Research & Development Activities at GAMS

OR2022

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Challenges (after 3+ decades in the business)

- How to always stay on the pulse of time?
- How to invest in new technologies (AI, ML, Quantum computing, …) being a small/medium sized company?
- How to excite young users without losing long term users?
- How to recruit young developers in a competitive market?

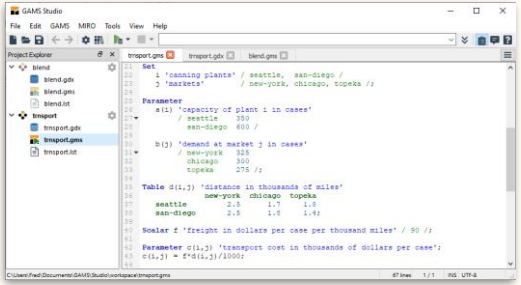
→ (academic) R&D projects & commercial projects

- What does GAMS contribute?
- How does GAMS benefit?

GAMS What do we offer?

GAMS - Modeling Platform

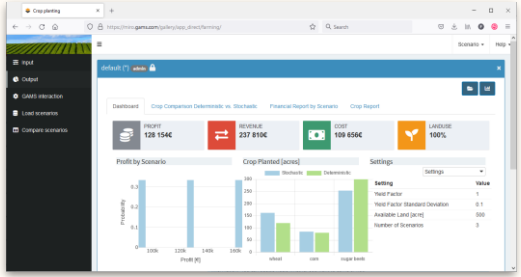
- **Algebraic Modeling Language** (platform independent)
- **Commercial and Academic Solvers** (packaged)
- **APIs for major programming languages** (C++, Java, Python, Matlab and more)



→ Domain Experts
→ Modellers/Developers

MIRO - Graphical UI Generator

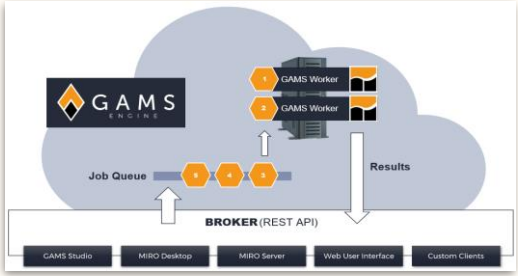
- **Turns models into web applications**
- **Interactive graphical output**
- **Extendable with custom code**
- **Local or Server Installation**



→ End Users
→ Analysts

Engine - Deployment Solution

- **Solves GAMS models on centralized resources** (on-prem or cloud)
- **REST API** (user & job management)
- **GAMS job scheduling & Load balancing**



→ IT Admins
→ Transparent to End Users

GAMS Joint Research Projects

- Research projects should meet certain criteria
  a. Help to determine the future orientation of our product portfolio
  b. Interesting/Innovative from technical point of view
     - High Performance Computing (HPC)
     - Machine Learning (ML)
     - Quantum Computing (QC)
     - …
  c. Relevant fields of application
     - Energy
     - Logistics
     - …

GAMS Joint Research Projects (2022-2025)

2022 - 2024

ProvideQ

Quantum Readiness for Optimization Providers

Technische Universität Braunschweig | Leibniz Universität Hannover | 4FLOW | KIT Karlsruher Institut für Technologie | GAMS | JKU Johannes Kepler Universität Linz | Universität zu Köln

2022 - 2025

RESUME

Multi-objective optimization: Impact of recycling potentials, **critical resources**, and supply risk on the German **energy** transition

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center | Fraunhofer ISI | GAMS | Universität Konstanz | BGR

GAMS Joint Research Projects

(6th/7th Energy Research Programme of the Federal Government/Basic Energy Research)

2015 - 2019

BEAM-ME

HPC based acceleration strategies for optimizing **energy** system models

2020 - 2023

UNSEEN

Combining Mathematical Optimization and Machine Learning on **HPCs** for optimizing **energy** system models

HLRS

KIT Karlsruher Institut für Technologie

JÜLICH Forschungszentrum

GAMS

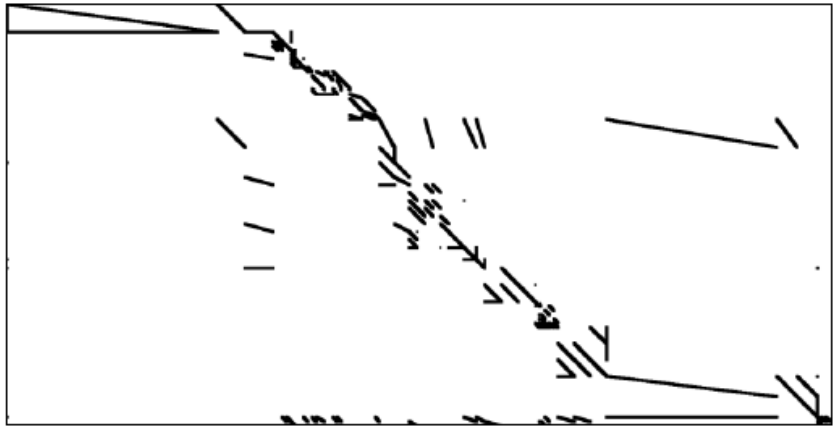
DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

TU berlin

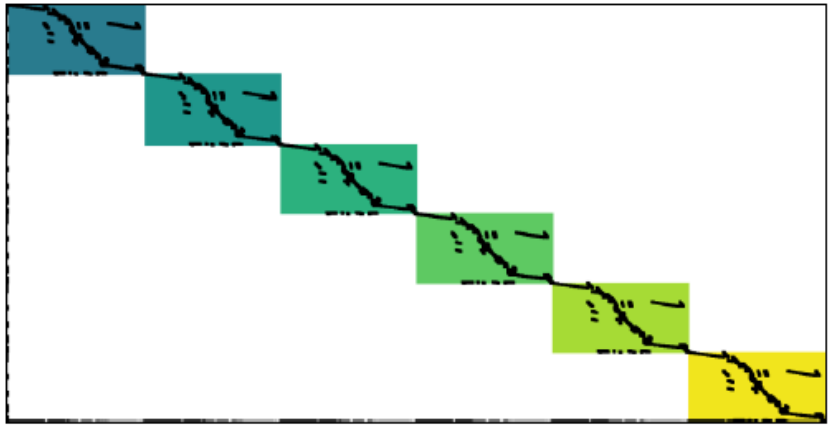
ZIB

BEAM-ME & UNSEEN in a Nutshell

- Important Problem, that cannot be solved
  - Large-scale Energy System Models (LP)
- Idea how to approach the problem
  - High Performance Computing (HPC)
- Challenge: Find/Develop suitable algorithm(s)
  - Parallel interior point solver PIPS → PIPS-IPM++[1]
  - Block diagonal structure required



"Random" non-zero pattern of problem matrix



Permutation reveals block structure

[1] https://github.com/NCKempke/PIPS-IPMpp

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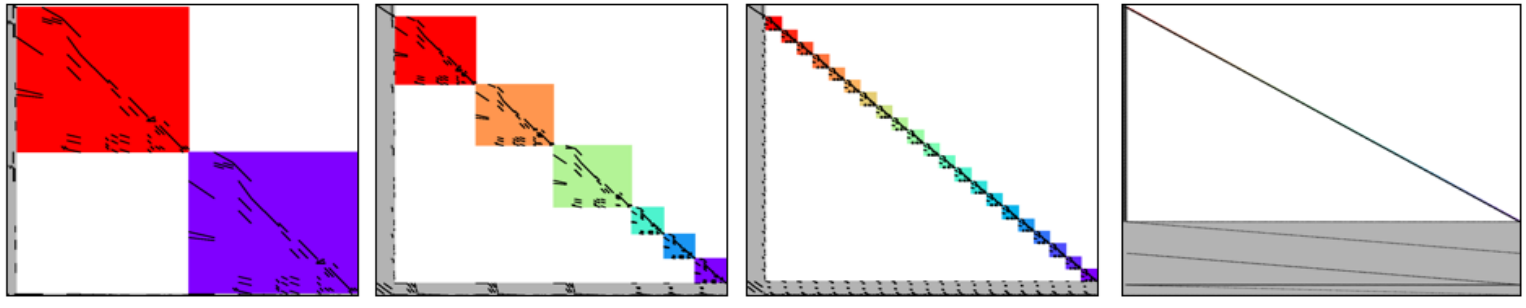


Plots show four different annotations of identical model

BEAM-ME & UNSEEN in a Nutshell

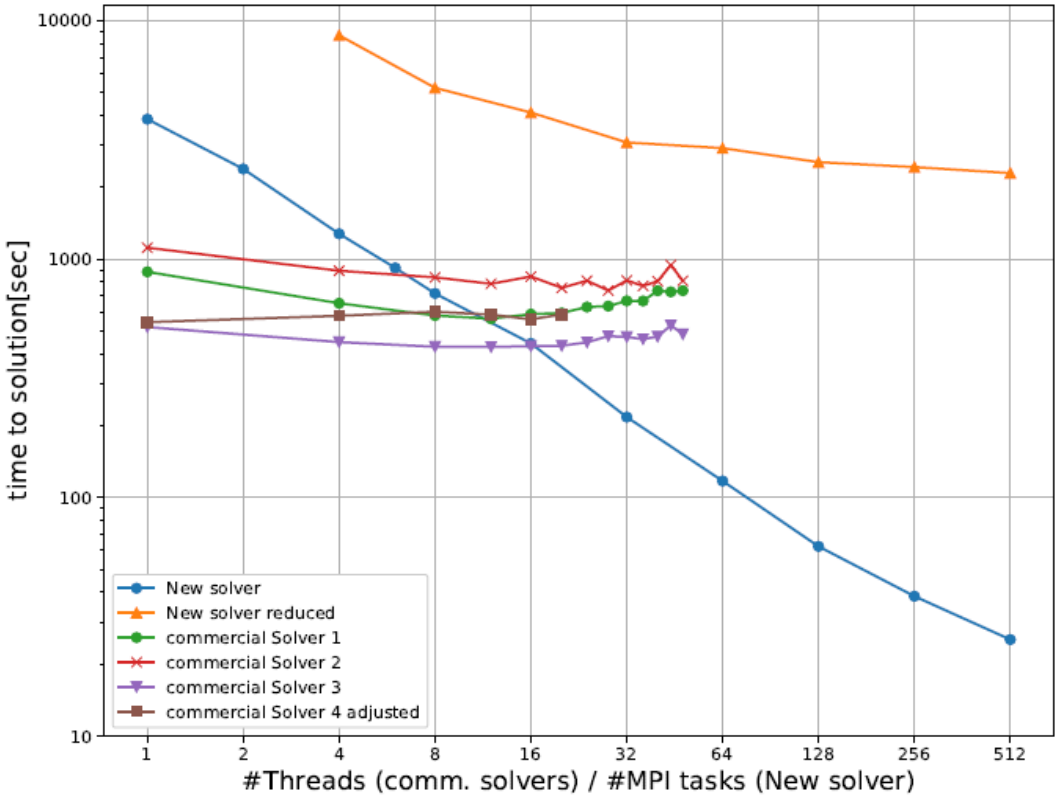
- Important Problem, that cannot be solved
  - Large-scale Energy System Models (LP)
- Idea how to approach the problem
  - High Performance Computing (HPC)
- Challenge: Find/Develop suitable algorithm(s)
  - Parallel interior point solver PIPS → PIPS-IPM++[1]
  - Block diagonal structure required
  - Finding a “good” block structure automatically is difficult

    → Extend GAMS to introduce block annotation facilities

    → Implement a GAMS/PIPS-IPM++ Interface

[1] https://github.com/NCKempke/PIPS-IPMpp

BEAM-ME & UNSEEN in a Nutshell



+ Proof of concept
+ Applied to various models in Model experiment[1]
- Works on some but not on all models
- Very challenging to use
  - Annotation is non-trivial
  - Compilation is non-trivial
  - Access to HPC is non-trivial
  - …

→ developing research results to market maturity

→ Project Proposal PEREGRINE

[1] Rehfeldt et al., A massively parallel interior-point solver for LPs with generalized arrowhead structure, and applications to energy system models (Link)

Project Proposal PEREGRINE

Parallelization in **e**ne**r**gy syst**e**m modellin**g**: New concepts for la**r**ge-scale analyses and development of **in**novative solv**e**rs

- **PIPS-IPM++** will be improved regarding performance and robustness by at least one full-time PIPS developer over three years

- The **block structure** annotation required by PIPS-IPM++ to efficiently parallelize the solution process will be **automated**

- GAMS/PIPS-IPM++ will be made available in the **cloud,** such that users no longer have to deal with finding suitable **HPC** hardware, compiling the PIPS source, etc

If you are interested, contact us for further information (and maybe become an associate partner).

BEAM-ME, UNSEEN, PEREGRINE

GAMS in different roles:

BEAM-ME UNSEEN PEREGRINE

- **Tool provider** Extend capabilities of Modeling Platform
- **Modelling Support**
- **SaaS Provider** (PEREGRINE): provide easy to use cloud solution

GAMS

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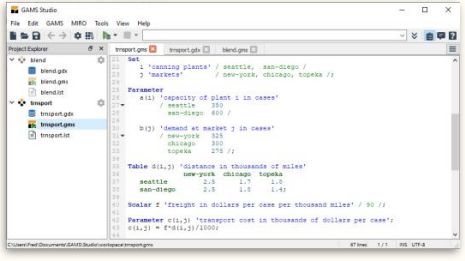

GAMS MIRO

MIRO -
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GAMS ENGINE

Engine -
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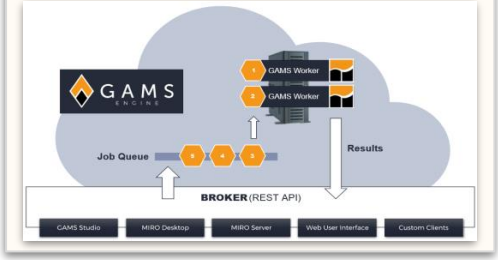

GAMS Commercial Projects (2016-2023)

Scheduling: Tailormade Scheduling Applications deployed in the cloud (SaaS)

United States Military Academy, West Point

- academic term scheduling
- term-end exam scheduling
- room scheduling

Agricultural Modelling: MIRO Web App and Custom Data Connectors

Leibniz Centre for Agricultural Landscape Research

- Multi-Objective Decision support tool for Agri-ecosystem Management model (MODAM)
- Data Connectors
- MODAM MIRO App

Energy System Modelling: TIMES MIRO Web App and TIMES Cloud Service

IEA Energy Technology Systems Analysis Program

- TIMES Model, Available to all members, no need for individual licenses
  https://iea-etsap.org/index.php/etsap-projects
- *Used by 120+ institutions in 50+ countries*

...

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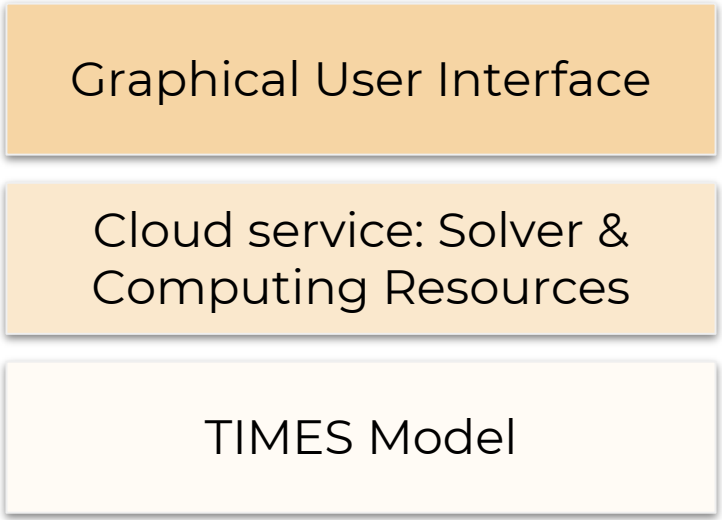
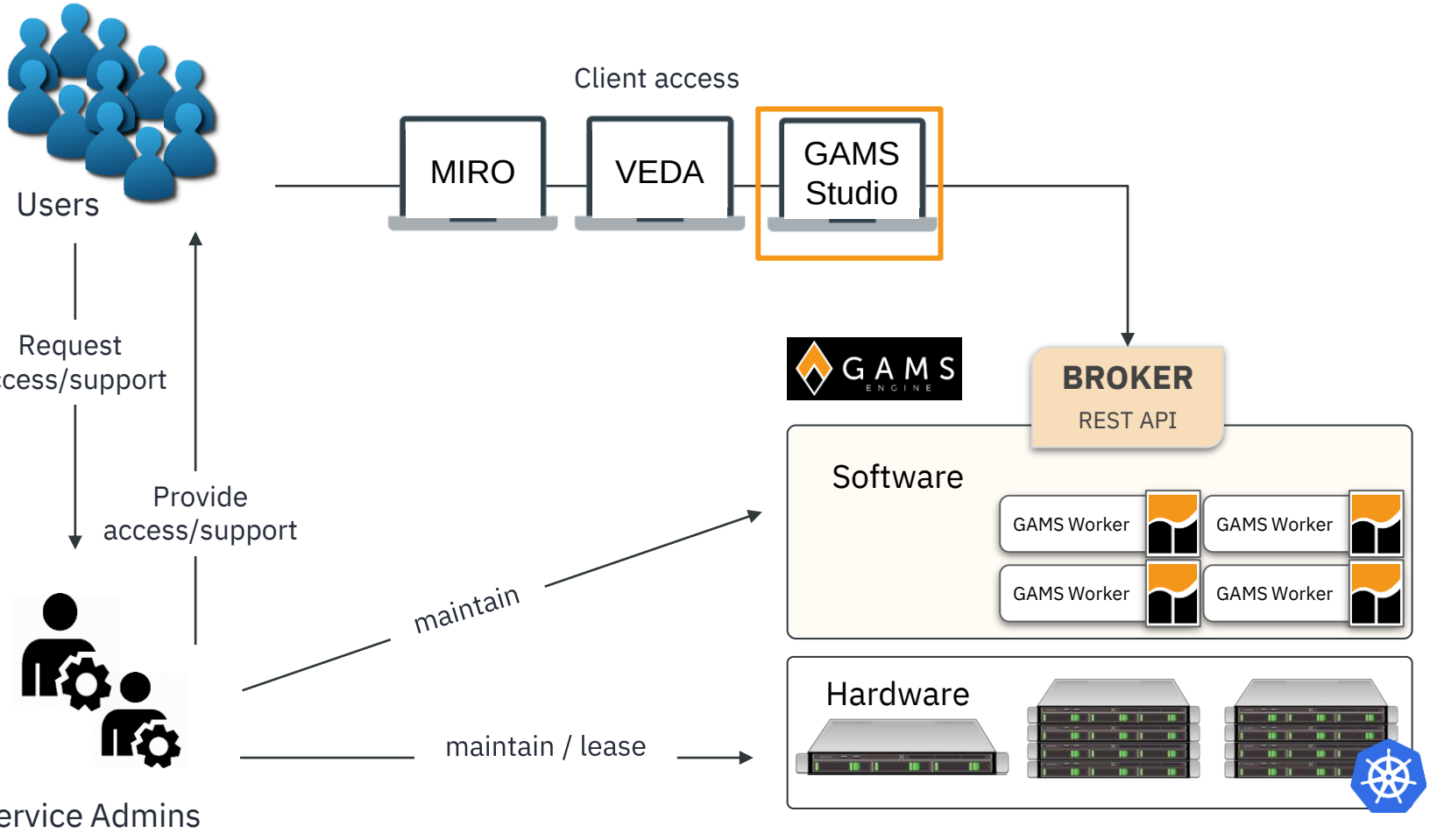
TIMES MIRO App and TIMES Cloud Service



TIMES Cloud Service

Solver, Computing Resources



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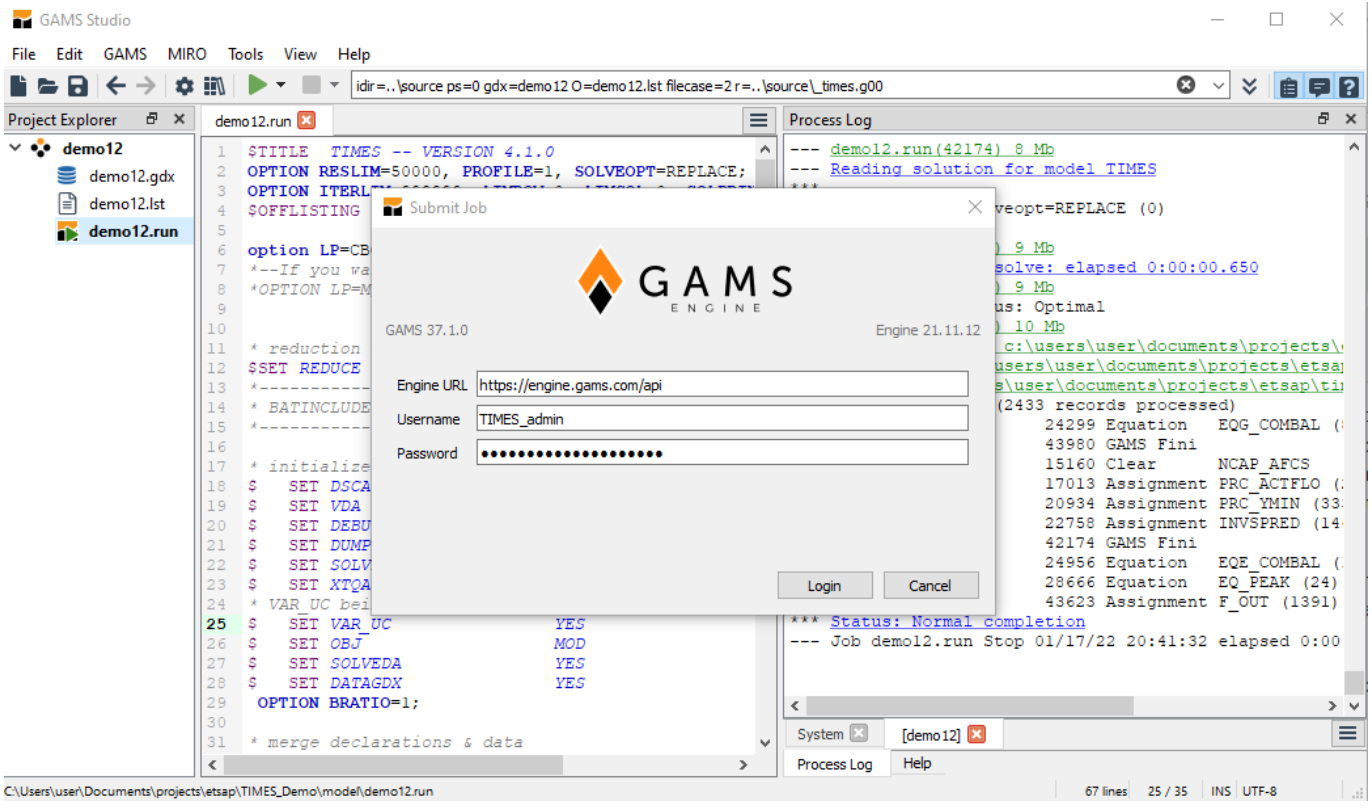
Solver, Computing Resources



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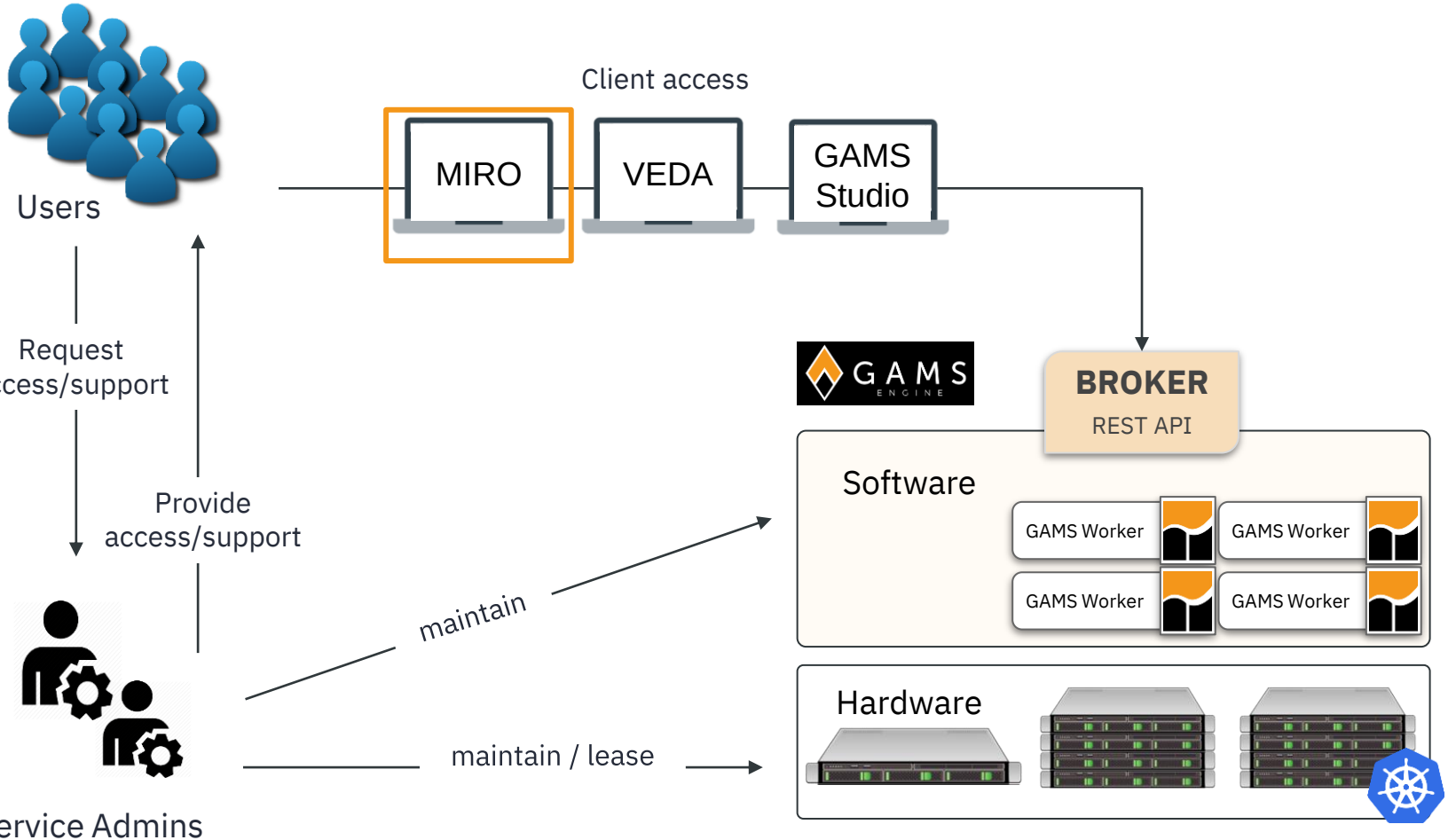

TIMES/MIRO App and TIMES Cloud Service

GAMS as GUI Developer and SaaS Provider

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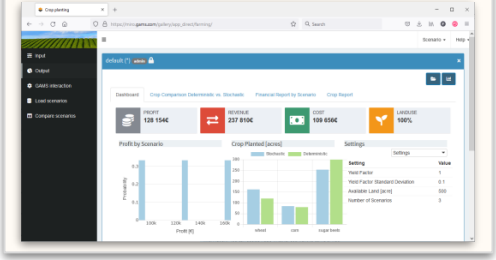

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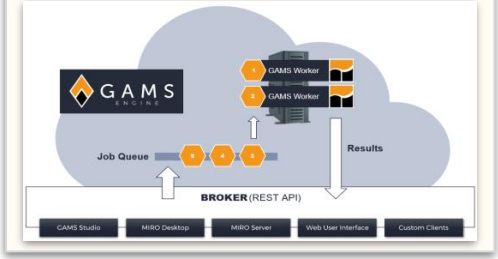

Summary

- GAMS is more than just a tool provider
- Close collaboration with clients/partners helps to determine the future orientation of our product portfolio
- Joint research projects are a great opportunity to invest in novel technologies for small/medium sized companies like GAMS
- Academic partner network opens opportunities for collaboration in Master/PhD theses (this is how many of today's employees were recruited)
- GAMS well established and innovative at the same time

Contact Us

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https://www.linkedin.com/company/gams-development