



Symphonic HiGHS

Operationalizing next moves with DecisionOps

Ryan O'Neil · June 27, 2024



👋 Hello, I'm Ryan O'Neil



Currently: Nextmv co-founder & CTO

Building a DecisionOps platform for OR practitioners

Previously: Grubhub, Zoomer, MITRE

Led decision engineering teams, built many a model


Likes cats, cellos, and camping

I also make excellent llama jokes in my spare time



This talk is about

 How Nextmv started using HiGHS and what we use it for

 How HiGHS works in Netmv's DecisionOps platform to provide scalable open-source optimization

 Some meanderings about OSS and optimization






How we HiGHS




How Nextmv has used HiGHS so far

 Large-ish custom models for incentive allocation in Go (~4m row x ~6m column MIPs)

 Shift scheduling and order fulfillment apps in Go

 Price optimization and facility location apps in AMPL

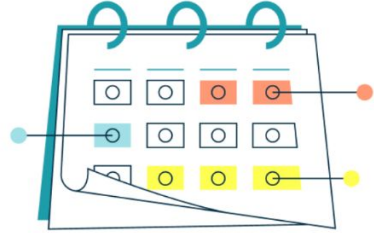
 AMPL partners built stochastic facility location models using AMPL, HiGHS, Nextmv, and Streamlit



HiGHS Shift Scheduling

HiGHS MIP Go Scheduling

Solve a shift scheduling problem with the low-code Nextmv Shift Scheduling app. Define available workers and open shifts, and then run the app to get an assigned shift plan.



Clone app

Customize app

GitHub

Available Workers

jane-doe

john-doe

jim-smith

ashley-jordan

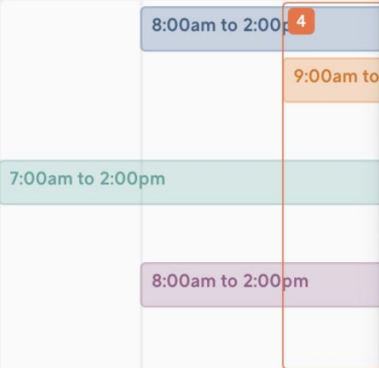
pam-linville

michael-adkins

cherise-fulmer

Date & times (Eastern Daylight Time)

2023-09-02 7 am EDT
2023-09-02 8 am EDT
2023-09-02 9 am EDT



Assigned workers (Eastern Daylight Time)

2023-09-02 7 am EDT
2023-09-02 8 am EDT
2023-09-02 9 am EDT
2023-09-02 10 am EDT
2023-09-02 11 am EDT
2023-09-02 12 pm EDT





HiGHS Shift Scheduling

Assign workers to shifts, minimizing overages and maximizing objectives.

HiGHS MIP Go Scheduling



HiGHS Order Fulfillment

Solves a MIP-based Order Fulfillment model with the Nextmv SDK.

HiGHS MIP Go Fulfillment



AMPL Price Optimization

Solves a price optimization Mixed Integer Programming problem using AMPL.

HiGHS AMPL Python Pricing



AMPL Facility Location

Solves a facility location problem using AMPL.

HiGHS AMPL Python Facility Location





DecisionOps with





Let's explore DecisionOps with HiGHS and Nextmv



- Leading open source optimization solver
- Applicable to many use cases and problem types



- Platform to build, test, deploy, and operate models efficiently
- Integrates with many optimization solutions

- **Deploy and run custom decision models on prod-ready infrastructure**
- **Perform experiments, share results, manage versions, monitor runs**



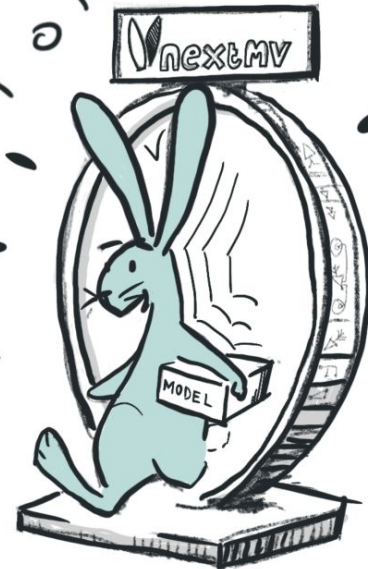
Are we supposed to jump across?



DEVELOPMENT



PRODUCTION





The workflow as we've known it

Elicit requirements from stakeholders

Translate requirements into solver speak

Test decision model in a solver (how?!?)

Hire a developer to wrap it in a microservice

Make that microservice work in the cloud

Live test (what?!? how?!?) 😱

Field questions from unhappy operators

```
maximize      cTx
subject to    Ax ≤ b
              x ≥ 0
              x ∈ Zn
```

Takes weeks to months,
involves multiple teams





Testing MIP model formulations

Traditionally

- Assemble test data on local machine
- Write custom code in notebook
- Set up, perform comparisons
- Translate to slides for collaboration

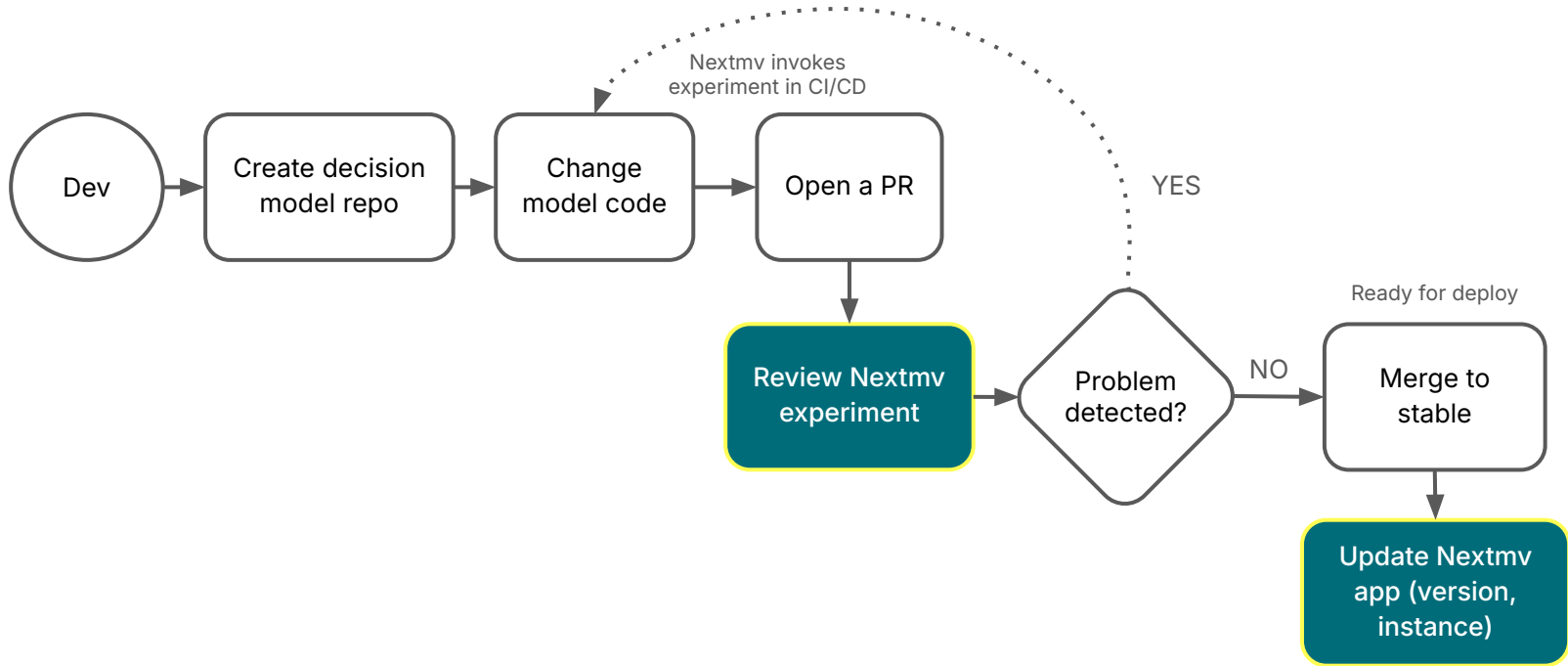
Ideally

- Have usable test sets ready to go
- Deploy/run model code remotely
- Tests are repeatable
- Results are sharable, consistent





A workflow with DecisionOps



Decision model testing framework

"I want to compare models in using production data"



Production testing

Go/no-go for production rollout
Ex: Shadow, switchback

"I want to compare models using historical data"



Historical testing

Validate model performance on sample inputs
Ex: Batch, acceptance, scenario, benchmarking

"I want to do systematic, repeatable testing"



Input sets

Model management, sharing

Run history

Infrastructure

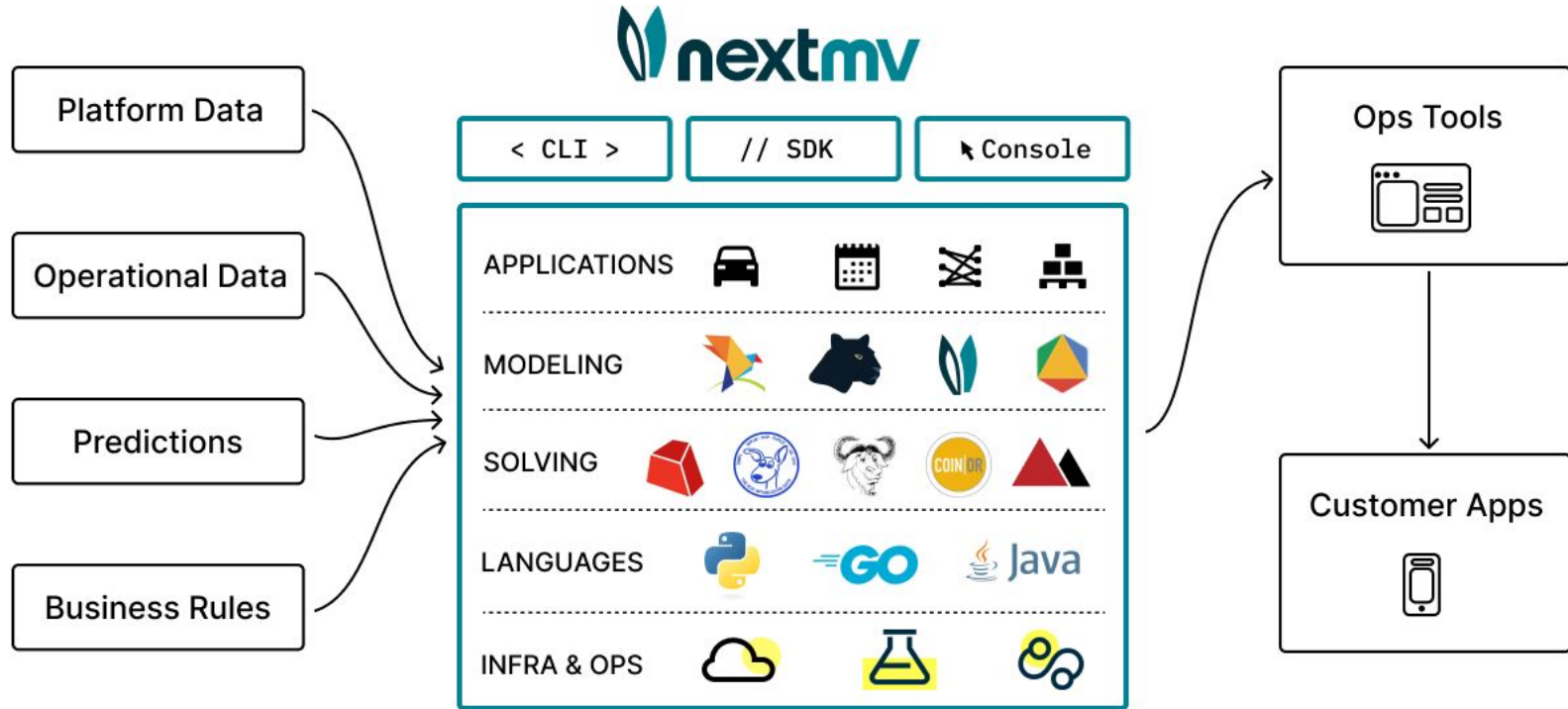
Observability

Stats Analysis

Randomizer



The Nextmv DecisionOps platform





Today's example: The Farm Share Company

- Consumer delivery service for farm-based goods
- Recently expanded to offer avocados (yeah, toast!)
- We want to price and supply avocados so as to maximize profits (while considering waste)
- How do we factor uncertainty into our transportation cost estimates?





nextmv speedrun



😬 What just happened?


- We cloned and ran HiGHS-based models for scheduling, order fulfillment, and facility location.
- We fit a price elasticity curve to the avocado data set.
- We ran a scenario test using that curve and different transportation costs in a HiGHS-based pricing model.





Test workflow in practice


benchmark		
succeeded last week in 4m 30 s		
>	✓	Set up job 2s
>	✓	Clean up 0s
>	✓	Clone 3s
>	✓	Clone console repository 6s
>	✓	Setup SSH Keys and known_hosts 0s
>	✓	Set go version to be latest supported 0s
>	✓	Set up go 0s
>	✓	Install CLI 6s
>	✓	Configure CLI 29s
>	✓	Run benchmark 3 m 37s

Yesterday ▾

 **Benchmark Degradation** APP 11:49 PM

Performance warning: new geometric mean is worse than 2% of the old geometric mean! (environment: dev, old version/value: 901534b / 9047118.95, new version/value: a665d59 / 9269395.81) [See details >>](#)

 1 

 [11 replies](#) Last reply today at 2:27 AM





OSS and optimization



Operations Research

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Ask questions, find answers and collaborate at work with Stack Overflow for Teams.

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Ask Question

Why is open source operations research software so far behind open source statistics and machine learning software?

Asked 2 years, 3 months ago Modified 2 years ago Viewed 5k times



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Like many who participate in this site, I work on projects in both operations research (OR) and statistics/[machine learning](#) (ML). The different states of open source software in these fields are often discouraging as an OR professional.

In statistics, the research culture encourages researchers to implement their contributions in the domain-specific language [R](#), so that practitioners have access to working software alongside a whitepaper.

In ML, companies like Google and Facebook spend gobs of money to develop open source tools like [TensorFlow](#) and [PyTorch](#), which provide state-of-the-art ML tools to the masses.

The state of open source software in statistics and ML allows incremental contributions by individual researchers to be quickly incorporated and utilized by their research communities.

But in OR (and [integer programming](#) and [combinatorial optimization](#) in particular), [Gurobi Optimizer](#) and [CPLEX](#) have a stranglehold on the state of the art. Using an open source solver means you are leaving performance gains on the table. The result is that academic research in these areas has less impact. because anyone who wants to use the research

Featured on Meta

- Upcoming initiatives on Stack Overflow and across the Stack Exchange network
- New Focus Styles & Updated Styling for Button Groups

Linked

- 29 [What are the advantages of commercial solvers like Gurobi or Xpress over open source solvers like COIN-OR or CVXPY?](#)

Related

- 6 [Interface for Cbc - COIN-OR](#)
- 7 [How to reduce the risk of wrong modelling in OR industry projects?](#)





pytorch

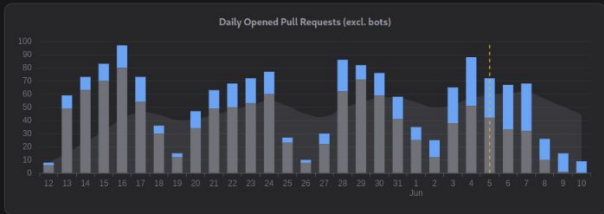
0 30d 90d 6m 1y all

Commits (30d)



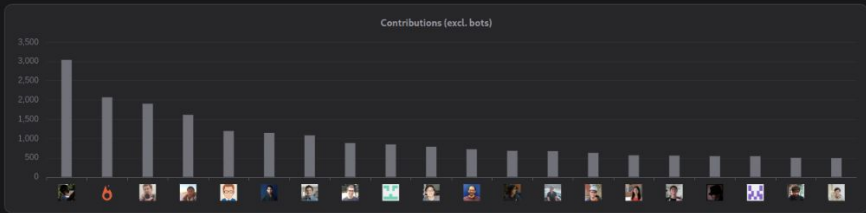
- Latest (excl. bots)
- CaoE** 7h ago: Set simlen based on ATEN_CPU_CAPABILITY. (#123514)...
 - xuhancn** 13h ago: fix miss isa boot check. (#128274)...
 - cyeyer** 14h ago: [3/N] Remove unused functions. (#127185)...
 - peterbell10** 16h ago: Don't create python tuple when _maybe_handle_torch_function is called from C++...

Pull Requests (30d)



- Latest (excl. bots)
- OPEN bdhirsh** 11h ago: add TORCH_FORCE_SYNCHRONOUS_COLLECTIVES to force functional collectives to be synchronous
 - OPEN xuhancn** 1h ago: [Don't merge] Try to restructure code
 - OPEN jamesjwu** 1h ago: Support allowedlisted modules and op overloads in ADI/AutoGradCache
 - OPEN ezyang** 2h ago: Add some guard to size oblivious has_internal_overlap

Contributors (all)



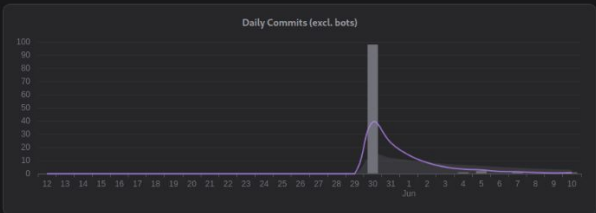
5d EMA 14d EMA Release



google or-tools

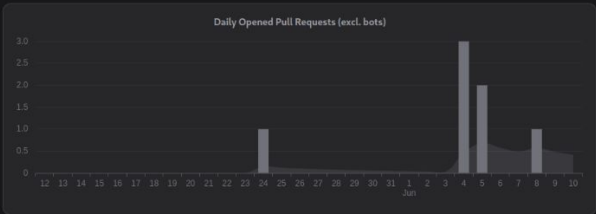
1 30d 90d 6m 1y all

Commits (30d)



- Latest (excl. bots)
- ron-at-swg** 4d ago: Update Python CMake file for OpenBSD (#4266)...
 - Iperron** 5d ago: Merge pull request #4262 from google/develop:bot@ps/bazel(pip-9d732ab251)...
 - ron-at-swg** 5d ago: Use correct tp_env definition for OpenBSD (#4259)...
 - Iperron** 6d ago: Merge pull request #4257 from ron-at-swg/OpenBSD-Updates...

Pull Requests (30d)



- Latest (excl. bots)
- CLOSED ron-at-swg** 3d ago: Update SWIG flags for OpenBSD
 - CLOSED varshneydevansh** 5d ago: replace CapSub with CapAdd for StartMin value
 - CLOSED ron-at-swg** 5d ago: Use correct tp_env definition for OpenBSD
 - CLOSED ron-at-swg** 6d ago: Updates for OpenBSD build support

Contributors (all)



5d EMA 14d EMA Release



SCIP 20 Workshop: "SCIP: Past, Present, Future"

Industry has a rather
different answer:

"Resoundingly yes!"

Future Needs



Does the world need an academic solver like SCIP?

Maybe no:

- ▷ Researchers are increasingly using Gurobi (no other solver) for experiments.
- ▷ The gap is increasing (see last slide).
- ▷ One reason: careful engineering, which is hard to do in a research project (e.g., tuning parallelization).

Well, yes:

- ▷ We need a framework, e.g., for branch-and-cut-and-price.
- ▷ It is essential to have the source code for developing MIP- or MINLP- solvers.
- ▷ It is scientifically sound to at least be able to understand what an underlying solver is doing instead of treating it as a black-box.





Of course we need high quality open source MIP

- Lots of companies use HiGHS, SCIP, OR-Tools, and others in production.
- Data science and software engineering users are particularly used to adopting and deploying OSS tools.
- We really should use more OSS optimization in research.



The screenshot shows the GitHub repository page for 'community-apps'. At the top, the repository name 'community-apps' is displayed with a 'Public' badge and a 'Watch 8' button. Below this, the current branch is 'develop', with '2 Branches' and '0 Tags' indicated. A search bar for 'Go to file' and buttons for 'Add file' and 'Code' are visible. A commit by 'nextmv-bot' is highlighted, with the message 'Bump app versions: demand-forecasting-ortools=v0.1.0,shift...'. Below the commit, a list of folders is shown, each with a 'Bump' button next to it:

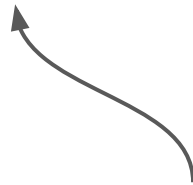
- .github/workflows
- .nextmv
- cost-flow-ortools
- demand-forecasting-ortools
- knapsack-ampl
- knapsack-gosdk
- knapsack-gurobi
- knapsack-java-ortools

cloud.nextmv.io



The screenshot shows the Nextmv Marketplace interface. On the left, there are navigation options: 'Marketplace', 'Apps', and 'Integrations'. The main area displays a grid of application cards:


- Featured:** Nextmv Routing. Description: Route drivers to stops for delivery, distribution, and sourcing use cases. Capacity, compatibility attributes and many more features. Tags: Nextroute, SDK, Go, Routing.
- HIGHS Shift Scheduling:** Assign workers to shifts, minimizing overages and maximizing objectives. Tags: HIGHS, MIP, Go, Scheduling.
- Order Fulfillment:** Solves a MIP-based Order Fulfillment model with the Nextmv SDK. Tags: HIGHS, MIP, Go, Fulfillment.
- OR-Tools Shift Planning:** Solve a MIP-based shift planning model with OR-Tools. Tags: SCIP, OR-Tools, Python, Scheduling.
- OR-Tools Routing:** Solve an unconstrained vehicle routing problem. Tags: SCIP, OR-Tools, Python, Routing.
- OR-Tools Shift Assignment:** Solve a MIP-based shift assignment model with OR-Tools. Tags: SCIP, OR-Tools, Python, Scheduling.
- Pyomo Shift Assignment:** Solve a MIP-based shift assignment model with Pyomo. Tags: CBC, Pyomo, Python, Scheduling.
- Pyomo Shift Planning:** Solve a MIP-based shift planning model with Pyomo. Tags: CBC, Pyomo, Python, Scheduling.





<https://github.com/nextmv-io/community-apps>



This is an exciting time!

 Our challenge is one of adoption. Solvers can lean into strengths instead of competing as commodities. If we grow the pie of optimization users, we all get more pie.

 Just like DS and ML, we need lots of “on ramps” to adoption. This means high quality commercial and open source solvers and platforms.

 The release of HiGHS marked an inflection point in open source solver development. It is accelerating!

... and so is commercial solver development!



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[@ryanjoneil](#)



www.nextmv.io





Time for Q&A



The logo for nextmv features a stylized white icon of two leaves or petals on the left, followed by the text "nextmv" in a bold, lowercase, sans-serif font. The logo is centered horizontally and spans across the orange, grey, teal, and yellow vertical bands of the background.

nextmv