Award #: 1835443

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

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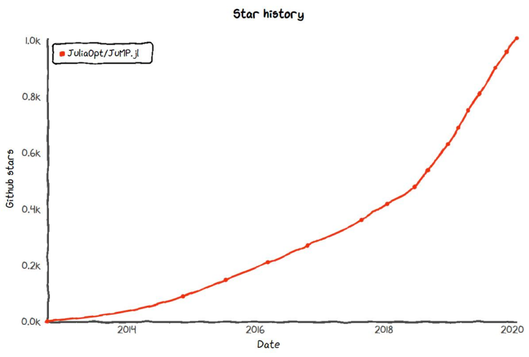
Cyberinfrastructure, Tools and Software Ecosystem

Modeling Language and Software Ecosystem for Mathematical Optimization



Beyond "Single-Use" Tools

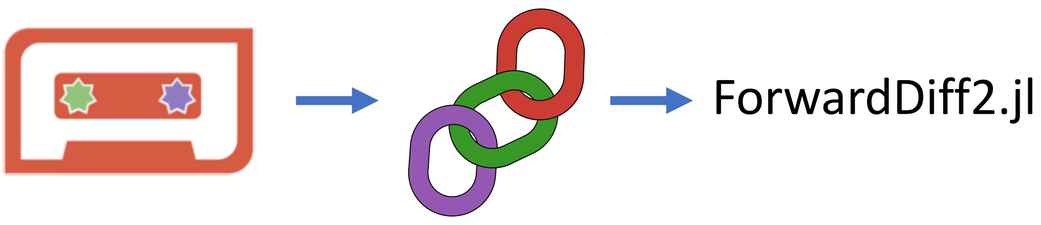
Goal: Tools that are performant, accessible, composable, flexible and adaptable.

Consequence: Serendipitous combination of tools by third parties.

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

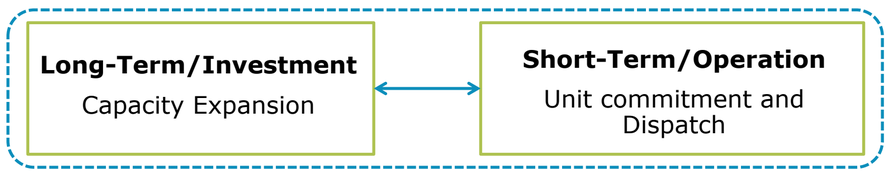
ConstraintSolver.jl + ForwardDiff2.jl → Differentiating the discrete: Automatic Differentiation meets Integer Optimization

Next-Generation Automatic Differentiation Tools:



Application Example: Technological Pathways to Deep Decarbonization in Electrical Networks

Original 2017 GenX Model:



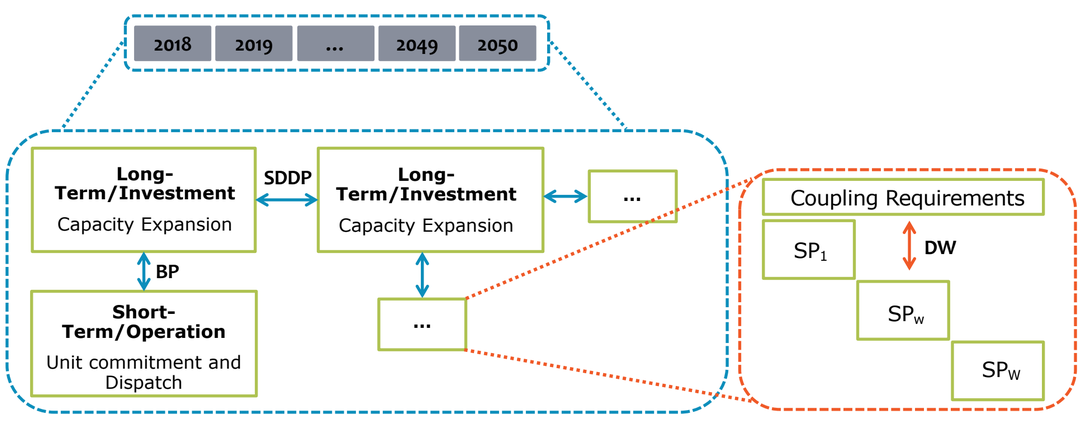
Monolithic Architecture

Initial Policy Insights:

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 Programing

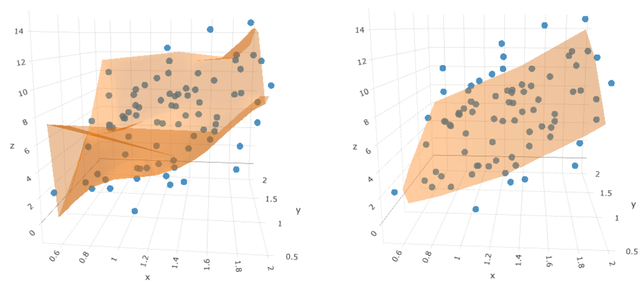
JUMP ParameterJuMP.jl SDDP.jl

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

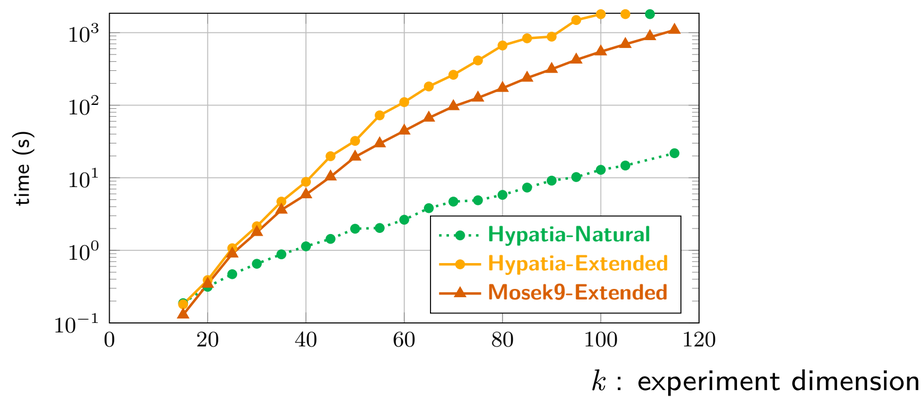


Multi-precision Arithmetic:

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

juliacon 2019

University of Maryland Baltimore

Google Summer of Code

NUMFOCUS