

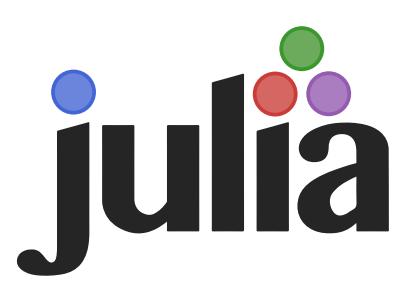


Award #: 1835443

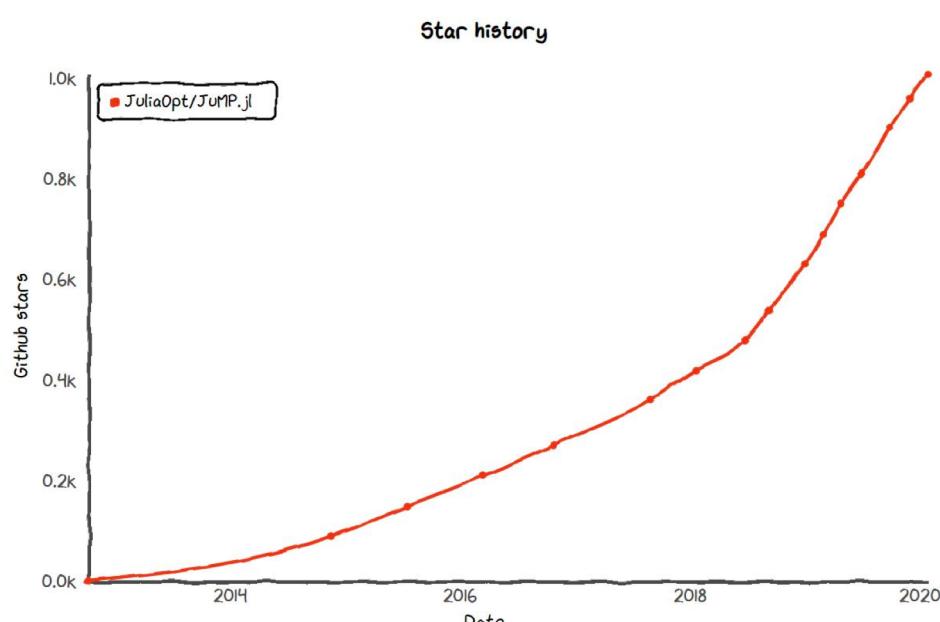
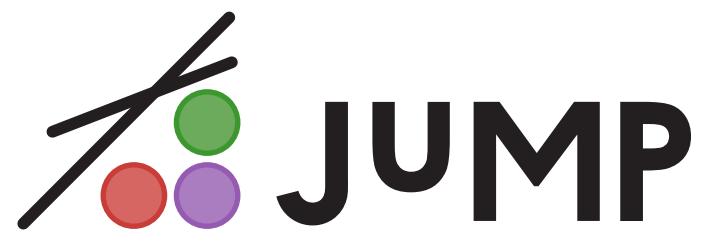
# CSSI Framework: Software: Next-Generation Cyberinfrastructure for Large-Scale Computer-Based Scientific Analysis and Discovery

PI: Alan Edelman, Co-PIs: Juan Pablo Vielma, Institutions: Massachusetts Institute of Technology

## Cyberinfrastructure, Tools and Software Ecosystem



Modeling Language and Software Ecosystem for Mathematical Optimization



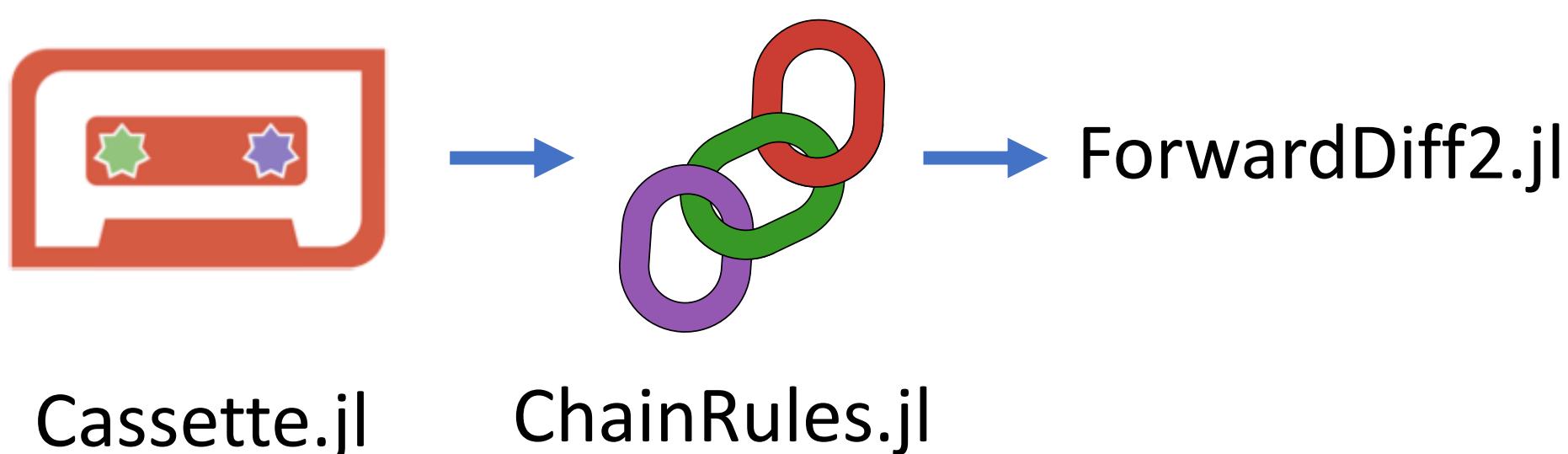
### Beyond "Single-Use" Tools

Goal: Tools that are performant, accessible, composable, flexible and adaptable.  
Consequence: Serendipitous combination of tools by third parties.

Example: <https://matbesancon.github.io/post/2020-01-23-discrete-diff/>

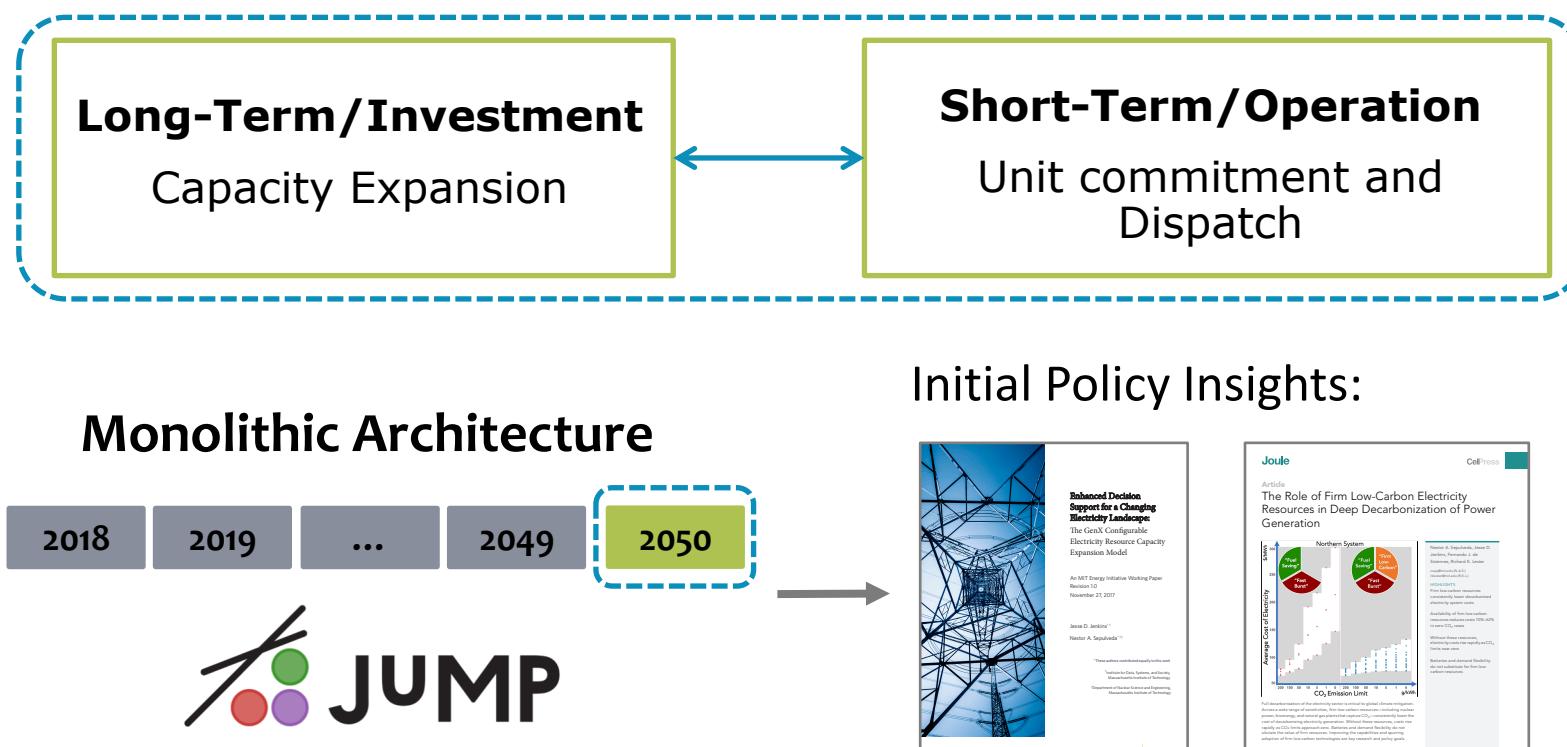
**ConstraintSolver.jl** + **ForwardDiff2.jl** → Differentiating the discrete:  
Automatic Differentiation meets Integer Optimization

### Next-Generation Automatic Differentiation Tools:



## Application Example: Technological Pathways to Deep Decarbonization in Electrical Networks

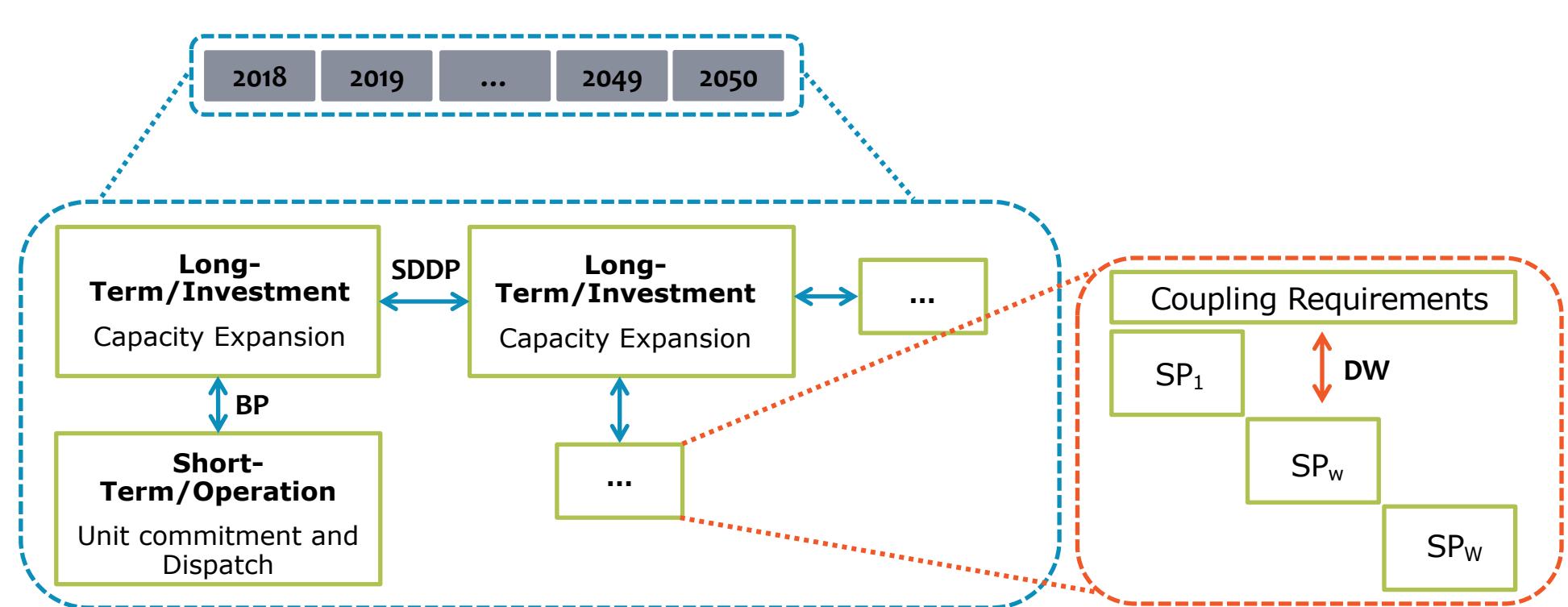
Original 2017 GenX Model:



### Improved Decomposition-Based Model:

Multi-year, high-resolution, stochastic and detailed.

FLIP Framework (Forward Looking Investment Planning)



BP: Benders Partitioning; DW: Dantzig-Wolfe; SDDP: Stochastic Dual Dynamic Programming

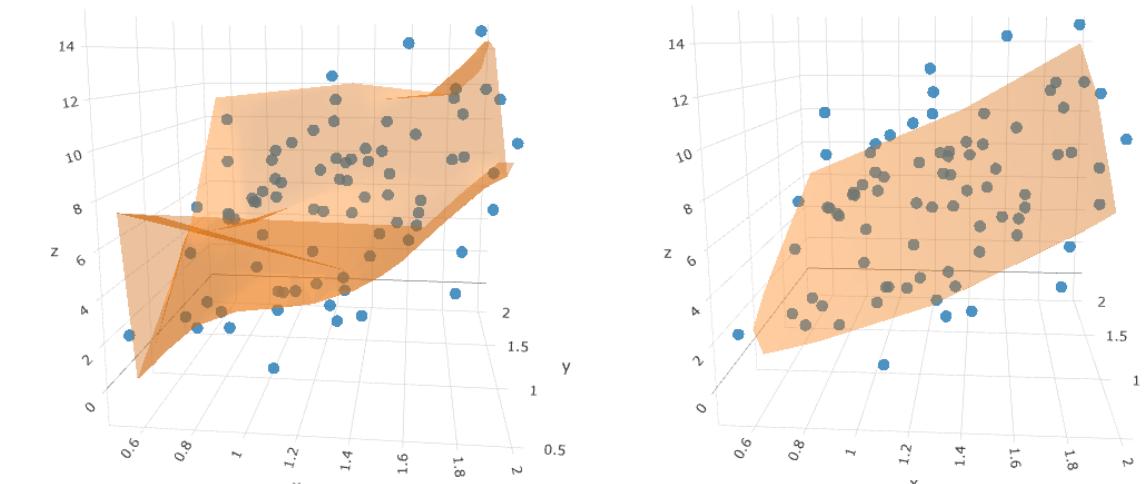


## Methodology Example: The Hypatia.jl Interior Point Solver for Convex Conic Optimization

A Highly-Configurable Open-Source Primal-Dual Generic Conic Solver

- Based on homogeneous self-dual embedding and written in pure Julia:
  - Generic Cones through Bring Your Own Barrier interface
  - Flexible direct/indirect linear system solves
  - Multi-precision and complex numbers
  - Large number of native cones allow for small natural formulations

### Sum-of-Squares++ for Shape Constrained Regression

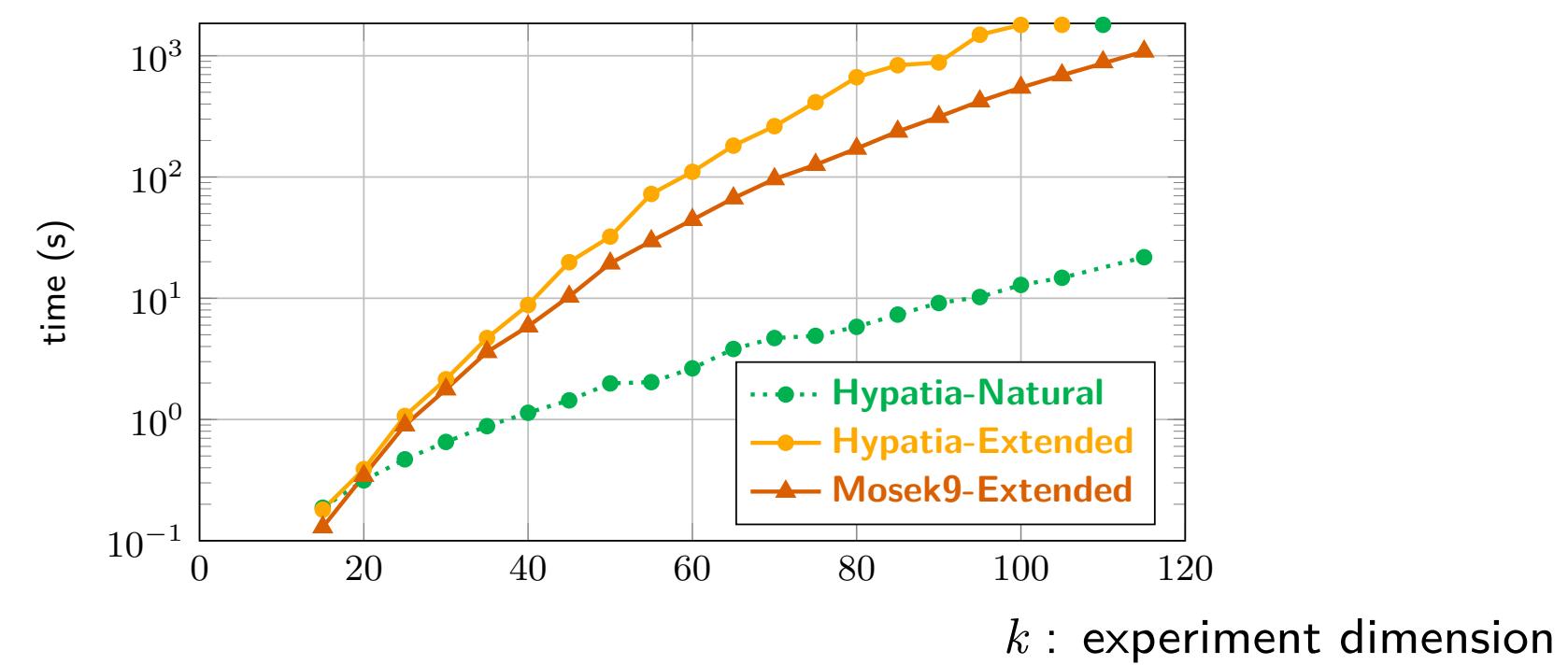


### Multi-precision Arithmetic:

float type	epsilon	residuals	iters	time (s)
Float32	$10^{-7}$	$10^{-5}$	42	0.529
Float64	$10^{-16}$	$10^{-14}$	86	1.33
Float128	$10^{-34}$	$10^{-17}$	42	1.21
BigFloat-32	$10^{-10}$	$10^{-6}$	22	1.99
BigFloat-64	$10^{-19}$	$10^{-11}$	30	1.96
BigFloat-128	$10^{-39}$	$10^{-20}$	47	3.06
BigFloat-256	$10^{-77}$	$10^{-39}$	84	6.28
BigFloat-512	$10^{-154}$	$10^{-77}$	158	15.3
BigFloat-1024	$10^{-308}$	$10^{-155}$	306	41.5
BigFloat-2048	$10^{-617}$	$10^{-304}$	607	135

### D-Optimal Experimental Design:

Standard SDP + Exp-Cone v/s Log-Det-Cone



## Community Building Activities



University of Maryland Baltimore



### 3RD ANNUAL JUMP-dev WORKSHOP

ESCUEDA DE INGENIERIA PONTIFICIA UNIVERSIDAD CHILE		Instituto Chileno Norteamericano	
March 12-14, 2019		PUC-Santiago	
Chris Coey MIT	Lea Kapelevich MIT	Stefan Karpinaki Julia Computing	Alessandro Soares PSR
Joaquim Dias Garcia PUC & U. de Rio	Tomasz Gajda-Gonzalez U. de Chile	Marcelo Flores U. de Santiago	Matteo Tanneau Polytechnique Montreal
Gary Davis Northwestern U.	Jose Daniel Lara UC Berkeley & NREL	Benedicto Lopes UCLouvain	Tillman Weisser U. de Almeria, Spain
Marcelo Fortes UdeS	Miles Lubin Google	Hans Harjula Los Alamos N. L.	Andrew David Warner Rosenberg
Michael Gorstka U. of Oxford	Alvaro Gonzalez Skoltech	Vitor Nesello U. of Bordeaux	
Alvaro Gonzalez Skoltech	Jorge P. Arango Google & Rice U.		
	Jordan Raviv U. of Wisconsin-Madison		

Sponsored by:  
[www.juliaopt.org/meetings/santiago2019](http://www.juliaopt.org/meetings/santiago2019)



Google  
Summer of Code

NUMFOCUS