GAMS Deployment

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Topics for Deployment

- **Protection of models**
  - Save/restart
  - Secure save/restart
  - Encryption

- **Embedding Models in an application**
  - Low-level APIs
  - GAMS OO API
  - Web application

- **Delivering models**
  - Delivering standalone applications

Protection

- Protection against "stealing" models or model ideas
- Guaranteeing integrity of the application

- GAMS offers the Save/Restart (Checkpoint) Facility
  - Capture the state of a (partial) GAMS model (data plus code)
  - Restarting (continued compilation plus execution)

- Secure Save/Restart Facility
  - Embed client's license in the checkpoint, so only the client with a particular license can restart from the checkpoint.

- Deployment licenses using the Checkpoint facility qualify for a discounted license fee

Protection cont.

- Capturing a model without data in a checkpoint can be sometimes difficult

- Alternative: Source file encryption

- GAMS still provides clear text listing file
    - Listing of the code
    - Equation listing, etc.

- GAMS offers features to
    - Hide data (no restart file has access to this data)
    - Make symbols read-only

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Embedding GAMS in your Application
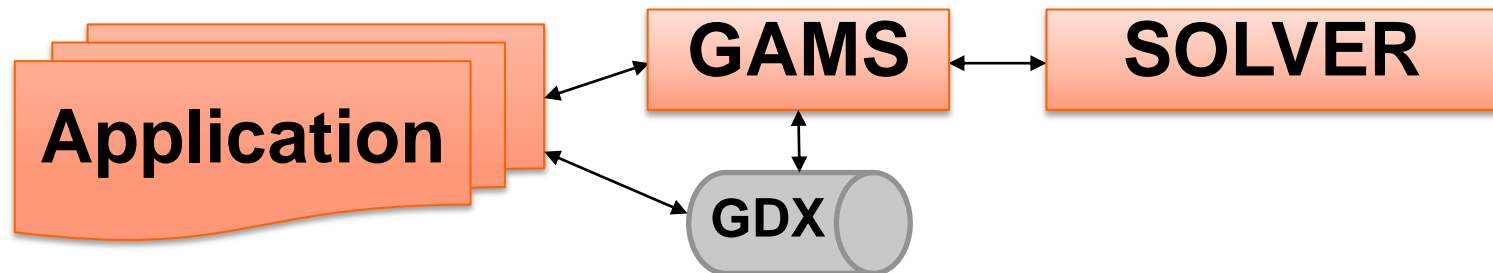
Creating Input for GAMS Model
→ **Data handling using GDX API**

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

- Prepare input data and retrieve results in a convenient way → *GAMSDatabase*

- Control GAMS execution → *GAMSJob*

- Seamless integration of GAMS into other programming environments

→ .NET API and several examples are part of the current GAMS release available at www.gams.com

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.

Put Facility/Windows Messages

- Put Files
  - ASCII files written from GAMS

- Windows Message
  - Communication between Windows Forms
  - Send Windows Messages from GAMS model to application
  - Capture Messages from a Windows Forms Application
  - Provide additional arbitrary information during GAMS execution

Windows Messages

- Simple executable to send Windows Messages to a particular Window:

argv[1]: Name of Window
argv[2]: Message

```c
int main(int argc, char* argv[]) {
    HWND receiver;
    COPYDATASTRUCT cds;

    receiver = FindWindow(NULL, argv[1]);

    cds.dwData = 1;
    cds.lpData = argv[2];
    cds.cbData = strlen(argv[2]);

    SendMessage(receiver, (UINT)WM_COPYDATA, (WPARAM)0, (LPARAM)&cds);
}
```

Windows Messages

```
Received Messages:
solve 1    : Model obj =        147.64
solve 2    : Model obj =        150.75
solve 3    : Model obj =        152.06
solve 4    : Model obj =        148.44
solve 5    : Model obj =        151.14
solve 6    : Model obj =        142.10
solve 7    : Model obj =        140.59
solve 8    : Model obj =        139.49
solve 9    : Model obj =        143.28
solve 10   : Model obj =        134.34
```
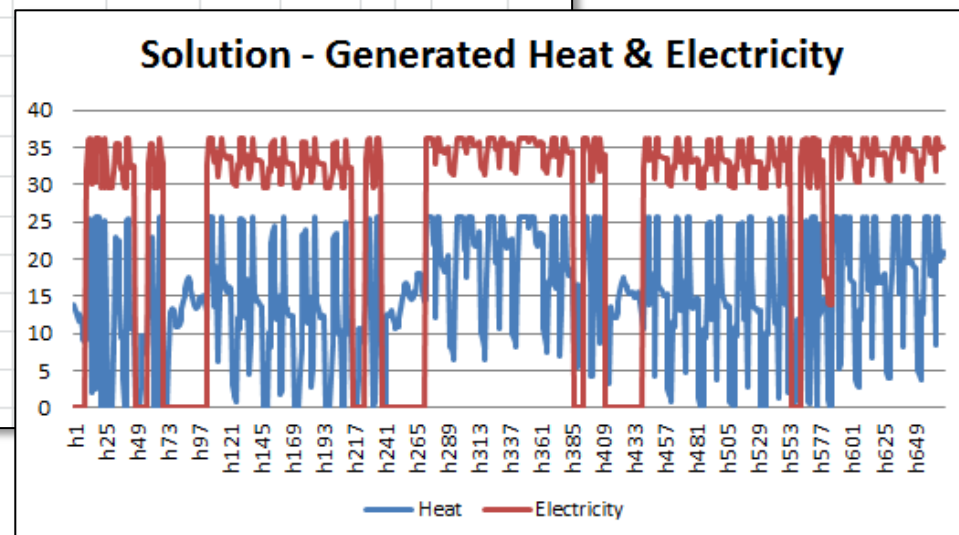
```
loop(s,
    c(i,j) = uniform(0.9,1.1)*c(i,j);
    Solve transport using lp minimizing z ;
    avgobj = avgobj + z.l;
    put_utility fx 'exec' / 'sendmessage Transport "solve ' s.tl:4 ': Model obj = 'z.l '"';
);
```

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Excel and GAMS

- VBA GAMS API to call GAMS from Excel

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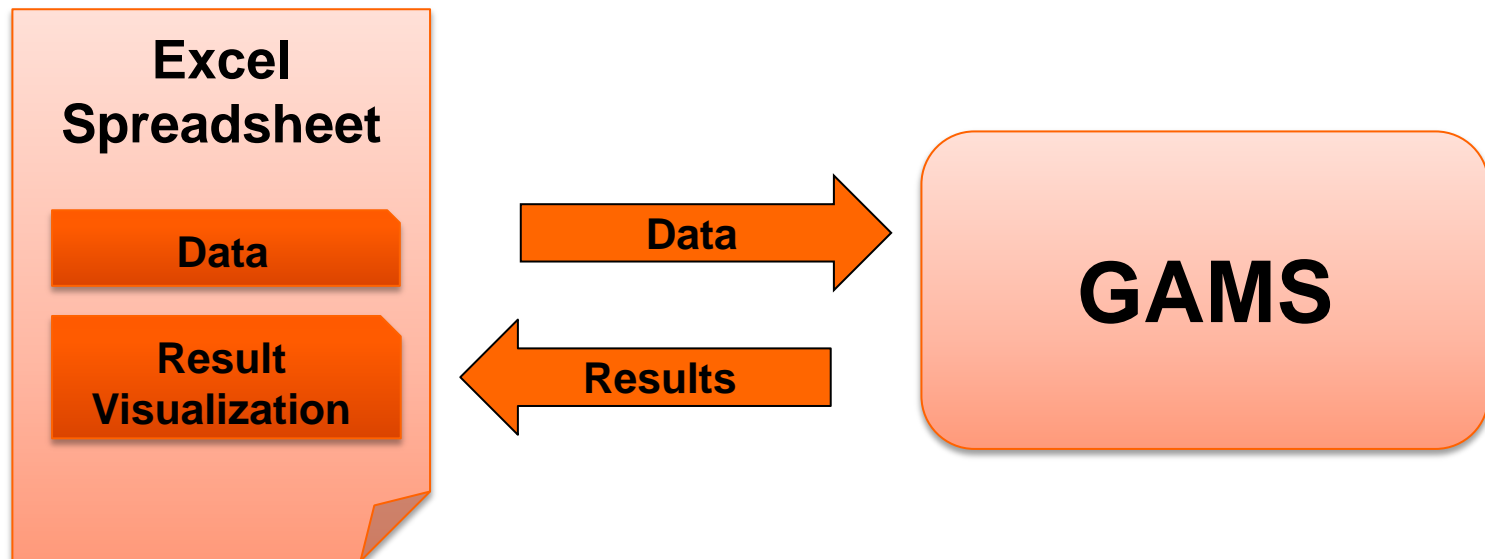
Excel and VBA - CHP

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
4	Coal	-17.62	-35.24											MWh	
5	WasteHeat				36.43	53.2	-42.56	-10.64	-53.2					MWh	
6	Steam	5.5	11				10.72			-16.7				kg/s	
7	Exhaust									16.7	-16.7			kg/s	
8	Heat			18				8.6184			39.84			MWh	
9	Electricity	-0.25	-0.5		13.77	29.55				10.39				MWh	
10															
11															
12															
13															
14															
15															
16															
17															
18															
19	**GAMS Directory:**	C:\GAMS\win32\23.9\													
20	**Working Directory:**	c:\tmp\													
21	**Solver:**	CPLEX													
22															
23															
24															
25		SOLVE		Clear Solution											
26															

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NEOS Case Studies

Wiki as Deployment Environment

- Technologies: Dokuwiki, JavaScript, PHP, …

- Useful for sharing knowledge of a particular model

- Run GAMS from wiki environment

- Sharing results of a GAMS model

- Start a GAMS model asynchronously and come back later to see the results (batch job)

- http://apps.gams.com/doku.php

Wiki – Line Optimization Example

JavaScript & Google Maps

Route 1	Route 2	Route 3	Route 4	Route 5	Route 6	Route 7	Route 8
Route 9	Route 10	Route 11	Route 12	Route 13	Route 14	Route 15	
Route 16	Route 17	Route 18	Route 19	Route 20	Route 21		

from	to	running time	accumulated running time
Amsterdam CS	Apeldoorn	89.00	89.00
Apeldoorn	Hengelo	69.00	158.00
Hengelo	Oldenzaal Grens	18.00	176.00

Showing 1 to 3 of 3 entries

Wiki – Interactive Applications

- Interactive Applications using Ajax (Asynchronous JavaScript and XML)
- Small models that allows the user to wait for the results
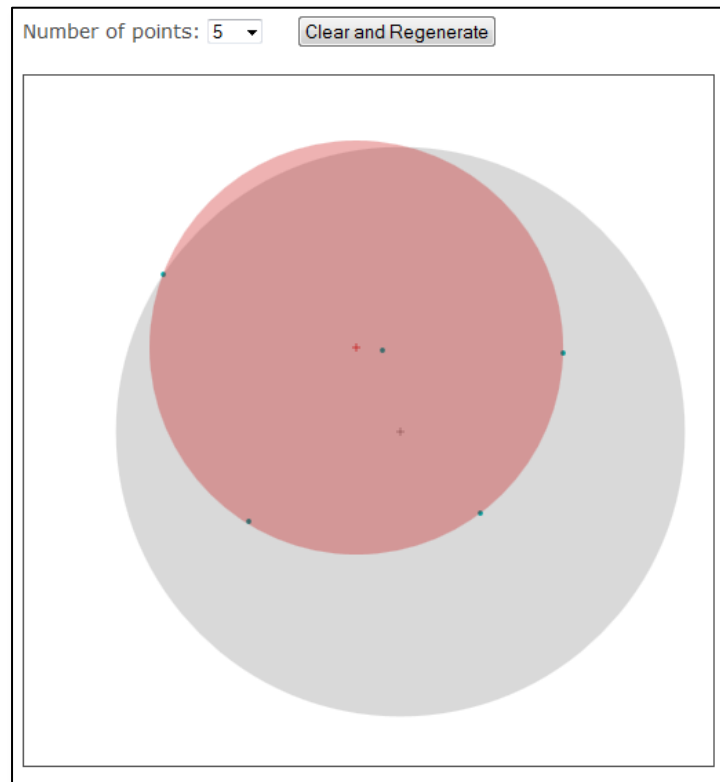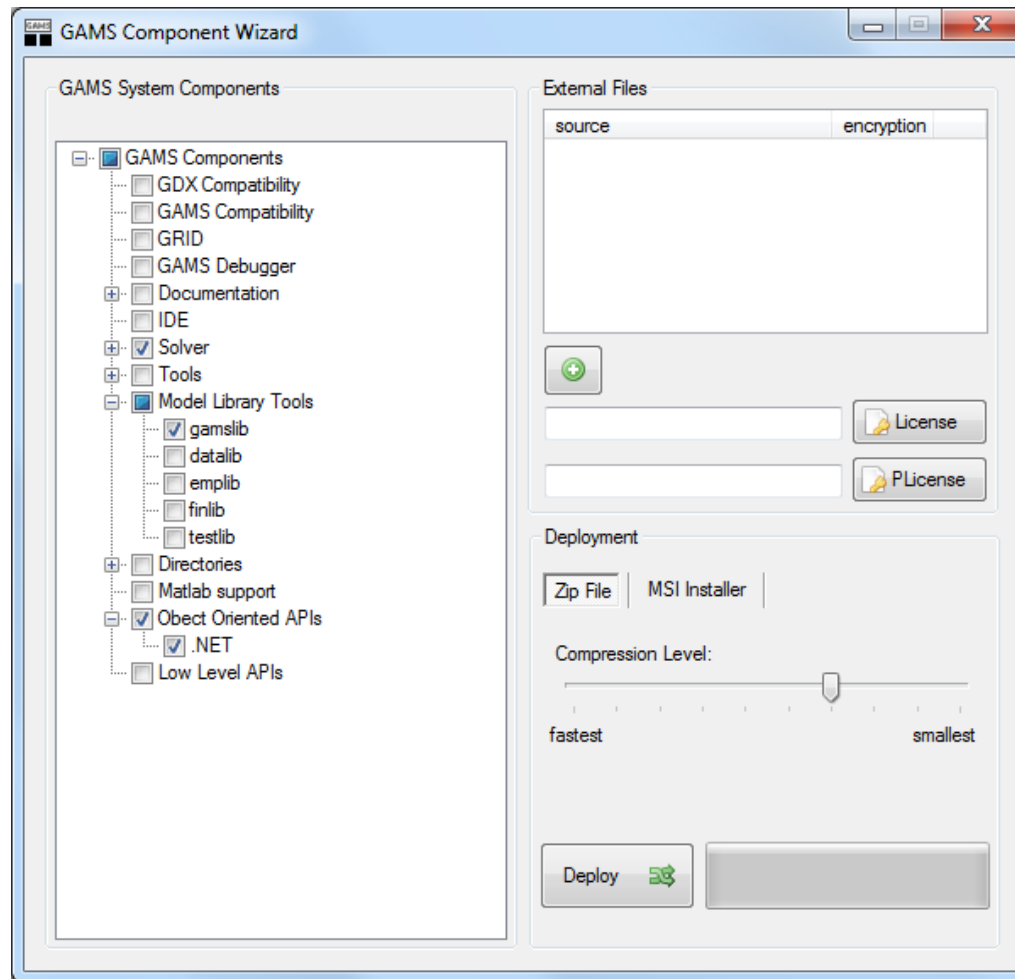
Delivering Models

- Minimal GAMS System
  - Deployment using a minimal GAMS System
  - Subset of a full GAMS Installation
  - Ship only the files that are necessary to run a particular model/application

- GAMS Component Wizard
  - Helps choosing the right files in a convenient way
  - Deploy as Zip file or as MSI Installer

Minimal GAMS System

Minimal GAMS System