Object Oriented GAMS API

.NET and Beyond

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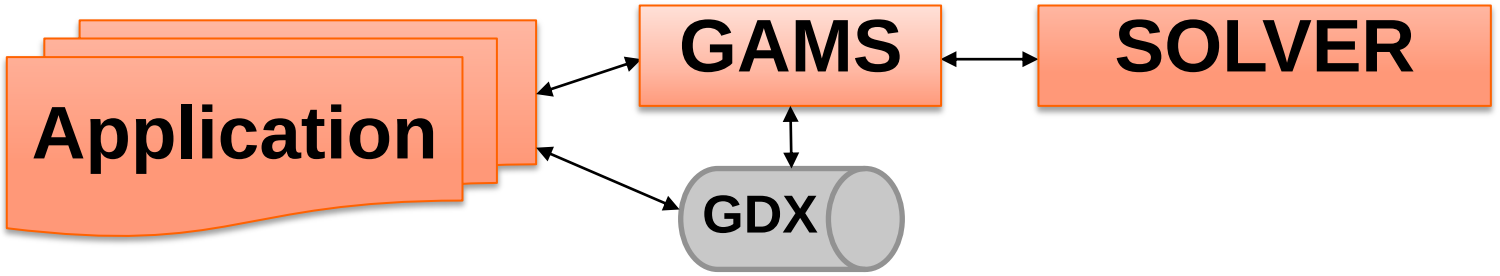
Outline

- Introduction
- Small example in C#, Java and Python
- Scenario Solving
- Seamless Integration

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

Low level APIs → object oriented API

- Low level APIs
  - GDX, OPT, GAMSX, GMO, …
  - High performance and flexibility
  - Automatically generated imperative APIs for several languages (C, Delphi, Java, Python, C#, …)

- Object-oriented GAMS API
  - Additional layer on top of the low level APIs
  - Object-oriented
  - Written by hand to meet the specific requirements of different object-oriented languages

Features of the object oriented API

- No modeling capability. Model is still written in GAMS
- Prepare input data and retrieve results in a convenient way → *GAMSDatabase*
- Control GAMS execution → *GAMSJob*
- Seamless integration of GAMS into other programming environments
- Scenario Solving: Feature to solve multiple very similar models in a dynamic and efficient way.
  →*GAMSModelInstance*

Small Example - C#

Transport.cs

```
using System;
using GAMS;

namespace TransportSeq
{
    class Transport1
    {
        static void Main(string[] args)
        {
            GAMSWorkspace ws = new GAMSWorkspace();
            GAMSJob t1 = ws.AddJobFromString(GetModelText())

            t1.Run();
            foreach (GAMSVariableRecord rec in t1.OutDB.GetVariable("x"))
            {
                Console.WriteLine("x(" + rec.Keys[0] + "," + rec.Keys[1] + "):");
                Console.WriteLine("    level=" + rec.Level);
                Console.WriteLine("    marginal=" + rec.Marginal);
            }
        }
```

Small Example - C#

```
        static String GetModelText()
        {
            String model = @"
          Sets
               i   canning plants   / seattle, san-diego /
               j   markets          / new-york, chicago, topeka / ;

          Parameters

               a(i)  capacity of plant i in cases
                 /    seattle     350
                      san-diego   600  /

               b(j)  demand at market j in cases
                 /    new-york    325
                      chicago     300
                      topeka      275  / ;

               < . . . >

          Solve transport using lp minimizing z ;";

            return model;
        }
    }
}
```

Small Example - Java

Transport.java

```
package TransportSeq;

import com.gams.api.*

class Transport1
{
    static void main(String[] args)
    {
        GAMSWorkspace ws = new GAMSWorkspace();

        GAMSJob t1 = ws.addJobFromString(getModelText());
        t1.run();

        for (GAMSVariableRecord rec : t1.OutDB().getVariable("x"))
        {
            System.out.println("x(" + rec.getKeys()[0] + ", " + rec.getKeys()[1] + "):");
            System.out.println("     level    =" + rec.getLevel());
            System.out.println("     marginal =" + rec.getMarginal());
        }
    }
}
```

Small Example - Python

transport.py

```
from gams import *

if __name__ == "__main__":
    ws = GamsWorkspace()

    t1 = ws.add_job_from_string(get_model_text())
    t1.run()

    for rec in t1.out_db["x"]:
        print rec
```

Scenario Solving - Loop

```
Loop(s,
     f = ff(s);
     solve mymodel min z using lp;
     objrep(s) = z.l;
);
```

- Data exchange between solves possible
- Model rim can change
- Each solve needs to regenerate the model
- User updates GAMS Symbols instead of matrix coefficients

Scenario Solving - GUSS

```
set dict / s.scenario.''
           f.param   .ff
           z.level   .objrep /
solve mymodel min z using lp scenario dict;
```

- Save model generation and solver setup time
- Hot start (keep the model hot inside the solver and use solver's best update and restart mechanism)
- Apriori knowledge of all scenario data
- Model rim unchanged from scenario to scenario

Scenario Solving - GAMSModelInstance

```
foreach (string s in scen)
{
    f.FirstRecord().Value = v[s];
    modelInstance.Solve();
    objrep[s] = z.FirstRecord().Level;
}
```

- Save model generation and solver setup time
- Hot start (keep the model hot inside the solver and use solver's best update and restart mechanism)
- Data exchange between solves possible

- Model rim unchanged from scenario to scenario

GAMSModelInstance - Example

- *bmult* is one parameter of the model which gets modified before we solve the instance:

```
GAMSParameter bmult = mi.SyncDB.AddParameter("bmult", 0, "demand multiplier");
bmult.AddRecord().Value = 1.0;
mi.Instantiate("transport us lp min z", opt, new GAMSModifier(bmult));
double[] bmultlist = new double[] { 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3 };

foreach (double b in bmultlist)
{
    bmult.FirstRecord().Value = b;
    mi.Solve();
    <...>
    Console.WriteLine("  Obj: " + mi.SyncDB.GetVariable("z").FindRecord().Level);
}
```

GAMSModelInstance - Example

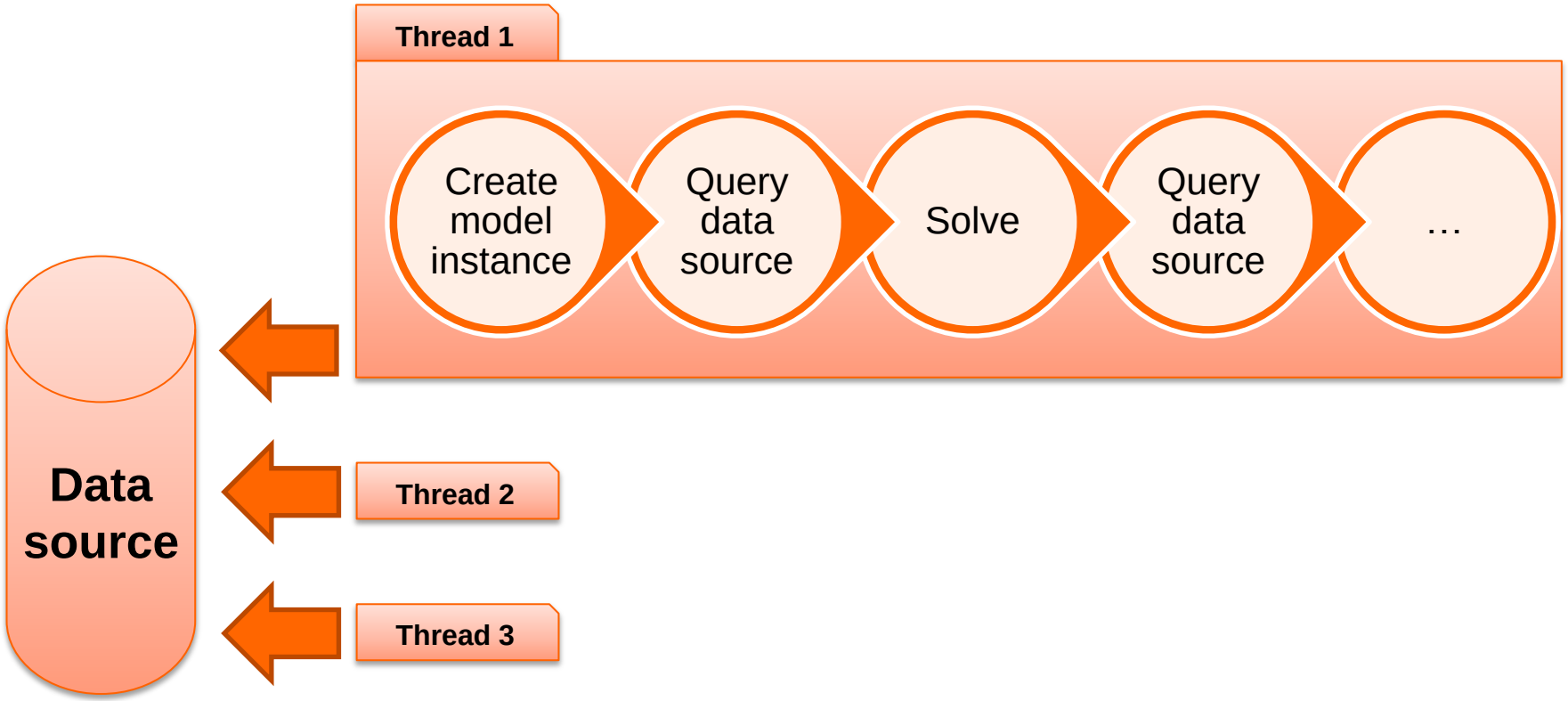
- Updating bounds of a variable:

```
GAMSVariable x = mi.SyncDB.AddVariable("x", 2, VarType.Positive, "");
GAMSParameter xup = mi.SyncDB.AddParameter("xup", 2, "upper bound on x");
mi.Instantiate("transport us lp min z", modifiers: new GAMSModifier(x,UpdateAction.Upper,xup));

foreach (GAMSSetRecord i in t7.OutDB.GetSet("i"))
    foreach (GAMSSetRecord j in t7.OutDB.GetSet("j"))
    {
        xup.Clear();
        xup.AddRecord(i.Keys[0],j.Keys[0]).Value = 0;
        mi.Solve();
        <...>
        Console.WriteLine("  Obj: " + mi.SyncDB.GetVariable("z").FindRecord().Level);
    }
```

GAMSModelInstances in Parallel

- Multiple GAMSModelInstances running in parallel with one common data source (work):



GAMSModelInstances in Parallel

- Threads consume data from source dynamically instead of getting a fixed amount of data at thread initialization time

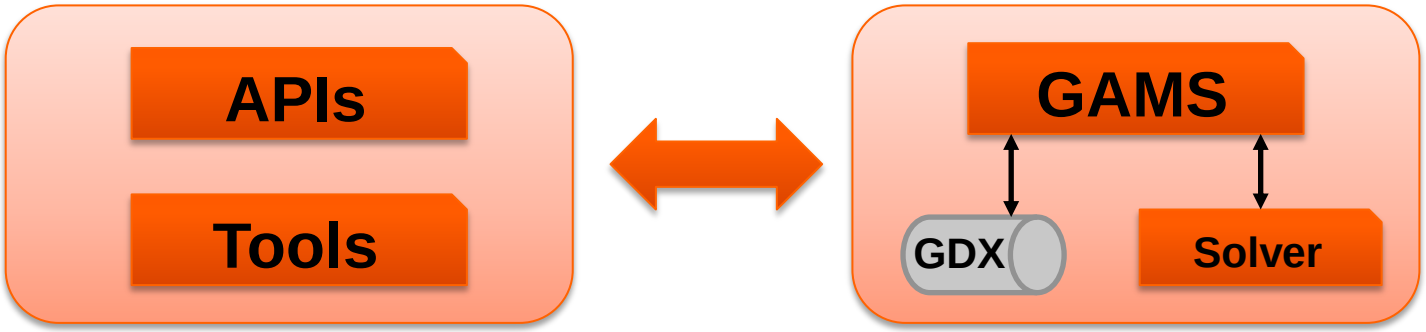
- Implicit load balancing by architecture:
  - Number of solves in a thread depend on its speed
  - Keeps all threads busy as long as possible

- Typical applications:
  - Scenario analysis
  - Decomposition algorithms (Benders, CG, …)

- Communication between threads for “dynamic” algorithms

Seamless Integration

- Separation of tasks



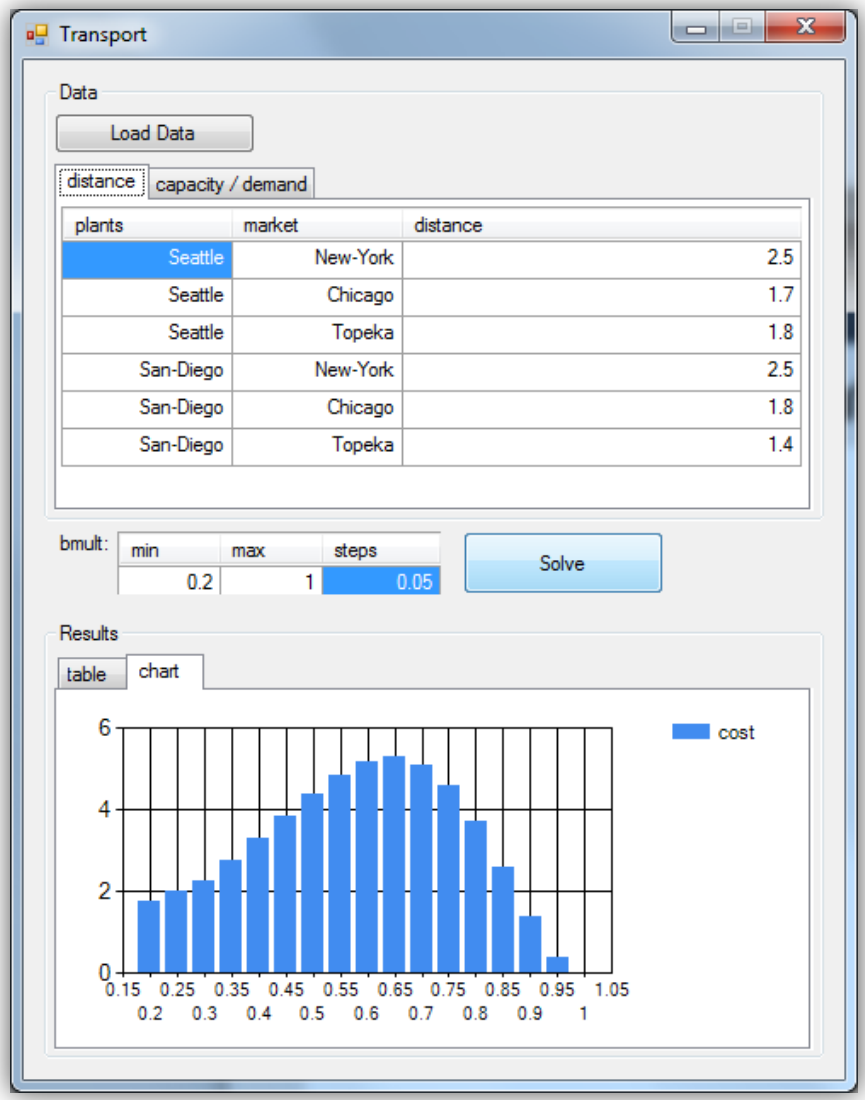
- Use GAMS for modeling and optimization tasks

- Programming languages like C# (.NET), Java and Python are well-suited for developing applications (GUI, Web, …)
  - frameworks available for a wide range of specific task:
    - GUI and Web development, …

- The object oriented GAMS API provides a convenient link to run GAMS in such environments

Seamless Integration

- Example: Small transport Desktop application written in C#
- Convenient data preparation
- Representation of the results in a predefined way
- Modeling details are hidden from the user



Seamless Integration

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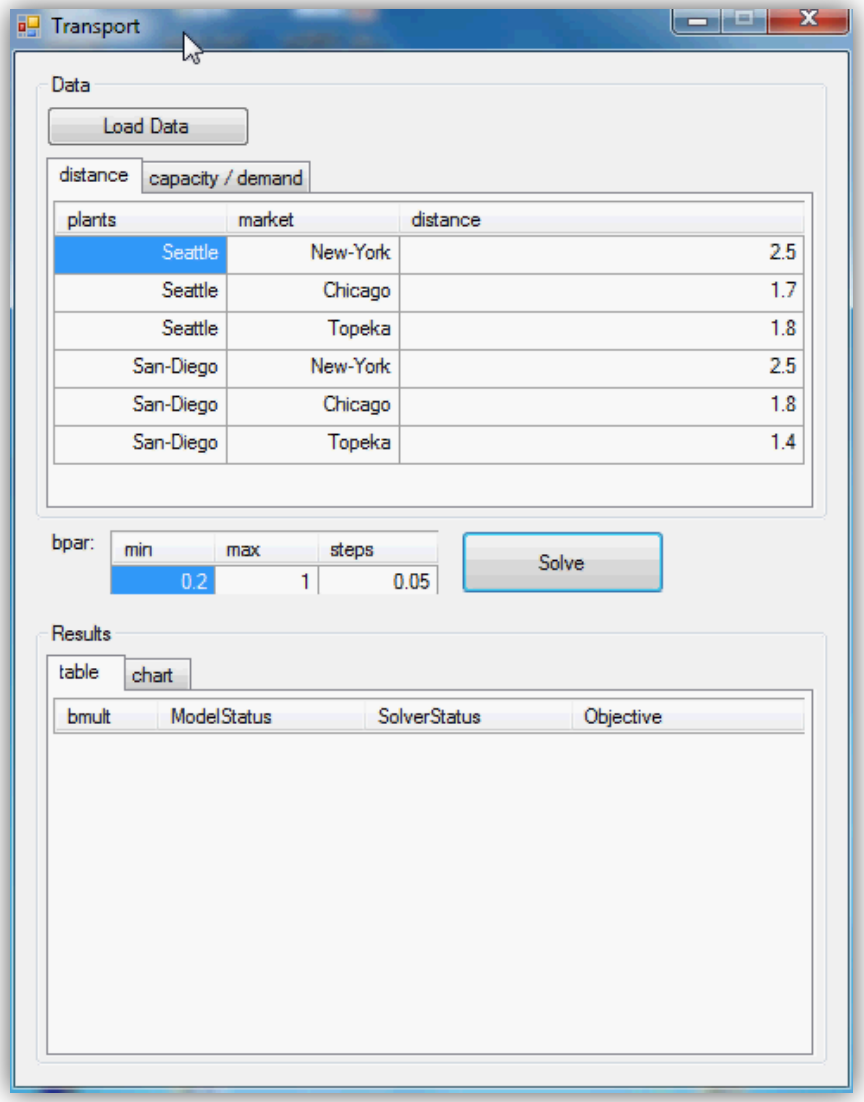

Summary

- Object Oriented API provides an additional abstraction layer of the low level GAMS APIs
- Powerful and convenient link to other programming languages
- .NET API is part of the current GAMS release available at *www.gams.com*. Many examples available:
  - Sequence of Transport examples
  - Cutstock, Warehouse, Benders Decomposition
- Python and Java under development.

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