GAMS

Keep the Model Hot

A Scenario Solver for GAMS

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Energizing the Future

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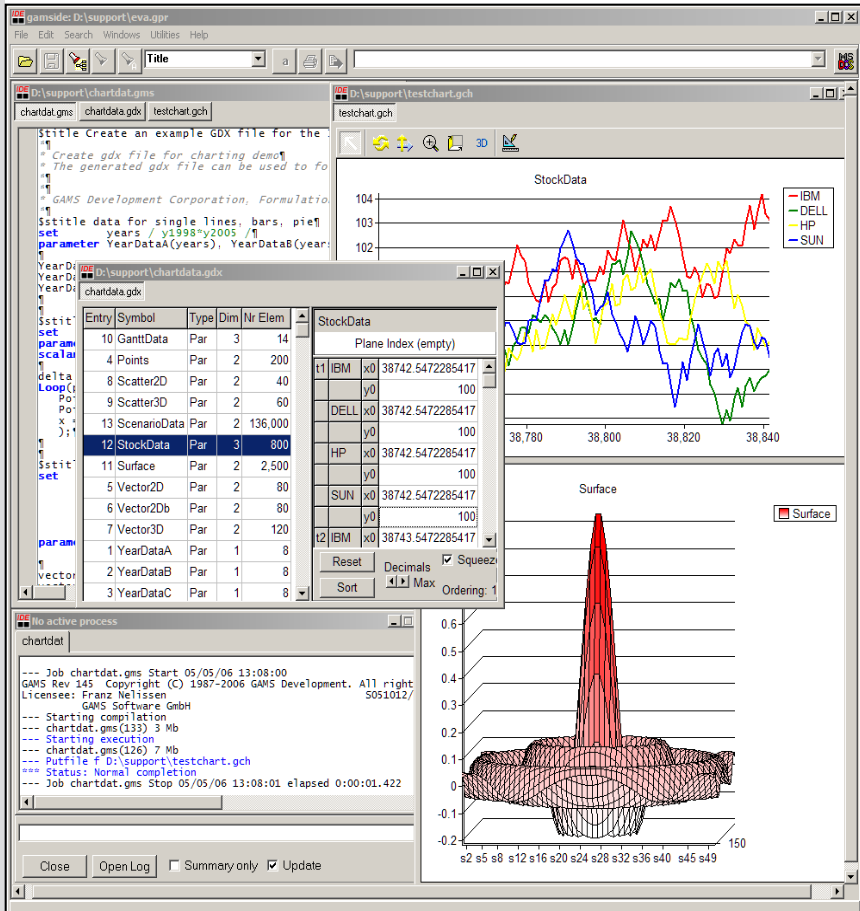
GAMS at a Glance



General **A**lgebraic **M**odeling **S**ystem:

Algebraic Modeling Language, Integrated Solver, Model Libraries, Connectivity- & Productivity Tools

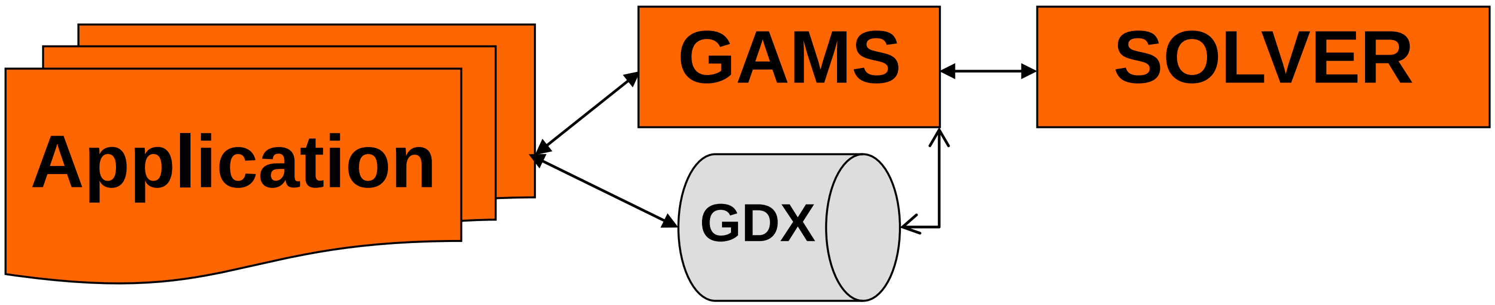
Design Principles:

- **Balanced mix of declarative and procedural elements**
- Open architecture and interfaces to other systems
- Different layers with separation of:
  - model and data
  - model and solution methods
  - model and operating system
  - model and interface

Outline

- Prelude
- GAMS Execution System
- Scenario Solver
- GMO + Python & Co

Calling GAMS from your Application



Creating Input for GAMS Model

→ Data handling using **GDX** API

Callout to GAMS

→GAMS option settings using **Option** API

→Starting GAMS using **GAMS** API

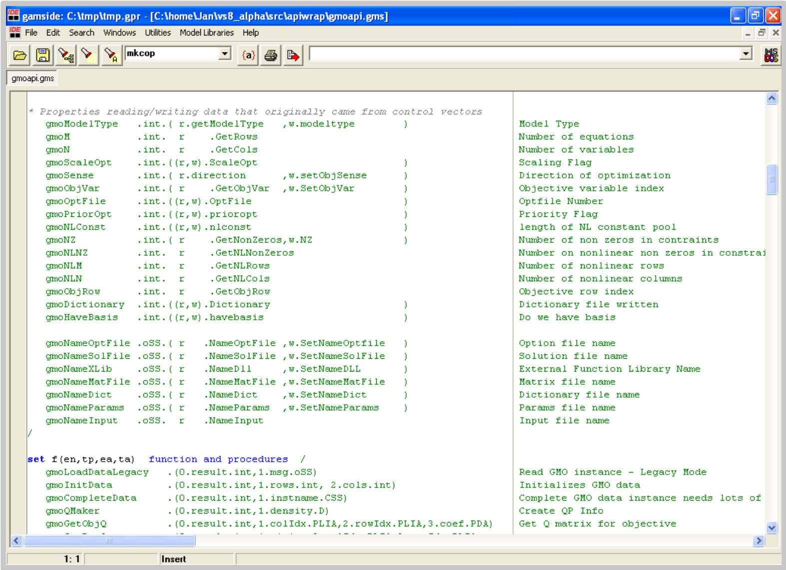
Reading Solution from GAMS Model

→ Data handling using **GDX** API

Automated Generation of APIs

'The GAMS Wrapper'

- API is defined using the GAMS language
- A tool written in GAMS is used to regenerate APIs for all languages
- Executed on request and nightly



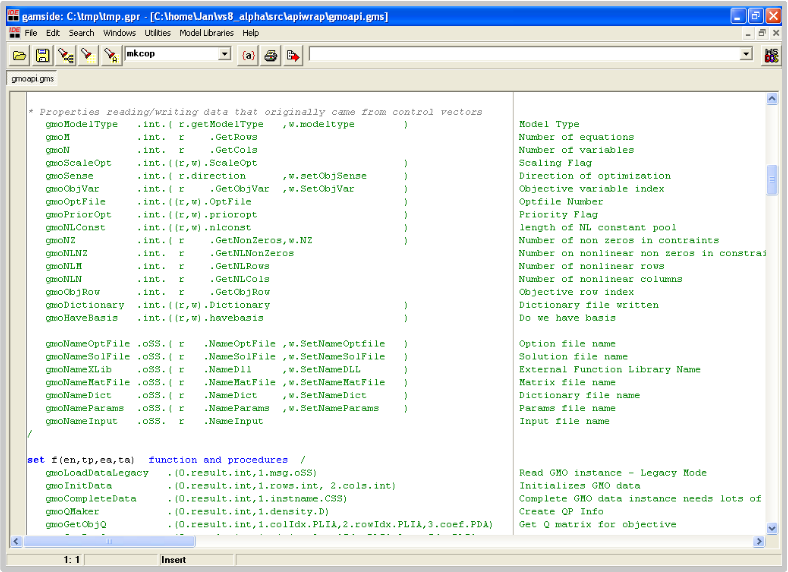
→ A change in the definition of the API immediately makes it into all language interfaces

→ No manual and therefore error-prone efforts required

Automated Generation of APIs

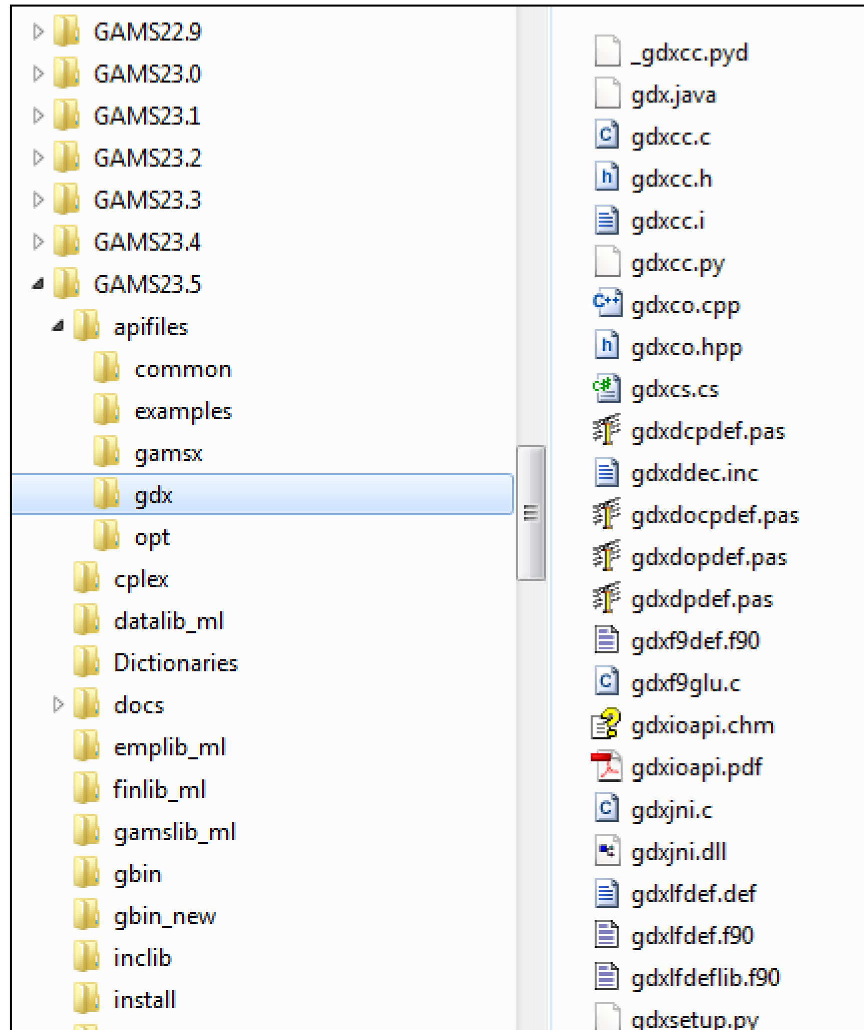
‘The GAMS Wrapper’

- Automated nightly testing
- API version checks
- Reusable for multiple GAMS component libraries
  - GAMS
  - GDX
  - Option
  - …

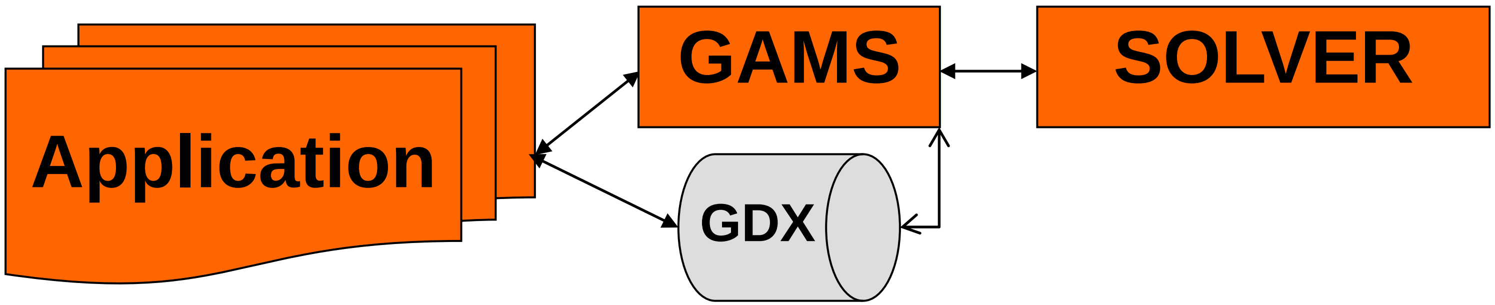


Distributed GAMS APIs

- Component Libraries
  - GAMS
  - GDX
  - Option
- Supported languages
  - C, C++, C#
  - Delphi
  - Fortran
  - Java
  - VBA, VB.Net
  - **Python**
- Examples/Documentation



GAMS Execution System



- Mix of declarative and procedural language elements
  - Multiple models
  - Loops/if-then-else
  - Well suited for decomposition approaches (SP)
  - Many examples in the GAMS Model library
    - Cutting stock
    - TSP
    - …

GAMS

GAMS Scenario Solver

```
Loop(s,
    d(i,j) = dd(s,i,j);
    f = ff(s);
    solve mymodel min z using lp;
    rep(s) = mymodel.objval;
);
```

Setting	Solve time (secs)
Solvelink=0 *(default)*	40.297
Solvelink=%Solvelink.LoadLibrary%	03.625

GAMS Scenario Solver

```
cost.. z=e=sum((i,j),f*d(i,j)/1000*x(i,j));
set dict / s.scenario.''
           d.param    .dd
           f.param    .ff
           x.level    .xx /
solve mymodel min z using lp scenario dict;
```

- Update model data instead of matrix coefficients/rhs
- Hot start (keep the model hot inside the solver and use solver’s best update mechanism)
- Save model generation and solver setup time
- Model rim unchanged from scenario to scenario
- Apriori knowledge of all scenario data

Scenario Solver – Cont.

- Dynamic model – rolling horizon

- Example:
  - Combined Heat and Power Planning with Heat Storage. All data known apriori but heat storage level.
  - Can’t use GAMS Scenario Solver
  - Implement Scenario Solver in Python
    - Identify some parameters as “modifiable” parameters
    - Implement rolling horizon in Python

GMO – GAMS Modeling Object

- Powerful & convenient API – a few calls do the job
- In-core communication between GAMS and the solver, making potentially large model scratch files unnecessary
- Support shared-library implementation of solver links
- Support multiple models
- Support meta-solvers (e.g. DICOPT, SBB, Examiner)
- Implement once, run everywhere (multiple platforms & multiple languages)
- Comprehensive – one-stop shop for all linking needs

GMO Talk by Steve Dirkse, TC40, 13:30-15:00

Python & Co with GMO

- Populated GMO object (e.g. by GAMS)
- GMO API to allow modification and alteration of bounds, rhs, “modifiable” parameters (NL expression evaluation)
- GMO/GEV (GAMS Environment Object) based solver links
- Runtime system (Python, Java, …)

→ Alternative way to implement decomposition, and other algorithmic ideas based on MP models.

- Examples:
  - TSP (subtour elimination constraint generation)
  - Markowitz portfolio optimization

Summary

- Automated API generation for various GAMS components (GAMS, GDX, OPT) in various languages including Python
- GAMS Scenario Solver approach for solving very similar models.
- GMO + Python & Co represent an alternative to GAMS execution system.

- Outlook: Get some of the improvements of the GMO + Python & Co approach back into GAMS
- (Python) API for GMO not published yet (available on request). Still unclear where this experiment will lead us.

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