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BEAM-ME

Methods to reduce computing times of linear energy system optimization models

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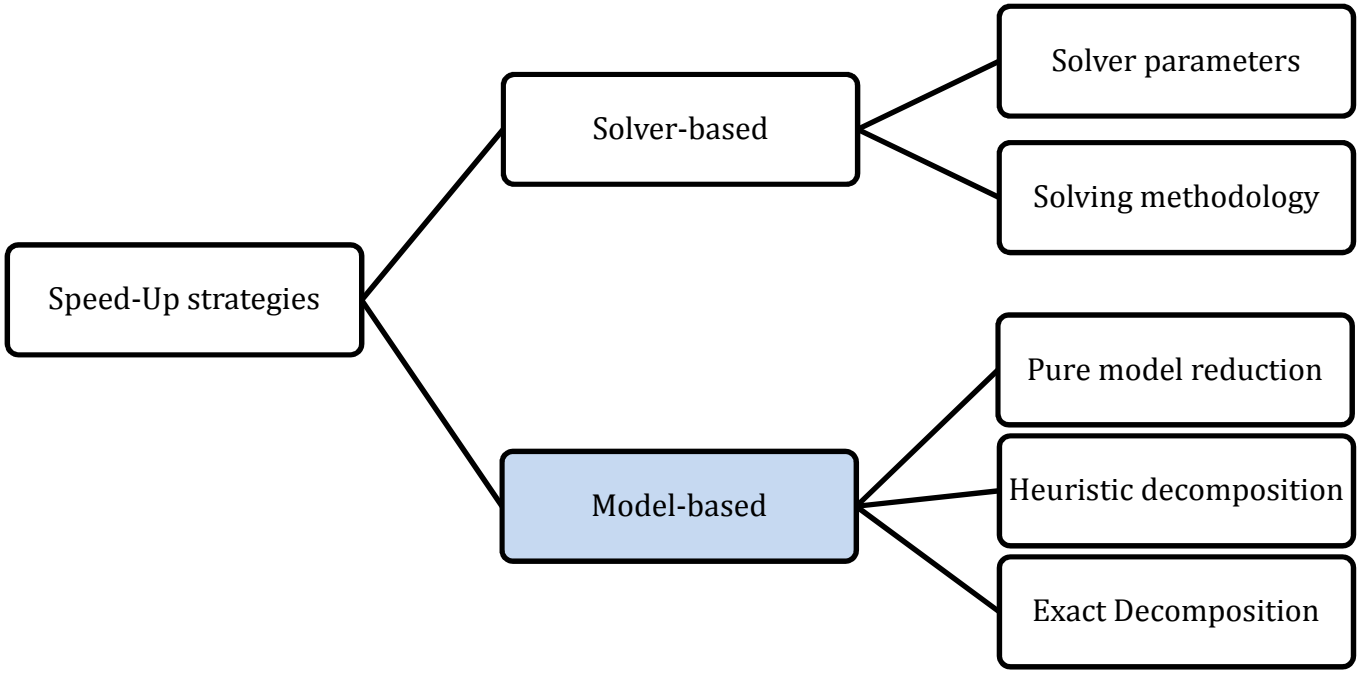
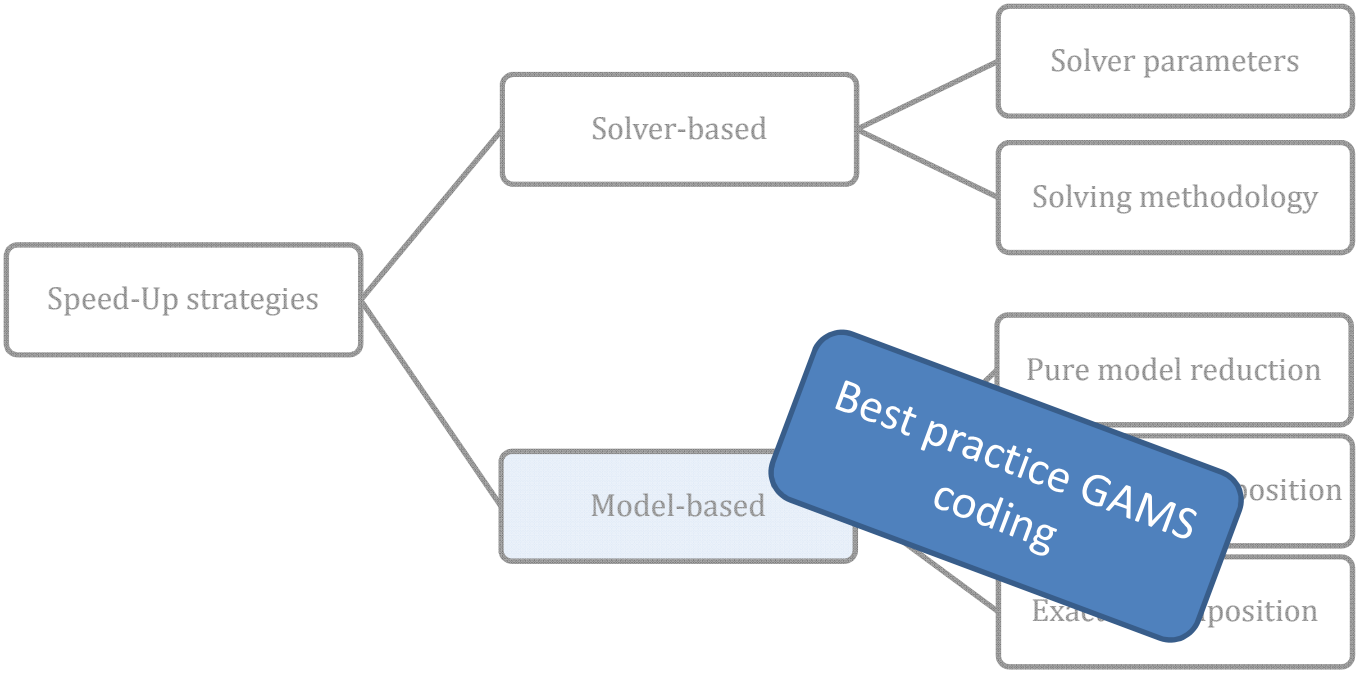
Approach I: Model-based computing time reduction



„Low Hanging Fruits“

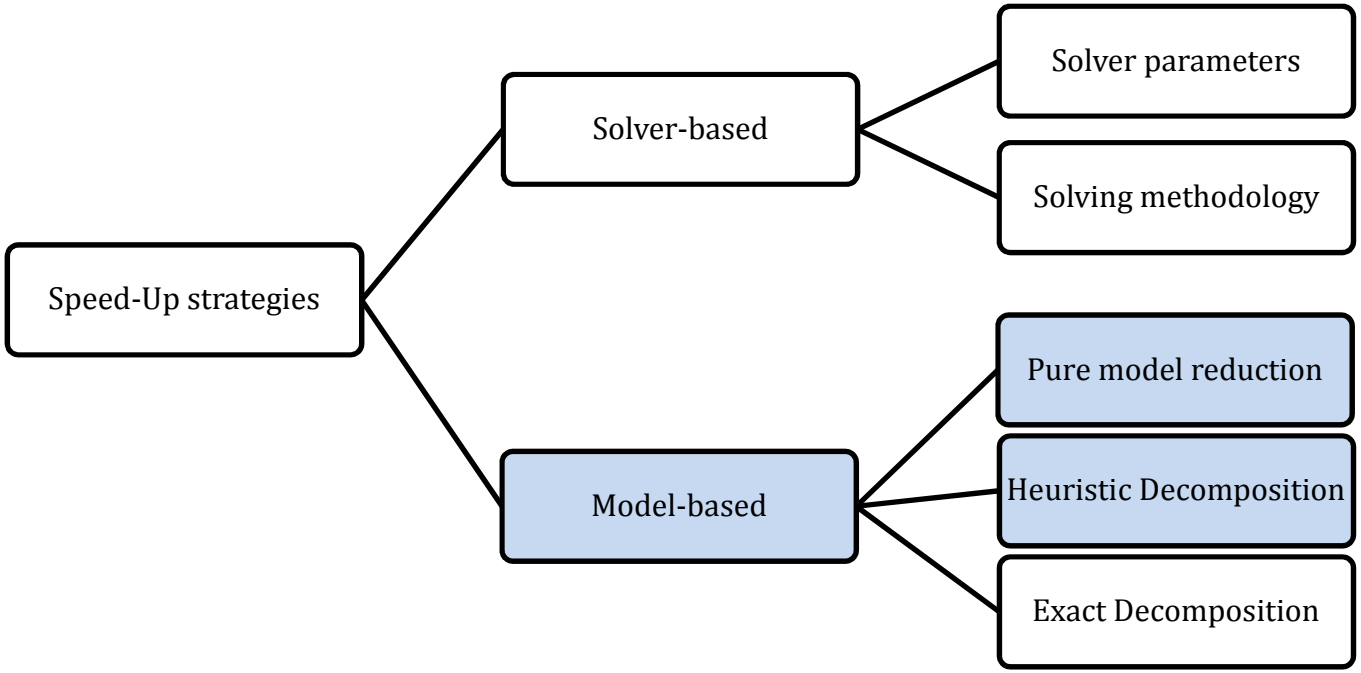


Source code improvement

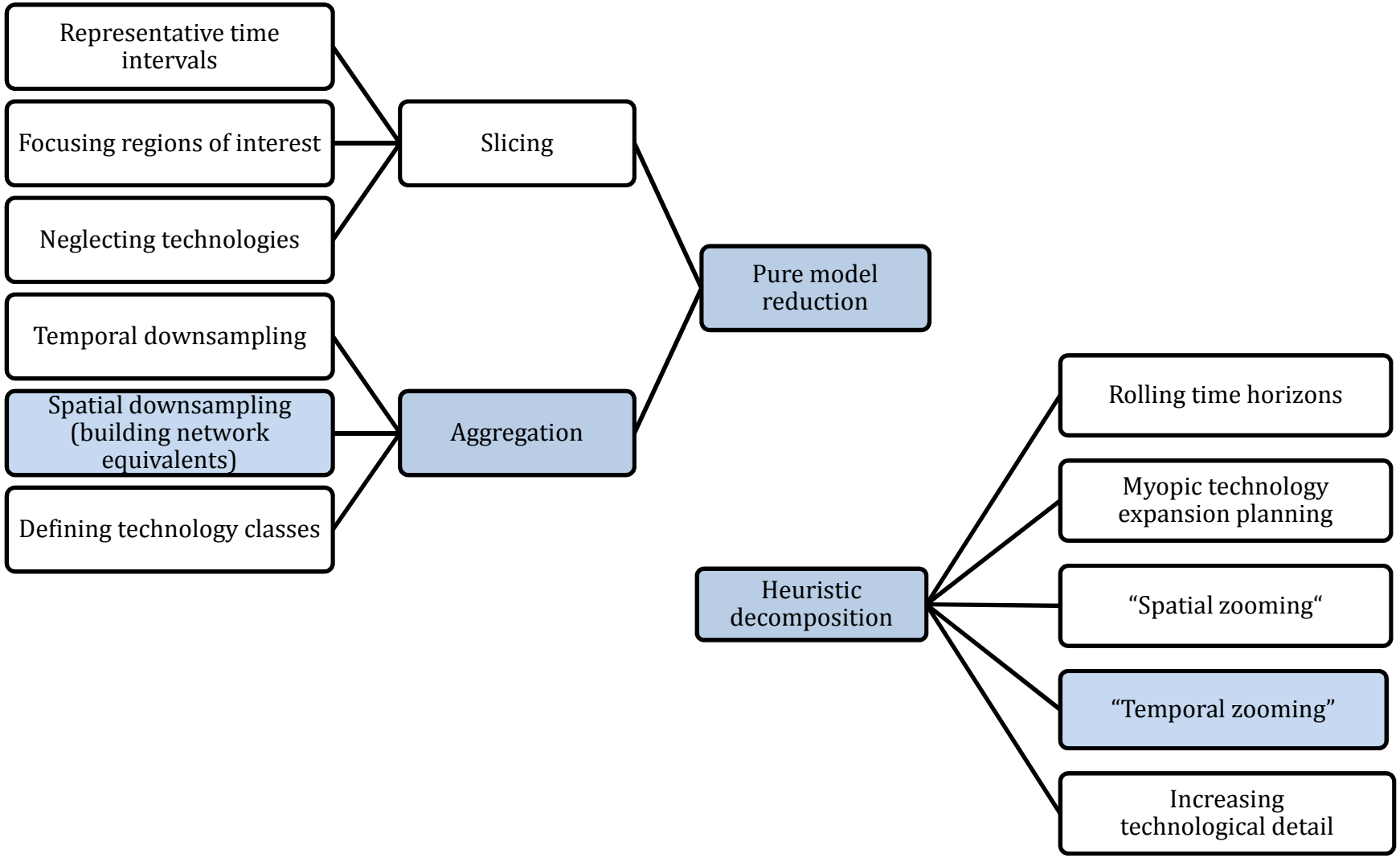
- Selection of measures (also useful to decrease memory need):
  - Input data should not differ much in its order of magnitude
  - Index order influences computing time
    - Useful, but not necessarily faster
    - Assignment statements with a different set order can be faster
    - It can be better to place large index sets at the beginning
  - Use of “option kill” , e.g. for long time-series input parameters saves memory
  - Abundant use of “Dollar Control over the Domain of Definition”
  - Consistent (and limited) use of defined variables
  - Avoid the consideration of technologies providing the same service at the same costs
  - Consider alternative formulation of model constraints (dense vs. sparse)

- Helpful references: “Speeding up GAMS Execution Time”
  by Bruce A. McCarl https://www.gams.com/mccarl/speed.pdf

Approach I: Model-based computing time reduction



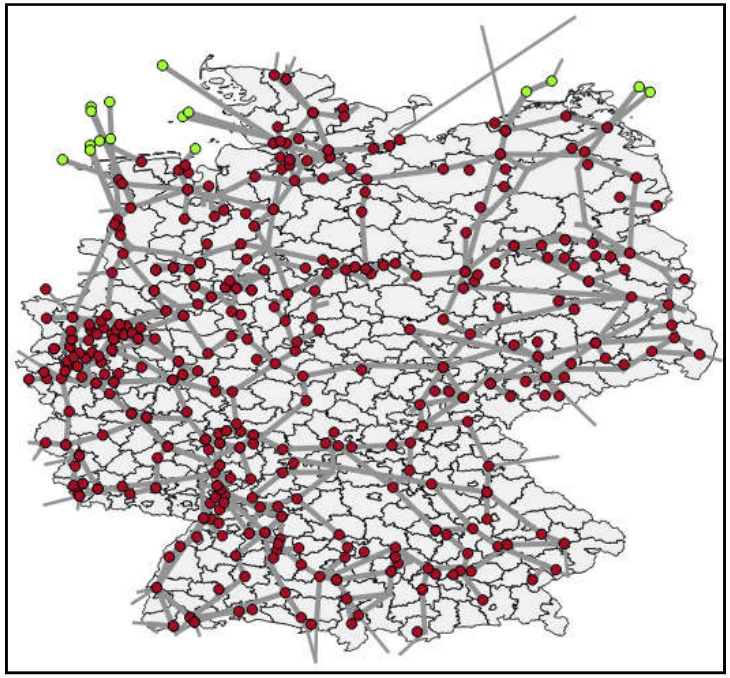
Presented speed-up approaches



Evaluation methodology

Evaluation: Overview

Model name	REMix
Author (Institution)	German Aerospace Center (DLR)
Model type	Linear programming minimization of total system costs **economic dispatch** / optimal dc power flow with **expansion of storage and transmission capacities**
Sectoral focus	Electricity
Geographical focus	Germany
Spatial resolution	488 nodes
Analyzed year (scenario)	2030
Temporal resolution	8760 time steps (hourly)

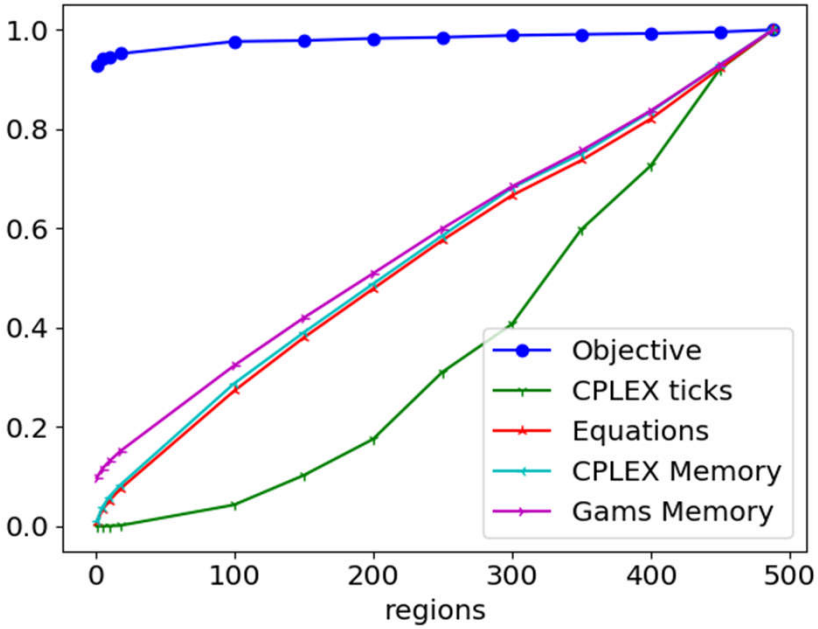


Solver	Commercial
Algorithm	Barrier
Cross-over	Disabled
Max. parallel barrier threads	16
Scaling	Aggressive

Results

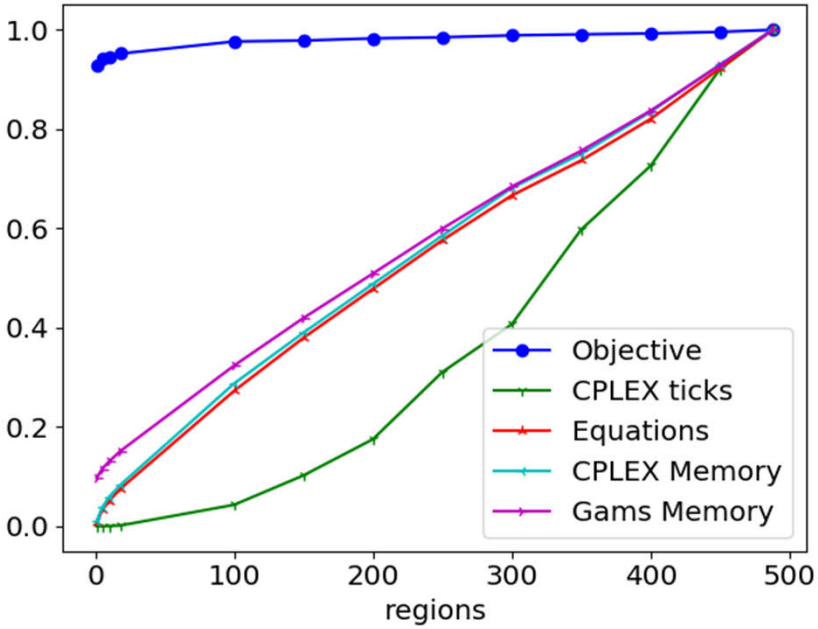
Results: Spatial aggregation

Performance

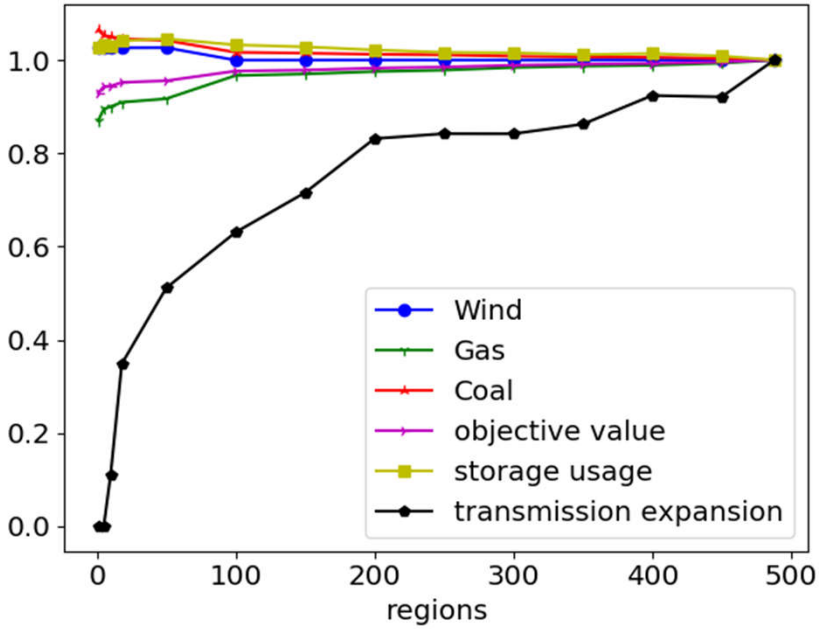


Results: Spatial aggregation

Performance

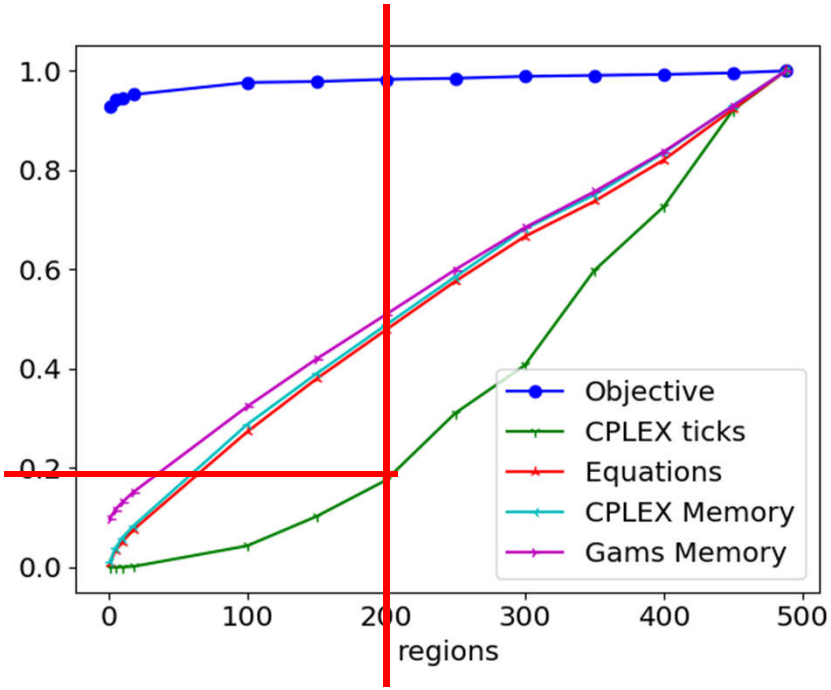


Accuracy

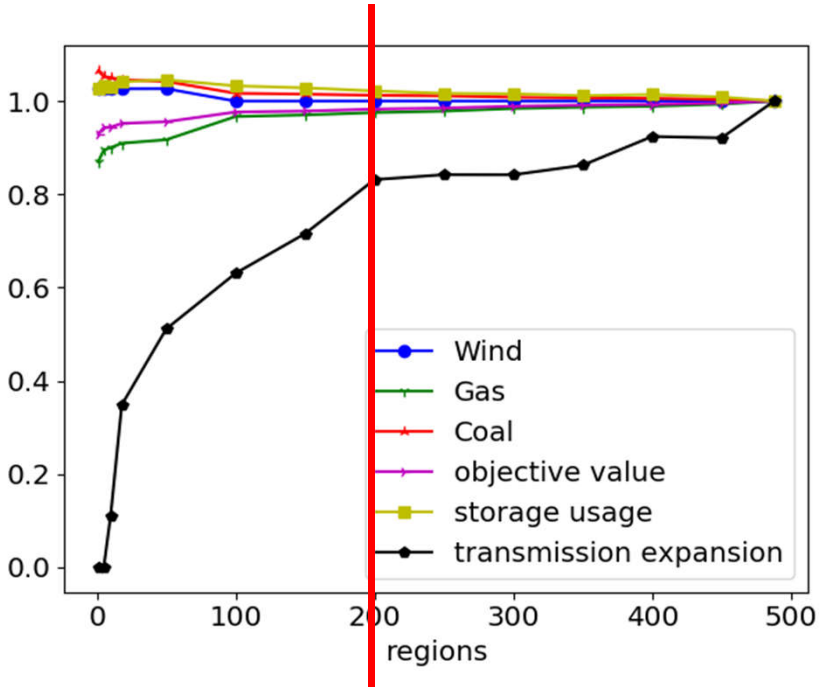


Results: Spatial aggregation

Performance



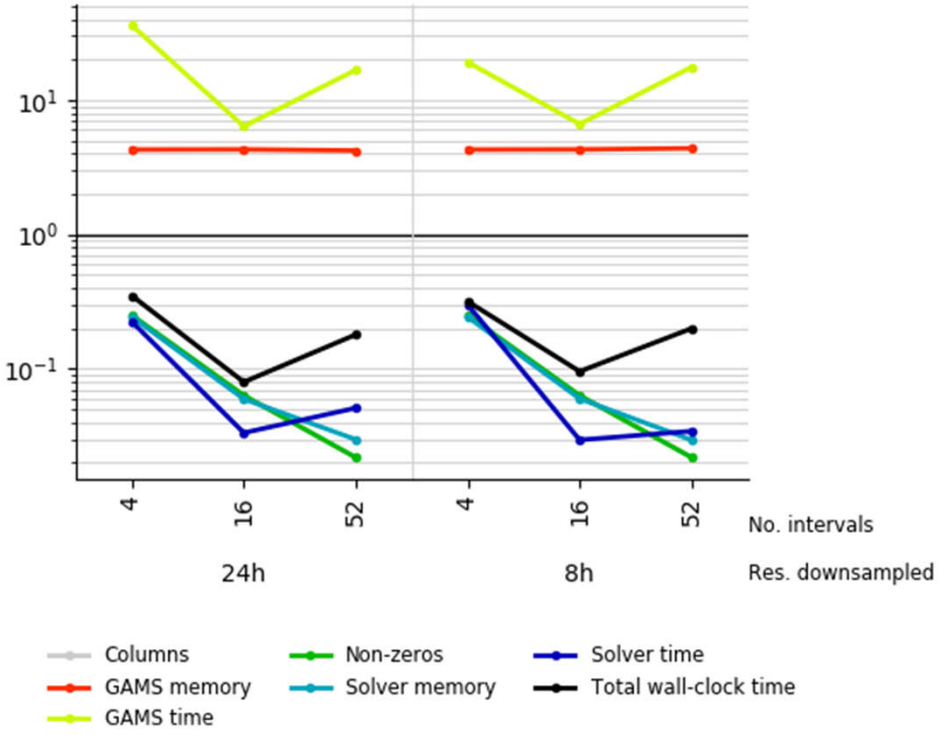
Accuracy



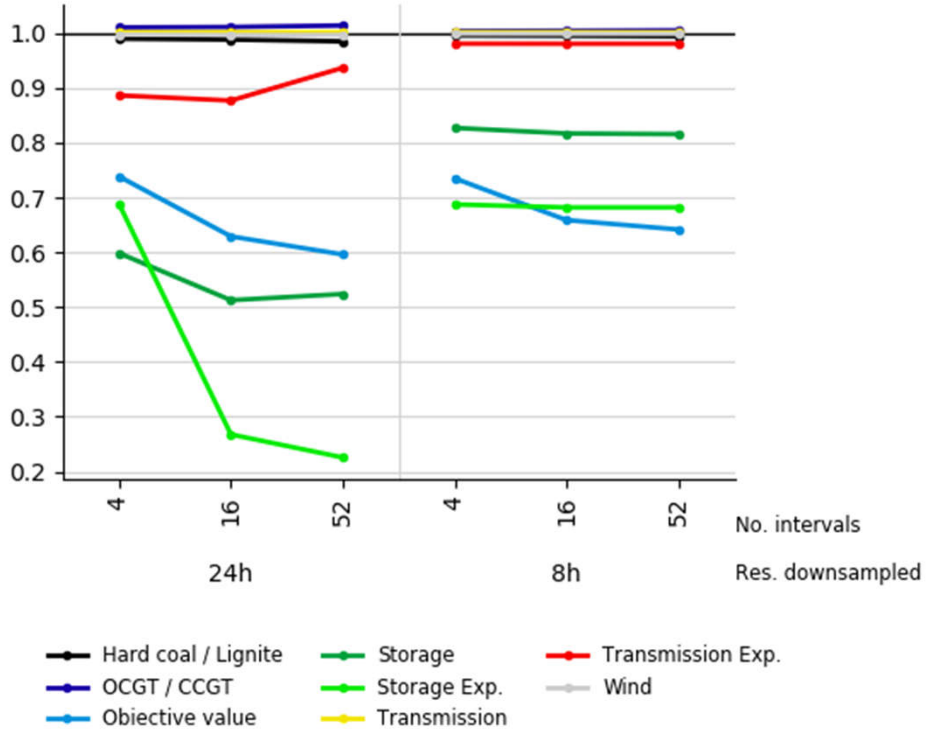
- Speed-up factor: ≈5
- Accuracy error mainly < 10 % (grids: ≈20%)

Results: Temporal zooming

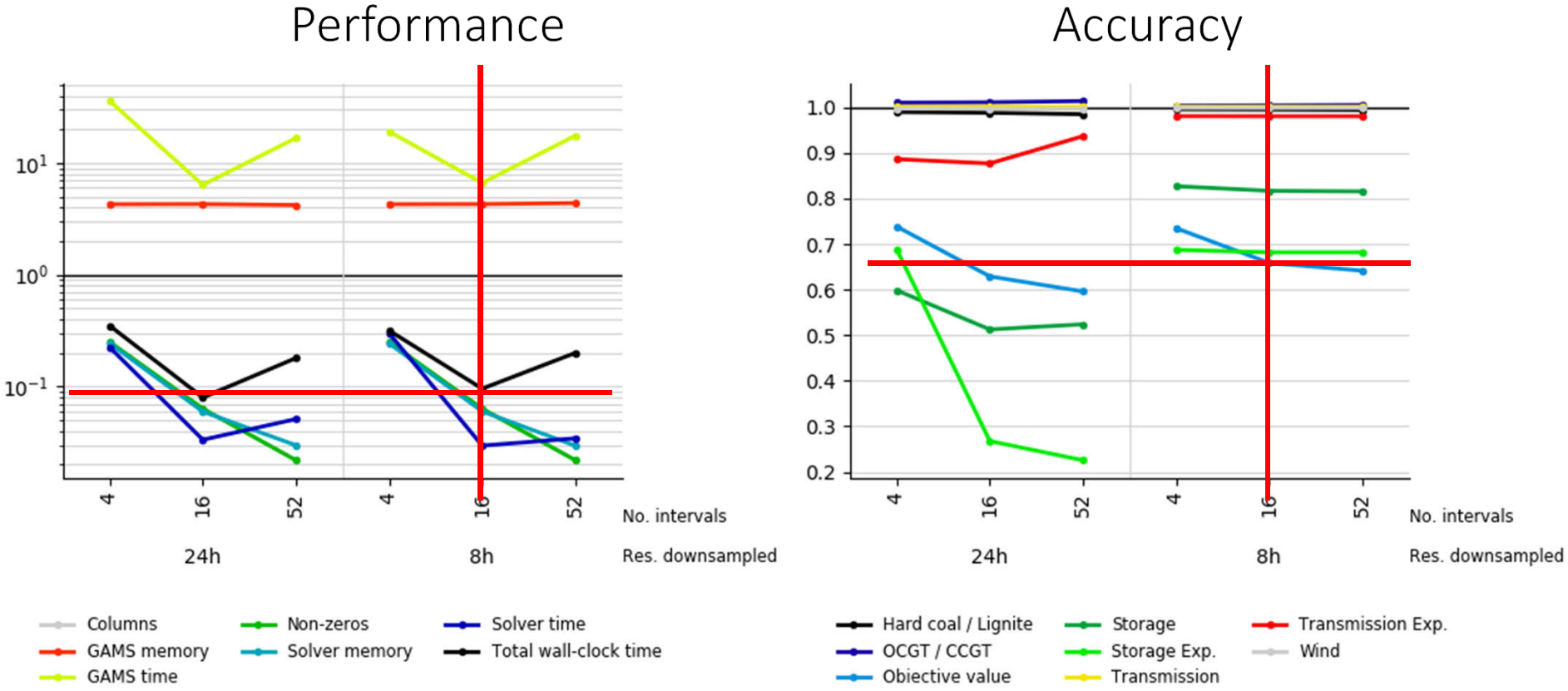
Performance



Accuracy



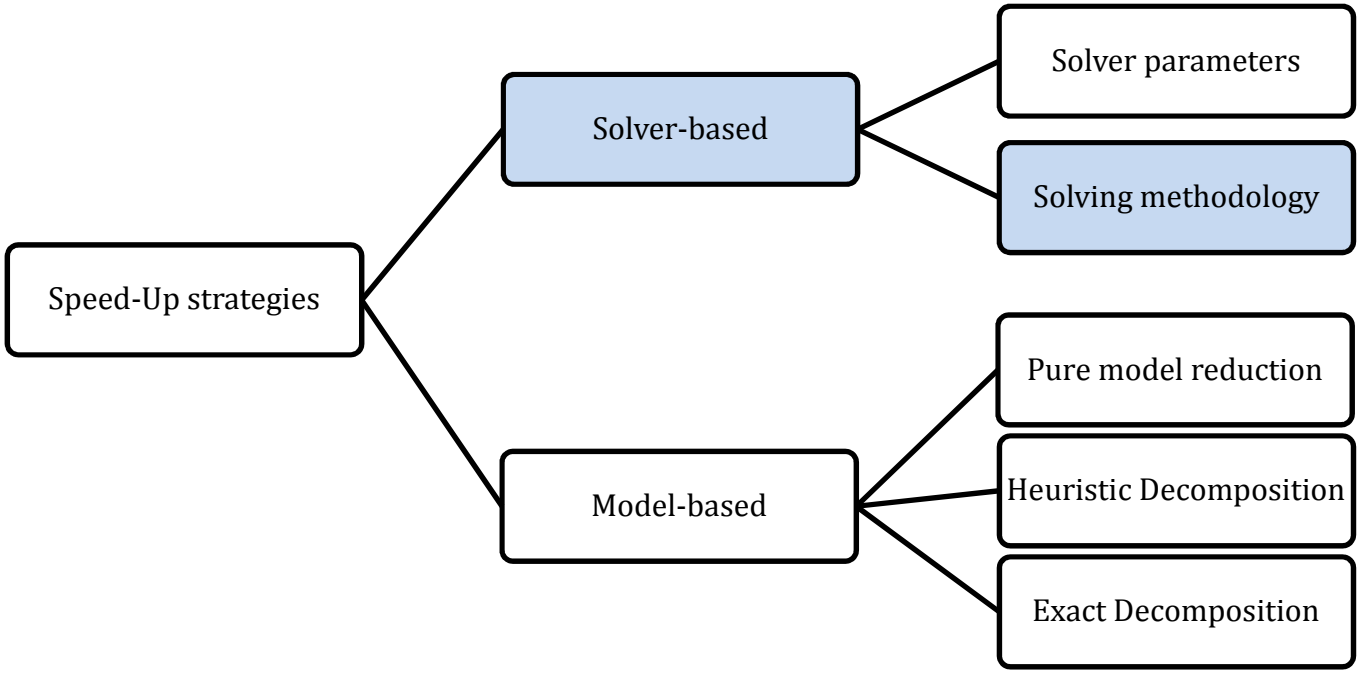
Results: Temporal zooming



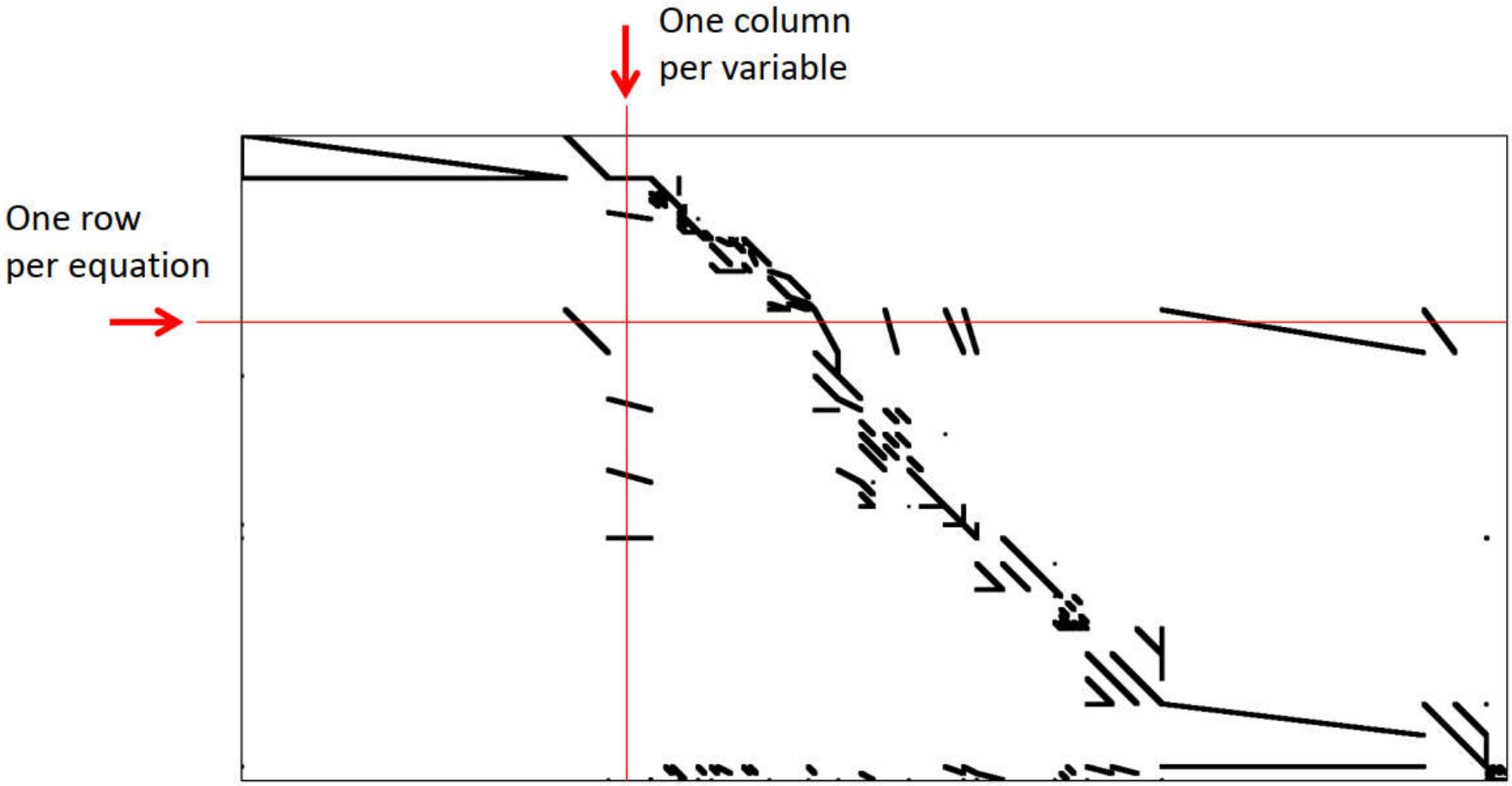
- Speed-up factor: >10 reachable
- Accuracy error of up to 35 %

Approach II: Hardware-based computing time reduction …

… and solver-based computing time reduction belong together!

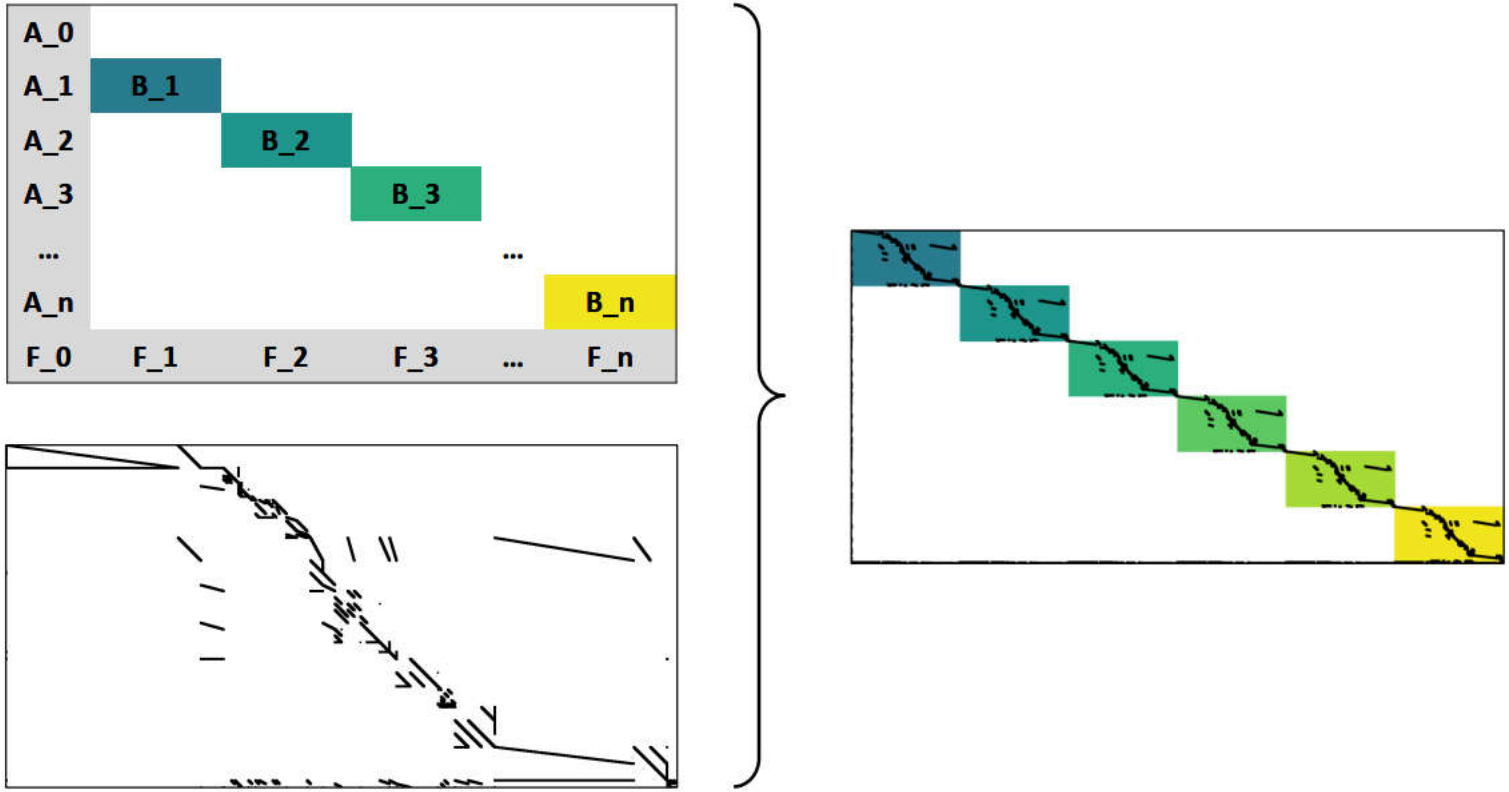


Annotation I



Rows and columns can be permuted without changing the optimization problem

Annotation II



- Annotation pre-structures the optimization problem
- The GAMS interface permutes the matrix and builds model blocks for PIPS-IPM
- The new solver PIPS-IPM can solve the problem parallelized on a supercomputer

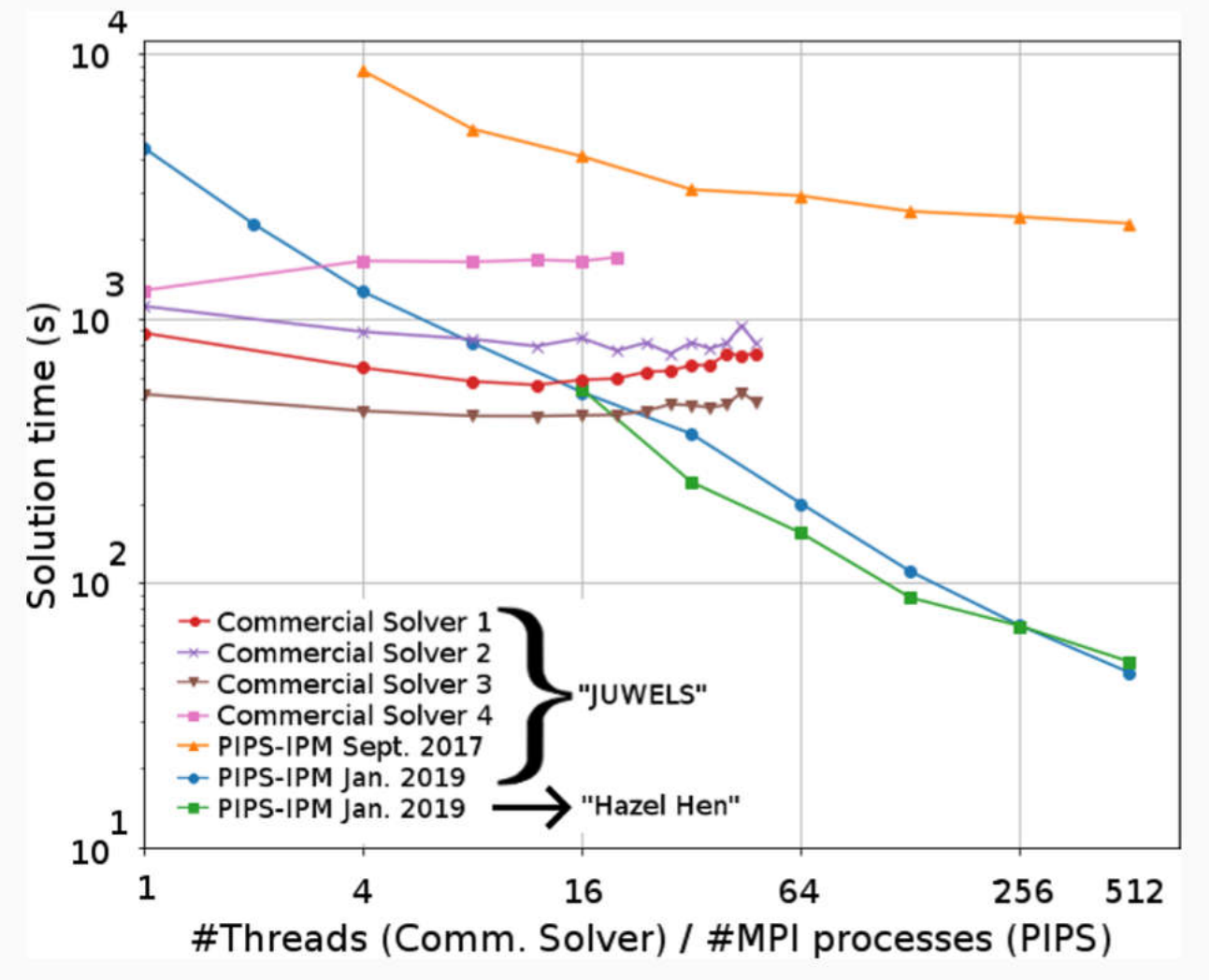
The new PIPS solver

Commercial Solvers:

- Poor scaling
- Time strongly depends on selected solver

PIPS:

- New version is much faster (note that original PIPS was developed for different problems!)
- Scaling is almost linear
- ***Still in beta state!***
  Issues:
  - parallel preprocessing
  - not suitable for all LPs



Conclusions

Conclusions

- Model based speed-up strategies
  - Slicing / Aggregation / Heuristics / Decomposition
  - Computing time reduction up to factor 10
- Solver based speed-up strategies
  - ESM Annotation → GAMS interface → new PIPS solver → HPC
  - Computing time reduction can reach > factor 100
  - New PIPS solver still in beta state
- BEAM-ME Best Practice Guide
  - publication planned by the end of 2019
  - To be notified, subscribe to the mailing list:

    beamme-news@dlr.de

    subject: „subscribe“

Project BEAM-ME

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Thank you!

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