Data-Parallel Computing Using Madagascar

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PASC16
“Write programs that do one thing and do it well. Write programs to work together. Write programs to handle text streams, because that is a universal interface.”

Doug McIlroy
\[ P = 8.0 \text{ mm} \]
\[ = \frac{5}{6} \times H \]
\[ = 2.5 \times h \]

\[ h = 3.2 \text{ mm} \]
\[ = \frac{1}{3} \times H \]
\[ = 0.4 \times P \]

\[ 2 \times P - 0.2 \text{ mm} \]
\[ = 15.8 \text{ mm} \]

\[ H = 9.6 \text{ mm} \]
\[ = 3 \times h \]
\[ = 1.2 \times P \]

\[ 4.8 \text{ mm} \]
\[ 1.7 \text{ mm} \]
\[ 3.2 \text{ mm} \]
In a nutshell, Madagascar... 
...has had 12,757 commits made by 97 contributors representing 1,118,533 lines of code 
...is mostly written in C with an average number of source code comments 
...has a well established, mature codebase maintained by a large development team 
...took an estimated 328 years of effort starting with its first commit in May, 2003
Contributors

+ Joseph Dellinger, William Symes, and many others...
Madagascar Contributors
Research Pyramid

- Implement
- Test
- Publish
Research Pyramid

- Programs
- Examples
- Workflows
- Papers
Research Pyramid

- **250 Papers**
- **1,800 Programs**
- **1,000 Scripts**
- **9,000 Figures**

Languages and Tools:
- LaTeX
- Python
- SCons
- Unix
- C
Least-Squares Inversion by Conjugate Gradients

- `sfconjgrad sfmodeling vel=vel.rsf \ mod=image0.rsf niter=100 \ < data.rsf > image.rsf`
- `sfdotest sfmodeling vel=vel.rsf \ mod=image0.rsf dat=data.rsf`

sfdotest: $L[m]^*d = 1165.87$
sfdotest: $L'[d]^*m = 1165.87$
sfdotesttest: fork/exec

random numbers
sfmodeling adj=n

random numbers
sfmodeling adj=y
Data-Parallel Processing

- `sfomp sfmodeling vel=vel.rsf \ split=3 < image.rsf > data.rsf`
- `mpirun -np 128 sfmpi split=3 \ sfmodeling vel=vel.rsf \ --input=image.rsf --output=data.rsf`
Submitting Parallel Jobs

- **pscons**: parallel scons (scons -j)
  - `Flow('data','image','modeling',split=[3,'omp'])`
  - `Flow('data','image','modeling',split=[3,'mpi'])`
  - `Flow('data','image','modeling',split=[3,1000])`

- **sfbatch**: jobs on a shared cluster
  - `sfbatch exe="scons NP=100 data.rsf"`
  - `scons BATCH=1 data.rsf`
What Does This Do?

sfbatch exe="sfconjgrad mpirun
-np 128 sfmpi sfomp split=3
sfmodeling vel=vel.rsf
niter=100 mod=image0.rsf
--input=data.rsf --output=image.rsf"
Conclusions

- Madagascar is an open-source package for multidimensional data analysis and reproducible computational experiments
  - 10 years in public existence 2006-2016

- Madagascar objects are multidimensional data arrays

- Using Unix-style encapsulation for data-parallel computations