JuMP + HiGHS

Oscar Dowson

HiGHS workshop 2025

Outline

What is JuMP

HiGHS.jl

Who’s using HiGHS.jl

MIP reformulations

Wish list

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, PyOptInterface, Python-MIP, YALMIP, ZIMPL, …

What is JuMP?

An open-source algebraic modeling language in Julia

```
using JuMP, HiGHS
function solve_knapsack(; w::Vector, c::Vector, W::Float64)
    model = Model(HiGHS.Optimizer)
    @variable(model, 0 <= x[1:length(c)] <= 1, Bin)
    @constraint(model, sum(wi * xi for (wi, xi) in zip(w, x)) <= W)
    @objective(model, Min, c’ * x)
    optimize!(model)
    return value.(x)
end
x = solve_knapsack(; w = rand(30), c = rand(30), W = 10)
```

What is JuMP?

Statistics of the github.com/jump-dev organization

- Under development since 2013
- Supports all major problem types, including MIP, NLP, SDP
- > 50 connected solvers
- > 60 repositories in github.com/jump-dev

In the last year

- > 10,000 downloads/month
- > 1,000 pull requests
- > 300 issues opened
- > 50 contributors

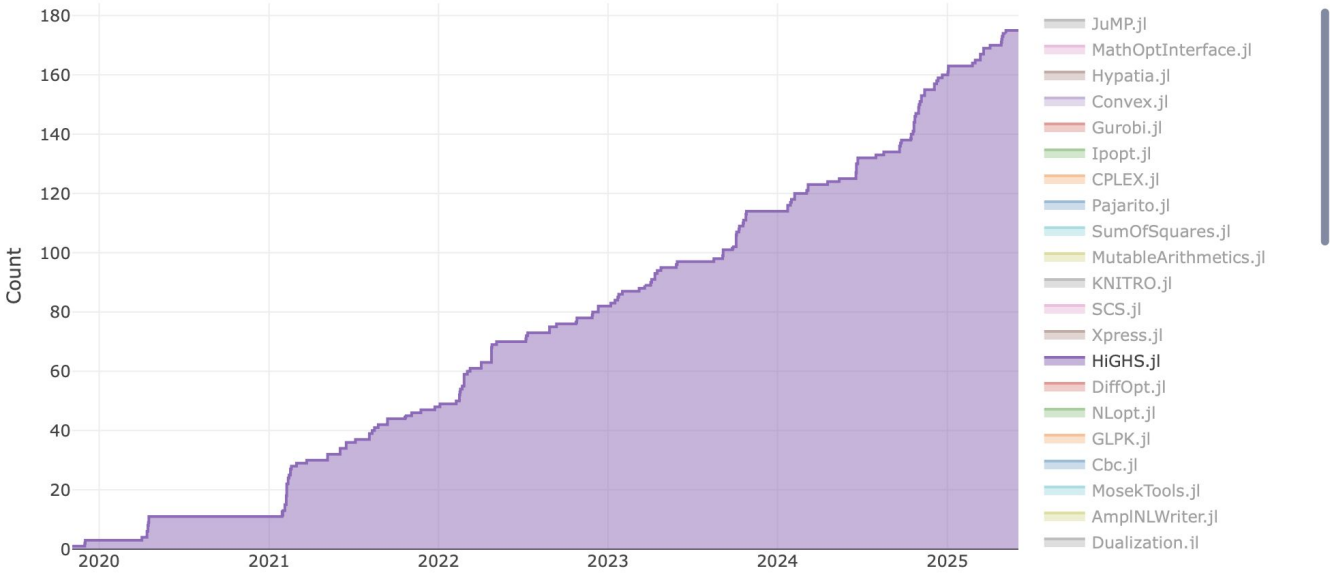
What is HiGHS.jl

The Julia interface to HiGHS

- github.com/jump-dev/HiGHS.jl
- A Julia package
- Wraps the complete C API. It can do anything C can do
- Provides an interface to JuMP
- Under development since 2019
- 12 contributors
- ~6,000 lines of Julia code

HiGHS.jl

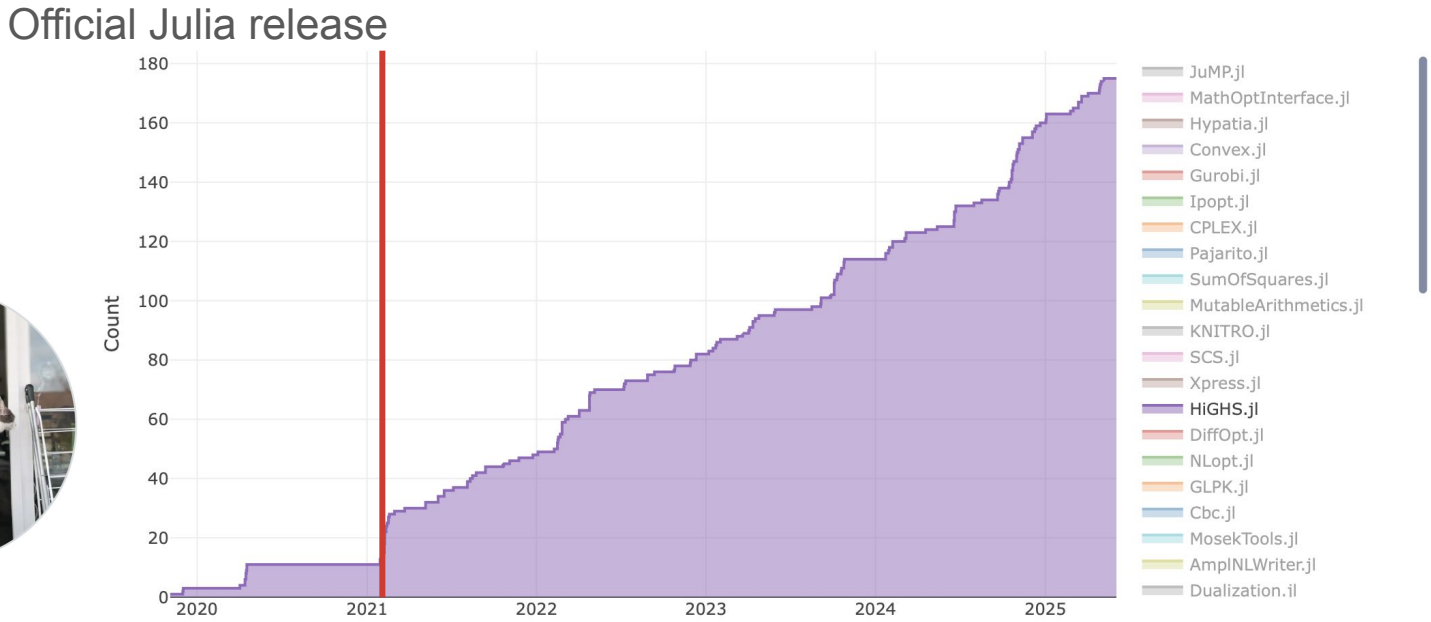
A history



HiGHS.jl

A history

Mathieu Besançon
matbesancon · he/him



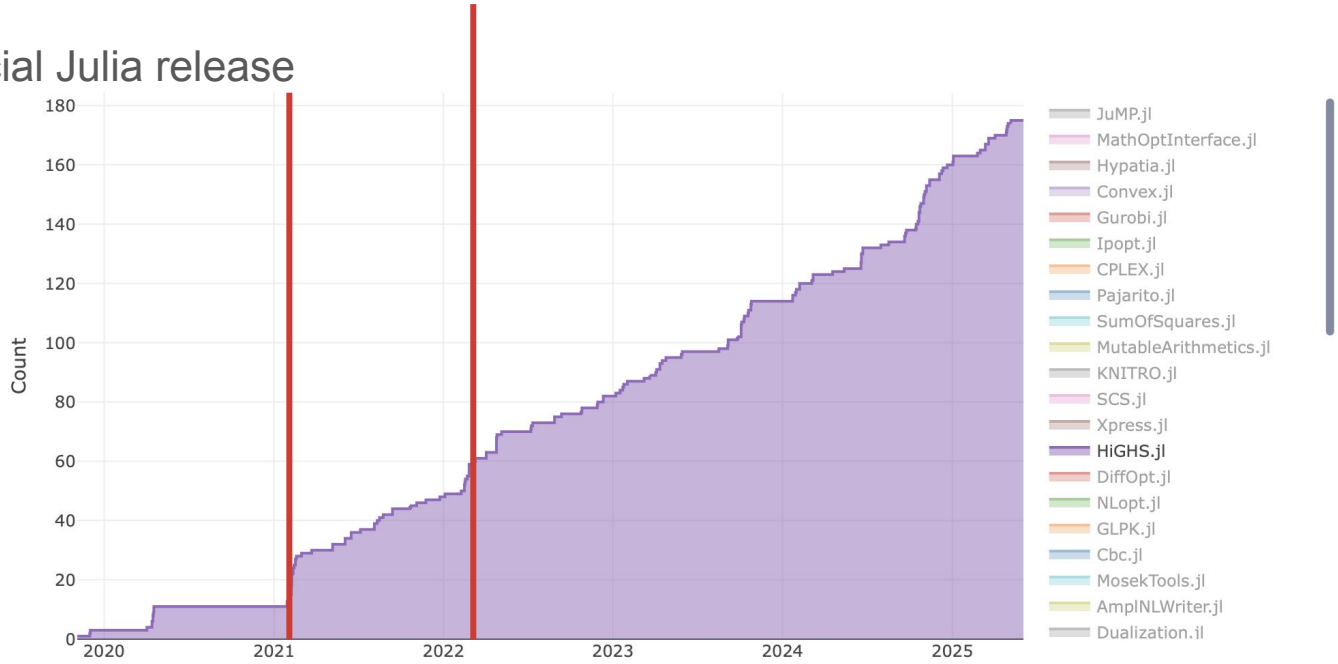
HiGHS.jl

A history

HiGHS.jl v1.0 release

Started using HiGHS in JuMP documentation

Official Julia release



Mathieu Besançon
matbesancon · he/him

HiGHS.jl

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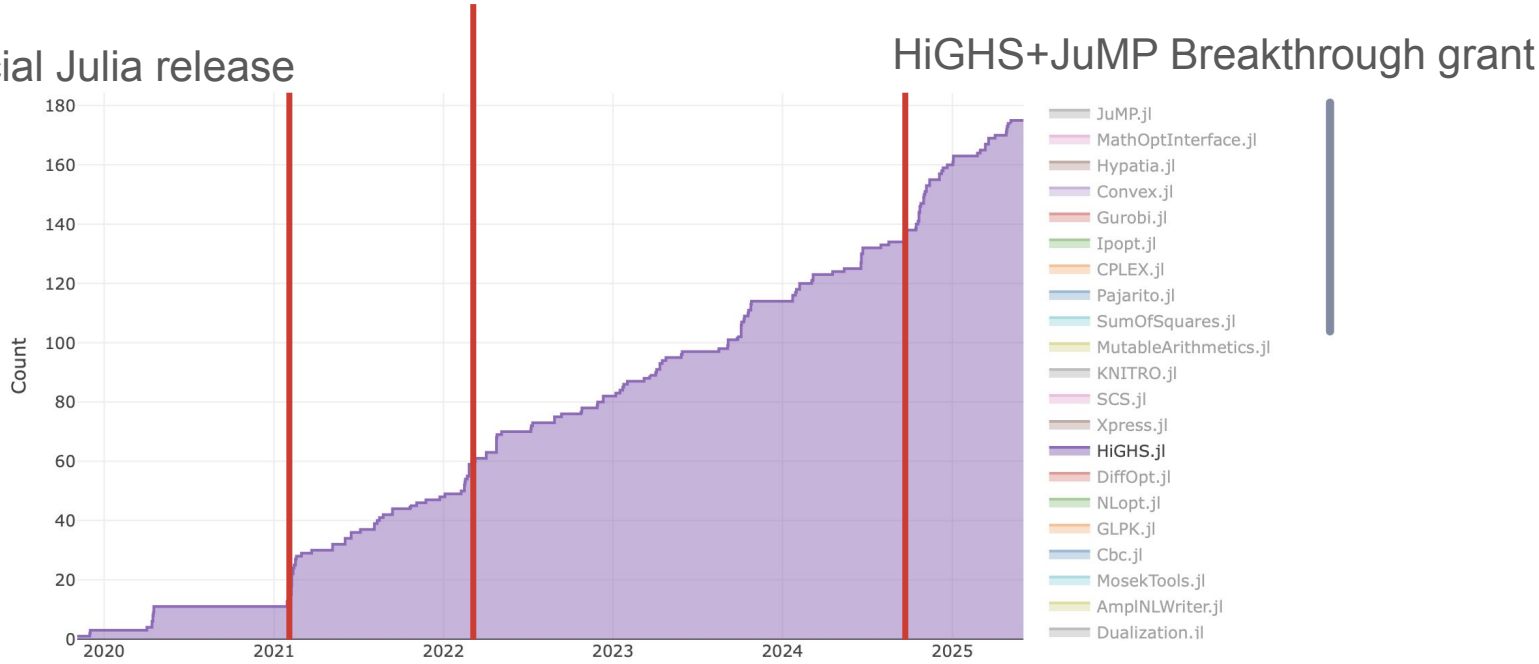
HiGHS+JuMP Breakthrough grant

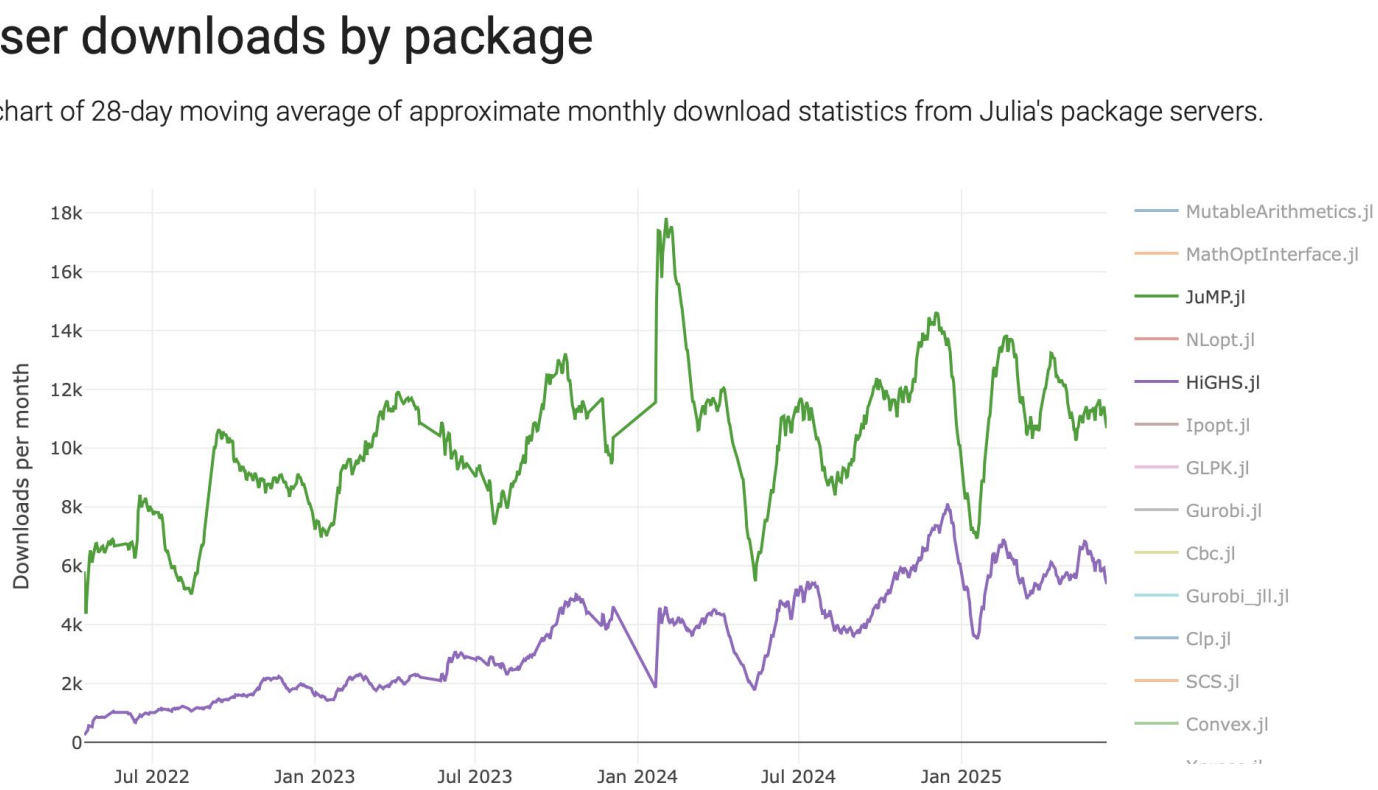


Mathieu Besançon
matbesancon · he/him

Who’s using HiGHS.jl

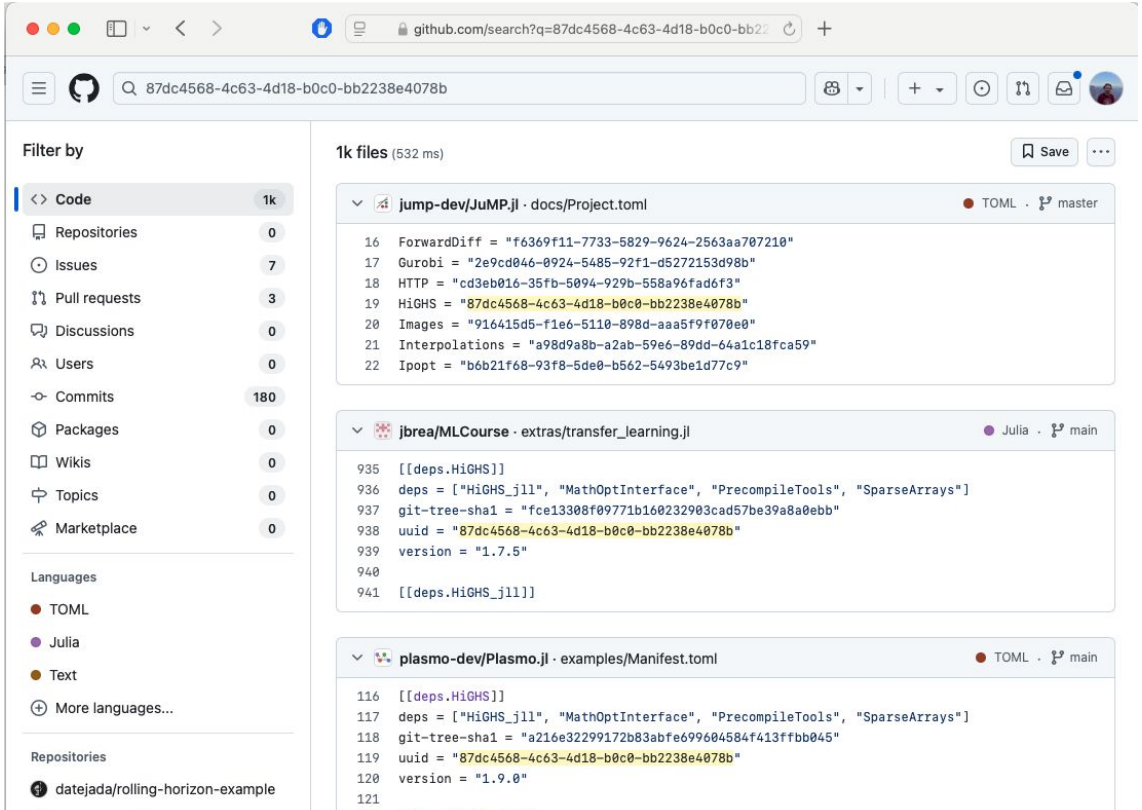
Who's using HiGHS.jl

*we don't collect identifiable statistics. Look at trend, not absolute



Who’s using HiGHS.jl

>1k projects on GitHub



Who’s using HiGHS.jl

Julia packages

Thomas Christensen
thchr

Follow

45 followers · **2** following

Technical University of Denmark
thomas@dtu.dk
https://thchr.github.io/

README | MIT license

PresentationScheduling.jl

CI passing | codecov 87%

Schedule a list of meetings, distributing research and journal club presentations so as to maximize the time-separation between presentations by the same individual.

Example

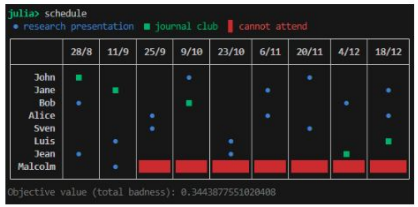
```
using PresentationScheduling

dates = Date("2024-08-28"):Week(2):Date("2024-12-18")
individuals = ["John", "Jane", "Bob", "Alice", "Sven", "Luis", "Jean", "Malcolm"]

presentations_modify = Dict("Malcolm" => 1, "Alice" => 3)
journals_modify = Dict("Malcolm" => 0, "Alice" => 0, "Sven" => 0)
cannot_attend = Dict("Malcolm" => dates[3:end])

schedule = optimize_presentation_schedule(
    individuals, dates, presentations_modify, journals_modify, cannot_attend;
    default_presentations=2,
    min_total=2,
    max_total=3,
    min_presentations=1,
    max_presentations=3,
    min_journals=0,
    max_journals=1,
    time_limit=20)
```

Which returns a `PresentationSchedule` that displays as a time-table:



Who’s using HiGHS.jl

Julia packages

Neel Smith
neelsmith

Follow

53 followers · **3** following

README GPL-3.0 license

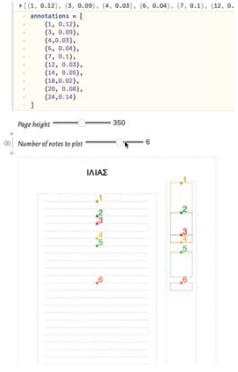
MiseEnPage.jl

Analyze the layout of manuscript pages edited following the conventions of the Homer Multitext project.

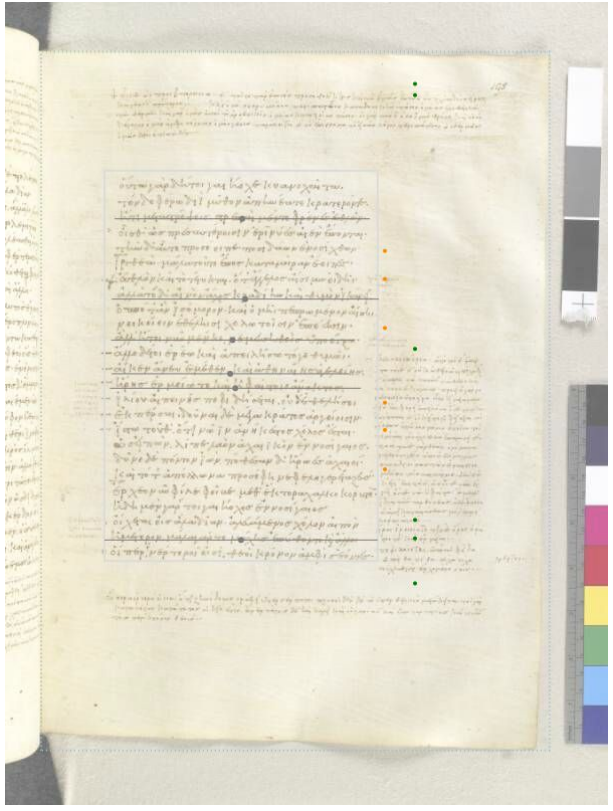
See the documentation.

Visualizations

Interactive Pluto notebook: optimizing placement of *scholia* under the proximity hypothesis:



Results of anlaysis, Venetus A, folio 195 *recto*: theoretical `y` position under the proximity hypothesis versus actual `y` positions:



Who's using HiGHS.jl

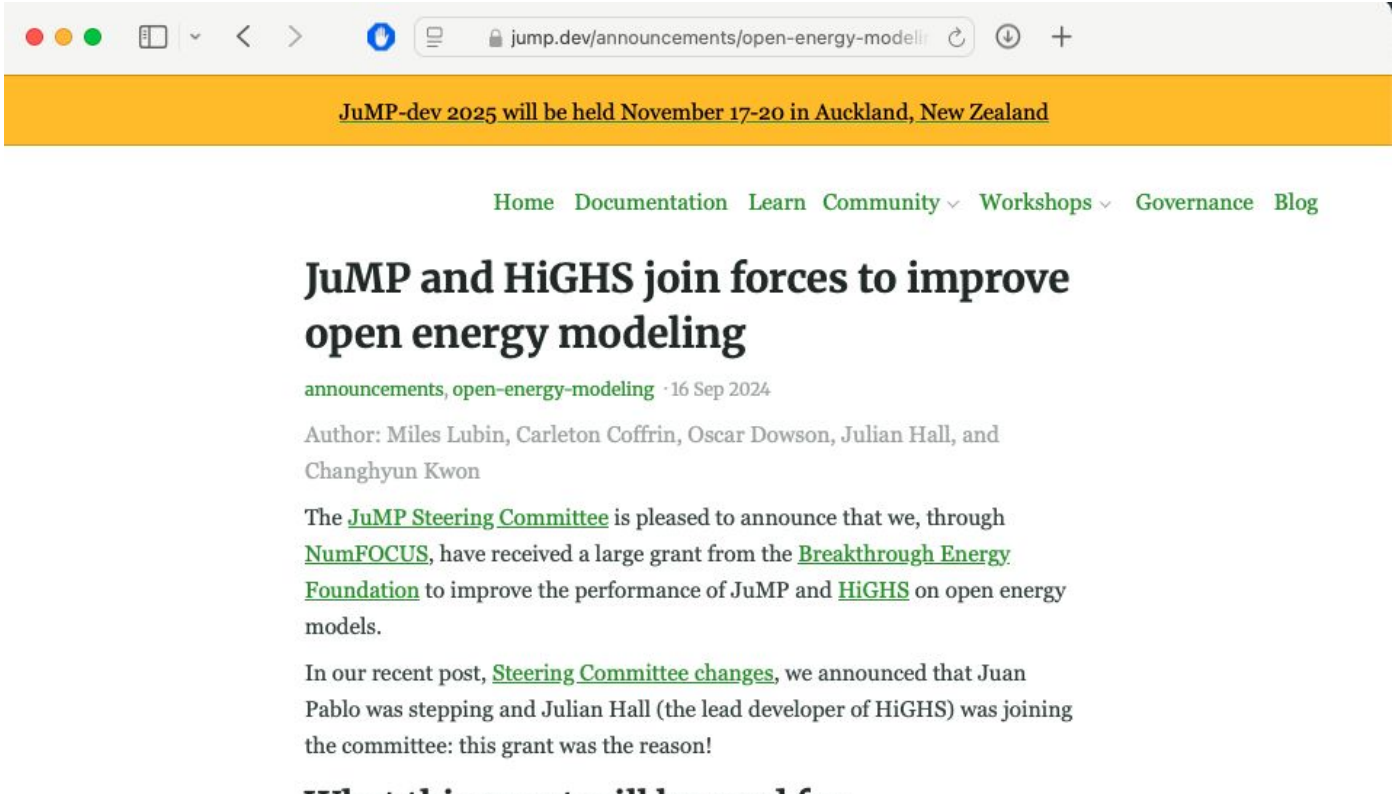
Energy system modellers

AnyMOD.jl, Dolphyn.jl, ElectricityEmissions.jl, EnergyModelsX, GenX.jl, IESopt.jl, MacroEnergy.jl, PowerModelsONM.jl, PowerModelsWildfilre.jl, PowerSimulations.jl, SpineOpt.jl, TulipaEnergyModel.jl, UnitCommittment.jl, WaterModels.jl, …

tl;dr: HiGHS is used by many groups, all around the world, to solve energy related optimization problems from real-time operation of a battery through long-term planning of continental-scale systems

Who's using HiGHS.jl

Energy system modellers



MIP reformulations

Bridging the gap between user formulations and the solver

MIP reformulations

Bridging the gap between user formulations and the solver

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model = Model(HiGHS.Optimizer)
@variable(model, x[1:3], Bin)
@constraint(model, x in SOS2())
```

MIP reformulations

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```

```
julia> print(unsafe_backend(model))
Feasibility
Subject to:
VariableIndex-in-ZeroOne
 x[1] ∈ {0, 1}
 x[2] ∈ {0, 1}
 x[3] ∈ {0, 1}
 v[4] ∈ {0, 1}
 v[5] ∈ {0, 1}
ScalarAffineFunction{Float64}-in-EqualTo{Float64}
 0.0 + 1.0 v[4] + 1.0 v[5] == 1.0
ScalarAffineFunction{Float64}-in-LessThan{Float64}
 0.0 - 1.0 x[1] <= 0.0
 0.0 + 1.0 x[1] - 1.0 v[4] <= 0.0
 0.0 - 1.0 x[2] <= 0.0
 0.0 + 1.0 x[2] - 1.0 v[4] - 1.0 v[5] <= 0.0
 0.0 - 1.0 x[3] <= 0.0
 0.0 + 1.0 x[3] - 1.0 v[5] <= 0.0
```

MIP reformulations

Bridging the gap between user formulations and the solver

```
using JuMP, HiGHS
model = Model(HiGHS.Optimizer)
@variable(model, x[1:3], Bin)
@constraint(
    model,
    x[1] --> {x[2] + x[3] == 0},
)
```

MIP reformulations

Bridging the gap between user formulations and the solver

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using JuMP, HiGHS
model = Model(HiGHS.Optimizer)
@variable(model, x[1:3], Bin)
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 0.0 + 1.0 x[2] + 1.0 x[3] + 1.0 v[4] == -0.0
ScalarAffineFunction{Float64}-in-LessThan{Float64}
 0.0 + 2.0 x[1] - 1.0 v[4] <= 2.0
 0.0 + 1.0 v[4] <= 0.0
```

Wishlist

*I’m an unusual customer

Wishlist

*I’m an unusual customer

Keep fighting the good fight

Wishlist

*I’m an unusual customer

- Stability. Keep fighting the good fight. All else optional.

Wishlist

*I’m an unusual customer

- Stability. Keep fighting the good fight. All else optional.

- Lazy constraint callbacks
- IIS
- Better documentation of the C API (this is really a TODO for me)
  - What fields can be NULL and when
  - What arrays need to be length N or N+1

JuMP-dev 2025

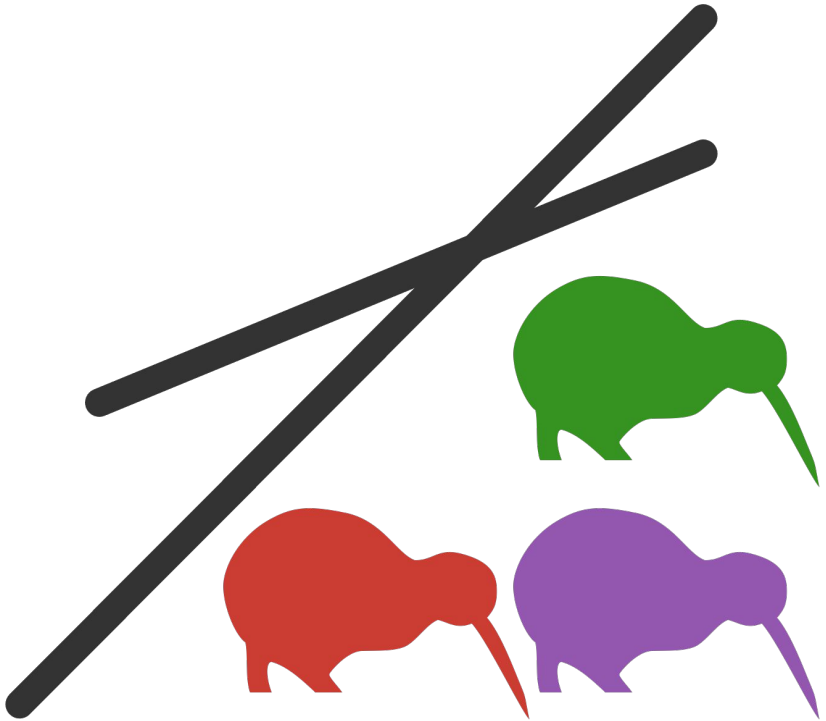
November 17–20

Auckland, New Zealand

More information at https://jump.dev

Need help? Join the JuMP forum

https://jump.dev/forum



The binary distribution problem

How to avoid compiling on user computers

The binary distribution problem

How to avoid compiling on user computers

JuliaPackaging/Yggdrasil

build_tarballs.jl script describes how to compile HiGHS

Cross compile 30 times

JuliaPackaging/HiGHS_jll.jl

Download single binary on install

jump-dev/HiGHS.jl

HiGHS

ERGO-Code/HiGHS

```
julia> import Pkg
julia> Pkg.add("HiGHS")
```

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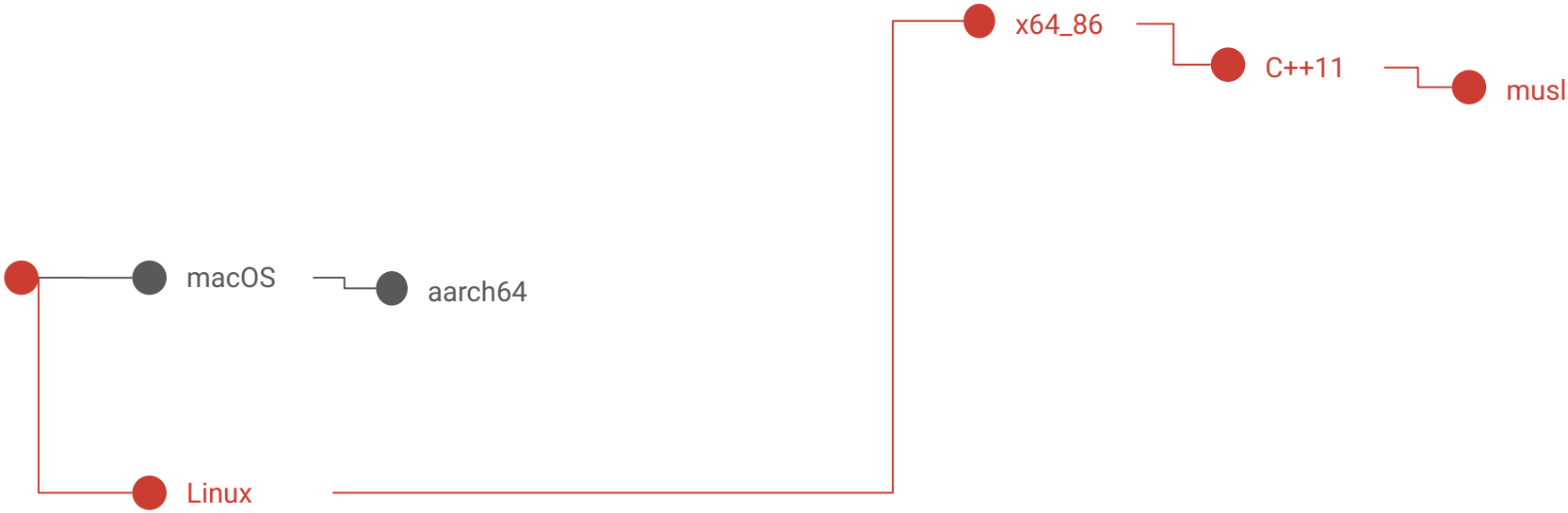

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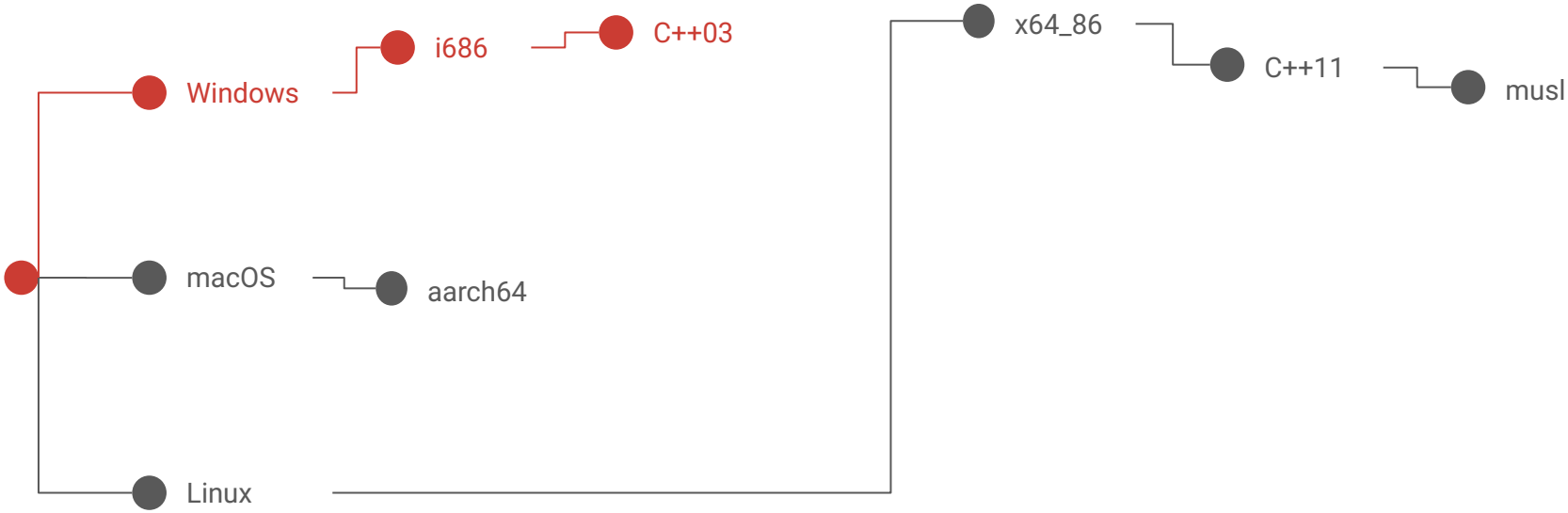

The binary distribution problem

How to avoid compiling on user computers