



Constraint Programming with JuMP

Benoît Legat

CP 2024

What is JuMP?

Part of the zoo of algebraic modeling languages



CMPL, CPLEX Concert, GNU MathProg, Gurobi C++/Python API, linopy, MATLAB, Mosek Fusion, MOSEL, ompr, OPTMODEL, PuLP, Python-MIP, YALMIP, ZIMPL, ...

What is JuMP?

An open-source algebraic modeling language in Julia

```
using JuMP, Ipopt
function constrained_linear_regression(A::Matrix, b::Vector)
    model = Model(Ipopt.Optimizer)
    @variable(model, 0 <= x[1:size(A, 2)] <= 1)
    @variable(model, residuals[1:size(A, 1)])
    @constraint(model, residuals == A * x - b)
    @constraint(model, sum(x) <= 1)
    @objective(model, Min, sum(r^2 for r in residuals))
    optimize!(model)
    return value.(x)
end
A, y = rand(30, 20), rand(30)
x = constrained_linear_regression(A, b)
```

Who uses JuMP? Academics

Mathematical Programming with Julia

An open-source approach to
Linear & Mixed Integer Programming
Version 1.0
Julia 1.7.2/JuMP 1.0



Richard Lusby & Thomas Stidsen



Changhyun Kwon



Roll over image to zoom in

Julia Programming for Operations Research

by [Changhyun Kwon](#) (Author)

4.5 ★★★★★ 50 ratings

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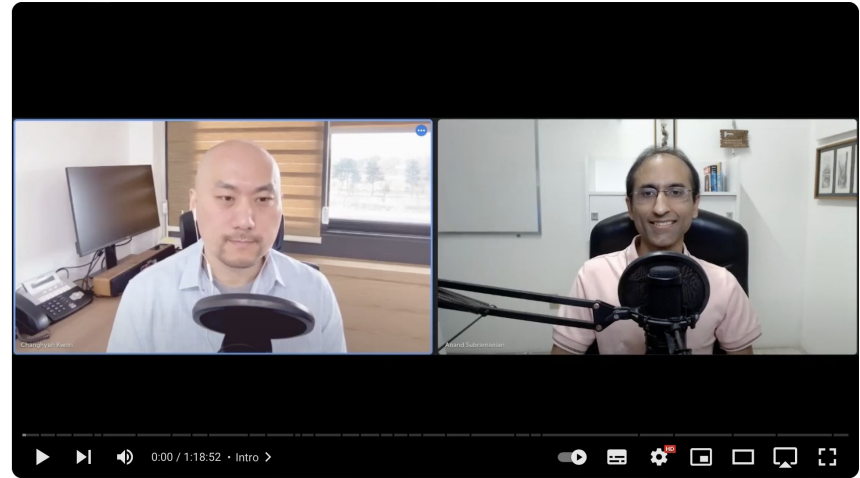
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Last Updated: December 2020

Based on Julia v1.3+ and JuMP v0.21+

The main motivation of writing this book was to help the author himself. He is a professor in the field of operations research, and his daily activities involve building models of mathematical optimization, developing algorithms for solving the problems, implementing those algorithms using computer programming languages, experimenting with data, etc. Three languages are involved: human language, mathematical language, and computer language. His team of students need to go over three different



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Who uses JuMP?

Companies

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Solving a Continent-Scale Inventory Routing Problem at Renault

Louis Bouvier , Guillaume Dalle , Axel Parmentier , Thibaut Vidal 

Published Online: 31 Oct 2023 | <https://doi.org/10.1287/trsc.2022.0342>

Abstract

This paper is the fruit of a partnership with Renault. Their reverse logistic requires solving a continent-scale multiattribute inventory routing problem (IRP). With an average of 30 commodities, 16 depots, and 600 customers spread across a continent, our instances are orders of magnitude larger than those in the literature. Existing algorithms do not scale, so we propose a large neighborhood search (LNS). To make it work, (1) we generalize existing split delivery vehicle routing problems and IRP neighborhoods to this context, (2) we turn a state-of-the-art matheuristic for medium-scale IRP into a large neighborhood, and (3) we introduce two novel perturbations: the reinsertion of a customer and that of a commodity into the IRP solution. We also derive a new lower bound based on a flow relaxation. In order to stimulate the research on large-scale IRP, we introduce a library of industrial instances. We benchmark our algorithms on these instances and make our code open source. Extensive numerical experiments highlight the relevance of each component of our LNS.

A two-step linear programming model for energy-efficient timetables in metro railway networks

Shuvomoy Das Gupta ^a  , J. Kevin Tobin ^b , Lacra Pavel ^a 

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<https://doi.org/10.1016/j.trb.2016.07.003> 

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Abstract

In this paper we propose a novel two-step linear optimization model to calculate energy-efficient timetables in metro railway networks. The resultant timetable minimizes the total energy consumed by all trains and maximizes the utilization of regenerative energy produced by braking trains, subject to the constraints in the railway network. In contrast to other existing models, which are *NP*-hard, our model is computationally the most tractable one being a linear program. We apply our optimization model to different instances of service PES2-SFM2 of line 8 of Shanghai Metro network spanning a full service period of one day (18 h) with thousands of active trains. For every instance, our model finds an optimal timetable very quickly (largest runtime being less than 13 s) with significant reduction in effective energy consumption (the worst case being 19.27%). Code based on the model has been integrated with Thales Timetable Compiler - the industrial timetable compiler of Thales Inc that has the largest installed base of communication-based train control systems worldwide.

Who uses JuMP?

Energy system modellers



Sienna

Learn more at www.nrel.gov/analysis/sienna.html

Tulipa

Electricity Market and Sector-Coupling Modelling Tools from TNO

6 followers 📍 Netherlands

The global electricity system is undergoing a major transformation

In response, researchers at MIT and Princeton have developed GenX, an online tool for investment planning in the power sector.

Sign up to become a beta user:

Sign up



The electricity sector is transforming

Electricity is central to national and global efforts to reduce carbon emissions. This sector is being reshaped with the deployment of variable renewable energy (VRE), energy storage, and innovative uses for distributed energy resources (DERs). At the same time, electrification of other sectors has the potential to improve energy efficiency overall, while also reshaping patterns of electricity demand and enabling the decarbonization of these end-uses.



New tool for electricity system planning

The MIT Energy Initiative and Princeton University's Zero-carbon Energy Systems Research and Optimization (ZERO) Lab have developed an open-source tool for investment planning in the power sector, offering improved decision support capabilities for a changing electricity landscape.

GenX, a least-cost optimization model, takes the perspective of a centralized planner to determine the cost-optimal generation portfolio, energy storage,



Highly configurable

- Modular and transparent code structure developed in Julia + JuMP
- Adjustable level of technology operating constraints and advanced technology options
- Linear programming (LP) model or mixed integer linear programming model (MILP)
- Produce energy, capacity, and procured ancillary service prices

mopo

Modelling tools for the energy transition

Who is (some of) JuMP?

<https://github.com/jump-dev/JuMP.jl/graphs/contributors>



Contributors 146



+ 135 contributors

Recent progress : Automatic Differentiation on GPUs

Best presentation prize at JuMP-dev workshop 2024

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RESEARCH INSTITUTE FOR DATA SCIENCE

 EICP
ENTERPRISE COMPUTING PROJECT

 UNIVERSITY OF WATERLOO | Institute for Data Science

 JuMP-dev
2024

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Constraint Programming in Julia

A brief history

2019 *Ole Kröger* implemented a solver in
Julia: `ConstraintSolver.jl`

2020 Polytechnique Paris
and Montreal develop
`SeaPearl.jl` in Julia



 **RelationalAI**

2022 sponsors *Oscar Dowson* to add official
support



Also develops of `MiniZinc.jl`

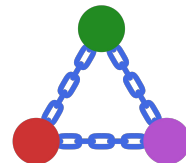
2021



Thibault Cuvelier starts interface
and reformulations in 2021

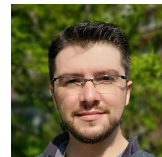
`ConstraintProgrammingExtensions.jl`

JuliaConstraints



Jean-François Baffier

Interface based on XCSP3



Local search solver in Julia: `CBLS.jl`