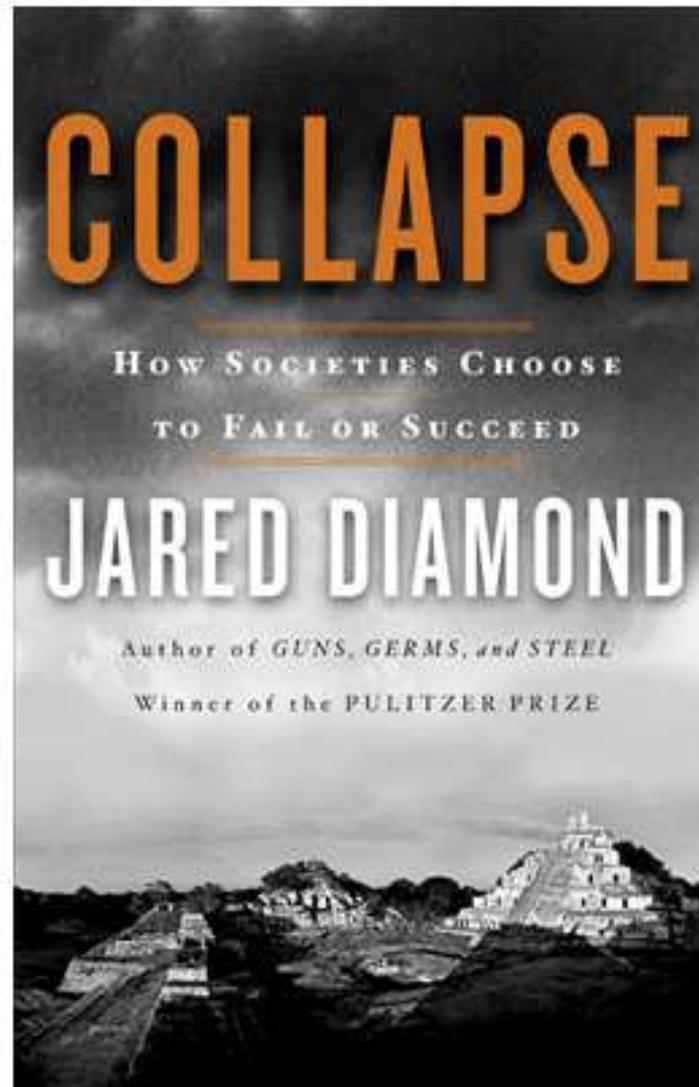


# Applications de l'optimisation ILOG au développement durable





# Applications de l'optimisation ILOG au développement durable

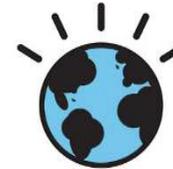
- Positionnement et offre
- Utilisation pour la recherche
- Le développement durable
  - Dans l'énergie
  - Dans l'eau
  - Dans la santé
  - Dans le transport

# Applications de l'optimisation ILOG au développement durable

- Positionnement et offre
- Utilisation pour la recherche
- Le développement durable
  - Dans l'énergie
  - Dans l'eau
  - Dans la santé
  - Dans le transport

# The Value of IBM ILOG Optimization Solutions

*Smarter Commerce for a Smarter Planet*

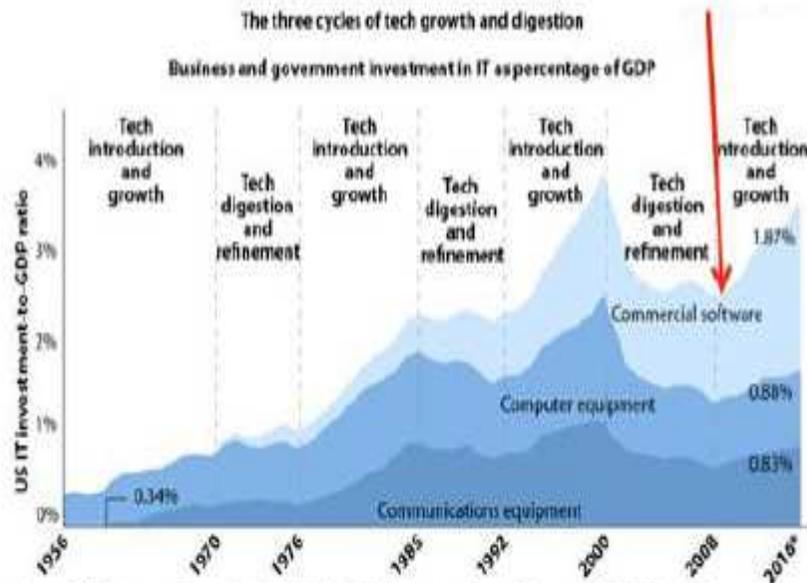


- Better
    - ◆ Get better performance for lower cost
    - ◆ Find non-obvious solutions for complex decisions
    - ◆ Produce quantifiable benefits to the bottom line
  - Faster
    - ◆ Automate decision processes consisting of many alternatives
  - Greener
    - ◆ Discover interactions among environmental impacts and business drivers
    - ◆ Realize opportunities to more efficiently operate a business in a better way
- Turn information and insights into action
    - ◆ IBM ILOG Optimization Solutions leverage the investments you are making in enterprise information technology and business automation

# Smarter Analytics : Business Analytics and Optimization

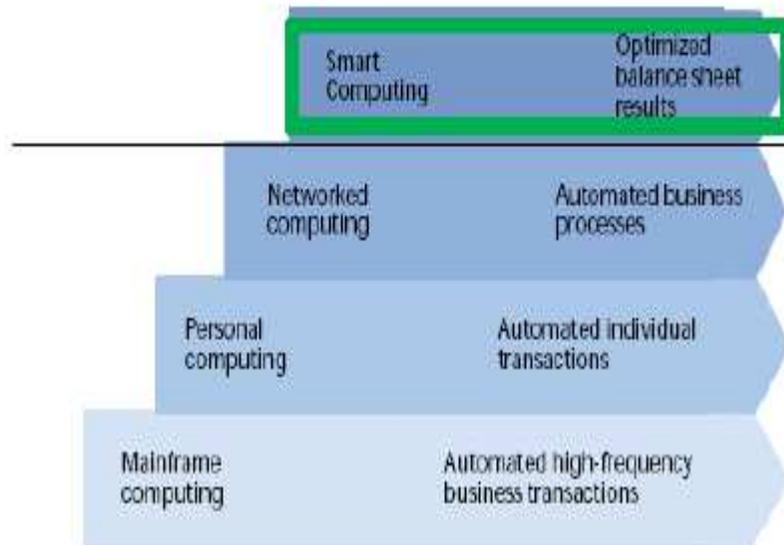


Based on: Competing on Analytics, Davenport and Harris, 2007



Source: US Commerce Department for 1956 to 2008; Forrester Research forecasts for 2009 to 2016  
\*Forrester forecasts

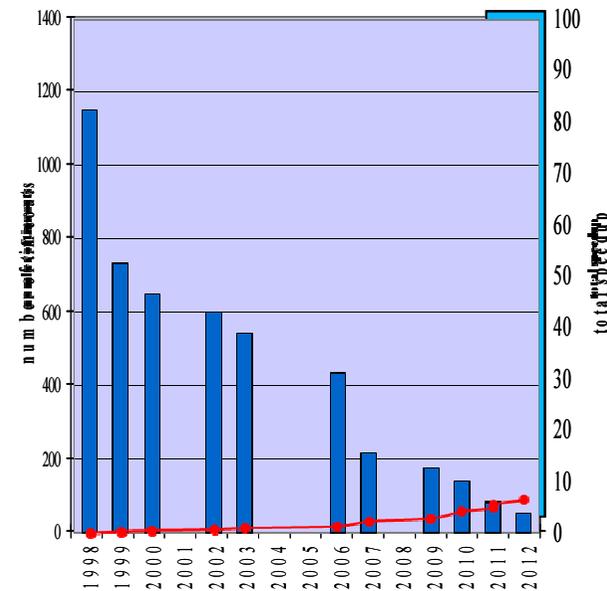
Andrew Bartels of Forrester Research says: there have been only three major IT technologies since 1960 (mainframes, PCs, networking), but that the fourth wave has started. It is “smart computing” or “optimization”.



## Progress in Linear and Integer Programming (CPLEX engine)

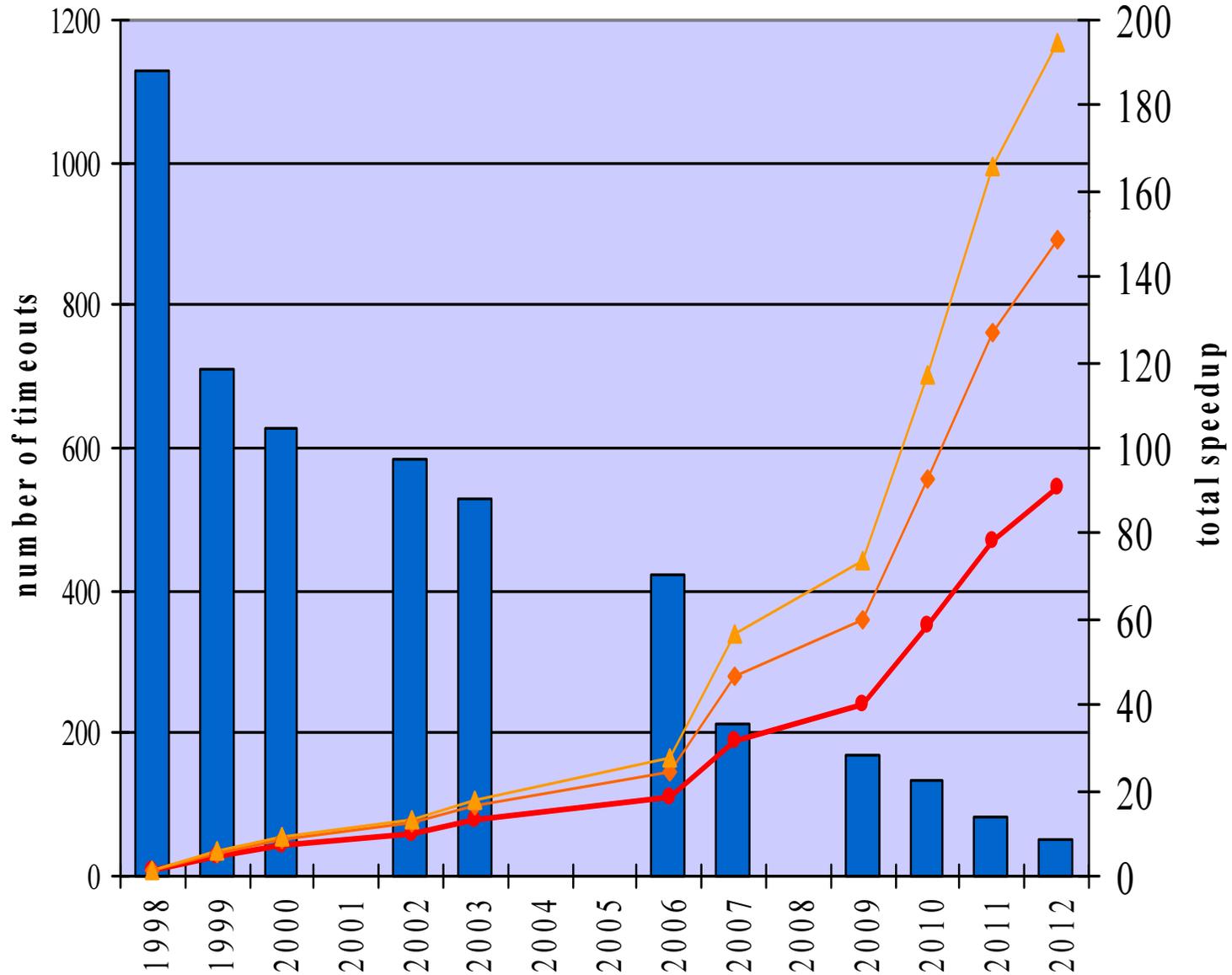
- Since the early 90s
  - Linear Programming
    - Algorithmic: More than 2000 times faster
    - Hardware: Factor 1000
    - **Net: Algorithm \* Machine ~ 2 000 000x**
  - Integer Programming
    - Tremendous improvements
    - Still, experimentation can be necessary
      - Algorithmic controls
      - User knowledge
      - (Re-)Formulation

- Benefits
  - Larger, more accurate models
    - Example: Portfolio optimization under uncertainty
  - Optimizing over multiple processes
    - Taking into account more constraints and objectives
  - Real-time, execution level models



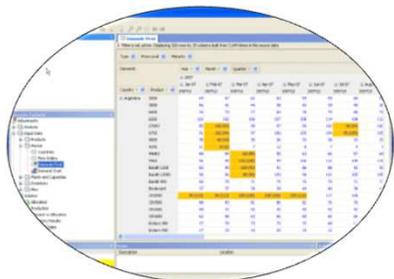
### Integer Programming

Date: 31 Oct 2012  
 Testset: 3177 models (1753 in  $\geq 10$ sec, 1515 in  $\geq 100$ sec, 1354 in  $\geq 1000$ sec)  
 Machine: Intel X5650 @ 2.67GHz, 24 GB RAM, 12 threads  
 (deterministic since CPLEX 11.0)  
 Timelimit: 10,000 sec

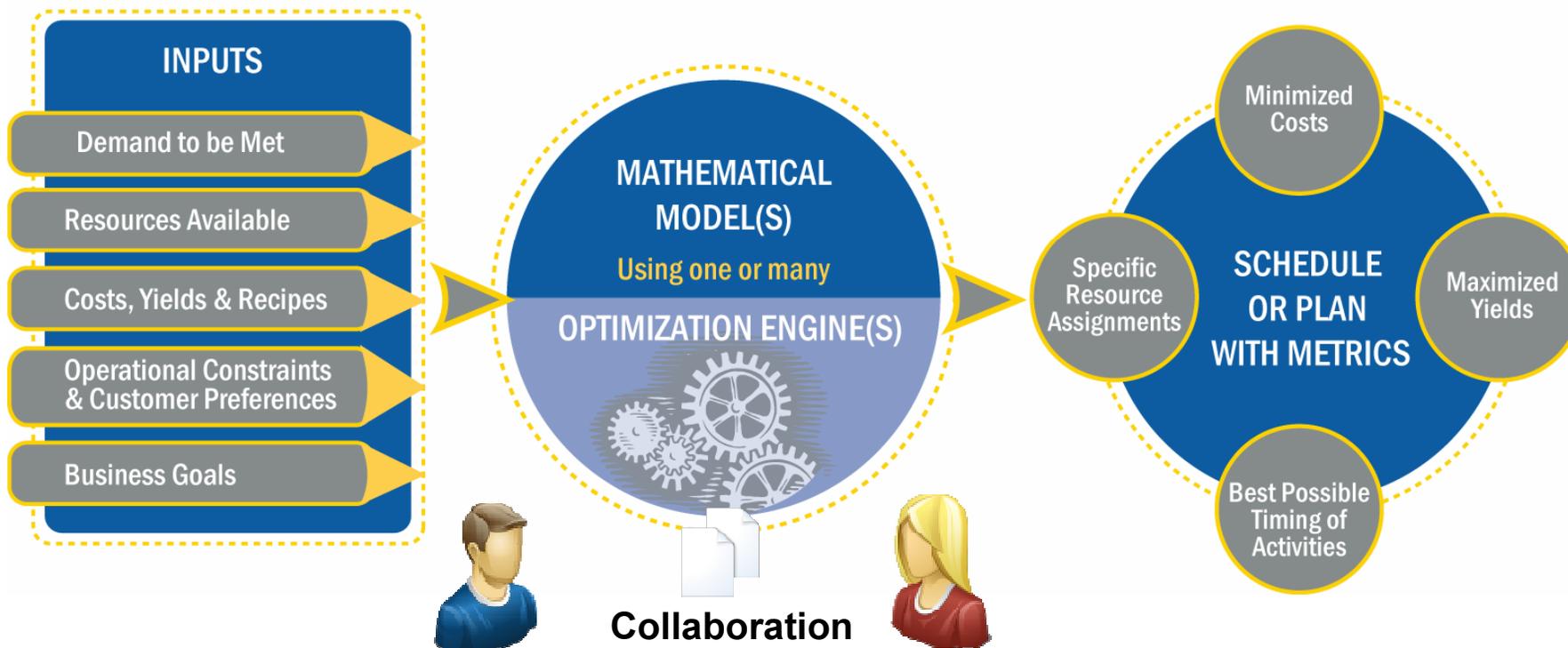
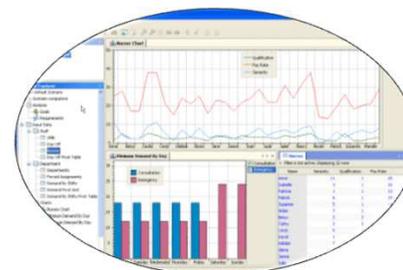


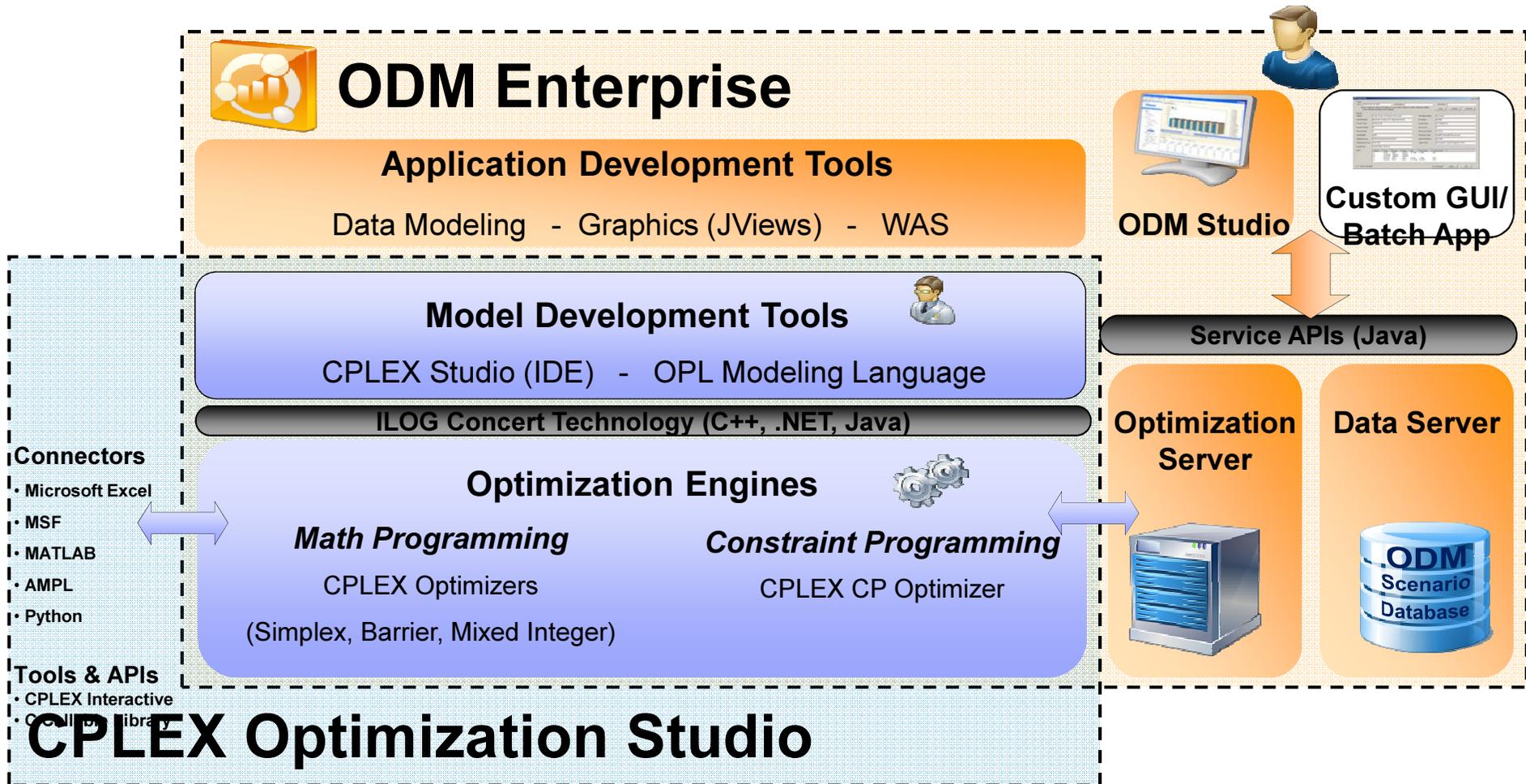
Date: 31 Oct 2012  
 Testset: 3177 models (1753 in  $\geq 10$ sec, 1515 in  $\geq 100$ sec, 1354 in  $\geq 1000$ sec)  
 Machine: Intel X5650 @ 2.67GHz, 24 GB RAM, 12 threads (deterministic since CPLEX 11.0)  
 Timelimit: 10,000 sec

# Optimization Supports Decision Making



## What-If Analysis





## About IBM and Optimization Solutions

### **ILOG built a huge Optimization ecosystem**

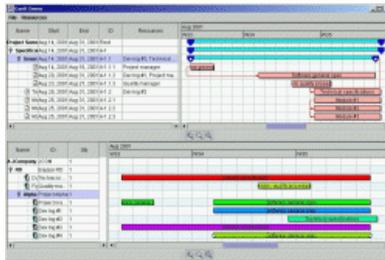
- **Leader in Optimization for 25 years**
- **Used by over 50% of the world's largest companies,**
- **About 300 projects implemented**
- **Embedded by 250+ largest software editors**
  - SAP APO, ORACLE (SNO, JDE, e-Business Suite, Siebel), JDA (Manugistics, i2 Tech), Infor, AspenTech, Jeppesen, Manhattan, Demandtech, Quintiq, Ortec, McHugh, Sabre, Giro, PTV, Paragon, GeoConcept, etc
- **Used by 1000+ Universities,**
- **R&D owning & mastering 100% of the technology**
- **Core offering, made ILOG's success and reputation**

***“ILOG Optimization solutions tackle the world's toughest problems allowing firms to gain a unique competitive advantage”***

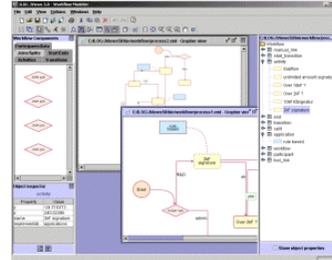
# JViews Enterprise included with ODM Enterprise

→ Build custom views with Gantt, Charts, Diagrammer, Maps, Flowcharts, etc

Model  
Monitor  
Analyse



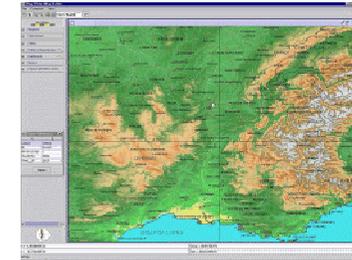
Schedule Editor



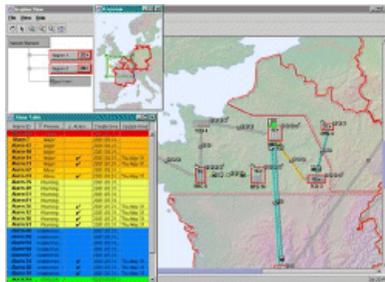
Flow Modeler



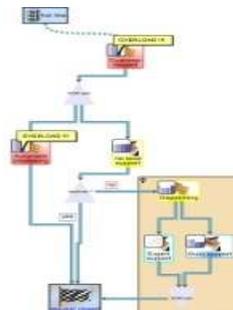
Drawing Editor



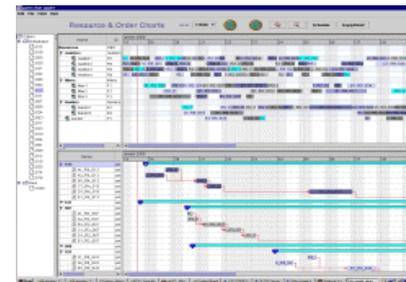
Map Editor



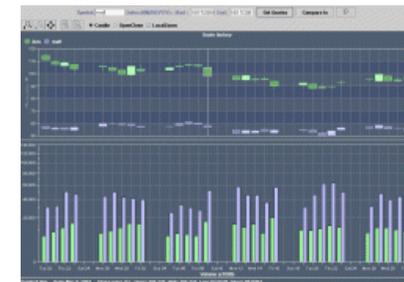
Network Monitoring



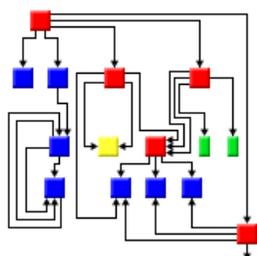
Workflow Monitoring



Supply Chain Monitoring



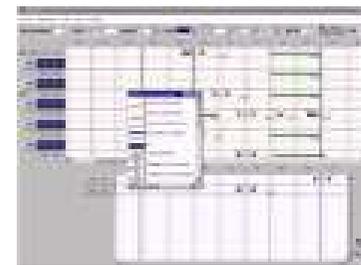
Real-Time Charts



Relationships, Smart Diagrams



Management Cockpits



Optimization Analysis



Numeric Data Charts

# ILOG optimization within IBM Research



# Applications de l'optimisation ILOG au développement durable

- Positionnement et offre
- Utilisation pour la recherche
- Le développement durable
  - Dans l'énergie
  - Dans l'eau
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# The IBM Academic Initiative

## *Our mission*

- Partner with academic institutions worldwide to better educate millions of students for a smarter planet and more competitive workforce

## *Our offerings*

- No-charge access to IBM technology & tools (thousands of software titles)
- No-charge access to course materials and curriculum (hundreds of modules)
- Skills enhancement supported by a worldwide community of IBM volunteers



[www.ibm.com/academicinitiative](http://www.ibm.com/academicinitiative)

# Full-version ILOG Optimization software available since 15Feb10

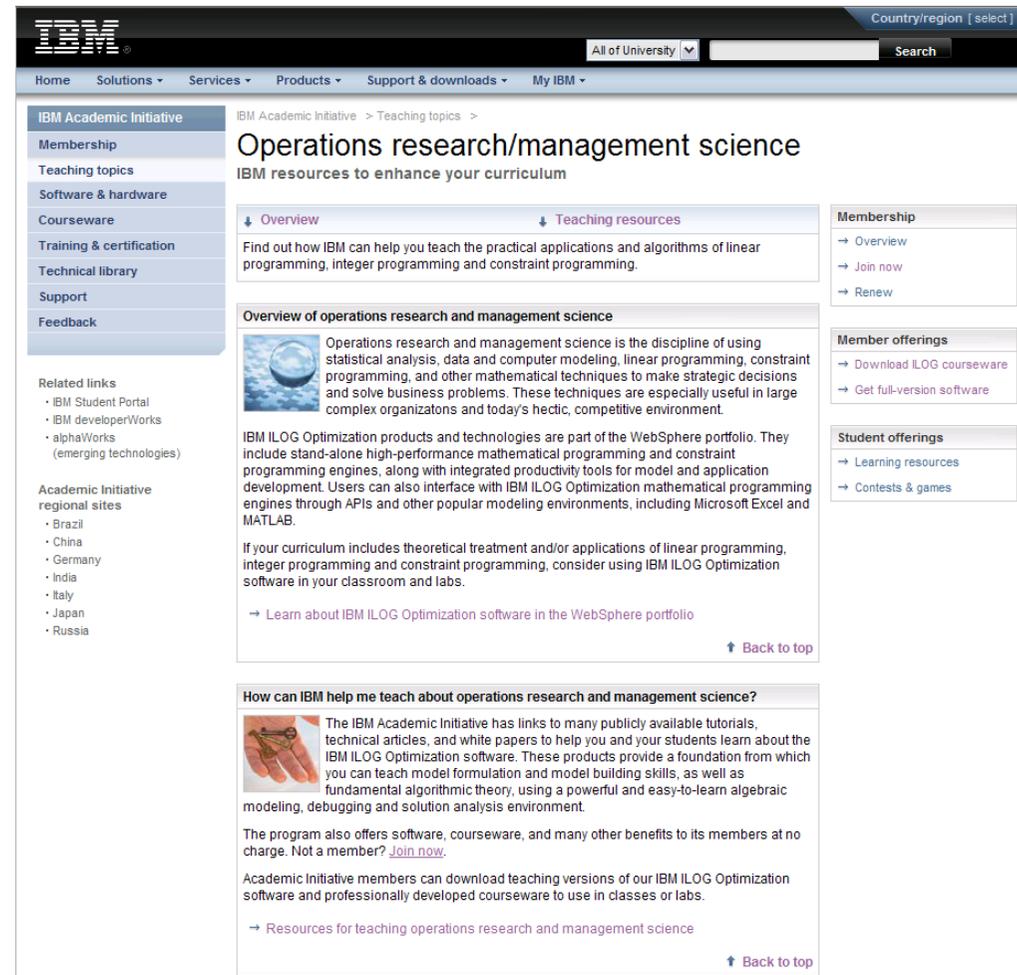
- Targeting both teaching and research in engineering & business schools

## Teaching

- Full version modeling and solver software supports undergraduate through graduate programs
- Professionally-developed courseware

## Research

- Full version modeling and solver software



The screenshot shows the IBM Academic Initiative website page for "Operations research/management science". The page is titled "Operations research/management science" and "IBM resources to enhance your curriculum". It features a navigation menu on the left with options like "Membership", "Teaching topics", "Software & hardware", "Courseware", "Training & certification", "Technical library", "Support", and "Feedback". The main content area includes an "Overview" section with a "Teaching resources" link, a "Membership" section with "Overview", "Join now", and "Renew" links, and a "Member offerings" section with "Download ILOG courseware" and "Get full-version software" links. The "Overview" section contains text about the discipline of operations research and management science, and the "Member offerings" section contains text about the IBM ILOG Optimization products and technologies.

[http://www.ibm.com/developerworks/university/teachingtopics/or\\_ms.html](http://www.ibm.com/developerworks/university/teachingtopics/or_ms.html)

# Downloading Software

IBM Academic Initiative: Software & hardware: Get software - Microsoft Internet Explorer

Address: [http://dw.raleigh.ibm.com/developerworks/university/software/get\\_software.html](http://dw.raleigh.ibm.com/developerworks/university/software/get_software.html)

Power: IBM i  
Power: Linux  
Rational software  
System z  
Tivoli software  
WebSphere software

Courseware  
Training & certification  
Technical library  
Community  
Support  
Feedback

Related links  
• IBM Student Portal  
• IBM developerWorks  
• alphaWorks (emerging technologies)

Academic Initiative regional sites  
• Brazil

IBM Academic Initiative members can obtain versions of a large collection of IBM software, at no charge. Most of the software can be downloaded from the Software Catalog, and a few additional products are available on CD by request. Members can also request virtual access to some software through the Amazon Web Services cloud or to IBM Power Systems or System z enterprise computing environments.

To download or request any IBM software, you must be a member of the IBM Academic Initiative. Not a member? [Join now!](#)

**Download full-version software**

All software downloads are available to members at no charge. The Software Catalog contains products from each IBM software brand (Information Management, Lotus, Rational, Tivoli, and WebSphere) that you can use to teach about database management, team collaboration, software development, systems performance and management, Web services, and many other technologies.

You can search for software in the catalog by specifying text (such as a product name), a category, or a part number.

[Download from the Software Catalog](#)

**Request software on CDs**

Only the products listed below are available on CD. Please note that each Academic Initiative member may request a maximum of one CD per product. We do not offer a CD that contains all of our products; you must request each product CD individually.

- AIX operating system and documentation
- Cluster Systems Management for AIX and Linux

Publicly available software

Download the developer or community edition of these products. Membership is not required.

- DB2 Express-C
- DB2 Express-C Virtual Appliance
- Informix Virtual Appliance
- Rational EGL Community Edition
- WebSphere Application Server Community Edition
- WebSphere sMash Developer Edition

IBM Academic Initiative: ILOG support - Microsoft Internet Explorer

Address <https://www.ibm.com/developerworks/university/support/ilog.html>

Country/region [ select ]

All of University Search

Home Solutions Services Products Support & downloads My IBM

IBM Academic Initiative

Membership

Teaching topics

Software & hardware

Courseware

Training & certification

Community

Technical library

Support

Feedback

Related links

- IBM Student Portal
- IBM developerWorks
- alphaWorks (emerging technologies)

Academic Initiative regional sites

- Brazil
- China
- Germany
- India
- Italy
- Japan
- Russia

IBM Academic Initiative >

## Support

Overview FAQs Rational ILOG

ILOG process Common questions Products requiring a key

Most ILOG Optimization products that are available to Academic Initiative members are protected by license keys. This requires you to perform additional steps with the ILOG products that you might not have to do with other IBM software.

Members can install the software key on their machine and distribute them to students. Keys should only be distributed to people who are entitled to use the software within the Academic Initiative [Software Usage Guidelines](#).

IBM ILOG resources

- Request ILOG key
- Quick Start Guide (350KB)
- ILOG Optimization Forums

**Step-by-step process for Academic Initiative members**

Follow this process to get license keys for ILOG products.

**Step 1: Determine if the product you want to use needs a license key**

View the [list of ILOG products requiring keys](#). If the product you want to use needs a license key, proceed to Step 2.

**Step 2: Get your license key**

Go to [ILOG Optimization Key Request](#) to submit our form and download the text key file.

**Step 3: Install the key**

Follow the instructions in the [Quick Start Guide](#) (PDF, 350KB) to install the key file on your system.

**Notes**

- The key must be installed on every computer that will run the ILOG Optimization products.
- The key has an expiration date between 12 and 15 months from the date you download it. After the expiration date, the key will no longer allow the software to run. We recommended that you download a new key every 12 months and we will send you an email to remind you.

## AI Technical Support

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- Product usage questions should be directed to our discussion forums:  
<http://www.ibm.com/developerworks/forums/category.jspa?categoryID=260>
- Program-related and other questions will be answered best-effort via email. Submit these online from the AI Support page or directly from:  
[https://www14.software.ibm.com/webapp/iwm/web/preLogin.do?lang=en\\_US&source=ai-support-rqst](https://www14.software.ibm.com/webapp/iwm/web/preLogin.do?lang=en_US&source=ai-support-rqst)

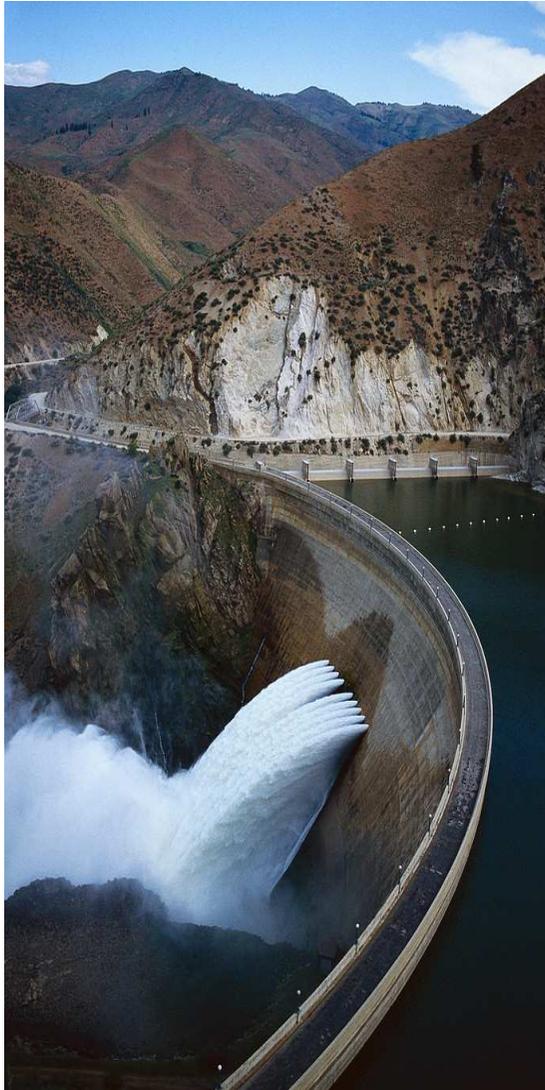
# Applications de l'optimisation ILOG au développement durable

- Positionnement et offre
- Utilisation pour la recherche
- Le développement durable
  - Dans l'énergie
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  - Dans le transport

## **The Third Industrial Revolution is based upon 5 Pillars (Jeremy Rifkin)**

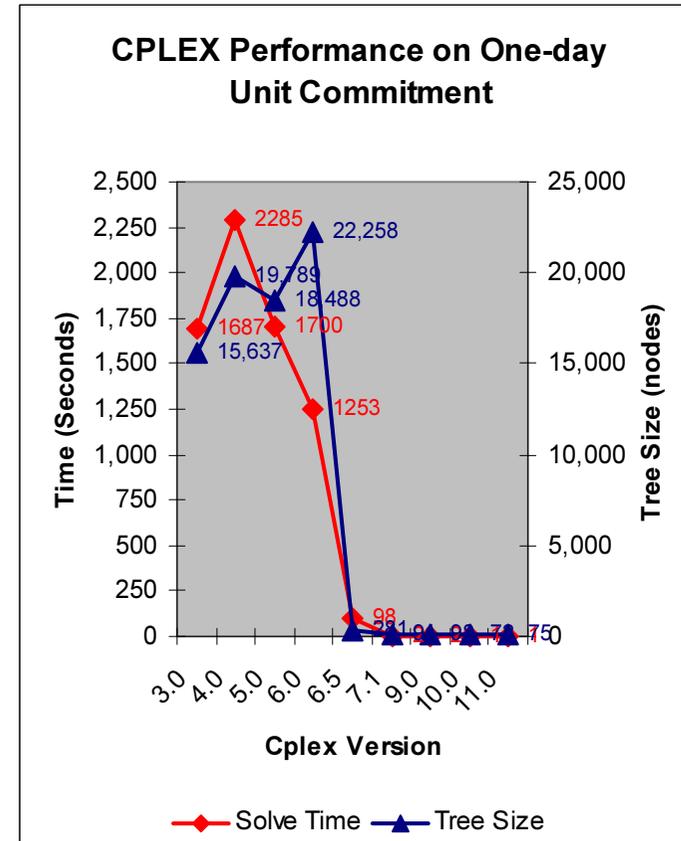
1. Shifting to Renewable Energy
2. Converting Buildings into Power Plants
3. Hydrogen and Other Energy Storage Technology
4. Smart Grid Technology
5. Plug in, Electric, Hybrid, and Fuel Cell based Transportation

## Optimization Problems in the Energy and Utility Industry



- Generation/Resource Planning
- Unit Commitment/ Economic Dispatch
- Hydro/Thermal Scheduling
- Optimal Power Flow/ Security Constrained Dispatch
- Network Planning
- Contract and Risk Management
- Power Market Simulation
- Nuclear Power Outage Scheduling
- ...

- Before 1999, unit commitment used specialized algorithms
  - Lagrangian Relaxation, Dynamic Programming
  - Hard to engineer, inflexible, uneven performance
- IBM ILOG CPLEX demonstrated that general MIP could solve unit commitment problems
  - Easier to adapt, flexible, good performance



***“The improvement of times...gives promise that this approach can be useful for solving UCPs in the future... These results show that realistic unit commitment problems can be solved to optimality by off-the-shelf software”***

Source: *The Next Generation of Electric Power Unit Commitment Models*. Benjamin F. Hobbs, Michael H. Rothkopf, Richard P. O'Neill, Hung-po Chao. Springer, 2001. ISBN 0792373340. p. 6-7.

## Benefits

- 2004 – “PJM Interconnection has implemented new problem-solving software that will save its customers an estimated \$56 million annually”
- By 2008, US FERC estimated PJM’s annual savings at \$200 million



- US FERC estimates that world-wide adoption of MIP for unit commitment could save \$10 to \$200 billion/year
- Additional benefits:
  - Solve larger problems == longer time horizons and larger markets
  - Solve more complex problems == new market features

## Optimizing the Grid: Unit Commitment at RED Eléctrica de España



**Business Problem:** Use exact mathematical methods to replace the approximate, heuristic methods Red Eléctrica de España, in charge of managing the Spanish national power grid, had been using for the last 20 years



**The methodology applied until now ... was an interactive methodology, which did not guarantee an optimum solution. There were many difficulties in the smaller systems and it was hard to find the most viable solution. Thanks to the new methodology, we have resolved this type of problem.**

**- Mr. Mustafa Pezic, REE Project Director**

▪ **The implementation of IBM ILOG OPL/CPLEX and ODM solution has provided great operational advantages to company's managers and engineers**

- “The new tool allows us to simplify all maintenance tasks and any changes made to the model, which in our particular case, are very frequent.”
  - “From a user viewpoint, it has brought greater trust in the solution and a significant reduction in planning time required by users. In parallel with this, from a development and maintenance viewpoint, there has been a significant reduction in associated costs, as well as in the duration of the processes.”
- REE reduced production costs by between €50,000 and €100,000 per day.
  - REE has reduced its carbon emissions by approximately 100,000 tons of CO<sub>2</sub> annually.

## Smart Grid: ILOG Optimization for Electrical Vehicles charging

- <http://www.youtube.com/watch?v=TSH-nUrt3js>



# Flemish Wastewater Treatment Facility

## Improving wastewater treatment and disposal in Belgium



### The need:

A huge municipal infrastructure that treats domestic wastewater for the Flemish Government -- with more than 2800 miles of pipe, 200 treatment plants as well as the transportation and disposition of 100,000 tons of sludge annually. Managing the process manually was impossible, and the Information Technology they were using lacked the power to deal with the complexity of the challenge.

### The solution:

They chose a new tool developed by Mobius based on IBM ILOG CPLEX mathematical optimization technology, that can model the entire process and generate recommended approaches for both short-term and strategic planning. Managers can explore "what if" scenarios to explore the effects of different investment strategies.

### What makes it smarter:

- Identifies potential bottlenecks, available resources and most efficient transportation alternatives for disposing of the sludge and presents planning solutions in less than a minute.
- Makes it easier for users to understand the proposed solutions and to carry out "what if" analyses – improving strategic planning and enhancing day-to-day operations.
- Offers a potential cost reduction of 2.5 million Euros, (over \$3 million US) or nearly 10 percent of its budget through reduced transportation costs and more efficient use of resources.

*“ The solution gave us a strategic understanding of how our system works, which is what we wanted. To our surprise, we also gained the ability to manage our system better on a day-to-day basis.”*

### Solution components:

- IBM ILOG CPLEX optimization software
- IBM ILOG OPL Development Studio
- IBM Business Partner - Mobius

## Dynamic pressure

- Leakage in water networks is a significant cause of water loss and NRW
- Most effective way to deal with water leakage is to locate the leakage and fix it
  - May be extremely time consuming and costly
    - Water is continuously lost until leakage is fixed
    - Quality of service to citizens is severely impacted
      - Disruptions in water supply
      - Blocked streets, noise, etc.
  - In many cases, it is difficult to detect or locate the leak
- Alternative/complementary approach: Dynamic Water Pressure Management
  - Lowering the pressure of the provided water can significantly reduce water loss
    - Does not require leakage detection
  - sufficient pressure must be maintained to provide the required time varying demand for water flow
  - Additional benefits:
    - Reduction in energy required to provide water
    - Reduces wear in water pipes
  - May be part of a larger NRW solution
    - Can be used as a stopgap measure until leak is detected, located and fixed

## Many use cases with water management

- Clean water
- Waste water
- <http://www.youtube.com/watch?v=xFEIO1SczNk>

# Optimasoft et les brancardiers



## A Leading Teaching University

### What if you could treat cancerous tumors faster and more accurately?

A research university optimizes treatment planning to speed treatment for cancer patients and improves patient outcomes.

### The Opportunity

The clinical staff at this university needed to optimize treatment planning for its advanced robotic treatment system, designed to precisely deliver radiation to cancerous tumors, while minimizing impact to healthy tissue. The cumbersome planning process could take hours, and it was often impossible to predict whether all of the clinical goals could be met.

### The Solution

Working with the advanced robotic treatment system's manufacturer and IBM, the university developed an application that optimizes treatment planning for patients. The new process is simpler and more intuitive, allowing the staff to consider individual criteria and more accurately determine how to best meet all clinical goals.

### What Makes it Smarter

Using rapid development of mathematical and constraint programming models, the university quickly creates the optimal treatment plans for each of its radio surgery cancer patients and makes the best use of its advanced robotic treatment system.

- Estimated decrease in treatment planning time of **50 percent**
- Improved personal treatment quality and outcomes

### Solution Component

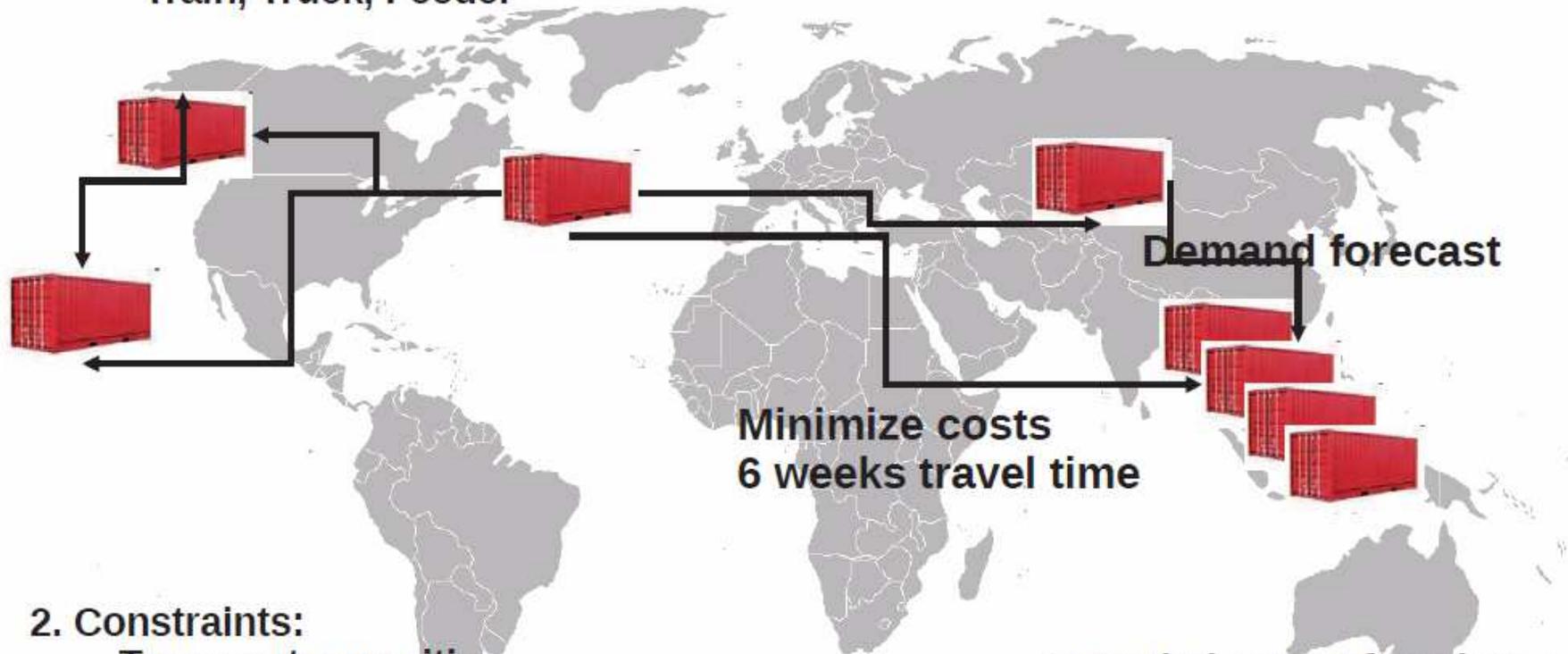
- IBM ILOG® CPLEX®

# Empty container repositioning

## 1. Decision variables:

- Chose transport modes and time
- Company vessel
- Train, Truck, Feeder

2 Million Empty Container moves per y  
Cost: ~ 500 M€



Demand forecast

Minimize costs  
6 weeks travel time

## 2. Constraints:

- Transport capacities
- Container demand for each location
- Storage capacities
- Business rules (e.g. Jone's act)

## 3. Optimize cost function:

- Transport costs
- + Storage costs
- + On / Off hire

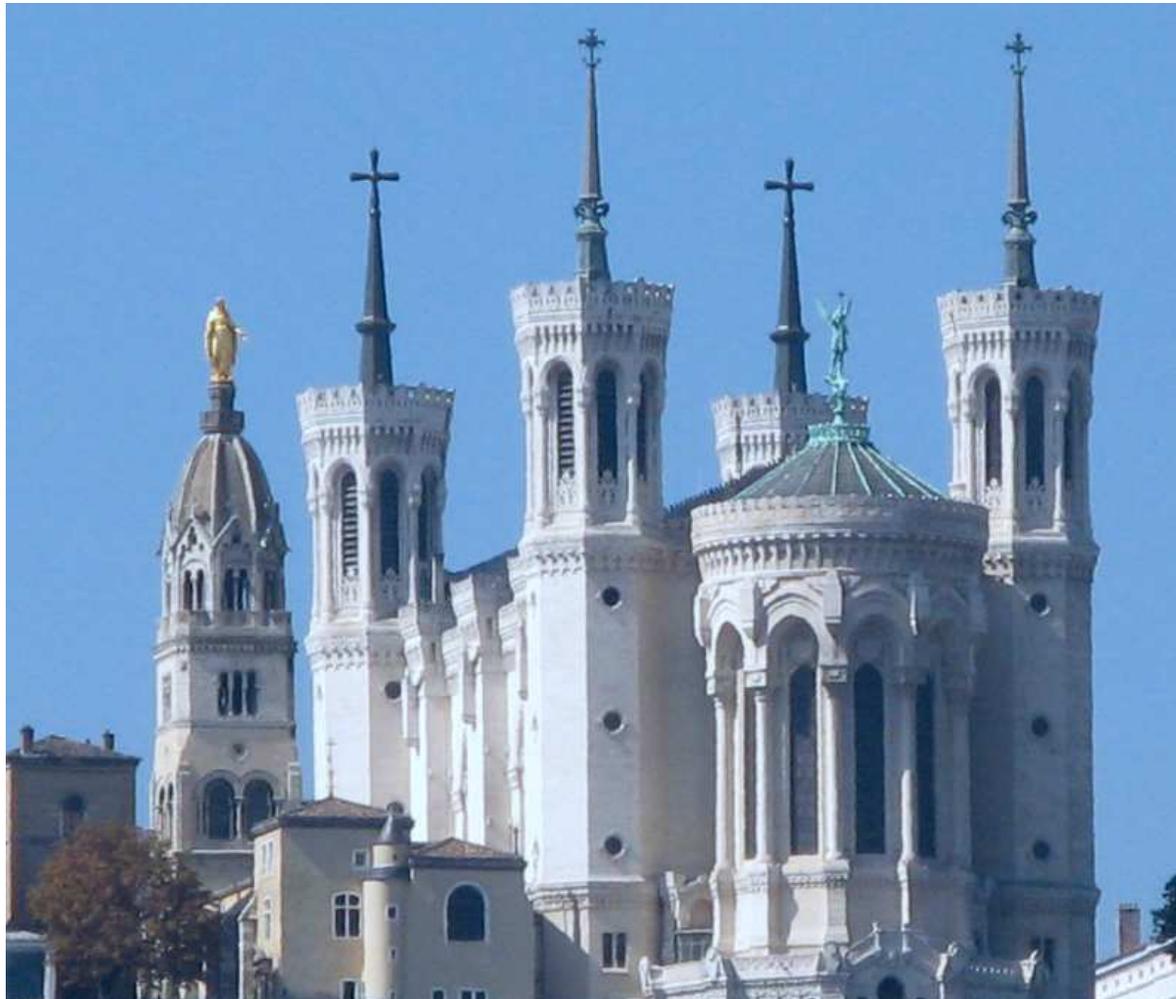
# Rolling Stock Allocation at Netherlands Railways

Travel & Transportation –  
Asset Optimization

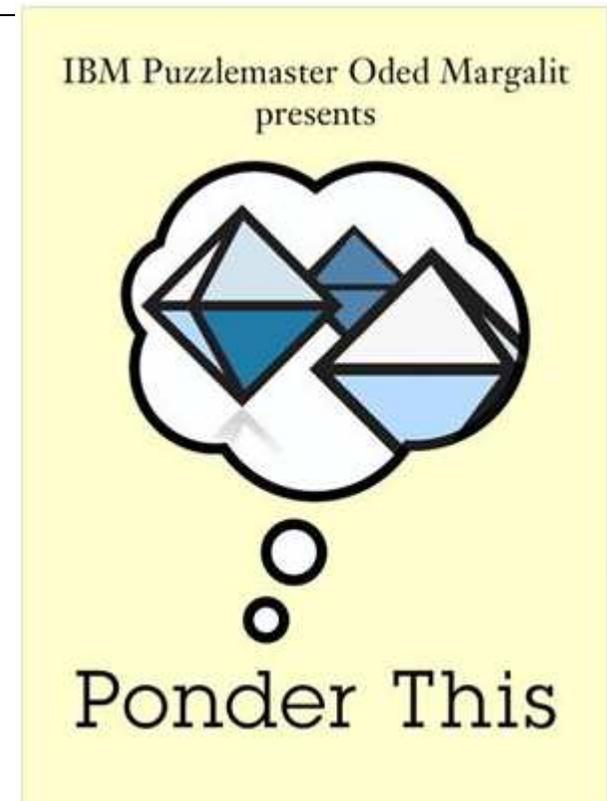
- Situation
  - Precisely matching trains and their cars to expected user traffic is crucial for a railway to keep costs down and service on time.
  - Netherlands Railways transports more than 1 million passengers a day in its own country, works with partners in Germany, Belgium and France, and a subsidiary in Great Britain that carries more than 300,000 passengers daily.
  - Netherlands Railways' more than 5,000 trains get passengers where they want to go in the Netherlands through a network of 390 stations and 2,800 kilometers of track.
- Solution
  - TIM, or Tool Inzet Materieel (Tool for Allocation of Rolling Stock) fully models the company's operations, including rail networks, stations and trains, and address constraints that included passenger preferences, seasonal variations in traffic and transportation regulations.
  - In all, about 56,000 variables and 32,000 constraints had to be accommodated.
  - ILOG OPL Development Studio proved the right tool for modeling the railway's operations, and ILOG CPLEX the matching mathematical programming (MP) engine for deriving optimal solutions from the models.
- Benefits
  - The improvement in operating efficiency has been between 5 and 10 percent, netting the railway cost savings of over €10 million annually.
  - Greater availability of rolling stock, as it is more accurately assigned
  - End users are able to make explicit choices between costs and customer satisfaction
  - Faster planning means shorter lead time for scheduling and rescheduling
  - Computer-generated plans contain fewer mistakes than manually built ones
  - Planners can focus on exceptional events, and eventually fewer planners may be needed to operate the railway

# Smarter Lyon

<http://www.youtube.com/watch?v=xuD-MbEDy7Q>



THANK YOU



Time for questions?  
Let us build together a smarter planet.  
Alex Fleischer [afleischer@fr.ibm.com](mailto:afleischer@fr.ibm.com)