GAMS

An Introduction

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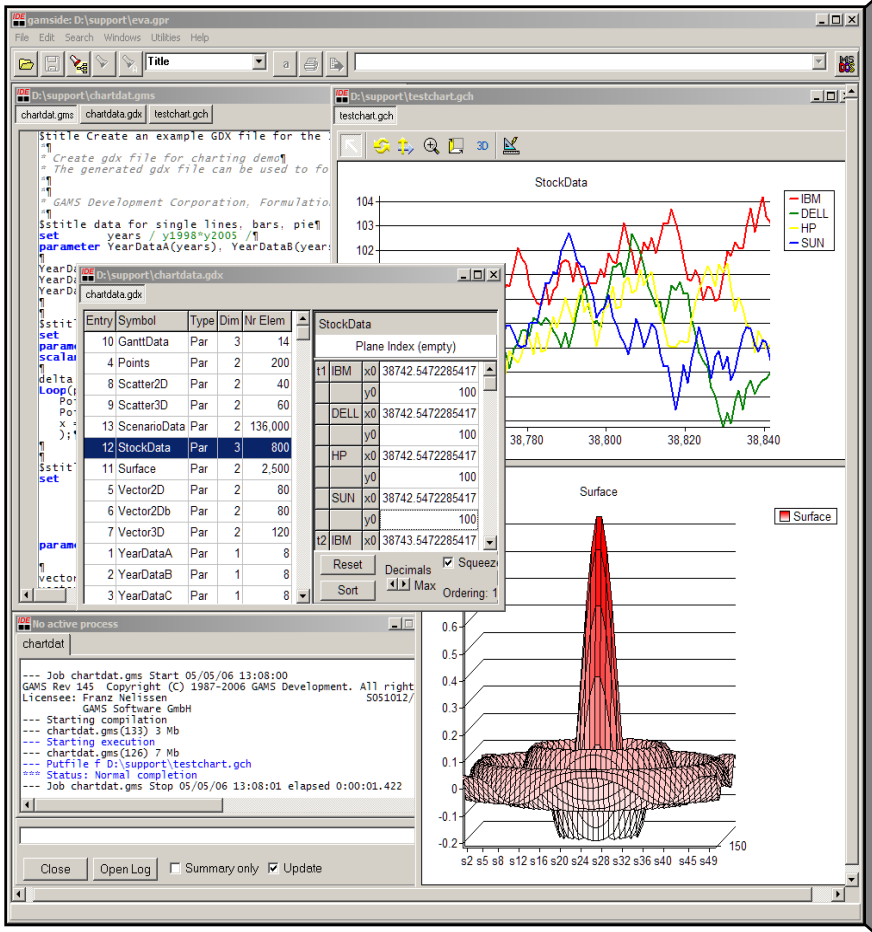
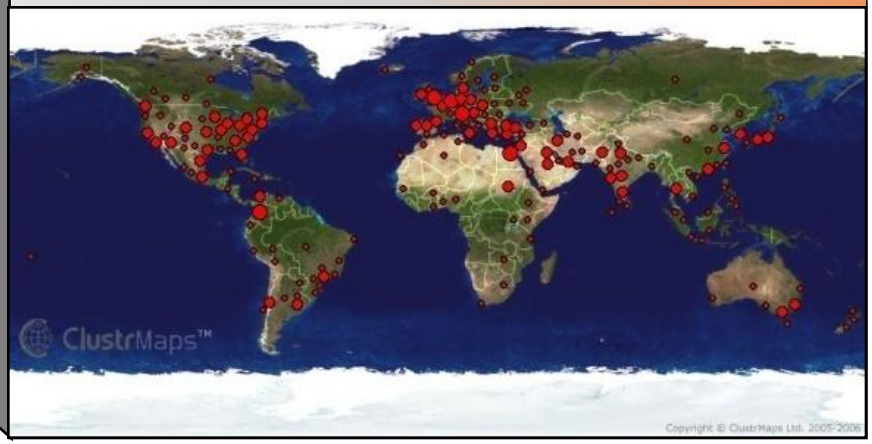
GAMS at a Glance



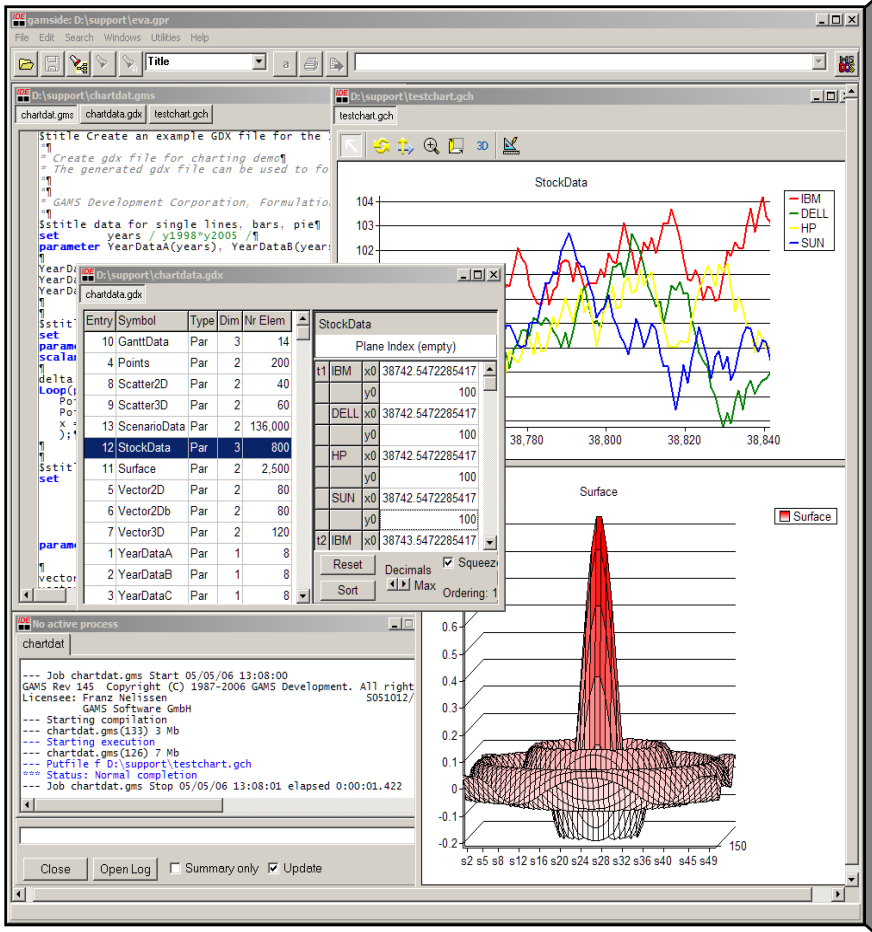
General **A**lgebraic **M**odeling **S**ystem

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH

- Broad academic & commercial user community and network



GAMS at a Glance



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

- Algebraic Modeling Language
- 25+ Integrated Solvers
- 10+ Supported MP classes
- 10+ Supported Platforms
- Connectivity- & Productivity Tools
  - IDE
  - Model Libraries
  - GDX, Interfaces & Tools
  - Grid Computing
  - Benchmarking
  - Compression & Encryption
  - Deployment System
  - …

GAMS' Fundamental concepts

- Different layers with separation of
  - model and data
  - model and solution methods
  - model and operating system
  - model and interface

- Open architecture and interfaces to other systems
- Balanced mix of declarative and procedural elements

System Overview

Interactive | **API / Batch**

Connectivity Tools

- Uniform Data Exchange:
  - ASCII
  - GDX (ODBC, SQL, XLS, XML)
- GDX Tools
- Component Library with Interfaces to C++, Java, .NET,…
- Ext. programs
  - EXCEL
  - MATLAB
  - GNUPLOT, …
- CONVERT

User Interfaces

GAMS Language Compiler and Execution System

Solvers

LP/MIP-QCP-MIQCP-NLP/DNLP-MINLP-CNS-MCP-MPEC,global, and stochastic

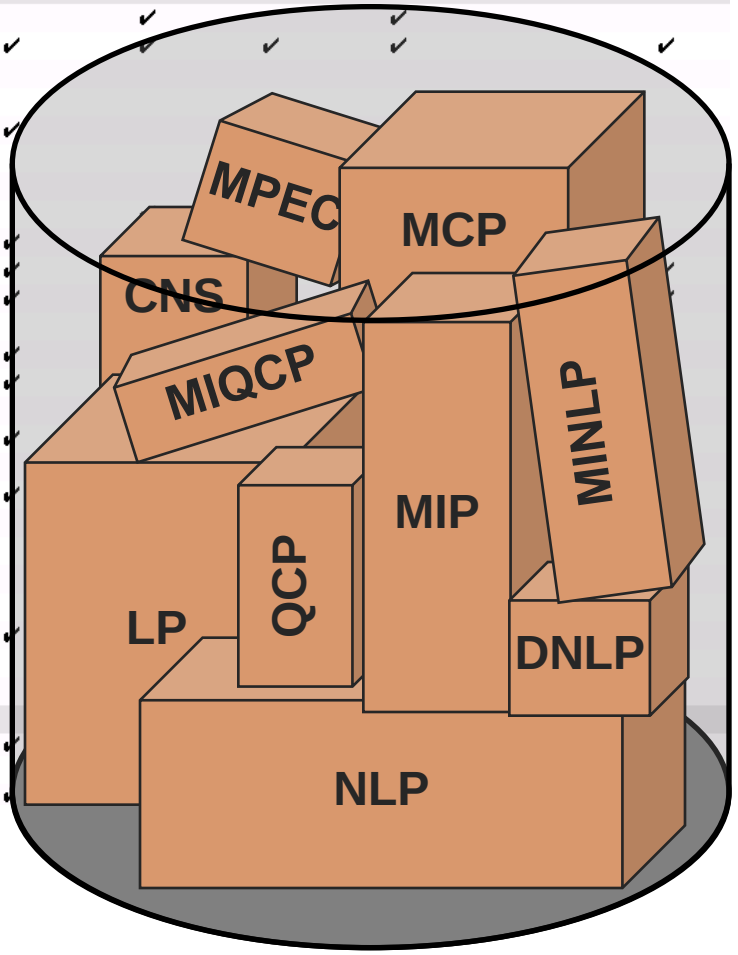
Productivity Tools

- Integrated **D**evelopment **E**nvironment (**IDE**)
- Integrated Data Browser and Charting Engine
- Model Libraries
- Benchmarking and Deployment
- Model Debugger and Profiler
- Transparent and reproducible Quality Assurance and Testing System
- Data and Model Encryption
- Grid Computing
- Scenario Reduction
- MPSGE for general equilibrium modeling

ALPHAECP, BARON, COIN, CONOPT, CPLEX, DECIS, DICOPT, KNITRO, LGO, LINDO, MINOS, MOSEK, OQNLP, PATH, SNOPT, XA, XPRESS, …

Supported Model Types (GAMS 22.7)

Solver/Model type availability - 22.7 May 1, 2008	LP	MIP	NLP	MCP	MPEC	CNS	DNLP	MINLP	QCP	MIQCP	*Stoch.*	*Global*
ALPHAECP								✔		✔		
BARON 8.1	✔	✔	✔				✔	✔	✔	✔		✔
BDMLP	✔	✔										
COIN	✔	✔										
CONOPT 3	✔		✔			✔	✔					
CPLEX 11.0	✔	✔										
DECIS	✔											
DICOPT												
KNITRO 5.1	✔		✔				✔					
LINDOGLOBAL 5.0	✔	✔	✔				✔					
LGO	✔		✔				✔					
MILES				✔								
MINOS	✔		✔				✔					
MOSEK 5	✔	✔	✔				✔					
MPSGE												
MSNLP			✔				✔					
NLPEC				✔	✔							
OQNLP			✔				✔					
OSL V3	✔	✔										
OSLSE	✔											
PATH				✔		✔						
SBB												
SNOPT	✔		✔				✔					
XA	✔	✔										
XPRESS 18.00	✔	✔										
Contributed Plug&Play solvers												
AMPLwrap	✔	✔	✔	✔	✔	✔	✔					
DEA	✔	✔										
Kestrel	✔	✔	✔	✔	✔	✔	✔					



Supported Platforms (GAMS 22.7)

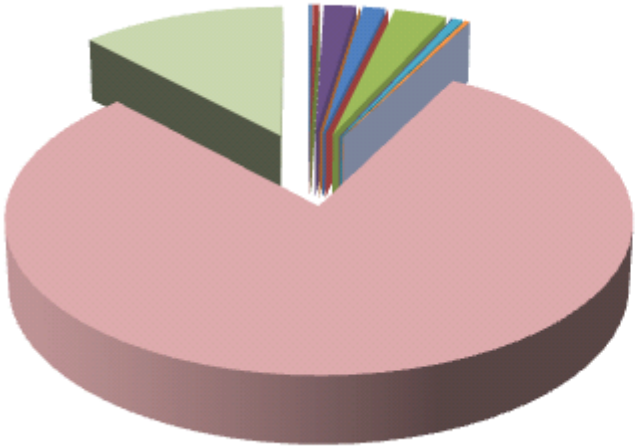
Solver/Platform availability - 22.7: May 1, 2008	x86 MS Windows	x86_64 MS Windows	x86 Linux	x86_64 Linux	Sun Sparc SOLARIS	Sun Sparc64 SOLARIS	Sun Intel SOLARIS	HP 9000 HP-UX 11[1]	DEC Alpha Digital Unix 4.0	IBM RS-6000 AIX 4.3	Mac PowerPC Darwin	Mac Intel32 Darwin	SGI IRIX[2]
ALPHAECP	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	
BARON 8.1	✔	32bit	✔	32bit						✔			
BDMLP	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
COIN	✔	✔	✔	✔			✔				✔	✔	
CONOPT 3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
CPLEX 11.0	✔	✔	✔	✔	✔	✔	✔	10.0	8.1	✔		✔	9.1
DECIS	✔	✔	✔	✔	✔	32bit	✔	✔	✔	✔			✔
DICOPT	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
EMP	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
KNITRO 5.1	✔	32bit	✔	✔	✔	32bit					✔	✔	
LINDOGLOBAL 5.0	✔	✔	✔	✔	✔	✔					✔	✔	
LGO	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
LOGMIP	✔	✔									✔	✔	
MILES	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
MINOS	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
MOSEK 5	✔	✔	✔	✔	✔	✔	✔	3.2			✔	✔	
MPSGE	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
MSNLP	✔	✔	✔	✔	✔	32bit		✔			✔	✔	
NLPEC	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
OQNLP	✔	32bit	✔	32bit									
OSL V3	✔	32bit	✔	32bit	✔	32bit		V2		✔			V2
OSLSE	✔	32bit	✔	32bit	✔	32bit				✔			
PATH	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
SBB	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
SNOPT	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
XA	✔	32bit	✔	✔	✔	32bit		✔	✔	✔			
XPRESS 18.00	✔	32bit	✔	32bit	✔	32bit		16.10		✔			
Contributed Plug&Play solvers													
AMPLwrap	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔			
DEA	✔	✔	✔	✔	✔	✔		✔	✔				
Kestrel	✔	32bit	✔	32bit	✔								

[1] GAMS distribution for HP 9000/HP-UX is 22.1.

[2] GAMS distribution for SGI IRIX is 22.3.

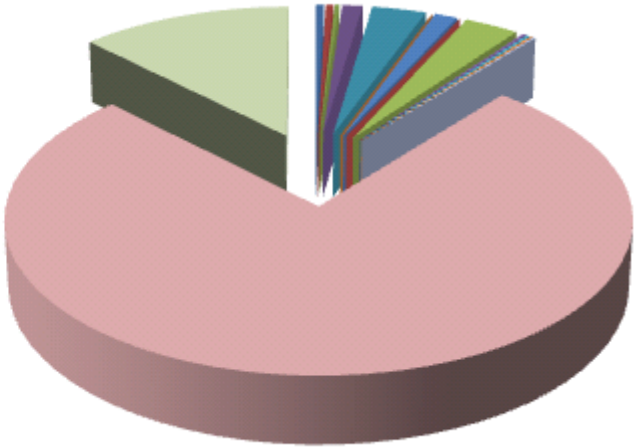
Downloads by Platform

GAMS 22.5



525+ Downloads
a week

GAMS 22.6

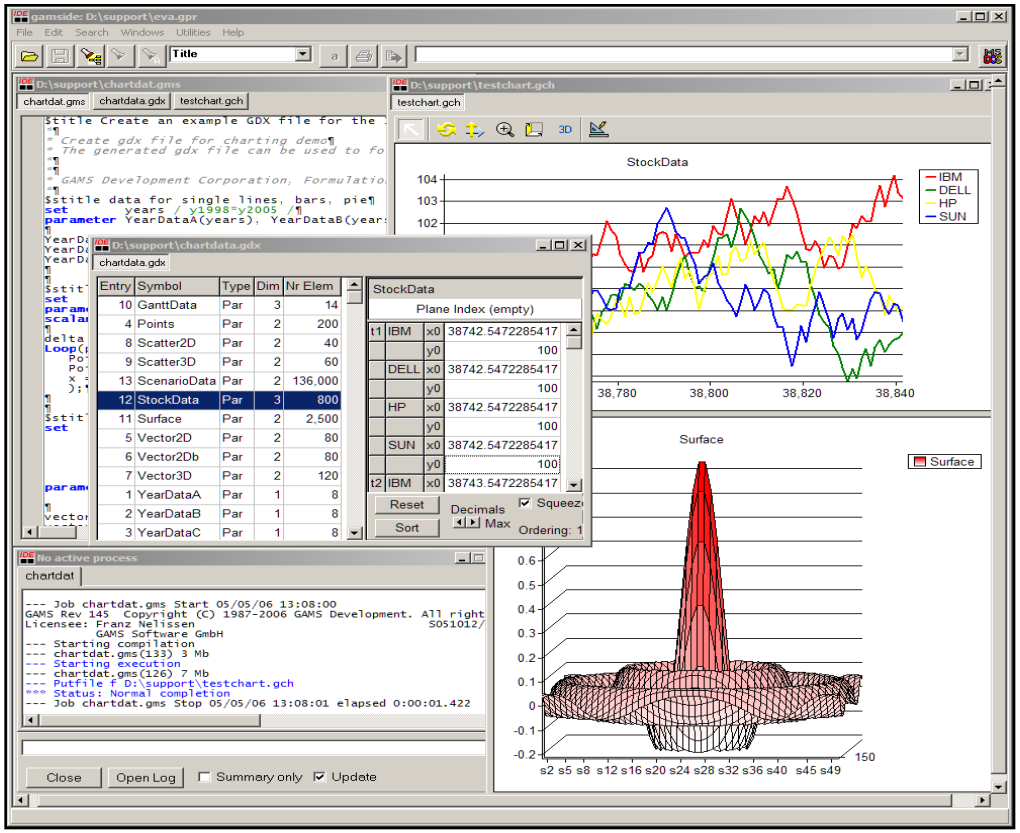


550+ Downloads
a week

- aix
- axu
- hp7*
- dar
- dii
- leg
- lei
- lnx
- lx3
- sgi**
- sig
- sol
- sox
- vis
- wei

Integrated Development Environment

- Project Management
- Documentation
  - User's Guide
  - McCarl User's Guide
  - Solver Manuals
- Model Libraries
- Solver Selection
- Option Editor
- Listing file
  - Tree view
  - Error navigation
- Spell checking
- …

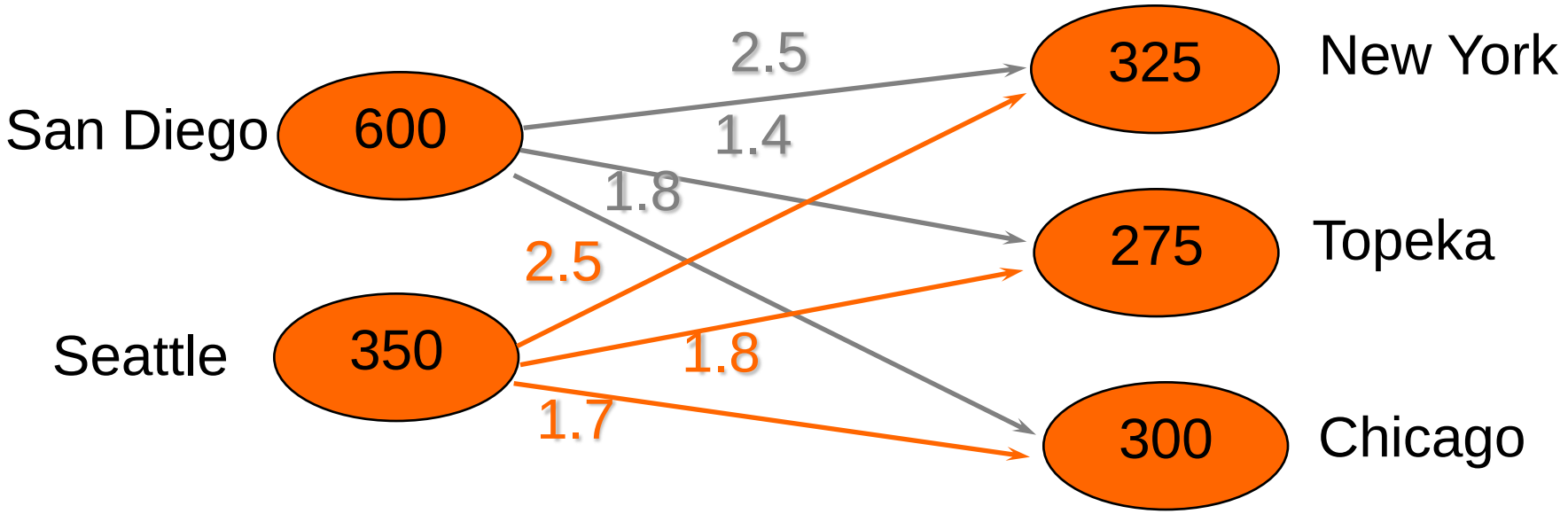


What is a Model?

- Mathematical Programming (MP) Model
  - List of Equations

- Collection of several intertwined MP Models
  - Data Preparation
  - Data Calibration
  - “Solution” Module (e.g. sequential, parallel, loop)
  - Report Module

A Transportation Model



Minimize	Transportation cost
subject to	Demand satisfaction at markets
	Supply constraints

Mathematical Algebra

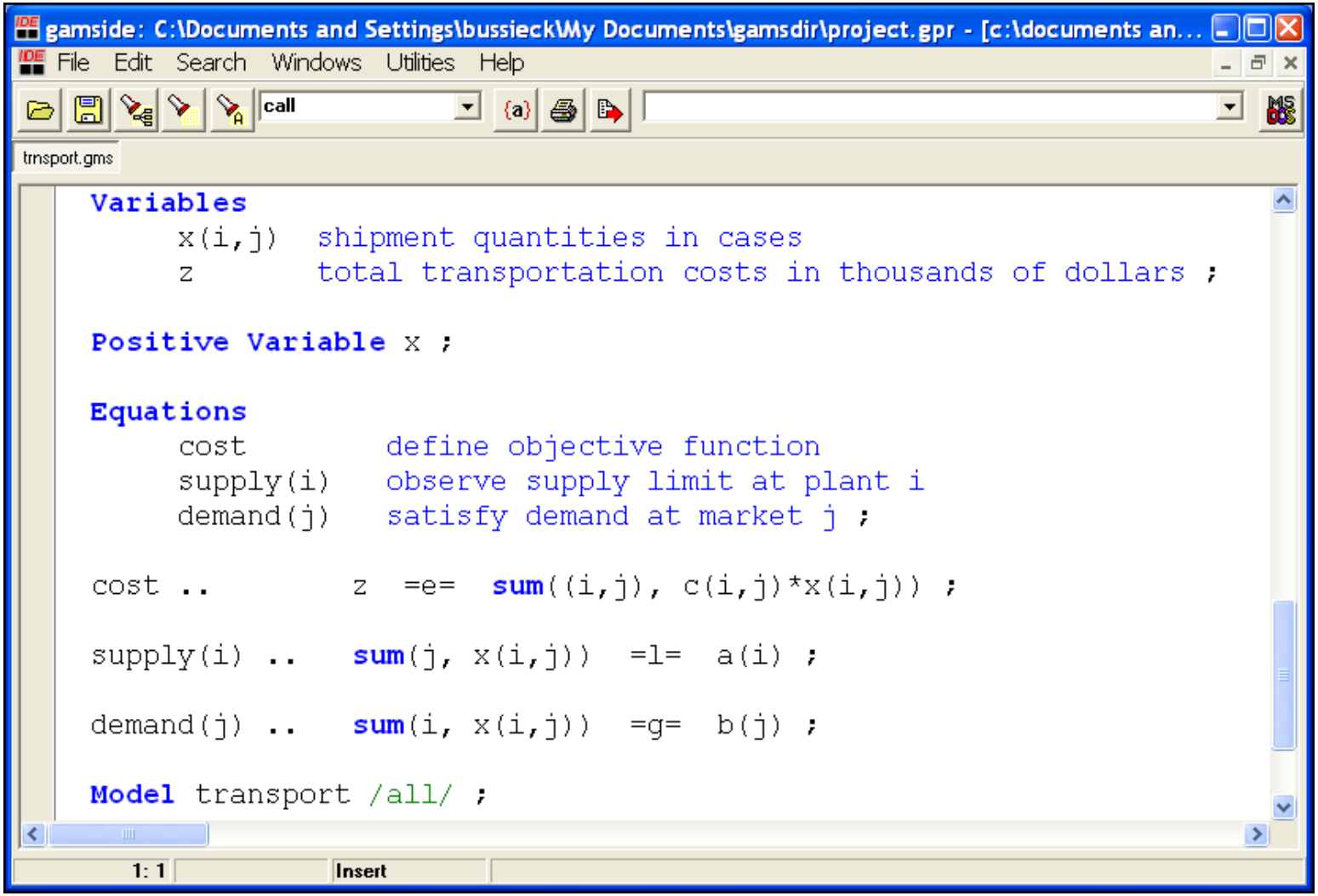
$$\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} tcost \cdot dist(c,p) \cdot x_p^c \rightarrow \min$$

$$\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} x_p^c \leq sup(c) \quad \forall c$$

$$\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} x_p^c \geq dem(p) \quad \forall p$$

$$x_p^c \geq 0 \quad \forall c,p : (c,p) \in \mathcal{N}$$

GAMS Algebra



A few Word about GAMS Syntax

- Symbols:
  - Sets
  - Parameters
  - Variables
  - Equations
  - Models
  - ASCII Output Files

```
Sets        i          canning plants   / seattle, san-diego /;
Parameters  a(i)       capacity of plant i in cases
      /     seattle     350
            san-diego   600  /;
Variables   x(i,j)     shipment quantities in cases;
Equations   supply(i)  observe supply limit at plant i;
Model       transport /all/ ;
File        fx         some file / 'c:\t\text.txt' /
```

- Statements
  - Declarations
  - Data Assignments
  - Equation Definition
  - Programming Flow Control
  - Option statement

```
Parameter c(i,j);
c(i,j) = f * d(i,j) / 1000 ;
supply(i) ..   sum(j, x(i,j))  =l=  a(i);
loop(i, put fx i.tl);
option reslim=10;
```

Input/Output through ASCII Files

- ASCII Input Data
  - Part of model input (**`$include file.txt`**)
  - Posix Utilities are part of GAMS System
    - Platform independent data file preparation
    - sed, awk, grep, cut, …

```
$call cut -d, -f1,3-5 file.txt > filenew.txt
```

- ASCII File Output
  - GAMS Put Facilities

```
file fy /result.csv/;
fy.pc = 5; fy.nd = 4;
loop((i,j)$x.l(i,j),
  put fy i.te(i) j.te(j) x.l(i,j) /;
);
```

Output using Put Utility

```
file fx /result.txt/;

put fx 'Shipped quantities between plants and markets' /;
put    '-----------------------------------------' /;
loop((i,j)$x.l(i,j),
  put 'Shipment from 'i.te(i):10' to 'j.te(j):10' in cases:'
      x.l(i,j) /;
);
putclose;
```

```
Shipped quantities between plants and markets
---------------------------------------------
Shipment from seattle    to new-york    in cases:       50.00
Shipment from seattle    to chicago     in cases:      300.00
Shipment from san-diego  to new-york    in cases:      275.00
Shipment from san-diego  to topeka      in cases:      275.00
```

Default Output in .lst File

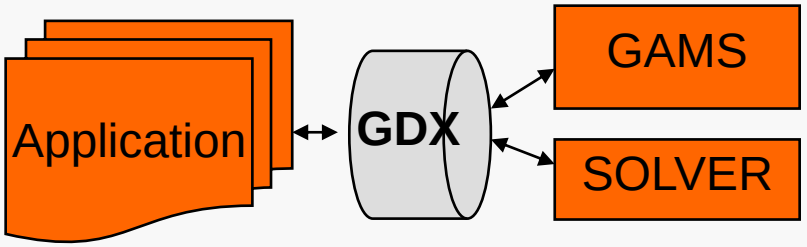
```
---- VAR x  shipment quantities in cases

                          LOWER      LEVEL      UPPER    MARGINAL

seattle  .new-york          .        50.000     +INF        .
seattle  .chicago           .       300.000     +INF        .
seattle  .topeka            .          .        +INF      0.036
san-diego.new-york          .       275.000     +INF        .
san-diego.chicago           .          .        +INF      0.009
san-diego.topeka            .       275.000     +INF        .
```

Default Output using Display Statement

```
----     68 VARIABLE x.L  shipment quantities in cases

                new-york      chicago       topeka

seattle           50.000      300.000
san-diego        275.000                   275.000


----     68 VARIABLE x.M  shipment quantities in cases

                chicago       topeka

seattle                        0.036
san-diego          0.009
```

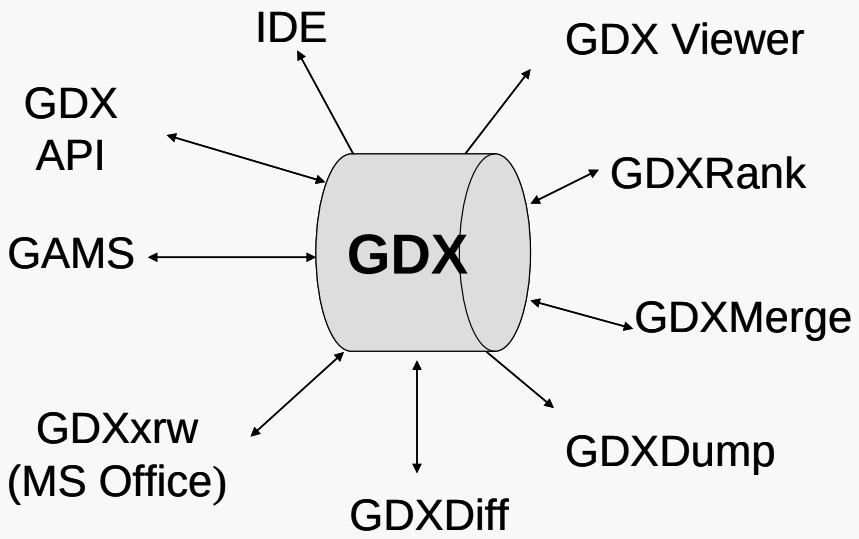
Gams Data eXchange

Binary Data Exchange

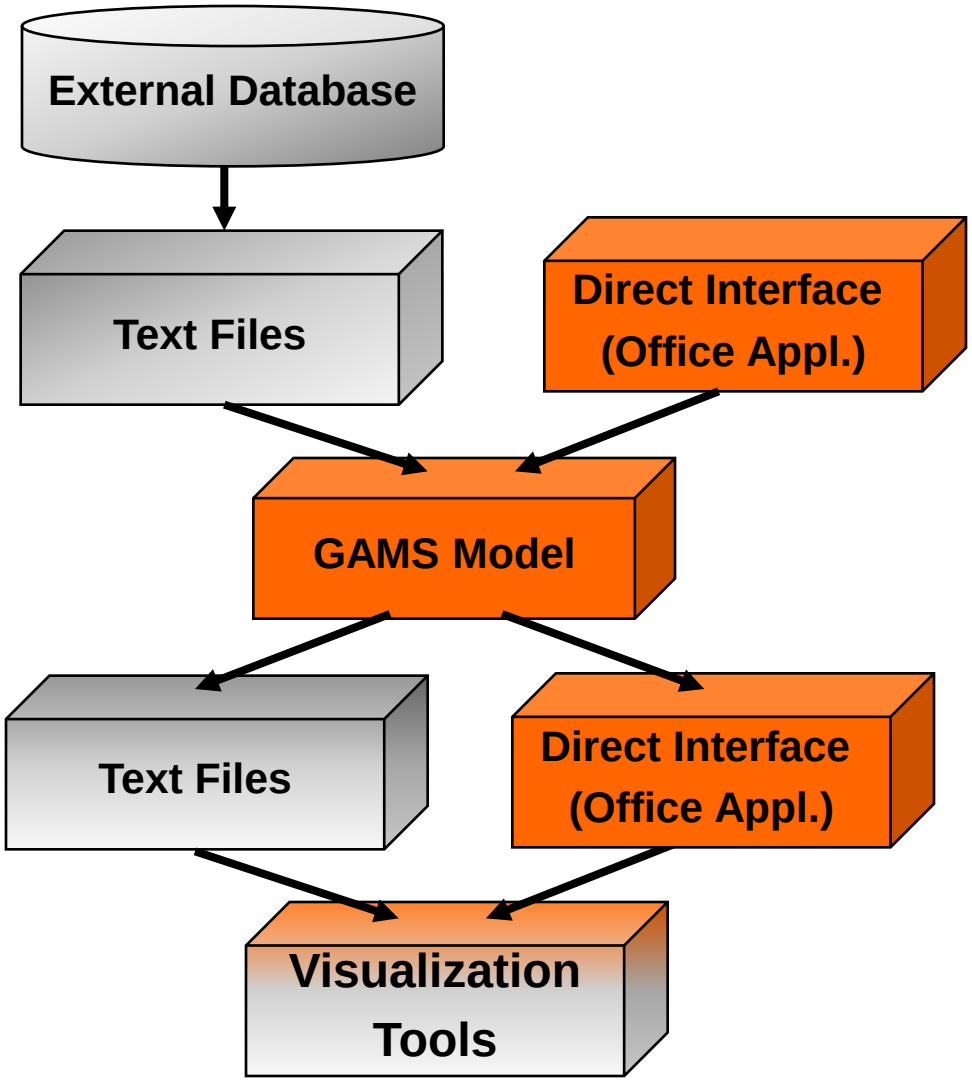


- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct Excel connectivity
- General API
- Scenario Management Support
- Full Support of Batch Runs

GDX Tools



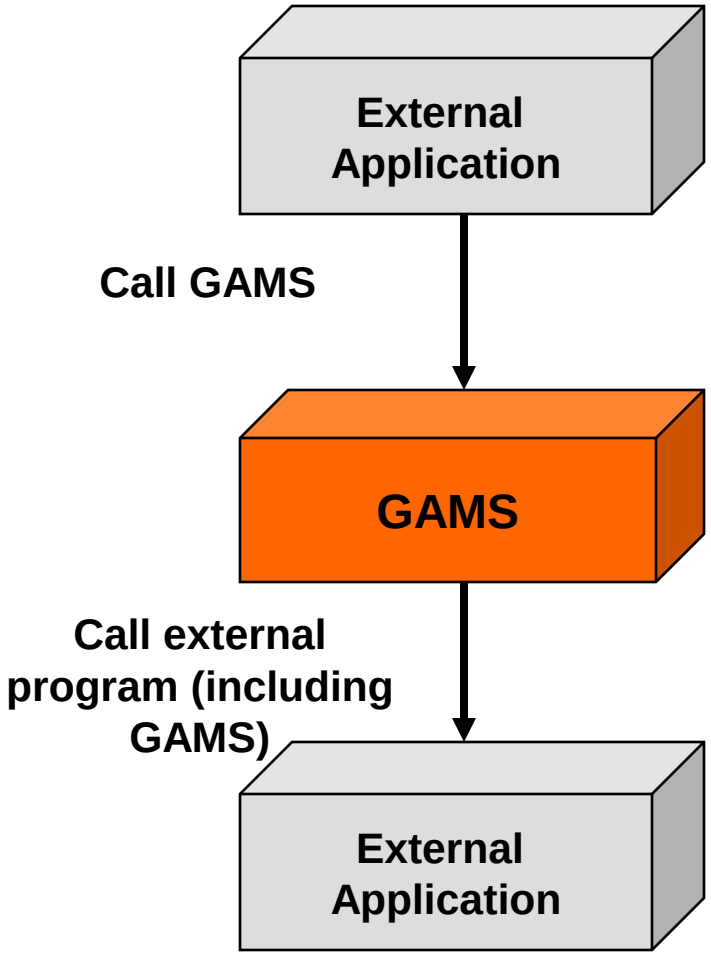
GAMS in Control



Import

Export

Application in Control



Programming Language or other Application

Application

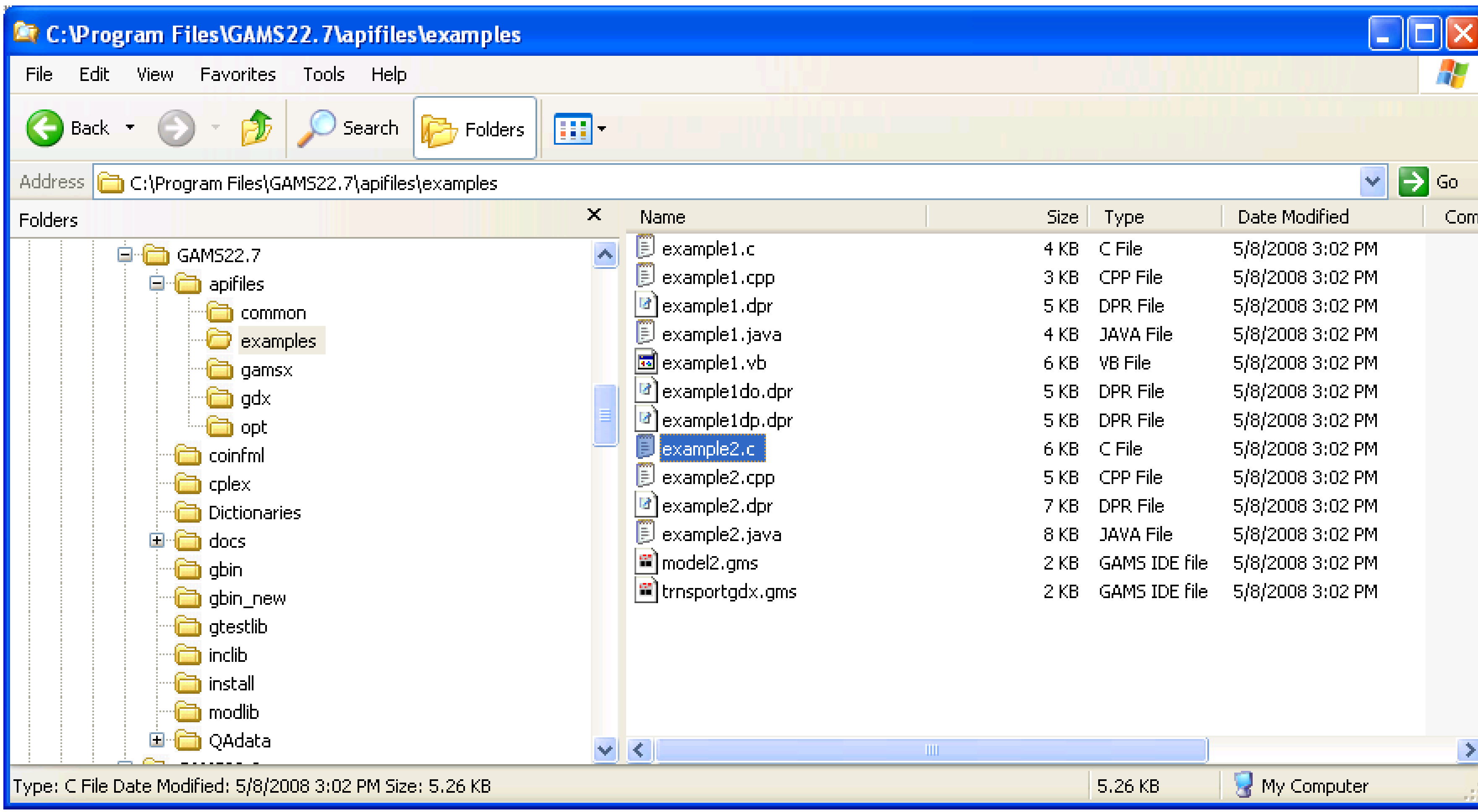
Calling GAMS from an Application

– Through ASCII files or using GDX API

Creating Input for GAMS Model
Callout to a GAMS (DLL/Executable)
Reading Output from GAMS Model

Works from basically every environment
– Web application (server side)
– Application Builder
  • Oracle, Eclipse, .NET, …
  • Regular Programming language C++, Java, VB, …
– MS Office Application / VBA

GAMS API Files and Examples



Sources of GAMS Information

Download: http://download.gams-software.com/
Release Notes: http://www.gams.com/docs/release/release.htm
Contributed Documentation: http://www.gams.com/docs/contributed
Contributed Software: http://www.gams.com/contrib/contrib.htm
Presentations: http://www.gams.com/presentations
Workshops: http://www.gams.com/courses.htm

Bruce McCarl's Newsletter: http://www.gams.com/maillist/newsletter.htm
GAMS User Group: http://www.gams.com/maillist/gams_l.htm
GAMS Google Group: http://groups.google.de/group/gamsworld
Support Wiki: http://support.gams-software.com

Other relevant sites on the Web: http://www.gams.com/hotlinks.htm

Thanks for your time!

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