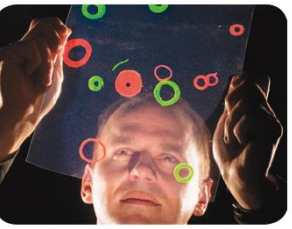

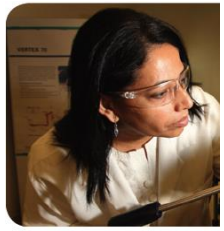

Sandia National Laboratories

Exceptional service in the national interest

1. Overview of Pyomo

PYOMO

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

CCR Center for Computing Research

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Pyomo Overview

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Idea: a Pythonic framework for formulating optimization models

- Provide a natural syntax to describe mathematical models
- Formulate large models with a concise syntax
- Separate modeling and data declarations
- Enable data import and export in commonly used formats

Highlights:

- Python provides a clean, intuitive syntax
- Python scripts provide a flexible context for exploring the structure of Pyomo models

```
# simple.py
from pyomo.environ import *

M = ConcreteModel()
M.x1 = Var()
M.x2 = Var(bounds=(-1,1))
M.x3 = Var(bounds=(1,2))
M.o  = Objective(
         expr=M.x1**2 + (M.x2*M.x3)**4 + \
              M.x1*M.x3 + \
              M.x2*sin(M.x1+M.x3) + M.x2)

model = M
```

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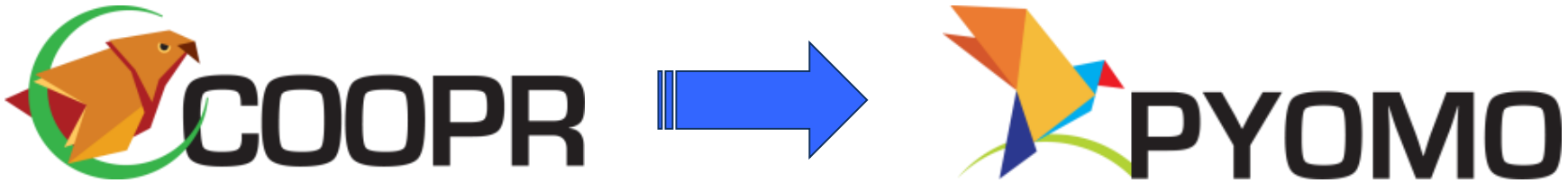
PYOMO COIN-OR

Overview

- What happened to Coopr?
- Three really good questions:
  - Why another Algebraic Modeling Language (AML)?
  - Why Python?
  - Why open-source?
- Pyomo: Software library infrastructure
- Pyomo: Team overview and collaborators / users
- Where to find more information…

What Happened to Coopr?



- Users were installing Coopr but using Pyomo
  - Pyomo modeling extensions were not distinct enough
  - Researchers cited “Coopr/Pyomo”
- Users/Developers were confused by the `coopr` and `pyomo` commands
- Developers were coding in Coopr but talking about Pyomo

We needed to provide clear branding this project!

Optimization Modeling

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Goal:

- Provide a natural syntax to describe mathematical models
- Formulate large models with a concise syntax
- Separate modeling and data declarations
- Enable data import and export in commonly used formats

Impact:

- Robustly model large constraint matrices (e.g. for MILPs)
- Integrated support of automatic differentiation for complex nonlinear models

Examples:

- AMPL, GAMS, AIMMS, …
- OptimJ, FlopCPP, PuLP, JuMP, …

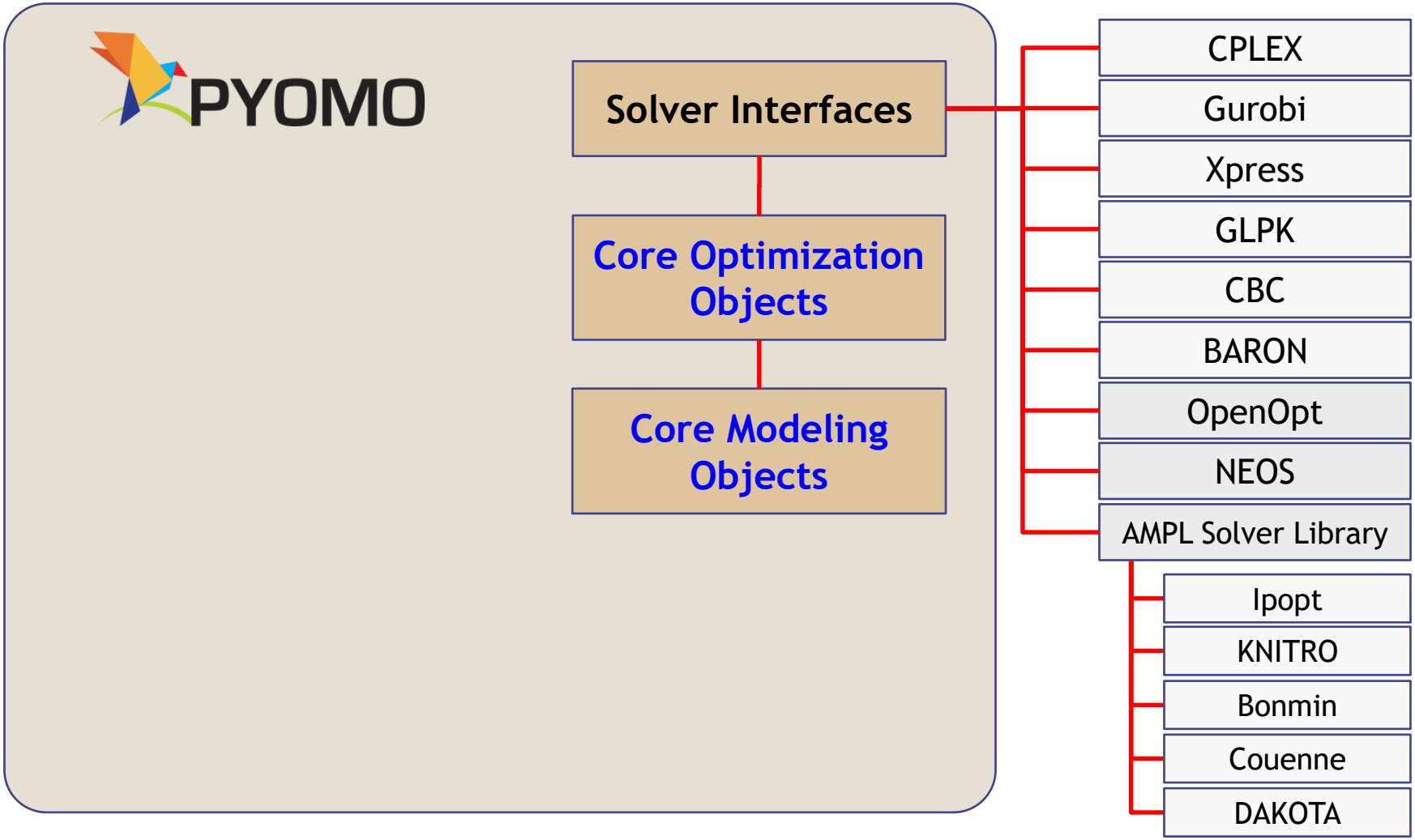
Why Model in Python?

- Full-Featured Library
  - Language features includes functions, classes, looping, namespaces, etc
  - Introspection facilitates the development of generic algorithms
  - Python's clean syntax facilitates rapid prototyping
- Open Source License
  - No licensing issues w.r.t. the language itself
- Extensibility and Robustness
  - Highly stable and well-supported
- Support and Documentation
  - Extensive online documentation and several excellent books
  - Long-term support for the language is not a factor
- Standard Library
  - Includes a large number of useful modules
- Portability
  - Widely available on many platforms

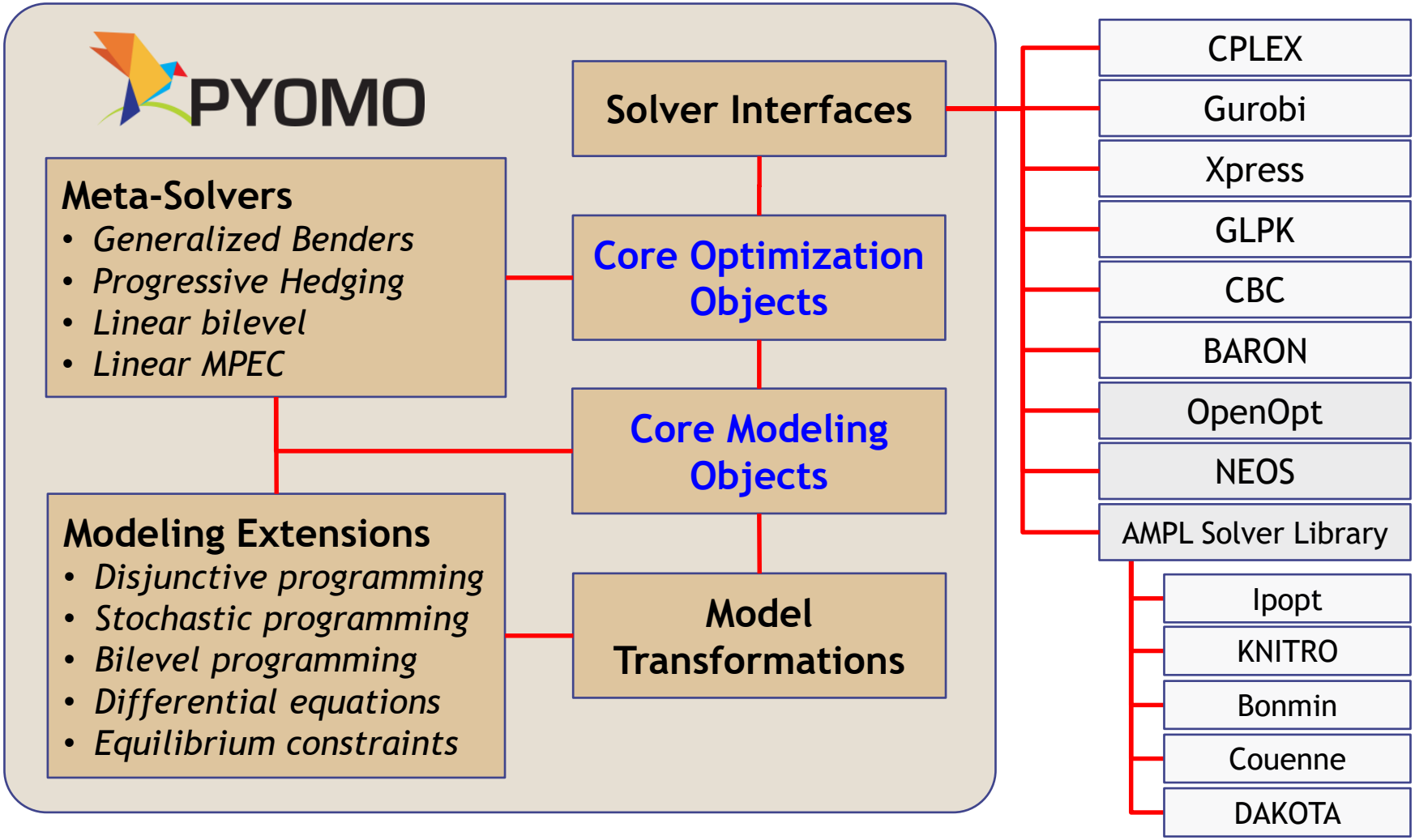
Why Open Source?

- Transparency and reliability
- Foster community involvement
  - Extend the modeling language
  - Develop new solvers / algorithms
  - Interface with additional external utilities
  - “Stone Soup” model
- Flexible licensing
  - Pyomo released under 3-clause BSD license
  - No restrictions on deployment or commercial use

Pyomo at a Glance



Pyomo at a Glance



Survey of Python Modeling Tools

- Pyomo
  - Supports concrete/abstract modeling for LP/MILP/NLP models
  - Modeling extensions for stochastic programming, bilevel, MPEC, etc
  - Separate model objects
- PuLP
  - Supports concrete modeling for LP/MILP models
  - Separate model objects
  - Simple object model
- APLEpy
  - Supports concrete modeling for LP/MILP models
  - Single global model object
- PyMathProg, pyglpk, cplex, gurobi
  - Python interfaces for specific solver tools

More than *just* mathematical modeling

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Scripting

- Construct models using native Python data
- Iterative analysis of models leveraging Python functionality
- Data analysis and visualization of optimization results

Model transformations (a.k.a. reformulations)

- Automate generation of one model from another
- Leverage Pyomo's object model to apply transformations sequentially
- E.g.: relax integrality, GDP -> Big M

Meta-solvers

- Integrate scripting and/or transformations into optimization solver
- Leverage Python's introspective nature to build "generic" capabilities
- E.g.: progressive hedging, SP extensive form -> MIP

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Who Uses Pyomo?

- Students
  - Rose-Hulman, UC Davis, U Texas, Iowa State, NPS
- Researchers
  - Government laboratories
    - Sandia National Labs, Lawrence Livermore National Lab, Los Alamos National Lab, National Energy Technology Lab, Federal Energy Regulation Commission
  - Universities
    - UC Davis, TAMU, Rose-Hulman, UT, USC, GMU, Iowa State, NCSU, U Washington, NPS, U de Santiago de Chile, U Pisa, …
  - Companies

Who Uses Pyomo?

- Software Projects
  - TEMOA – Energy economy optimization models
  - Minpower – Power systems toolkit
  - Water Security Toolkit – Planning/Response for water contamination
  - SolverStudio – Excel plugin for optimization modeling

For More Information

See the Pyomo homepage

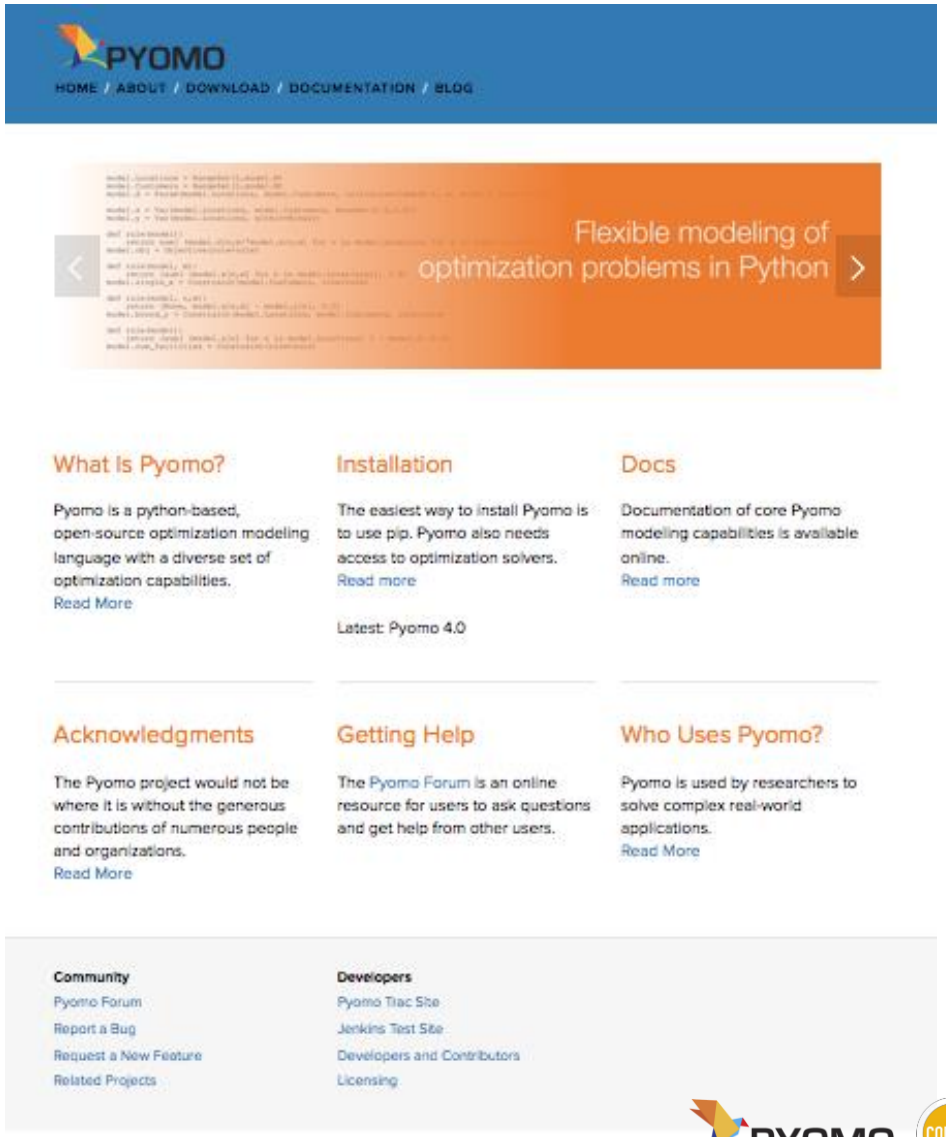
- www.pyomo.org

The Pyomo homepage provides a portal for:

- Online documentation
- Installation instructions
- Help information
- Developer links

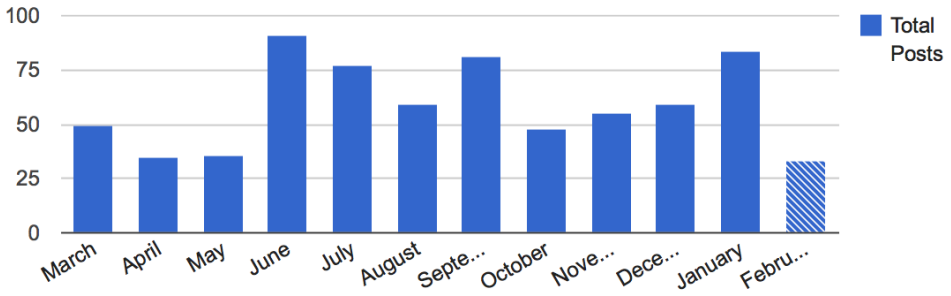
Coming soon:

- A gallery of simple examples

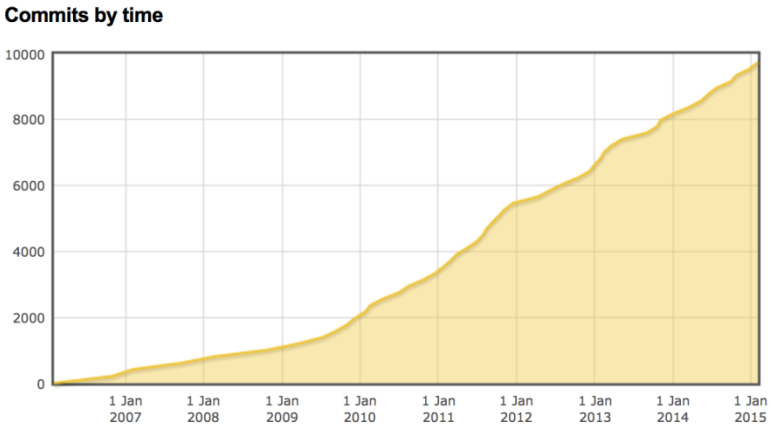


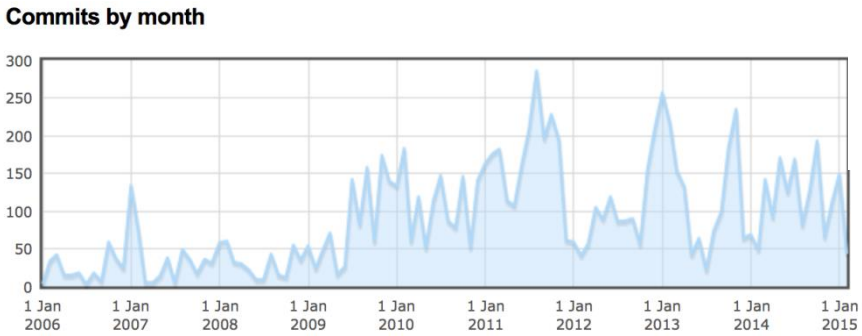
Development, Community Activity

- Pyomo Forum
  - Active discussion list



- Active developer community





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