Pre-Conference Workshops

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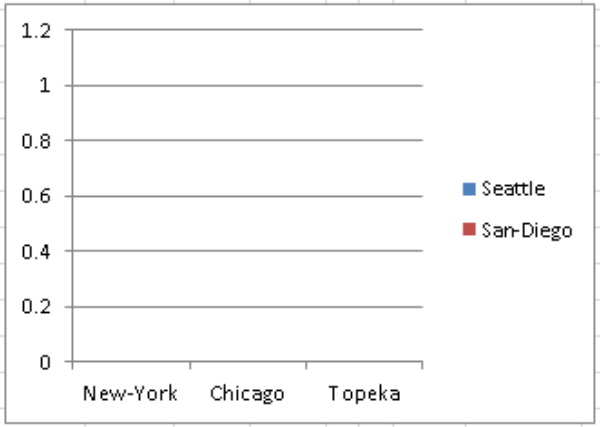
Outline

Excel and GAMS

	A	B	C	D	E	F
1	**Distance**	New-York	Chicago	Topeka		Supply
2	Seattle	2.5	1.7	1.8		350
3	San-Diego	2.5	1.8	1.4		600
4						
5	Demand	325	300	275		
6						
7	Freight cost	90				
8						
9						
10	**SHIPMENT**	New-York	Chicago	Topeka		
11	Seattle					
12	San-Diego					
13						
14						
15						
16						
17						
18	**GAMS Directory:**	C:\GAMS\win64\24.8.5\				
19	**Working Directory:**	c:\tmp\				
20	**Solver:**	CPLEX				
21						
22						
23						
24						
25						



Clear Solution

SOLVE LP

SOLVE MIP

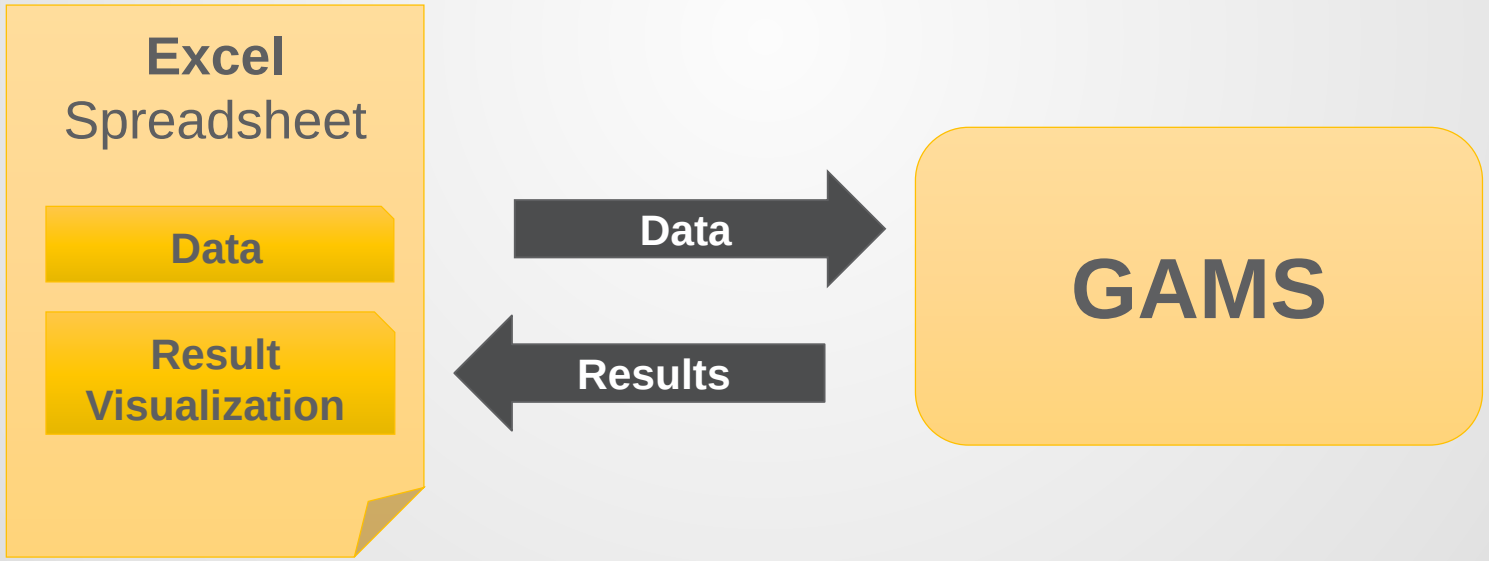
Main | Model | Listing

Hands-On
TransXLS

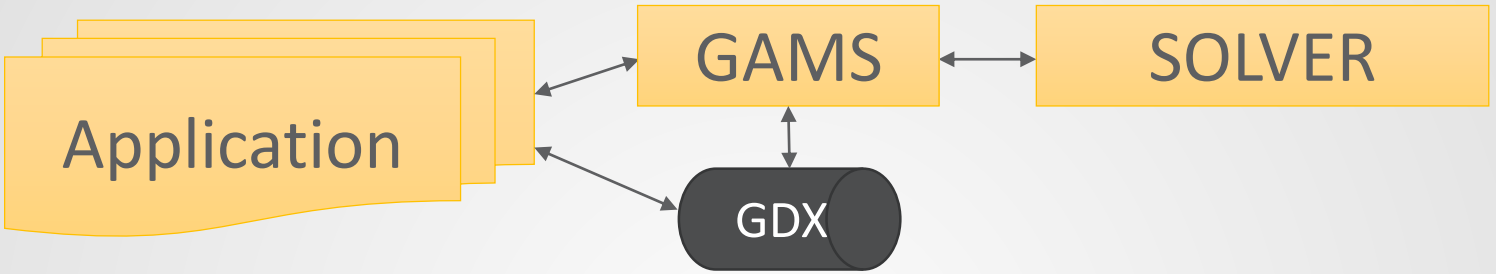
Excel and GAMS

- VBA GAMS API to call GAMS from Excel

- Exchange of input data and results using either **GDXXRW** or **GDX API**



Embedding GAMS in 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

- Control GAMS execution → *GAMSJob*
- Prepare input data and retrieve results in a convenient way → *GAMSDatabase*
- Scenario Solving: Feature to solve multiple very similar models in a dynamic and efficient way →*GAMSModelInstance*
- Seamless integration of GAMS into other programming environments
- .NET, C++, Java and Python APIs are part of the current GAMS release available at *www.gams.com*. Many examples available:
  - Sequence of Transport examples (Tutorial)
  - Cutstock, Warehouse, Benders Decomposition, …

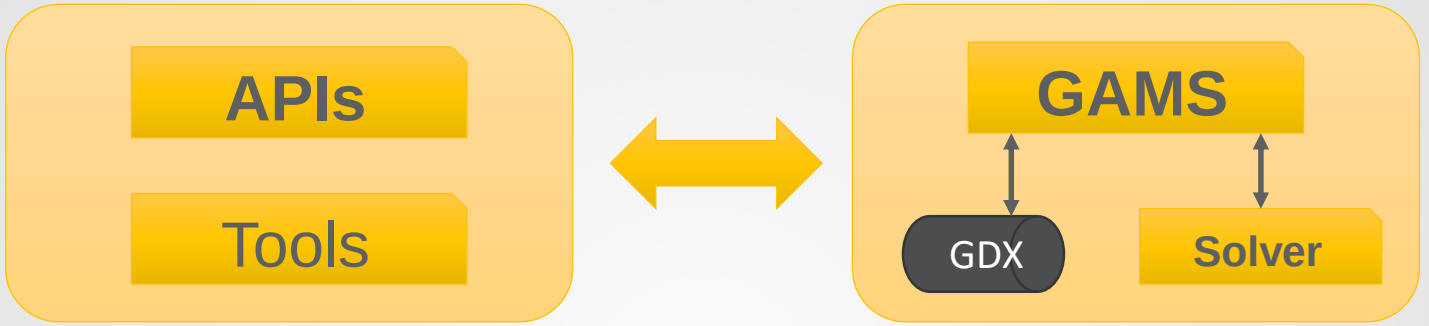
Small Example – C#

```
using System;
using GAMS;

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

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

Hands-On
TransportSeq.sln

Seamless Integration

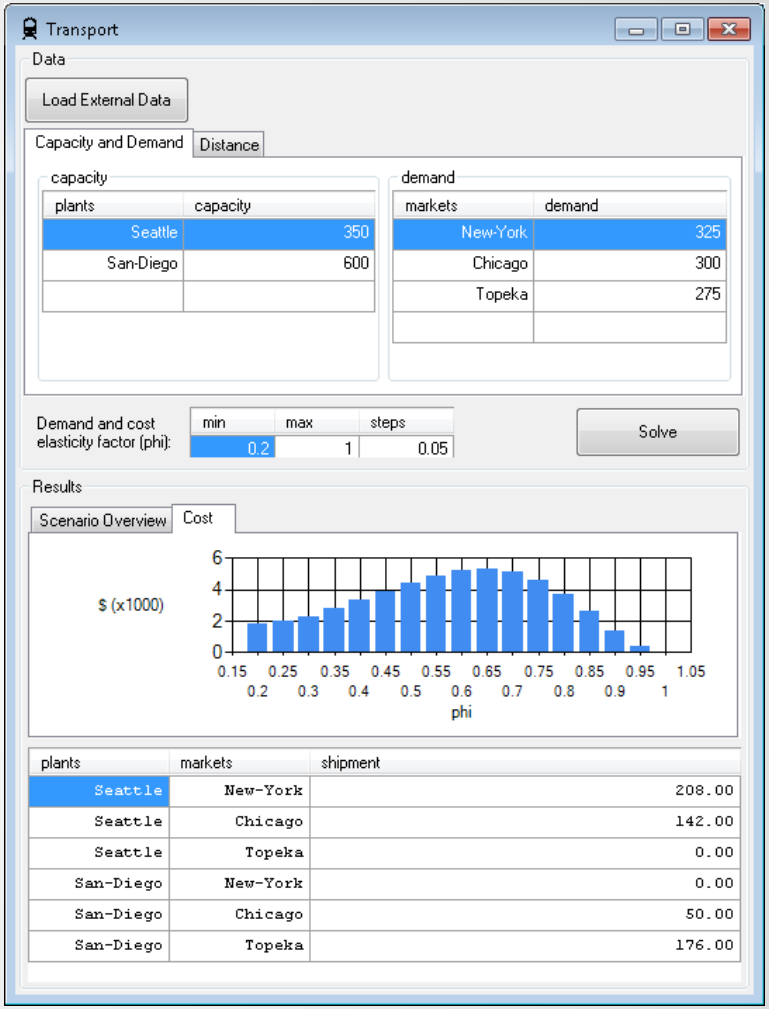
- GAMS concept: Separation of tasks



- Use GAMS for modeling and optimization tasks
- Programming languages like C# (.NET), C++, Java and Python are well-suited for developing applications
  - Frameworks available for a wide range of specific task:
    - GUI
    - 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



Hands-On
TransportGUI.sln

Scenario Solving

Solving Transport in a loop with different scenarios for the demand:

```
Loop(s,
     d(i,j) = dd(s,i,j);
     solve transport using lp minimizing z;
     objrep(s) = transport.objval;
);
```

Scenario Solving – GUSS

```
set dict / s.scenario.''
           d.param   .dd
           z.level   .objrep /
solve transport using lp minimizing z;
```

- 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 etc.

GAMSJob

- Manages the execution of a GAMS program given by GAMS model source

creates

GAMSCheckpoint

- Captures the state of a GAMSJob

initializes

GAMSModelInstance

- A single mathematical model generated by a GAMS solve statement

modifies

GAMSModifier

- Marks elements of a GAMSModelInstance to be modifiable

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);
}
```

Hands-On
Transport7

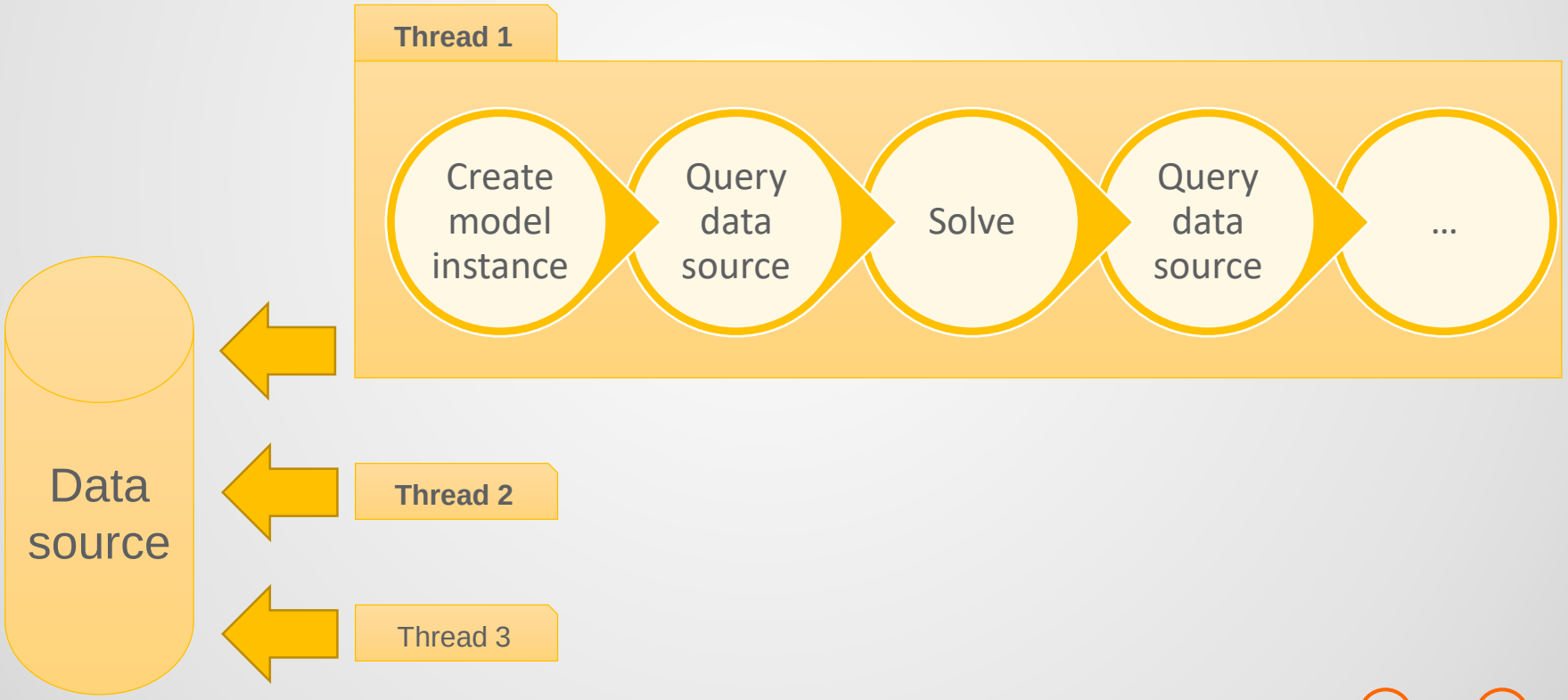
GAMSModelInstance – Example

- 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

Hands-On
Transport8

Summary

- Object Oriented API provides an additional abstraction layer of the low level GAMS APIs
- Powerful and convenient link to other programming languages
- Versions for .NET, C++, Java, and Python are available and part of the current distribution
- Many examples are available:
  - Sequence of Transport examples (→ Tutorial)
  - Cutstock, Warehouse, Benders Decomposition, …

Thank You

Meet us at the GAMS booth!