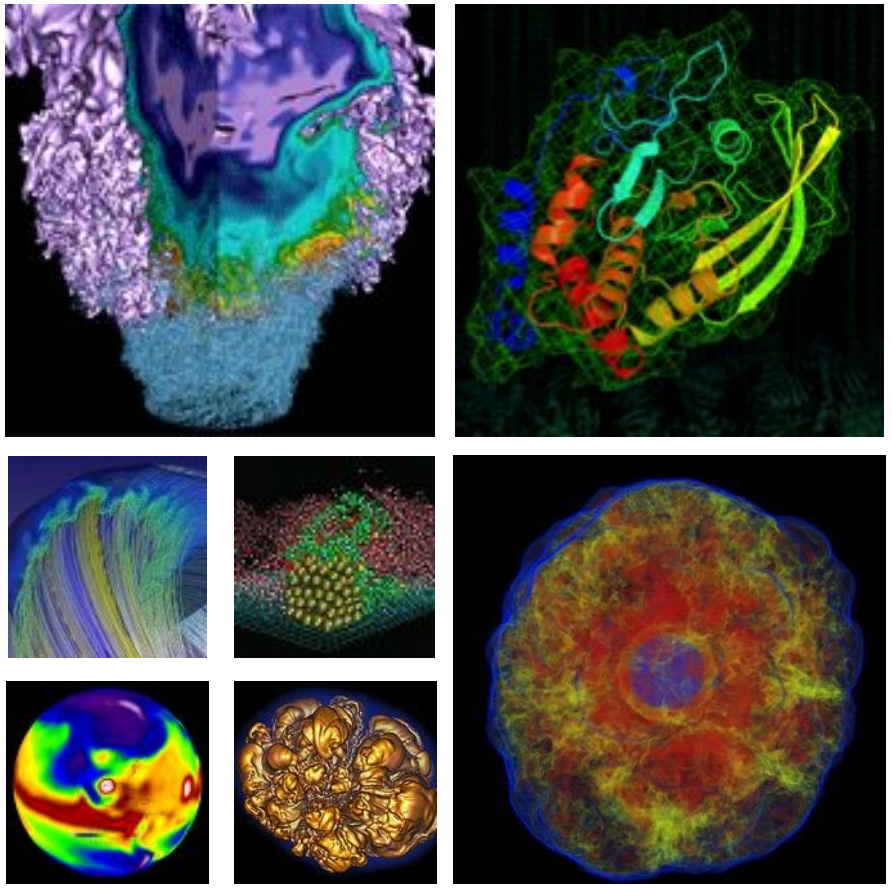
Using Craypat & Reveal on Cori



Rebecca Hartman-Baker

User Engagement Group Leader

June 9, 2017

Outline

I. **Profiling with Craypat**

II. **Using Reveal for OpenMP**

I. PROFILING WITH CRAYPAT

Profile of Cochise in the Chiricahua Mountains by Ken Bosma, http://www.flickr.com/photos/kretyen/2879059366/

I. Profiling with Craypat

- Introduction
- Simple profiling
- Full-service profiling

Introduction

- **Craypat is Cray's Performance Analysis Tool**
- **Evaluate program behavior on Cray supercomputer**
  - Under any PrgEnv
- **Find hotspots, load imbalance, inefficiencies**
  - I/O, memory usage
  - MPI communications
  - Flops
  - Recommendation for rank reordering (sometimes)
- **Profiler with limited tracing abilities**
  - Tracing tools with better performance: MAP, VampirTrace

Simple Profiling with CrayPat

- **`perftools-lite` module easier to use & does (almost) everything in `perftools`**
- **Compile code with `perftools-lite` module loaded**
- **Run code as normal**
- **Output:**
  - Stdout & `*.rpt` file: report with execution time, memory high-water mark, aggregate FLOPS rate, top time-consuming user functions, MPI info, etc.
  - `*.ap2` file: can be viewed with Apprentice 2
  - (Possibly) `MPICH_RANK_REORDER` file

Example Output (Preamble)

```
CrayPat/X:  Version 6.4.0 Revision bc8f5bd  05/24/16 17:52:13
Experiment:                  lite  lite/sample_profile
Number of PEs (MPI ranks):     64
Numbers of PEs per Node:       64
Numbers of Threads per PE:      1
Number of Cores per Socket:    68
Execution start time:  Thu Oct 13 09:30:31 2016
System name and speed:  nid04403  1401 MHz (approx)
Intel knl CPU  Family:  6  Model: 87  Stepping:  1
MCDRAM: 7.2 GHz, 16 GiB available as quad,  flat (  0% cache)


Avg Process Time:   558.16 secs
High Memory:       1,899.7 MBytes     29.7 MBytes per PE
I/O Read Rate:    4.032070 MBytes/sec
I/O Write Rate:   3.618872 MBytes/sec
```

Example Output (Function Performance)

Table 1: Profile by Function Group and Function (top 10 functions shown)

Samp%	Samp	Imb. Samp	Imb. Samp%	Group Function PE=HIDE
100.0%	55,700.3	--	--	Total
49.3%	27,466.0	--	--	ETC
15.6%	8,679.3	1,276.7	13.0%	__cray_HCOSS_01
12.2%	6,821.2	1,167.8	14.8%	__cray_COS_V_01
8.9%	4,948.8	581.2	10.7%	_COS_Z
2.3%	1,285.3	335.7	21.0%	gotoblas_daxpy_k_knl
1.9%	1,071.1	235.9	18.3%	gotoblas_blas_memory_alloc_knl
1.9%	1,039.9	185.1	15.3%	gotoblas_dger_k_knl
35.5%	19,747.6	--	--	USER
23.0%	12,803.4	1,592.6	11.2%	intgrd_
7.6%	4,229.4	1,033.6	20.0%	dfshre_
3.1%	1,707.7	501.3	23.1%	drlhre_
14.7%	8,169.4	21,597.6	73.7%	MPI
14.7%	8,169.4	21,597.6	73.7%	MPI_Recv

Simple Profiling Recipe

- **Load/unload modules:**
  - `module unload darshan`
  - `module load perftools-base perftools-lite`
- **Compile and run your code as usual**

Full-Service Profiling

- **Motivation:**
  - Need more info than perftools-lite provides
  - Want to ignore certain subroutines
  - Focus on particular class of functions
  - Tracing rather than profiling
- **Super-deluxe profiling recipe**
- **pat_build options**

Super-Deluxe Profiling Recipe (1)

- **Load/unload modules:**
  - `module unload darshan`
  - `module load perftools-base perftools`
- **Compile code as usual, making sure to preserve object files**
- **`pat_build -O apa myapp`**
  - Generates executable called `myapp+pat`
- **Run `myapp+pat`**
  - Results in output file with name like `myapp+pat+######.xf` or directory called `myapp+pat+######`

Super-Deluxe Profiling Recipe (2)

- **`pat_report myapp+pat+*.xf`**
  - Generates `myapp+pat+*.apa`
- **`pat_build -O myapp+pat+*.apa`**
  - Generates executable called `myapp+apa`
- **Run `myapp+apa`**
- **`pat_report myapp+apa+*.xf`**

`pat_build` Options

- **`pat_build -O apa myapp`**
  - Craypat output for `myapp+pat` will be sampling to determine which subroutines can be ignored in full run. Additional file, `*.apa`, produced from `pat_report`
  - After this run, `execute pat_build -O *.apa` file to re-instrument `myapp+pat` into `myapp+apa` and run `myapp+apa` to get performance info
- **`pat_build -g tracegroup myapp`**
  - *`tracegroup`* is group of functions that can be automatically traced by CrayPat. Options include: `blas`, `fftw`, `mpi`, `netcdf`, `petsc`
- **`pat_build -w myapp`**
  - Do tracing experiment instead of profiling

II. PARALLELIZATION WITH CRAY REVEAL

“Happiness Revealed,” by Leonard Farshore, https://flic.kr/p/9z7isd

Cray Reveal

- Tool for porting to shared-memory or offload programming models
- Combine profiling info from Craypat and Cray compiler annotation to determine where to place OpenMP directives (generated automatically)
- Works ONLY with Cray programming environment

Using Cray Reveal

1. **Compile with perftools-lite-loops to set up perftools work loop estimates experiment**
2. **Run representative job**
3. **Rebuild with CCE program library**
4. **Run Reveal**
5. **Insert directives, consider loop reordering, and analyze performance from optimizations**

Cray Reveal Recipe (1)

- **Load/unload modules:**
  - `module unload darshan`
  - `module swap PrgEnv-intel PrgEnv-cray`
  - `module load perftools-base perftools-lite-loops`
- **Compile & link as normal**

Cray Reveal Recipe (2)

- **Run representative job as normal**
  - Representative job: something that runs a relatively short time but performs proportionally the same work as typical production run
- **Output of run includes .ap2 file with loop work estimates**

Cray Reveal Recipe (3)

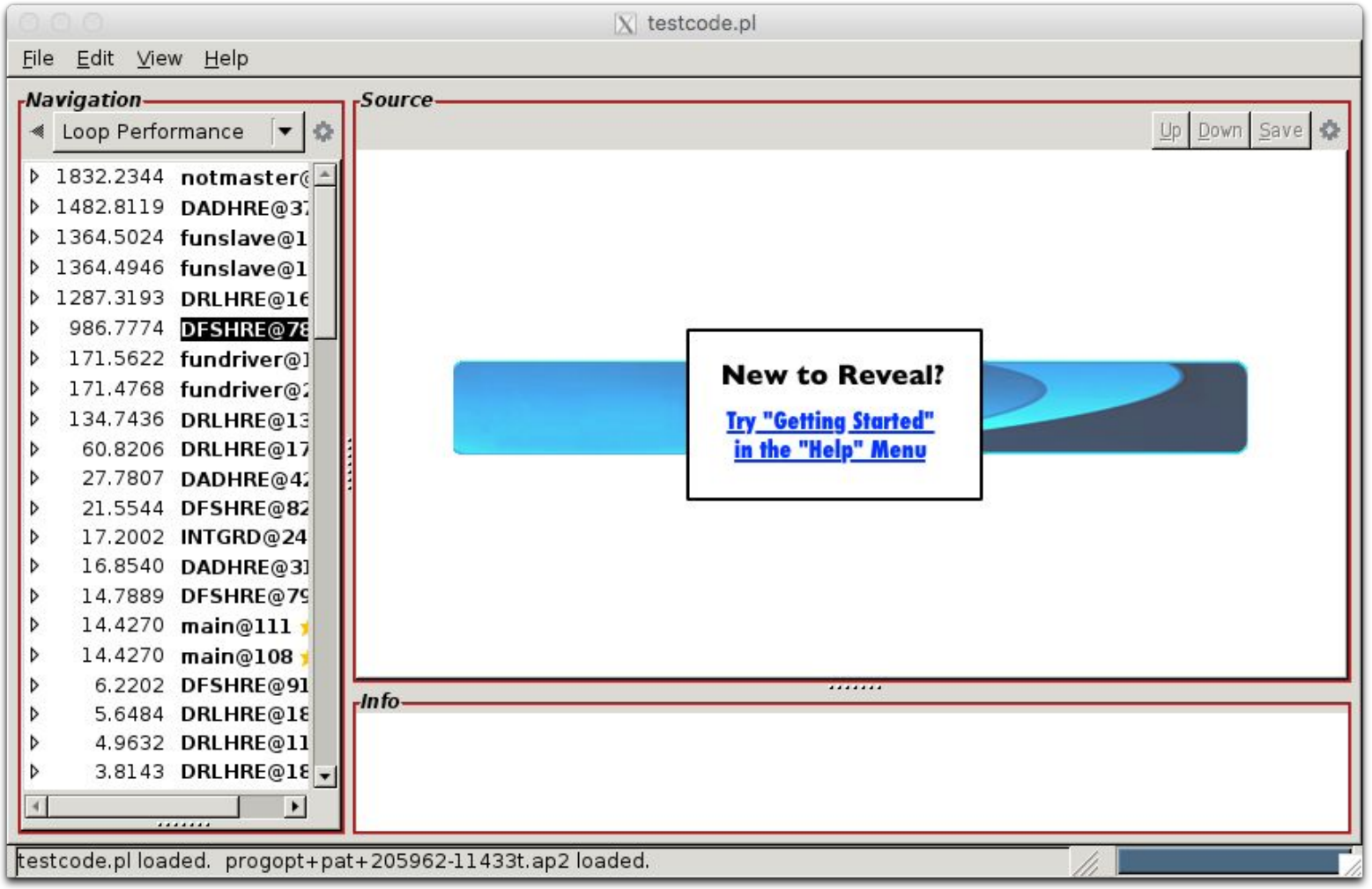
- **Load/unload modules:**
  - `module unload darshan`
  - `module swap PrgEnv-intel PrgEnv-cray`
  - `module unload perftools-lite-loops`
- **Compile & link with**
  - `-h pl=/directory/path/myapp.pl` (for compiler feedback)
  - `make clean; make`

Be sure to use full path for program library directory!

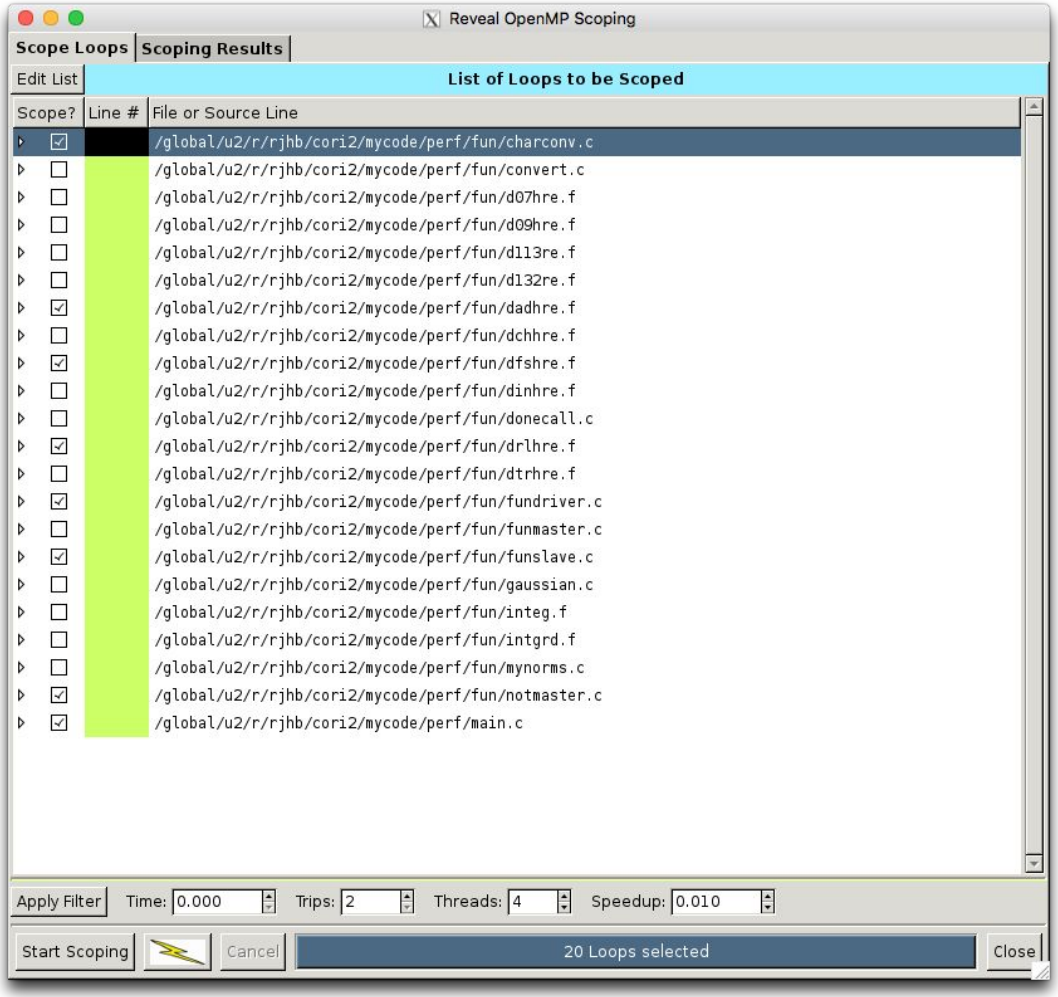
Cray Reveal Recipe (4)

- **Run Reveal**
  - `reveal /directory/path/myapp.pl` (compiler info only)
  - `reveal /directory/path/myapp.pl myapp+########+##t.ap2` (compiler + profiler info)

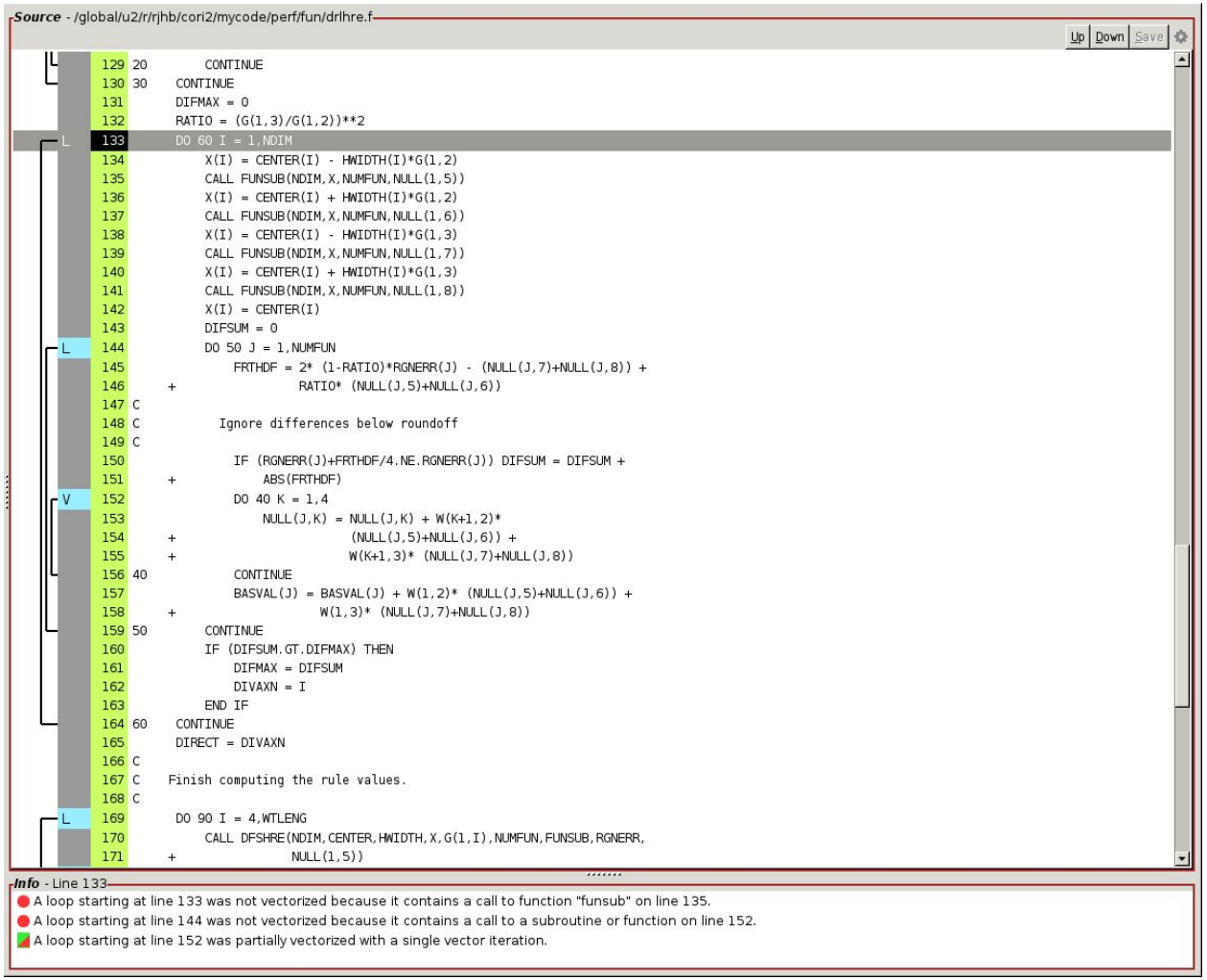
Opening Screen



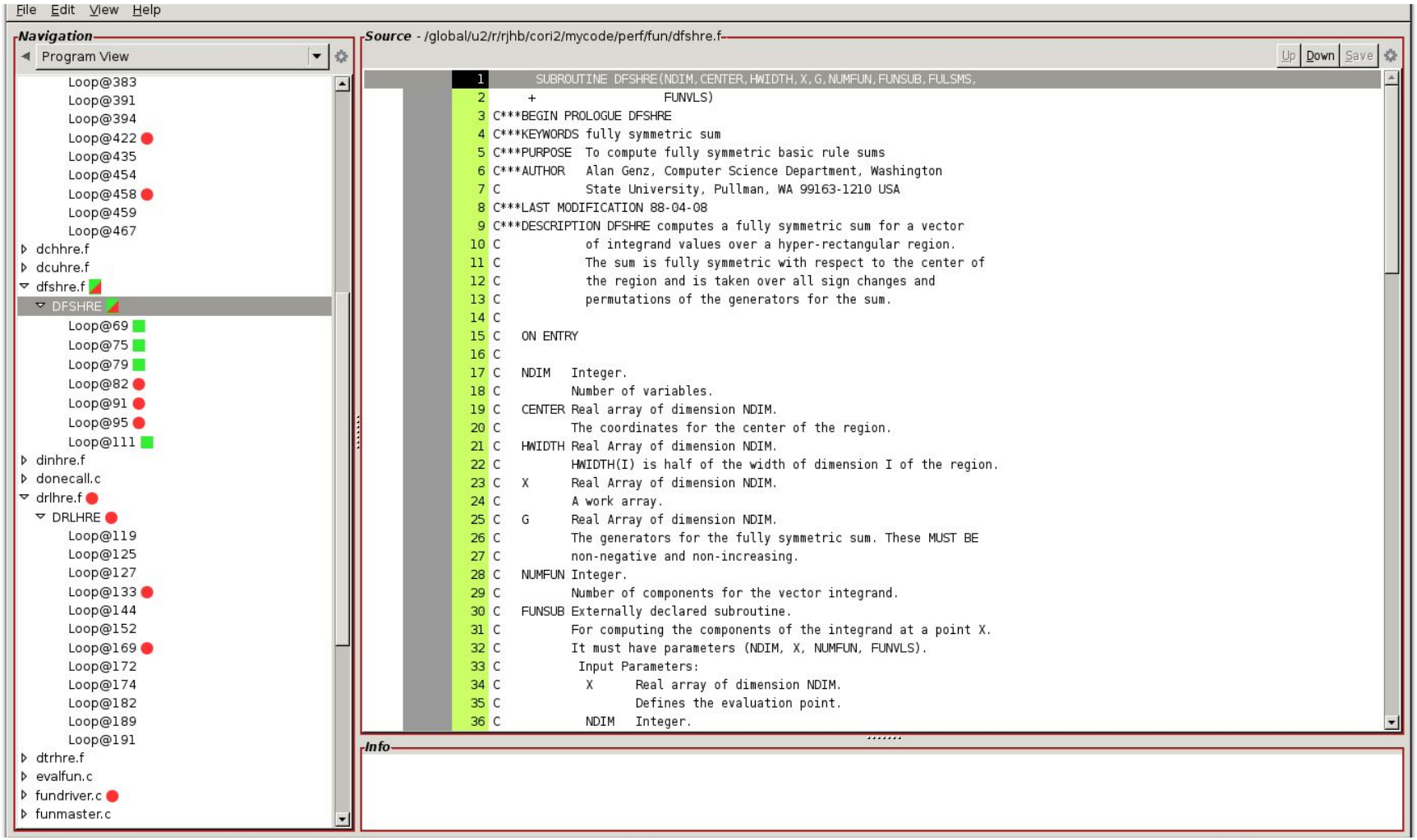
Scoping Window



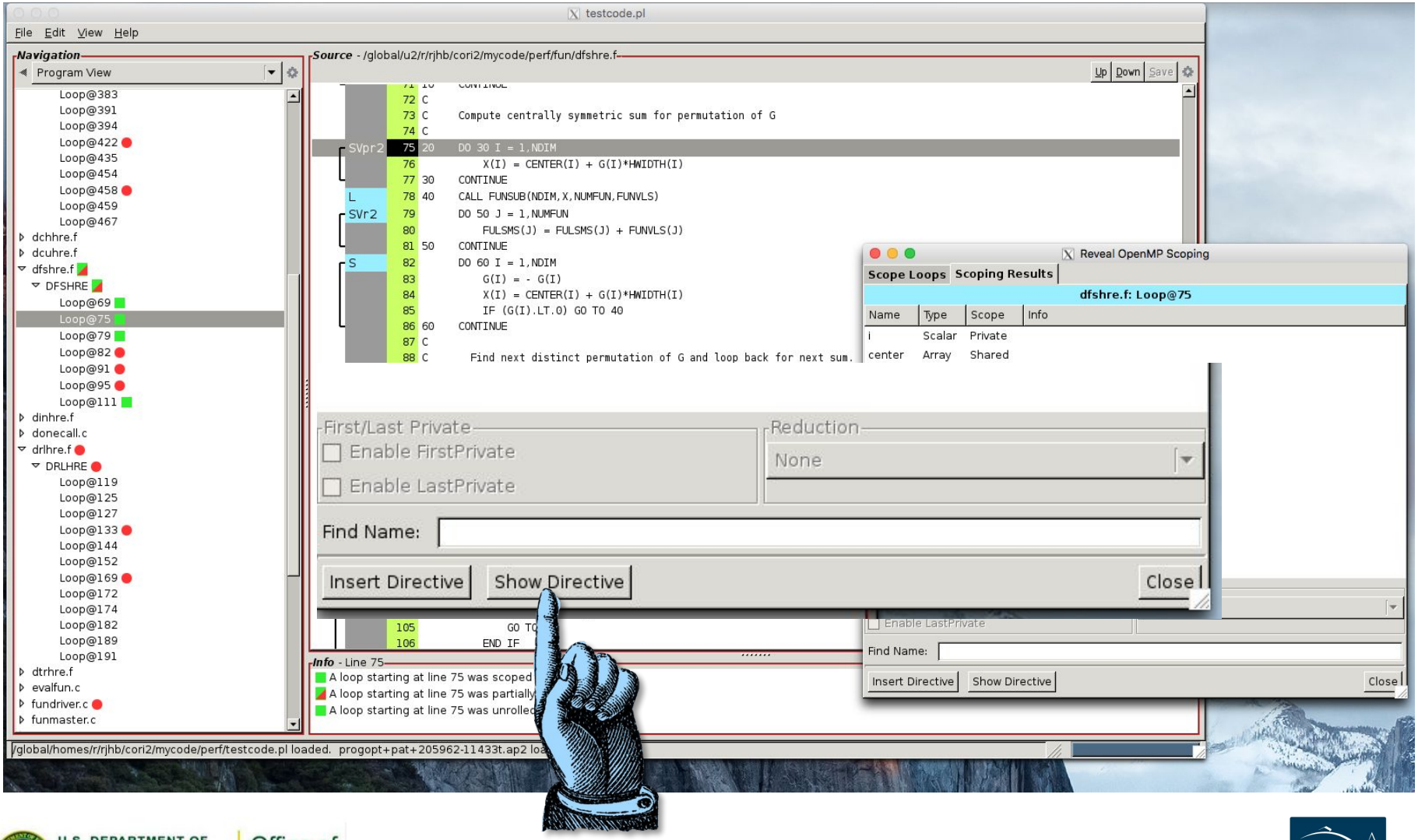
Compiler Annotations & Explanations



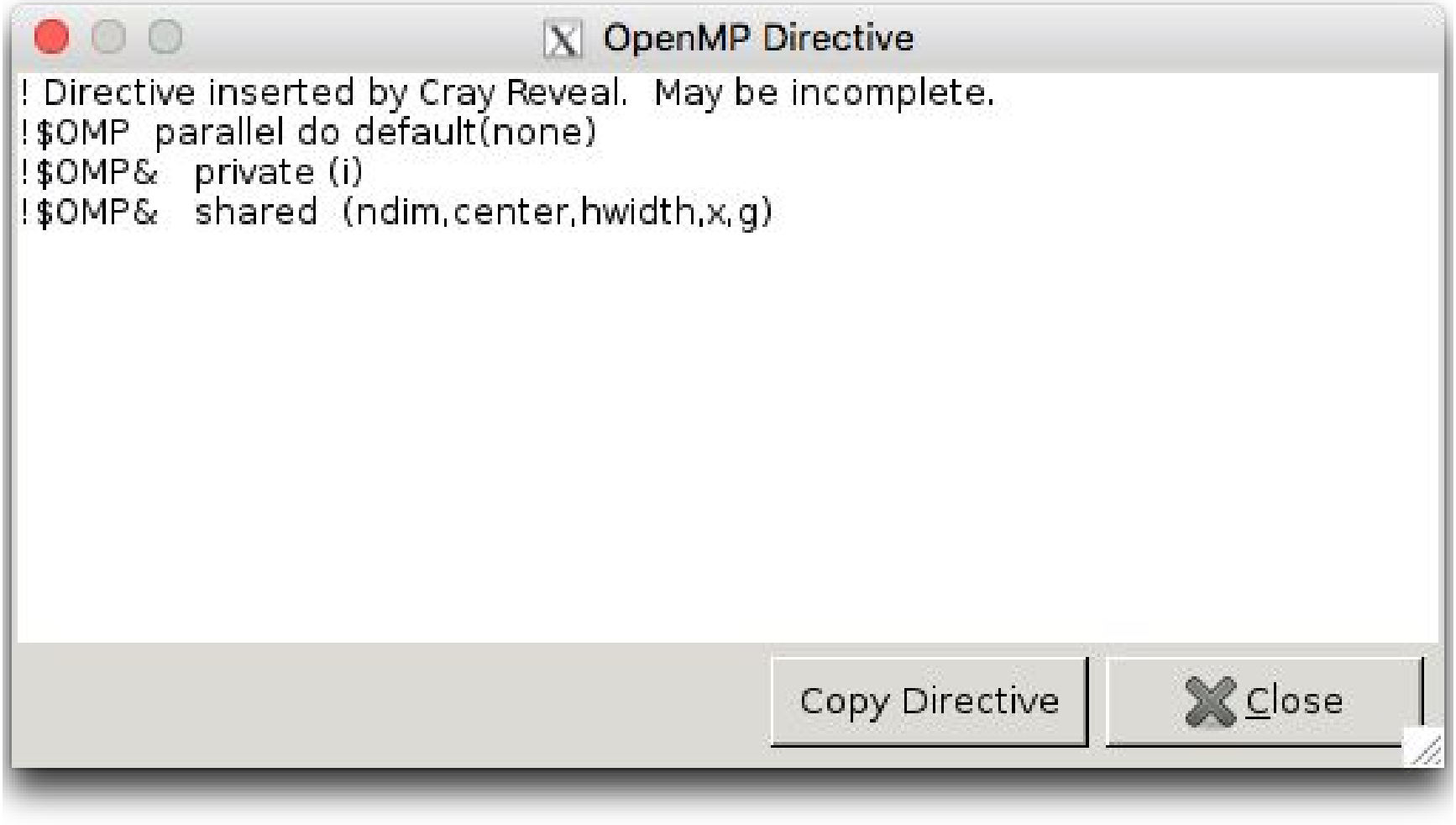
Partial Success in Subroutine



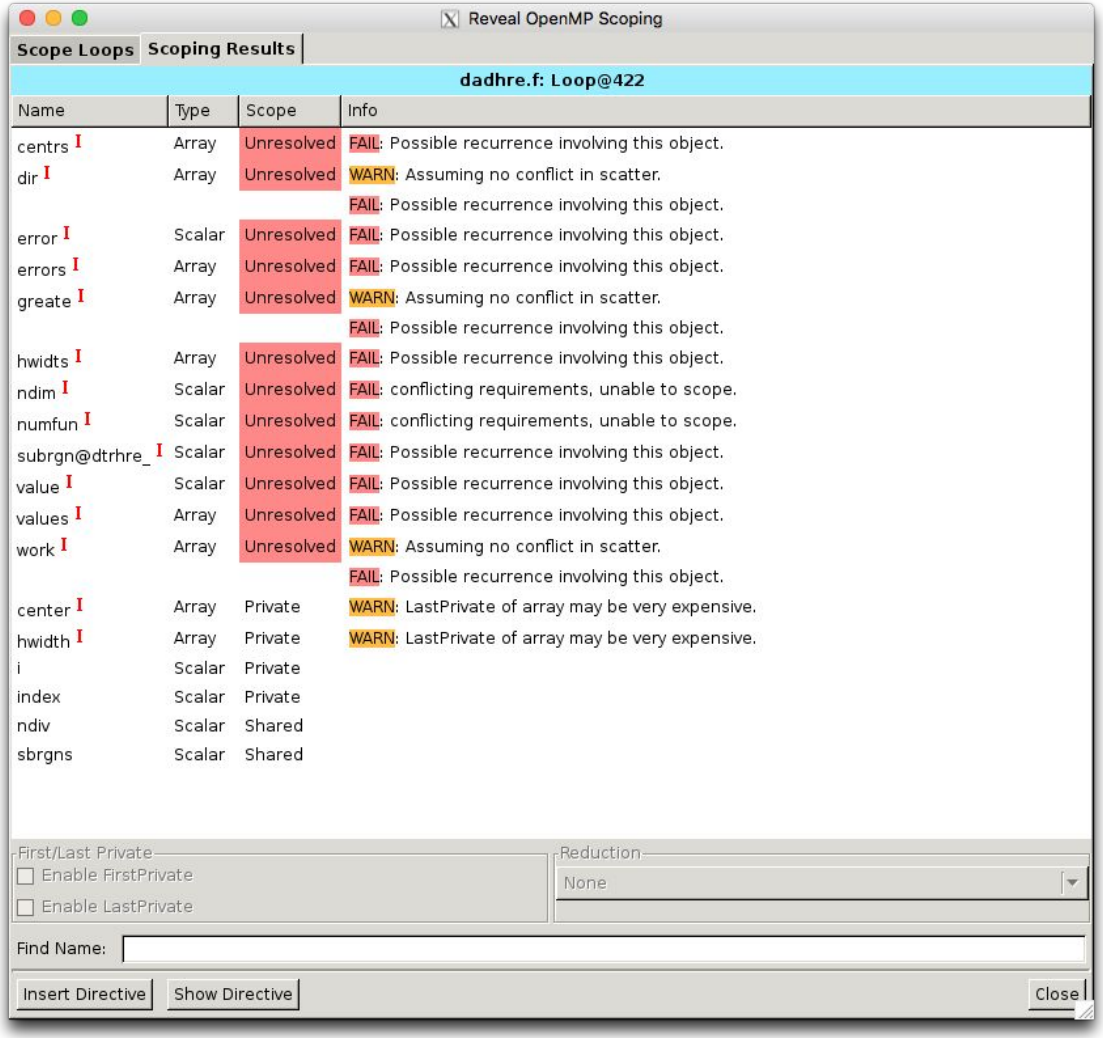
Successful Scoping



Directives Generated by Reveal



Unsuccessful Scoping



Unsuccessful Scoping Directive

Cray Reveal Recipe (5)

- **Insert directives**
- **Examine compiler feedback to determine potential loop reordering**
  - E.g., row- vs. column-ordered memory access patterns
  - Moving conditionals outside of loops
  - Cray compiler good at loop optimizations but requires some human help at times
- **Analyze performance after optimizations**
  - (Lather, rinse, repeat)

National Energy Research Scientific Computing Center