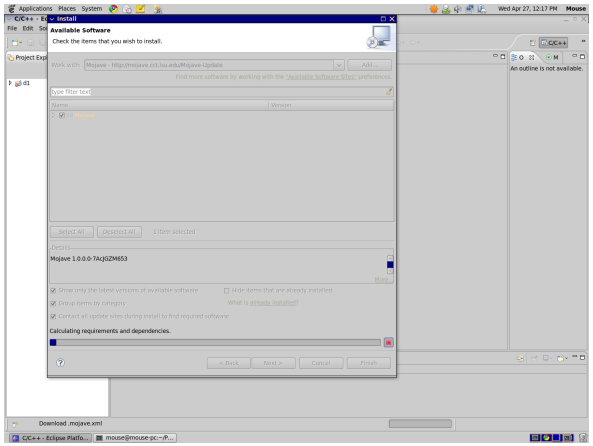


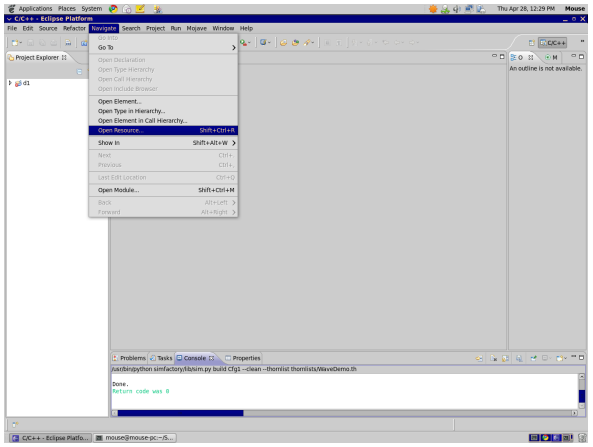
Step 6.

- Eclipse will automatically calculate dependencies and install the Mojave plug-in. This may take a while.

Mojave: Development

The Mojave menu code resides in an XML file, .mojave.xml. As the XML file shows, the Mojave menu items are front-ends to commands and scripts used in Cactus operations. How to open the file:

- Hit **Ctrl+Shift+R** or click on **Navigate - Open Resource** and type .mojave.xml in the text box.



Finding .mojave.xml.

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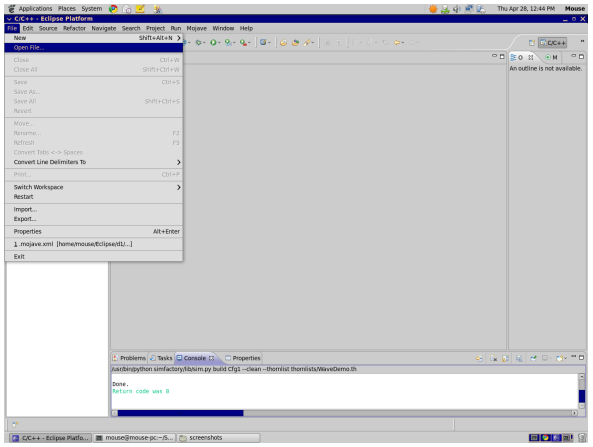
- If .mojave.xml does not appear, go to **File - Open File** ...



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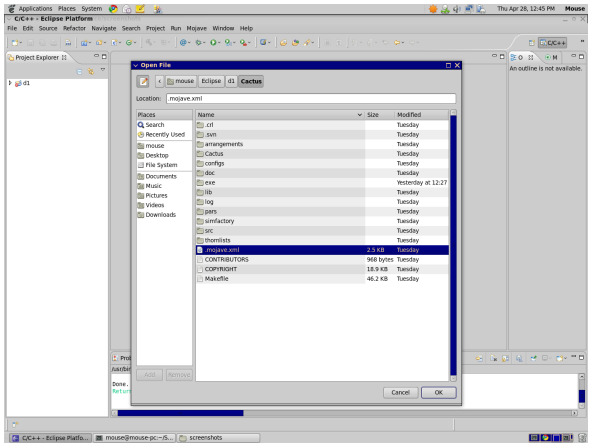
- If .mojave.xml does not appear, go to **File - Open File** . . . then open *workspace-name/project-name*/Cactus/.mojave.xml in your home directory.

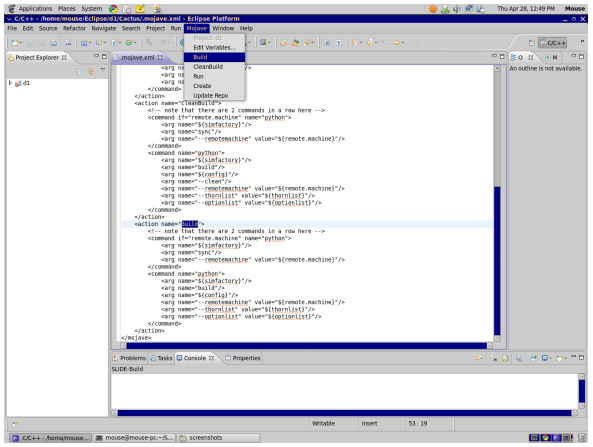


Finding .mojave.xml.

Mojave: Development

The XML file is comprised of actions which correspond to the menu items. The series of commands set within each action tag is executed when the menu item is clicked.

- Notice how the **Build** action corresponds to the **Build** menu item.



Structure of .mojave.xml.

Mojave: Development

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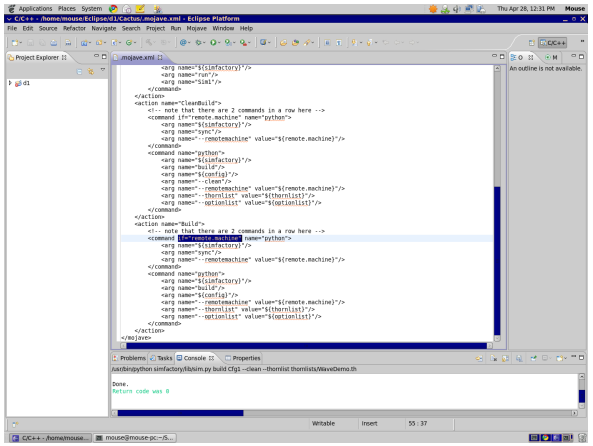
- The first command under **Build** checks **if** the **remote.machine** variable is set.

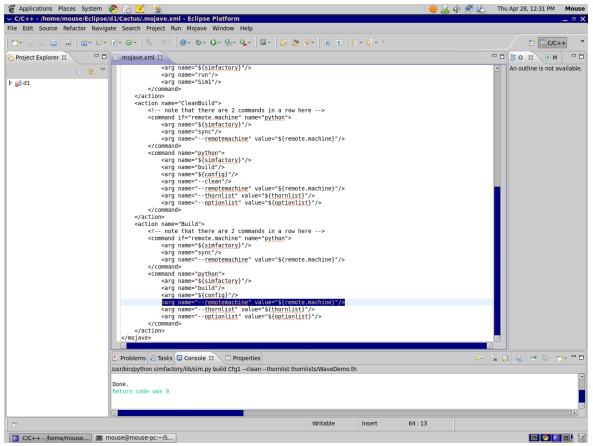


Structure of .mojave.xml.

Mojave: Development

The XML file is comprised of actions which correspond to the menu items. The series of commands set within each action tag is executed when the menu item is clicked.

- The first command under **Build** checks **if** the **remote.machine** variable is set.
- It is included with **–remotemachine** in the build command if so; otherwise both arguments are left off and the build is done locally.



Structure of .mojave.xml.

Summary

- Cactus is a powerful framework for developing portable applications, particularly suited to large collaboration.
- Cactus is currently used by many groups around the world, in several fields.
- For more information: `http://www.cactuscode.org`, Users' guide (available online, also distributed with Cactus)

Thanks

Thanks go to

- All funding for Cactus
- LSU for support at CCT
- Cactus community

The End

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- community building