An Open Source Hydroeconomic Model for California's Water Supply System: PyVIN

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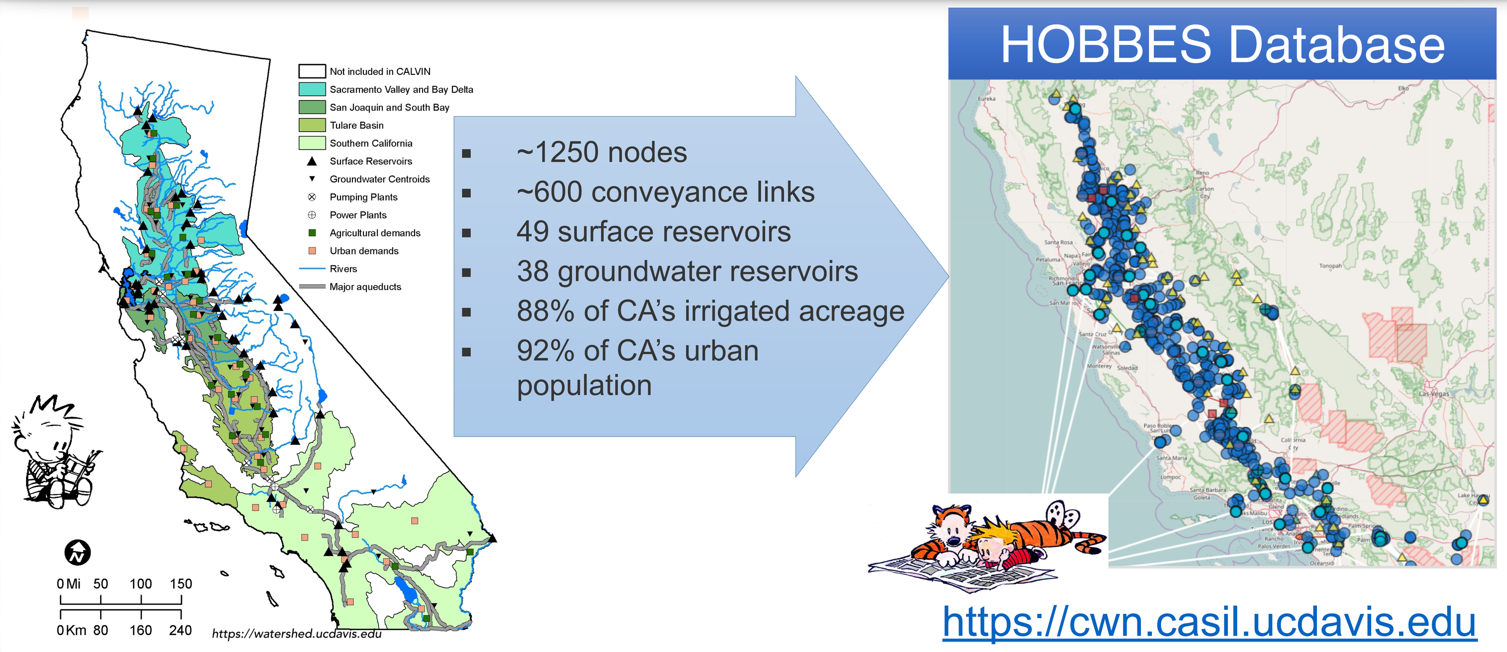
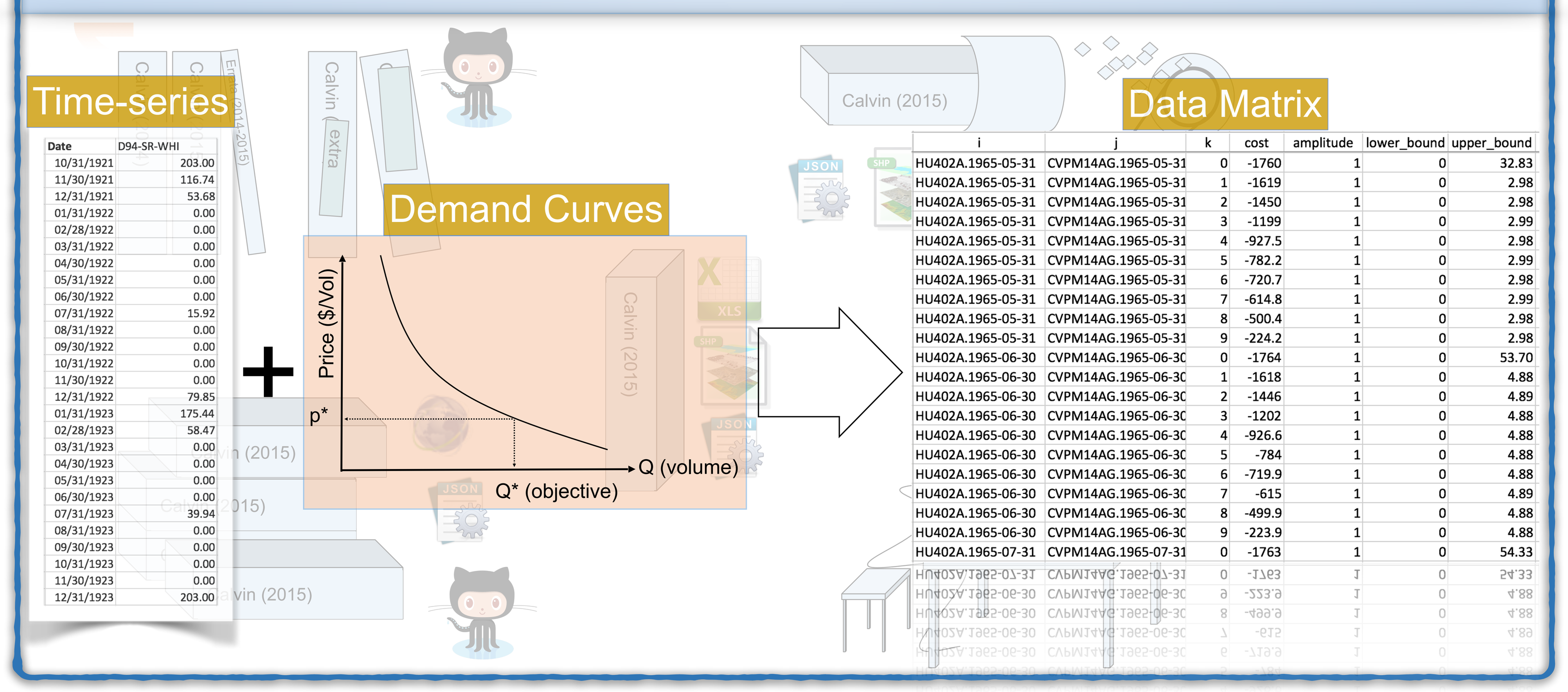
1 Open source database with existing CALVIN data: hydrology & economics



https://cwn.casil.ucdavis.edu

2 Input: a HOBBES tool converts time-series data into matrix format



3 PyVIN network flow optimization model

- Linear programming network flow model with gains & losses

$$\text{minimize} \quad Z=\sum_i \sum_j \sum_k c_{ijk} X_{ijk}$$

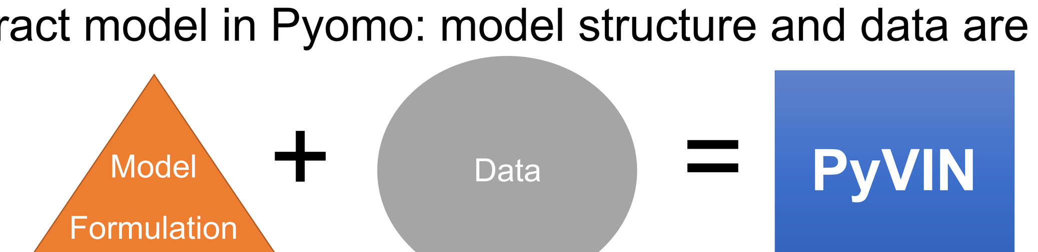
$$\text{subject to} \quad \sum_i \sum_k X_{jik} = \sum_i \sum_k a_{ijk} X_{ijk} + b_j \quad \text{for all nodes } j$$

$$X_{ijk} \leq u_{ijk} \quad \text{for all arcs}$$

$$X_{ijk} \geq l_{ijk} \quad \text{for all arcs}$$

where
Z: total cost
X: flow on the arc
c: unit cost (or penalty)
b: external flow
a: amplitude
l: lower bound
u: upper bound

- An abstract model in Pyomo: model structure and data are separate



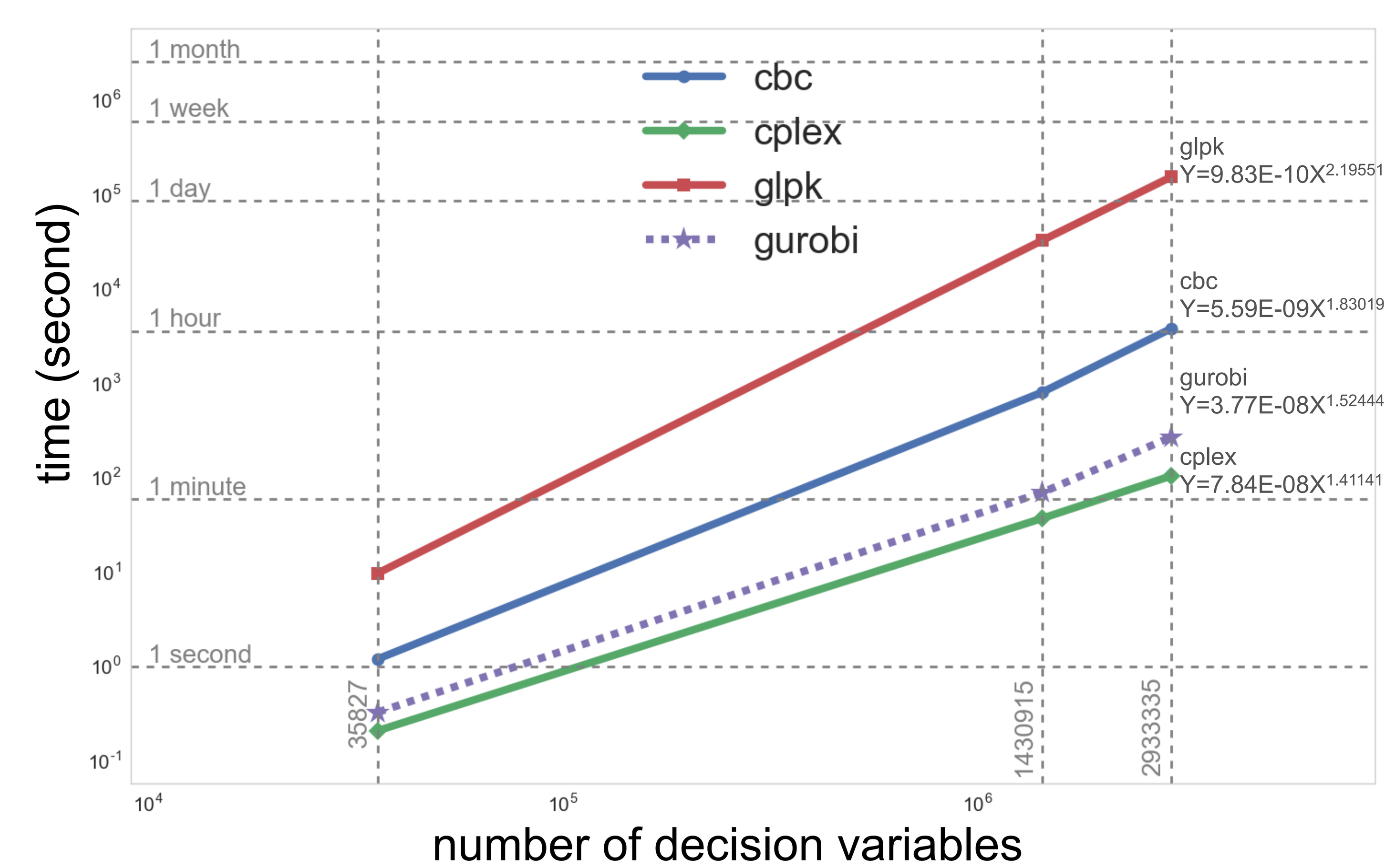
- Uses freely available state-of-the-art solvers and not solver specific

Installed Solvers:
- CPLEX
- CBC
- GUROBI
- GLPK

- The source code and data are publicly available on GitHub

4 Solver runtime comparison for different model sizes and solvers

- Runs are performed on UC Davis College of Engineering's HPC1 (High Performance Computer)
- CBC, CPLEX and GUROBI are run in parallel, and GLPK is run in serial

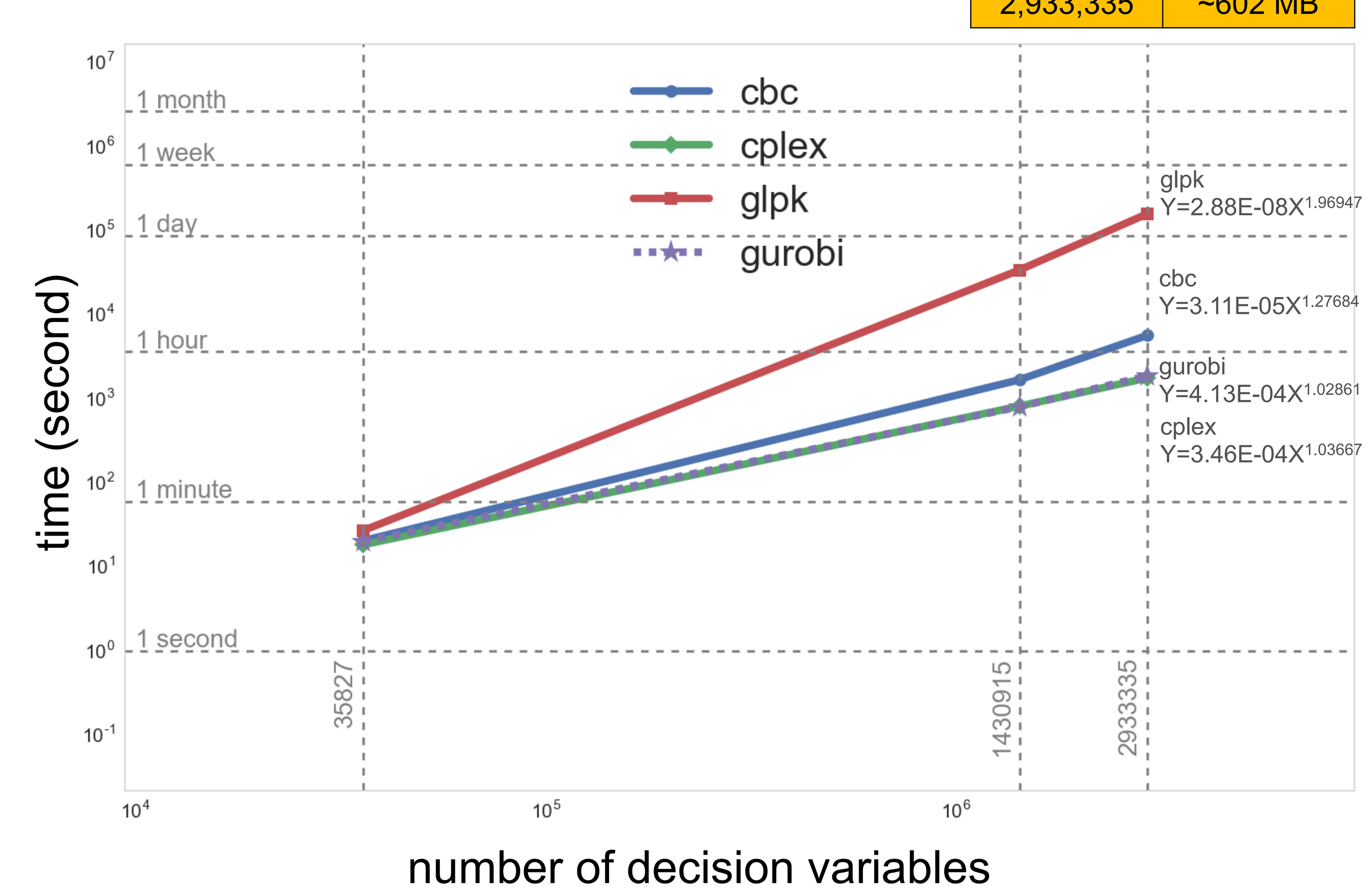


5 Total calculation time comparison

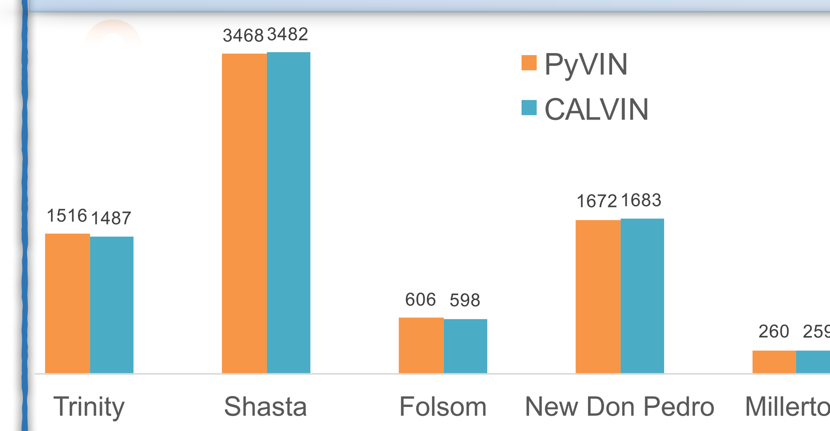
preprocess	solver	postprocess
Pyomo builds the model	Solver solves the model	Results are written in .json or .yaml

- Differences get bigger as model size increases
- cplex and gurobi have similar total calculation time

# of decision variables	output file size (json)
35,827	~7.5 MB
1,430,915	~300 MB
2,933,335	~602 MB



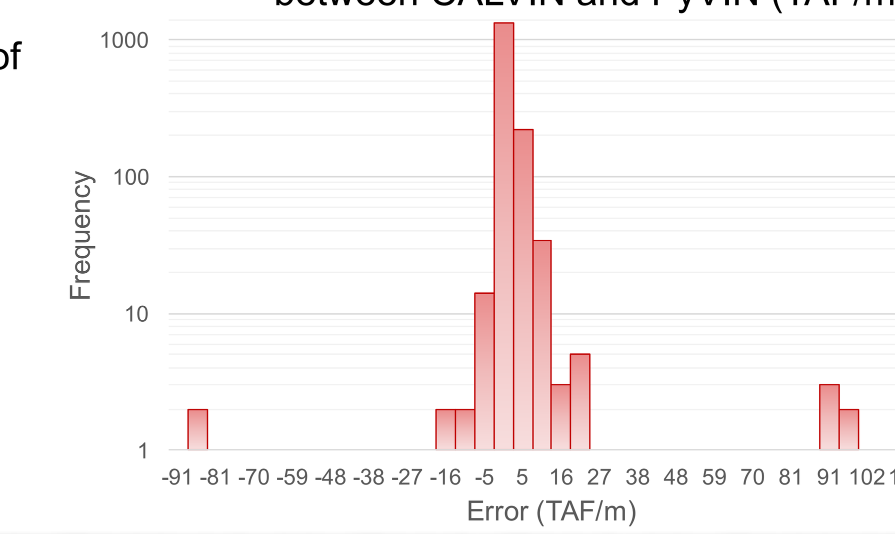
6 Comparing preliminary results from PyVIN to existing CALVIN results



Average storage comparison of selected reservoirs (TAF)

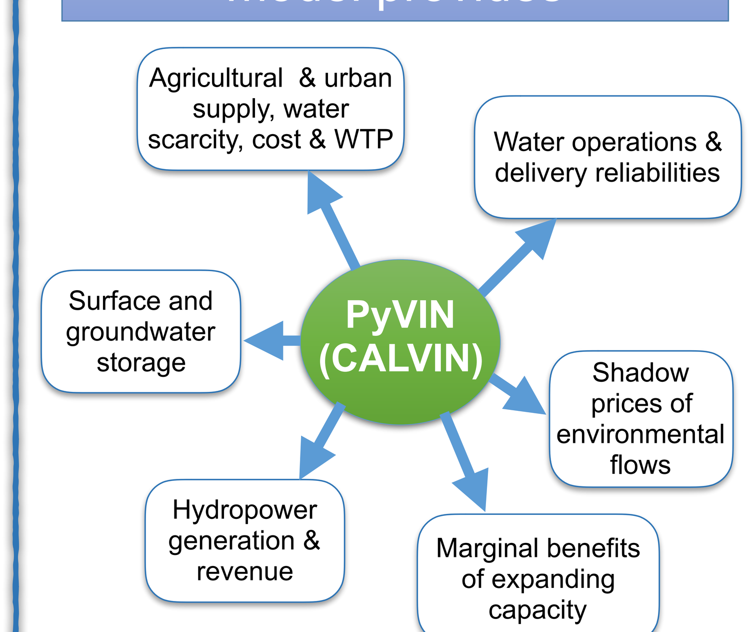
- PyVIN model is still under development and minimum in-stream flow requirements are not fully represented yet
- Small differences on selected reservoirs' average storage

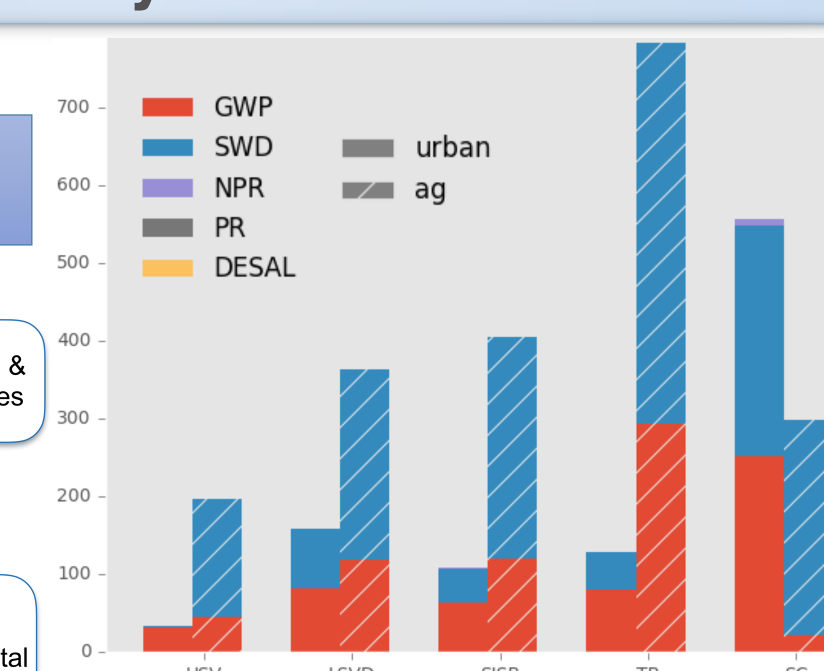
Monthly average flow differences between CALVIN and PyVIN (TAF/m)



7 Postprocessed preliminary results from PyVIN

Some useful results the model provides





- Regional urban and agricultural water supply portfolios (TAF/m)

Regions:
USV: Upper Sacramento Valley
LSVD: Lower Sacramento Valley & Delta
SJSB: San Joaquin & South Bay
TB: Tulare Basin
SC: Southern California

8 References & Acknowledgements

- Draper, A. J., Jenkins, M. W., Kirby, K. W., Lund, J. R., & Howitt, R. E. (2003). Economic-engineering optimization for California water management. *Journal of water resources planning and management*, *129*(3), 155-164.
- Pyomo: http://www.pyomo.org
- PyVIN repository: https://github.com/msdogan/pyvin
- HOBBES repositories: https://github.com/ucd-cws/calvin-network-tools & https://github.com/ucd-cws/calvin-network-data

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