Internationale Energiewirtschaftstagung (IEWT)
Vienna, Austria

GAMS

Solving Large-Scale Energy System Models

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Agenda

1. GAMS – Company Overview
2. BEAM-ME – Project Background
3. BEAM-ME – High-Performance-Computing
4. Summary

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Company Overview

Company History

- Roots at World Bank (1976)
- went commercial in 1987
- Locations:
  - GAMS Development Corp. (Fairfax, USA)
  - GAMS Software GmbH (Germany)
- Product: The **G**eneral **A**lgebraic **M**odeling **S**ystem

GAMS at a Glance

- High-level algebraic modeling language
- Focus lies on modeler
- All major solvers available (30+ integrated)
- Used in more than 120 countries (research and production)

Agricultural Economics	Applied General Equilibrium
Chemical Engineering	Economic Development
Econometrics	**Energy**
Environmental Economics	Engineering
Finance	Forestry
International Trade	Logistics
Macro Economics	Military
Management Science/OR	Mathematics
Micro Economics	Physics

BEAM-ME

Project Background

The BEAM-ME Project

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

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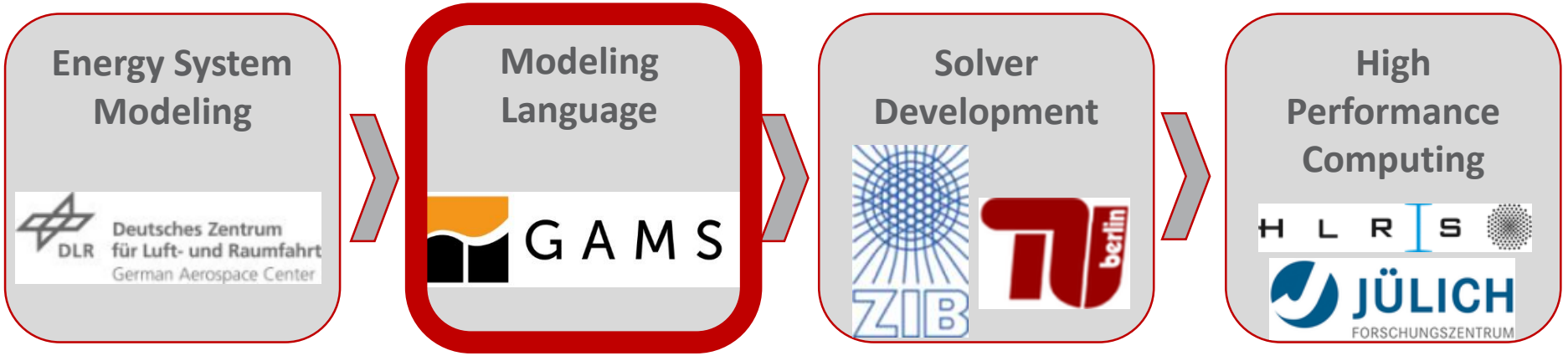
What exactly is BEAM-ME about?

Implementation of acceleration strategies from mathematics and computational sciences for optimizing energy system models

An Interdisciplinary Approach:

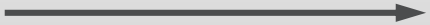


Model Parameters that Drive Complexity

Time

Planning Horizon

short term



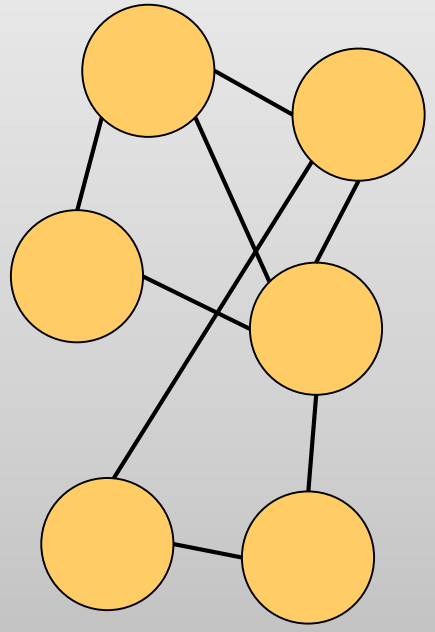
long term

Discretization

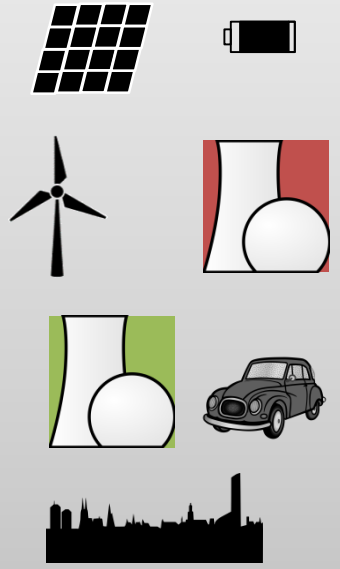
coarse

fine

Regional Aggregation



Technology Parameters



(Very-) Large-scale LP

- Scalable (resolution time, space, and technology)
- Block structure

BEAM-ME

High-Performance-Computing: An Example

Available Computing Resources

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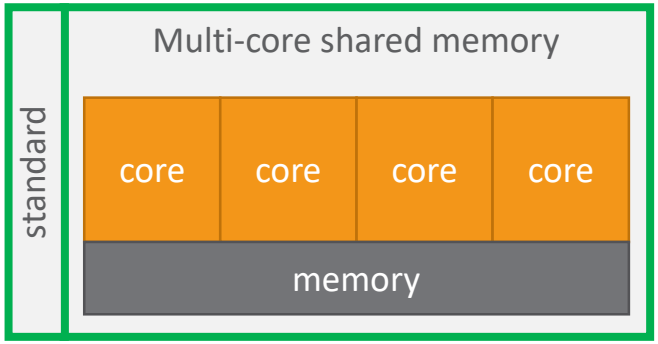
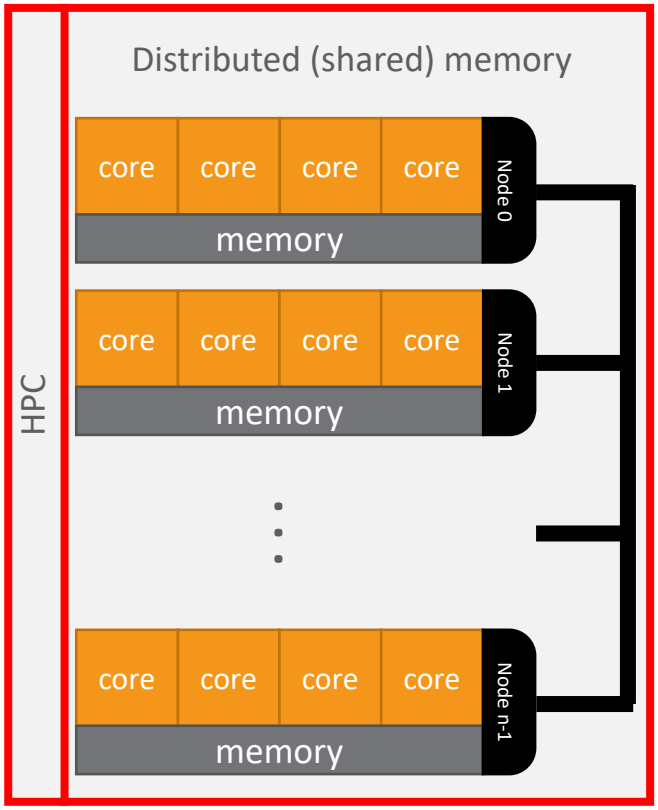


Convenient to use.

Capabilities of standard hardware should be exploited first.

CHEAP



Complex to use.

But huge speedup potential for *certain* models/methods.

EXPENSIVE

JUWELS at Jülich Supercomputing Centre

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Hardware characteristics

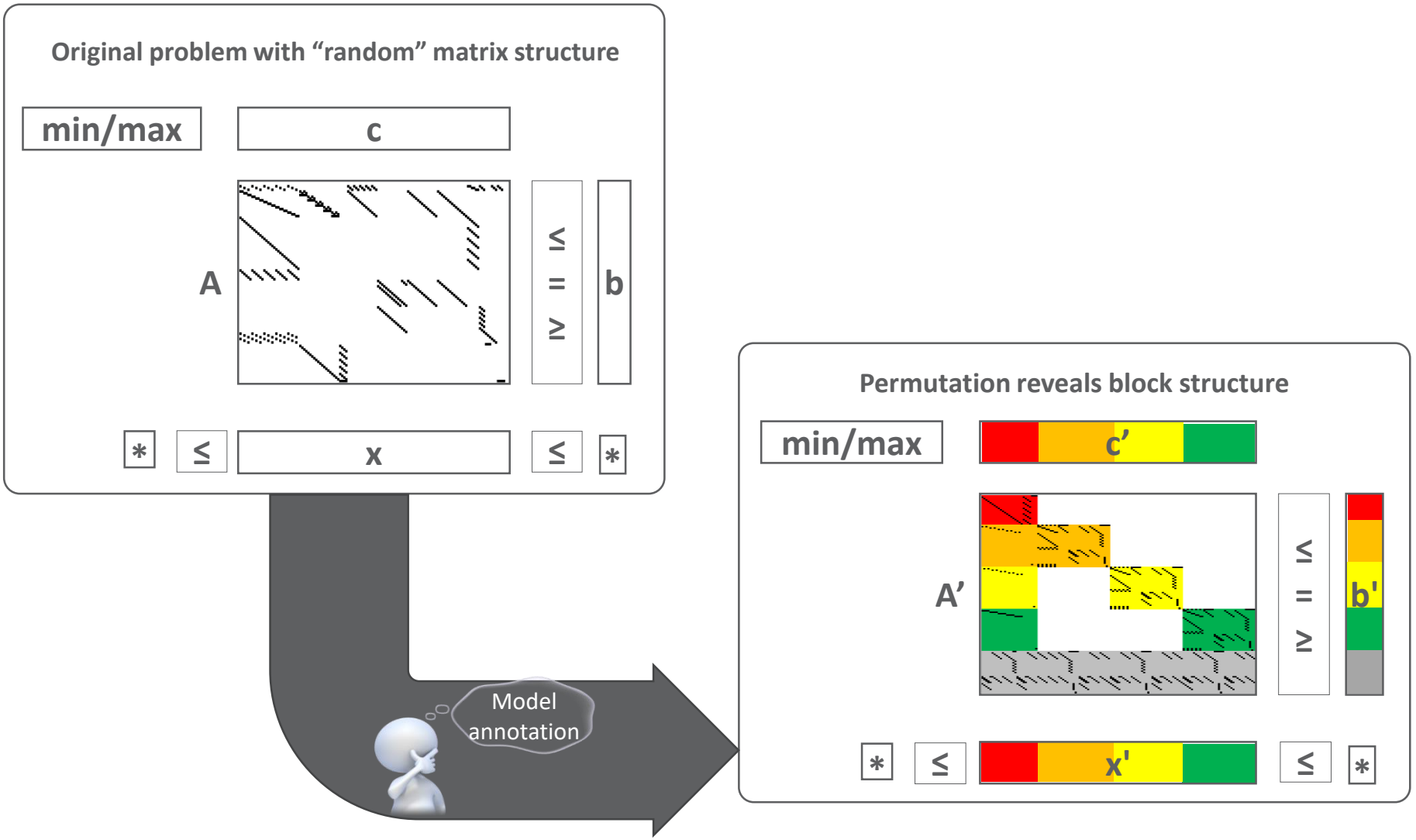
- 2271 standard compute nodes
  - 2x24 cores, 2.7 GHz
  - 12x8 GB, 2666 MHz
- …

Also tested on other target platforms at JSC Jülich and HPC center Stuttgart

GAMS/PIPS-IPM Solver Link Overview

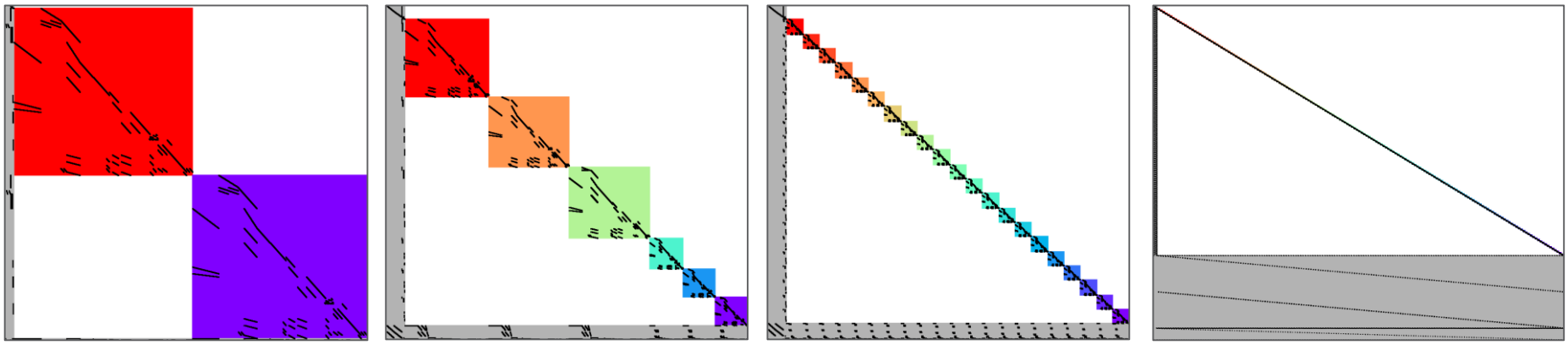
- **P**arallel **I**nterior-**P**oint **S**olver for LPs (and QPs), designed for high-performance computing platforms
- Originally developed for stochastic problems by Cosmin Petra (Argonne National Lab)
- Had already been applied to very-large-scale problems
- extension to support linking constraints implemented by ZIB

GAMS/PIPS-IPM Solver Link
How it Works



Model Annotation cont.

- How to annotate Model depends on how the model should be “decomposed” (by region, time,…)

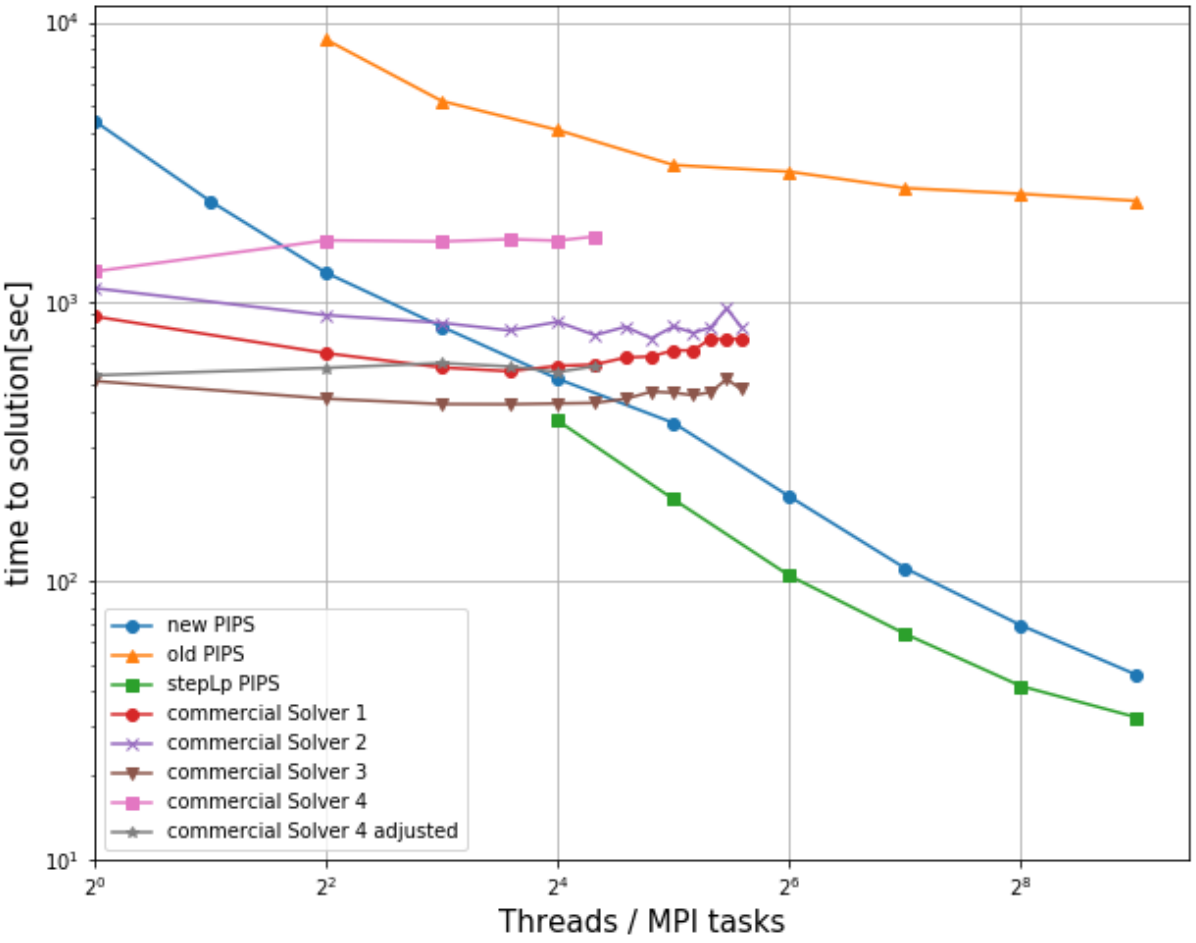


Plots show four different annotations of identical model

- Blocks of equal size are beneficial

Computational Result(s)

Solution time comparison for an LP with
5,109,959 rows, 5,631,494 columns, 20,303,816 non-zeroes
solved on single node of JUWELS @JSC with
Dual Intel Xeon Platinum 816



Summary

Summary

- Increasing complexity makes solving ESM more difficult
- Conventional solution strategies at their limits, new approaches needed
- Before thinking of HPC, model should be brought “in shape” and capabilities of “standard” hardware should be exploited
- Annotation Facilities to allow users the definition of block structures are available
- PIPS-IPM is open source, but hardware is expensive
- Currently: user knowledge required in order to fully exploit HPC capabilities

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Thank you for your kind attention

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