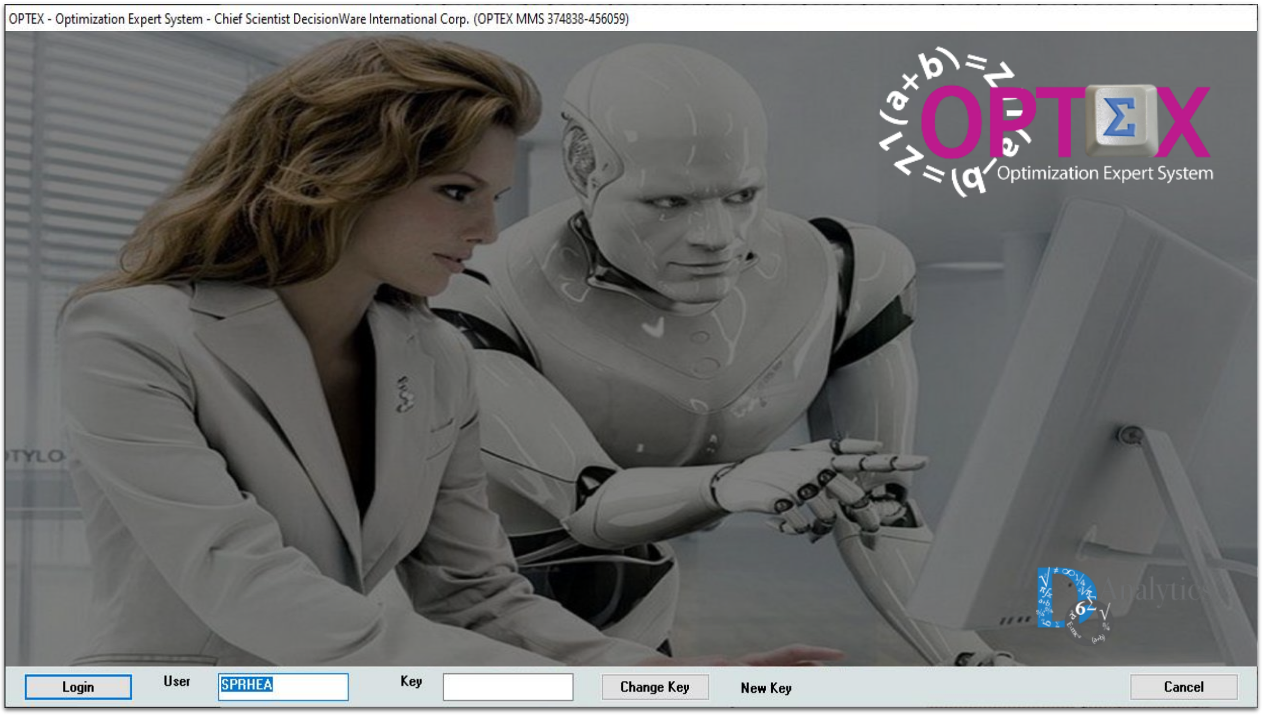
OPTEX OPTIMIZATION EXPERT SYSTEM

A NEW APPROACH TO MAKE
HIGH COMPLEXITY LARGE-SCALE MATHEMATICAL MODELS



THE FIRST STEP IN INDUSTRY 4.0 REVOLUTION :
THE BEST WAY TO MAKE SOFTWARE IS HAVEN'T TO DO IT

Ing. Jesús Velásquez-Bermúdez, Dr. Eng.
Chief Scientist DecisionWare - DO Analytics
jesus.velasquez@decisionware.net

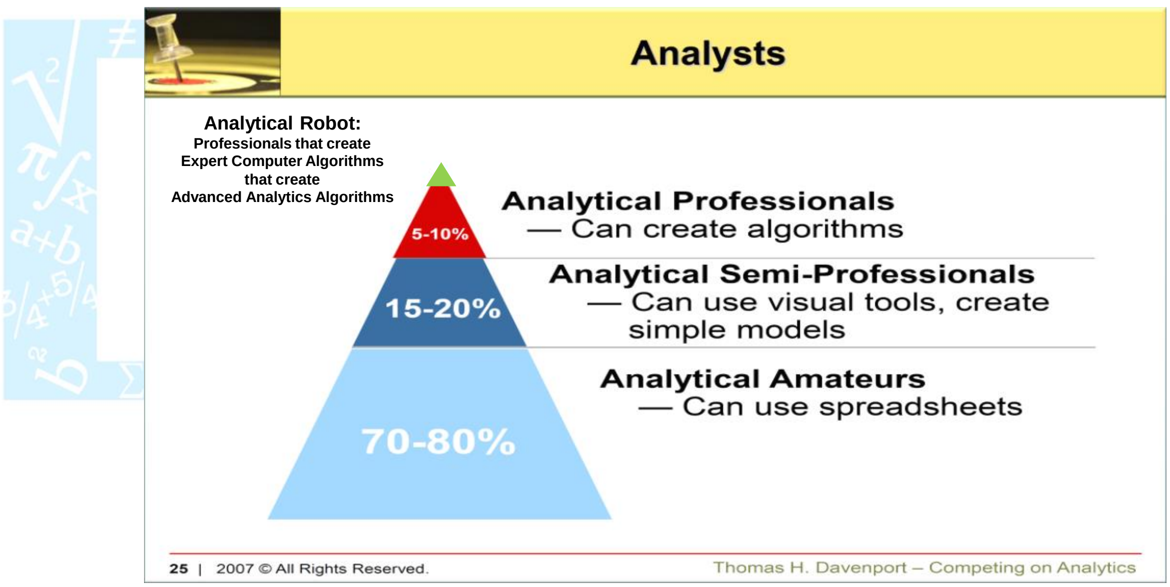
1. INTRODUCTION

OPTEX is the **DO ANALYTICS (DOA)** optimization technology.

The paper **The Future of Mathematical Programming** presents the future of **OPTEX**:
https://www.linkedin.com/pulse/future-mathematical-programming-jesus-velasquez/

1.1. ADVANCED ANALYTICS PROFESSIONALS

Consistent with the development of the Artificial Intelligence, Automation has come to stay, to the field of the Advanced Analytics, where analysts and modelers received help of robots to do their job; Tomas Davenport, in his seminal book "**Competing on Analytics**", displayed three types of professionals involved with Analytics: i) Amateur, ii) Semi-professional and iii) Professional, twelve years after the publication of the book, comes a new type of professional: the "robotizer", professionals that **make algorithms which, in turn, make advanced analytical algorithms**, this speed-up the process of use of Advanced Analytics for those organizations that believe in it, and therefore opening more gap with those who do not believe.



1.2. INDUSTRY 4.0 REVOLUTION

Industry 4.0 is a name given to the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing. Industry 4.0 is commonly referred to as the fourth industrial revolution. **Industry 4.0** fosters what has been called a "smart factory". Within modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real-time both internally and across organizational services offered and used by participants of the value chain. (Wikipedia).

OPTEX Optimization Expert System is a robot, based on concepts of Artificial Intelligence, that writes advanced analytics algorithms that are required for the digital transformation of enterprises, **OPTEX** automatically linking them to the enterprise information system; in summary, **OPTEX** is a skilled robot that creates robots for complex processes using advanced mathematical methodologies (state-of-the-art). This robotization process is at the highest level of automation, because it does not replace manual human work but supports the construction of robots replacing human cognitive tasks, related to the modeling of stochastic processes or business/industrial processes optimization. **OPTEX** is result of praxis, since it has been used in several industrial/commercial projects that give rise to practices included in **OPTEX**.

OPTEX increases productivity of mathematical modeler; understanding productivity such as: make more models in less time, ensuring the quality of the produced algorithms. For this purpose, the process of mathematical modeling has been normalized and standardized, this makes **OPTEX** independent of industrial mathematical technologies. As well as in the manual work robots enhance human ability, in the cognitive process, robots promote knowledge, systematized all tasks that are repetitive.

The cognitive robots are fundamentals for **Industry 4.0.**

1.3. A NEW APPROACH TO MAKE LARGE-SCALE MATHEMATICAL MODELS

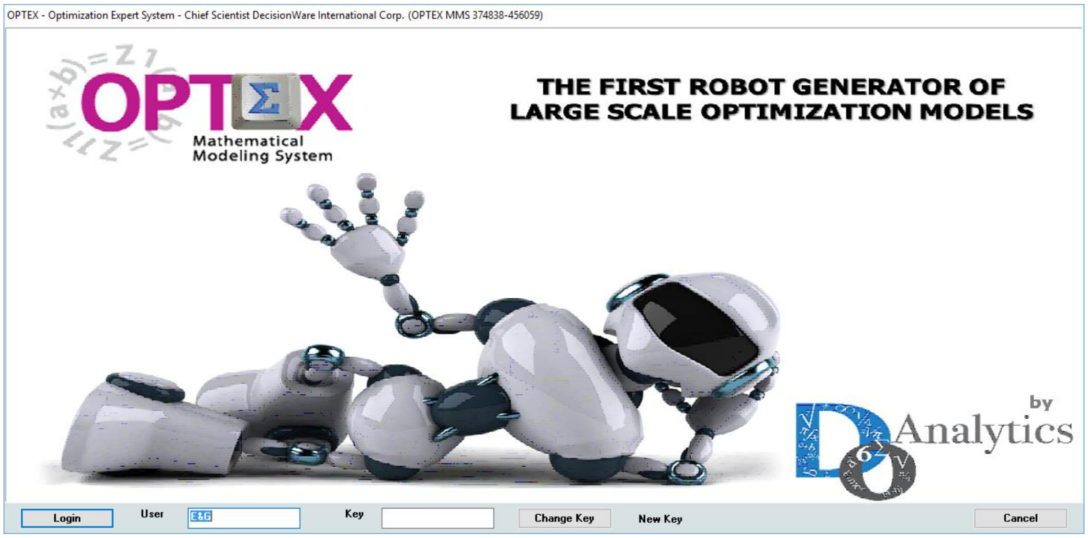
OPTEX reduces to the minimum the cost of developing mathematical models; proposes a new way to implement optimization software, which traditionally involves the implementation of one "executable" program for each model. Since its birth in 1991, **OPTEX** is conceived as a meta-tool (a robot, an expert system) that allows the development of "all" mathematical models required in just one work environment. **OPTEX** “automatically” integrates information support system, generating a generic user interface that allow you to browse the tables of the information system. Last, but most important, **OPTEX** can generate models based on low-level programs such as **C**, or high-level programs based on algebraic languages like **GAMS, AIMMS, IBM ILOG OPL**,... **OPTEX** ensures minimum implementation times, competitive computing times and portability of the mathematical models. **OPTEX** make intensive use of large-scale methodologies, like Benders Decomposition.

Using **OPTEX,** the algebraic formulation of mathematical models is stored in a relational information system, **MMIS** (**M**athematical **M**odels **I**nformation **S**ystem), and therefore the tables that compose the **MMIS** can be loaded by any mechanism valid for manipulating tables, including **EXCEL**, while keeping the advantages of relational databases. For this reason, **DO ANALYTICS** has developed **OPTEX-EXCEL-MMS** that enables modelers, non-experts in optimization technologies or without knowledge of **SQL** (**S**tructured **Q**uery **L**anguage), to solve complex mathematical problems associated with the database.

As part of the **MMIS** the modeler must develop the “data model”, tables that should fill the end-user. This system, called **IDIS** (**I**ndustrial **D**ata **I**nformation **S**ystem), can reside on **DBF** tables, **EXCEL** books, **CSV** files or any **SQL** server data type (**ORACLE, DB2, SQL Server, MySQL**,...).

One of the advantages of separate the algebraic formulation from the optimization technology is that the modeler is not required to know the syntax of the optimization technology to implement the mathematical model, instead focusing his efforts on the algebraic formulation and complete records of the tables in accordance with given instructions (filling forms/templates). The generated code is error-free, it is the result of many experiences that ensure quality and proper operation; the modeler can learn from the code generated by **OPTEX**

After formulating the mathematical model, the user has two choices: i) to load the tables in the data base **MMIS** or ii) to maintain **EXCEL** formulation and control the execution from the **OPTEX-EXCEL-MMS** interface or from the **OPTEX** web interface. In any case, **OPTEX** is responsible for generating the algorithm program for the associated model.



One of the biggest advantages of this approach is that it minimizes the time of development of mathematical models that can be implemented quickly, by expert mathematical modelers that do not require deeper knowledge in: i) programming optimization languages, ii) large scale optimization methodologies, iii) **SQL** statements to connect databases and iv) programing languages to make data displays; converting the time saved in avoided cost.

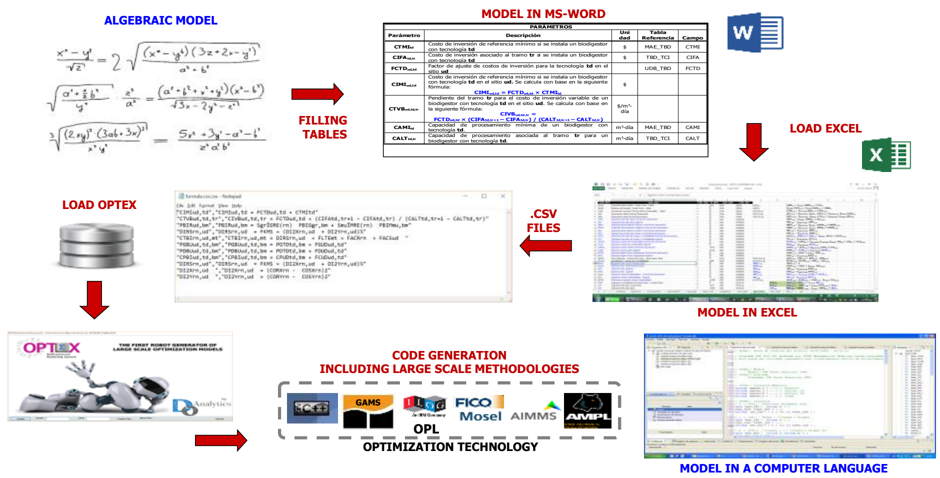
This makes of **OPTEX** a fast computing meta-platform oriented to the design, implementation, start-up and maintenance of **DSSs** based on a philosophy of concurrent development, in real time. Therefore, reducing the development work of computer programs to a minimum (maybe "zero"). It translates into the immediate availability of additions and/or changes in the models, then the time can be used more effectively in the mathematical modeling process and in the design of the interface **DSSs** with other tools of the user organization, as may be the **BI**, **ERP**, **WMS**, …

OPTEX supports all activities required to implement "real-life" solutions, the process to follow for each mathematical model can be summarized in the following steps:

1. Mathematical modeling, whose product is a conceptual algebraic model;
2. Data Modeling, whose product is the data model of an information system;
3. Automatic implementation of the information system;
4. Generation of optimization programs that are capable of generate the numerical problems
5. Solving the problem using numerical algorithms specialized in accordance with the format of the problem;
6. Storage solution in the information system; and
7. Query and routing the results of the model.

The following diagram shows the process when working with base on **EXCEL**: i) algebraic model in the blackboard, ii) algebraic formulation in templates in **MS-WORD**, iii) algebraic formulation in tables in **MS-EXCEL**, iv) algebraic formulation in csv format in **ANSI** standard, v) import the csv files to **OPTEX-MMIS,** vi) computer algorithm of the model in an optimization technology.

DEVELOPING MATH MODELS - OPTEX FLOW CHART



1.4. OPTEX DECISION SUPPORT SYSTEMS

The following are Decision Support Systems developed using **OPTEX**:

OPCHAIN-HEALTH: Health Systems - Advanced Supply Chain Optimization
https://www.linkedin.com/pulse/opchain-health-dss-integrates-mathematical-models-during-velasquez/

OPCHAIN-E&G: Electricity & Natural Gas - Advanced Supply Chain Optimization
https://www.linkedin.com/pulse/electricity-natural-gas-advanced-supply-chain-jesus-velasquez/

OPCHAIN-SCO: Advanced Supply Chain Optimization. Traditional & State-of-The-Art Models
https://www.linkedin.com/pulse/supply-chain-optimization-jesus-velasquez/

OPCHAIN-DCO: Scientific Marketing: Advanced Demand Chain Optimization
https://www.linkedin.com/pulse/scientific-marketing-advanced-demand-chain-jesus-velasquez/

OPCHAIN-RPO: Integrated Regional Planning Cities & Regions: Smart, Analytical, & Sustainable
https://www.linkedin.com/pulse/integrated-regional-planning-cities-regions-smart-jesus-velasquez/

OPCHAIN-MINES: Mathematical Programming Applied to Mining & Metallurgical Industries
https://www.linkedin.com/pulse/mathematical-programming-applied-mining-metallurgical-jesus-velasquez/

OPCHAIN-OIL: OIL Supply Chain Optimization
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OPCHAIN-SME/PYME: An Advanced Analytics Decision Support System to Be Used on Demand in the Cloud
https://www.linkedin.com/pulse/advanced-analytics-decision-support-system-used-demand-velasquez/

OPCHAIN-TSO: Optimization of Complex Transport Systems
https://www.linkedin.com/pulse/optimization-logistics-operations-ports-jesus-velasquez/
https://www.linkedin.com/pulse/logistics-operations-optimization-ports-ships-systems-jesus-velasquez/
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OPCHAIN-ASO: Advanced Analytics Applied to Academic Systems
https://www.linkedin.com/pulse/universitycollege-scheduling-time-tabling-using-jesus-velasquez/

OPCHAIN-BANK: Optimization Applied in Financial Enterprises
https://www.linkedin.com/pulse/financial-enterprises-modeling-advanced-analytics-jesus-velasquez/

All **OPCHAIN** models can be used in the form **O**ptimization **A**s **A** **S**ervice (**OAAS**) in the cloud.

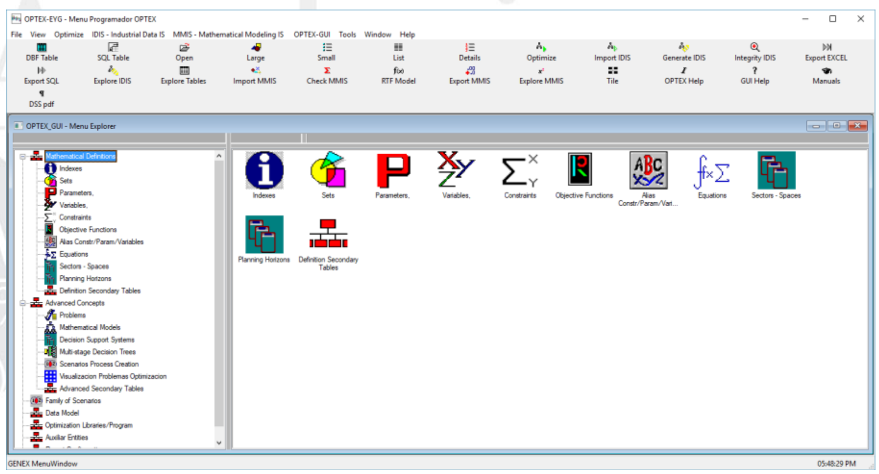
2. STRUCTURED MATHEMATICAL MODELING

Sort the elements that are part of a mathematical model around the concepts of information systems involves the need to structure the process of mathematical modeling in a way to store all elements in the tables of the **MMIS**; this implies organize the mathematical model from an "universal" point of view such as an information system; then, it is possible to affirm that the information system that supports mathematical modeling in **OPTEX** is the first step towards standardization and normalization of the algebraic formulation of mathematical models, which is needed to socialize the Mathematical Programming based in the portability of the models between optimization technologies.

2.1. MMIS - MATHEMATICAL MODELING INFORMATION SYSTEM

The **MMIS** manages the following elements (objects, entities):

- Tables
- Fields
- Indexes
- Sets
- Variables
- Parameters
- Restrictions
- Equations
- Objective Functions
- Problems
- Models
- Decision Support Systems
- Application

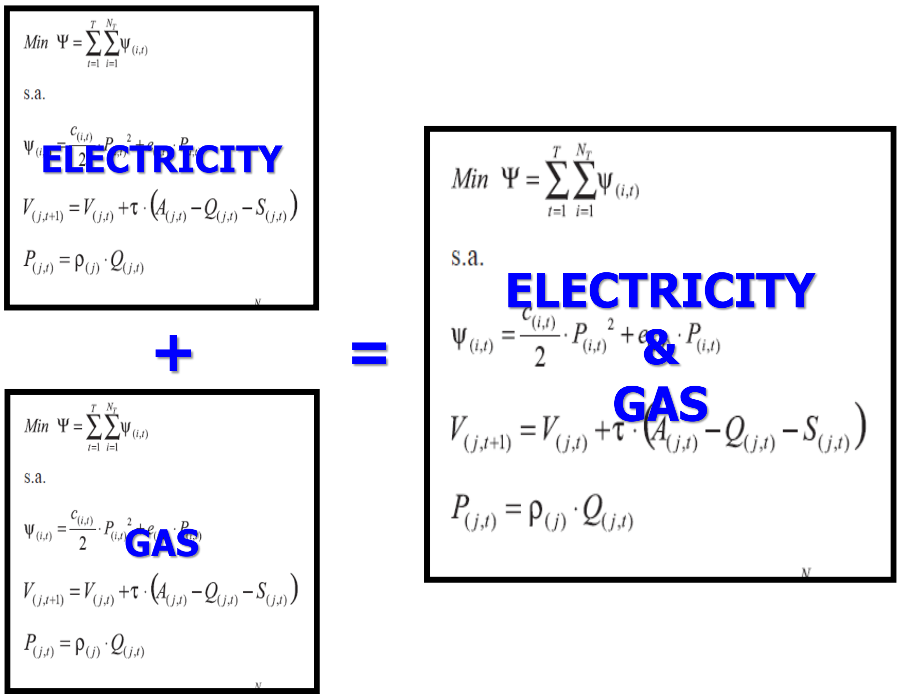


From the above objects, four haven't a universal definition:

- **Problem:** set of constraints;
- **Model:** set of problems;
- **DSS:** set of models; and
- **Application:** set of DSSs.

MMIS standardizes the management of entities and relationships centered about its database algebraic language that allows management of linear and non-linear equations.

The above objects are critical to addressing large-scale problems by coordinating multi-problem models; **OPTEX** is based on the vision that sees the Mathematical Programming as a standard that can be understood by any expert modeler, this standardization is so solid that ensures that the binding of Mathematical Programming problems is a new problem of Mathematical Programming. **OPTEX** capitalized this advantage as the union/partition of two problems correspond to union/partition of the restrictions of the two problems, which is performed based on tables that store the parameterization of the problems and not based on the union of two computer programs, which it is more difficult, may be impossible, to standardize. For example, an integrated model of the electricity-gas system is the union of the equations of the two individual systems (gas & electricity) plus the coordination constraints.



The **MMIS** handles all aspects of the formulation, the solution and the use of mathematical models. Conceptually, **OPTEX** groups information according to the steps that must be faced in the process of developing an application:

- Formulation of mathematical definitions;
- Formulation and solution of problems and models;
- Optimization connectivity libraries;
- Using models

2.2. SOLVING OPTIMIZATION PROBLEMS

The formats of problems that can be solved with **OPTEX** dependent of optimization libraries that are available to the end-user, making it possible to formulate linear or non-linear models (**LP, MIP, QP, QPQC, MECP, NLP,...**).

In addition to solving the basic optimization problems, **OPTEX** includes several advanced services, for real-world problems, aimed at facilitating the implementation of large problems. Among the services offered **OPTEX** generates models that includes:

- Variables for feasibility analysis.
- Initial pre-set value for any variable.
- Equations for re-optimization including fixed variables.
- Convex hull generation.
- Generation of multi-criteria Pareto efficiency frontiers
- Parallel/Distribute optimization of multi-problem models.
- Disjunctive optimization
- Large-scale optimization methodologies

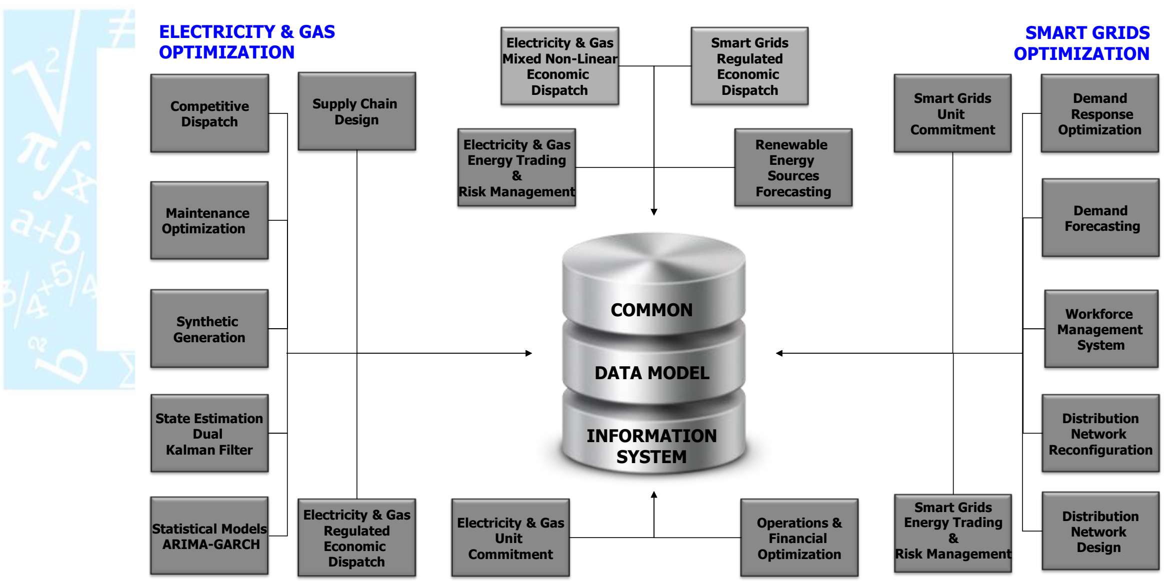
2.3. INTEGRATION OF MULTIPLE MODELS AND PROBLEMS

Due to the complexity of real systems, **DSS**s are composed of multiple mathematical models which are integrated through the data stream, thereby generating the information required by the decision maker to address all hierarchic levels: strategy, tactic, operation and real-time operations. The connection of data and models defines the decision-making chain, which supports management productivity of organizations.

The different models must share information stored on a common database, coherent and standardized, to allow data integration along the decision-making chain, in which some of the outputs of a model becomes the inputs of the models of subsequent stages, so this coordinated effort guarantees "optimization" of the entire system, it is impossible to obtain with a single model. Researchers and producers of technology solutions share this point of view.

The concept of objects allows an **OPTEX** problem being part of several models and a restriction to be part of various problems and so on. This approach facilitates the handling of large-scale optimization models; since under the partition and decomposition scheme, a model consists of several coordinated problems whose solution is performed in accordance with an optimization methodology like Bender Theory or Lagrangean Coordination.

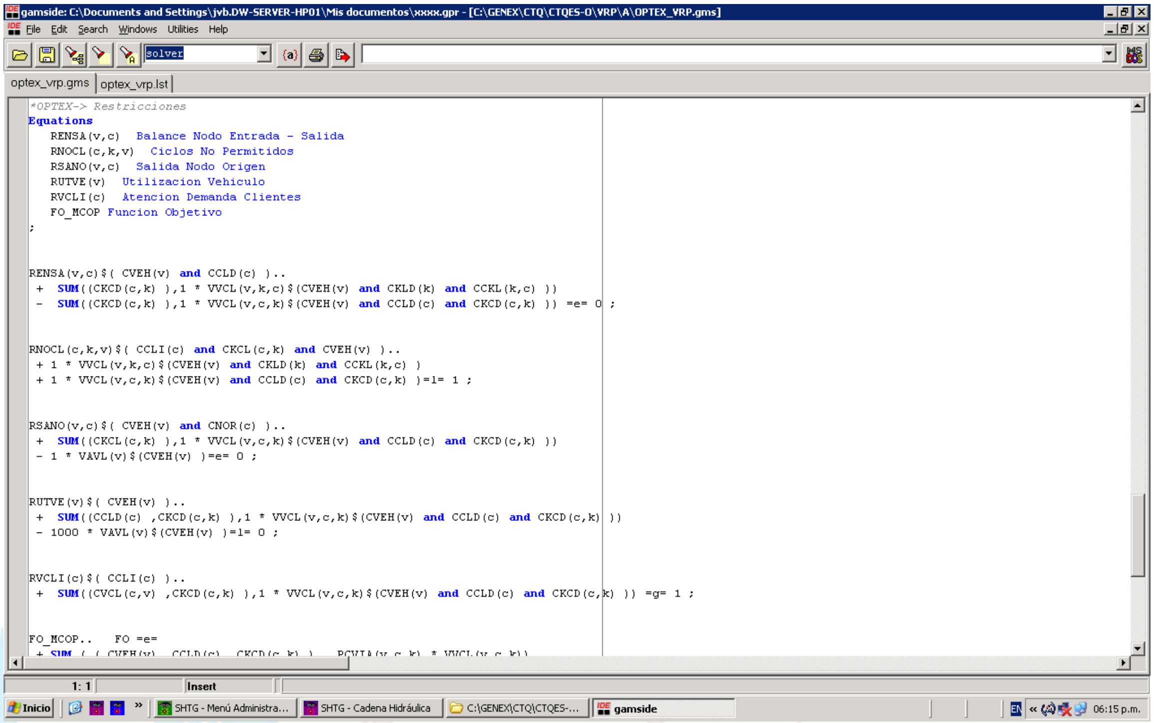
The next diagram shows the integration of models of an **DSS** for the electric sector.



2.4. PROGRAM CODE GENERATION

OPTEX generates programs of mathematical models in high-level algebraic languages, like **GAMS, IBM ILOG OPL**, **MOSEL**, **AIMMS, AMPL,** …, and in languages of general purpose like **C** and **PYTHON** (in development), making it in a generic meta-platform that works as interface for multiple Mathematical Programming technologies that do not support services offered by **OPTEX.**

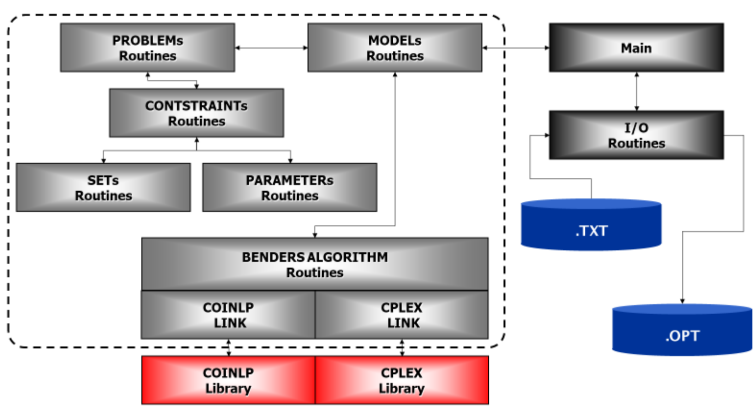
For example, with **GAMS**; **OPTEX** facilitates to the user the connectivity between mathematical models and information system, aspect that is not explicitly considered in **GAMS**; in this way the modeler can generate **GAMS** programs including **SQL** connectivity with the information system of the end-user.



The **C ANSI** program generation allows to develop applications based on complex process of interconnection models, which can be personalized according with specific characteristics of end-user, indispensable requirement when it comes to operative solutions for industrial processes and product and/or person distribution.

The diagram presents the **C** program structure.

OPTEX-C – PROGRAM STRUCTURE

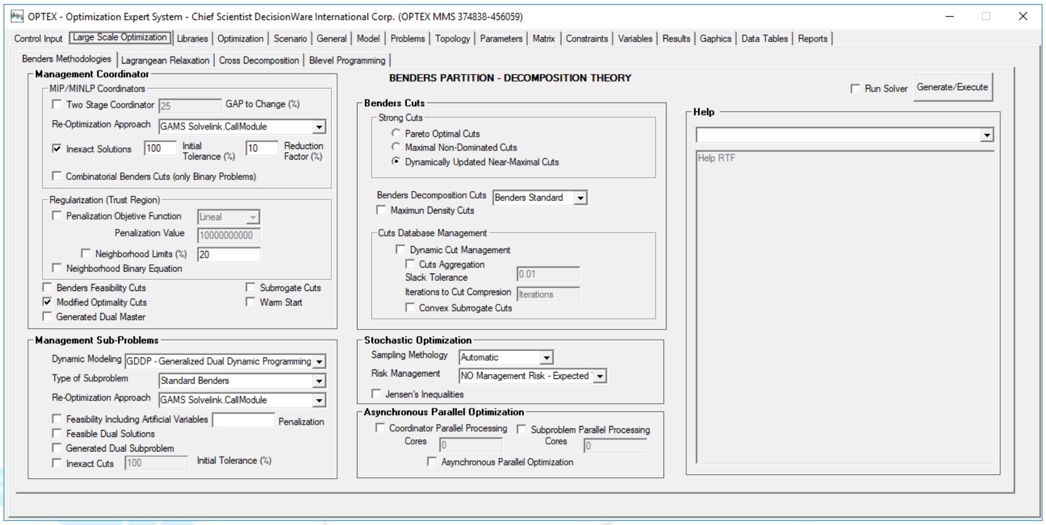


2.5. LARGE SCALE & STOCHASTIC OPTIMIZATION

The concept of multi-problem model facilitates the implementation of Large-Scale Optimization Methodologies (**LSOM**) based on multi-level partition and decomposition, using Bender's Theory and/or Lagrangean Relaxation. **DOA** algorithmic developments are concentrated in large-scale methodologies rather than the solution of basic problems. Focusing its research effort in generating effective computational codes to resolve such problems by making use of the advantages that today offer computers with multiple CPUs and computer grids. Thus, the no-expert modeler in this type of technology can access them in multiple computing technologies.

Considering that large scale technologies are the necessary complement to the basic optimization solvers (**IBM CPLEX, GUROBI, XPRESS,** …), since the union of the two powers allow to solve larger and more complex mathematical problems, **OPTEX** incorporated as part of its services the automatic generation of computer algorithms using the variations and the improvements that have been developed by researchers.

The screen allows the parameterization of a model using the Benders Theory so that the user can make a research to determine what methodology can be called the “best” for its specific problem. **OPTEX** includes various variations of the basic theory like Generalized Benders Decomposition (**GDP**), Dual Benders Decomposition (**DBD**), Nested Benders Decomposition (**NBD**) and others.



For dynamic systems, **OPTEX** includes the **GDDP** (**G**eneralized **D**ual **D**ynamic **P**rogramming) a large-scale methodology developed by **DOA** for speed-up the solution time of large dynamic models compared with **NBD** which is based on the concept of L-Shape linear models. **GDDP** is applicable to any convex dynamic model (LP, MIP, NLP, MINLP, NLP) and “some” non-convex models. The first version of **GDDP** was implemented in 1991; the first publication, in a Scientific Journal, in 2002.

OPTEX includes as part of their services the modeling of **M**ulti-**S**tage **S**tochastic **P**rogramming (**MS-SP**) that implies to handle random processes over the decision trees and solve problems with different types of objective functions, for example: i) expected value; ii) MiniMax or Maximin and iii) maximum regret; additionally, **OPTEX** includes several alternative to risk management, including conditional-value-at-risk constraints (**CVaR**).

The conversion of deterministic (core) model to stochastic models is automatic, in the sense that the user must only configure the conversion process and **OPTEX** generates the stochastic model from the deterministic formulation. The problems are generated using "split" variables with non-anticipative constraints. The uncertainty dimensions may be defined by the users, considering which are the more convenient considering the type of model and dynamic of the stochastics process. The solution of these problems can be accomplished through direct solution of equivalent deterministic problem or using large scale optimization methodologies. Sampling methods may be included in the algorithms.

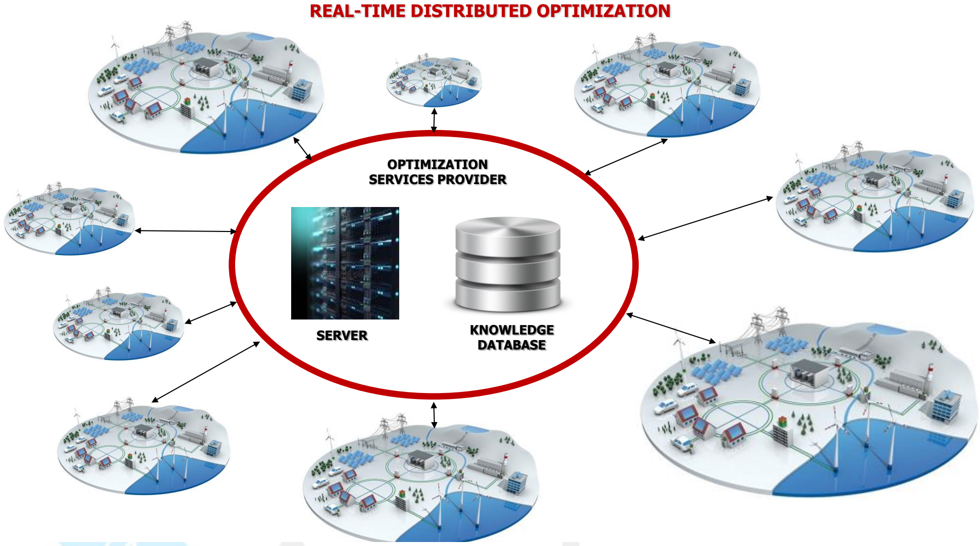
2.6. PARALLEL & DISTRIBUTED OPTIMIZATION

In the future, the real-life solution based on Mathematical Programing, applied to large physical and social structures/organizations, must be based on multilevel parallelism using the modern computational architectures then, **L**arge **S**cale **O**ptimization **M**ethodologies (**LSOM**) are the fundamental to atomize an optimization/equilibrium mathematical problem in multiple types of sub-problems that can be solve using the concepts of:

- **Asynchronous Parallel Optimization (APO)** (solving complex model using parallelization): defined as the solution of a large problem using the multiple cores of a workstation/server and/or a grid of computers;

- **Real-Time Distributed Optimization (RT-DO)**: defined as the solution of a problem in which multiple agents work coordinately to permanently keep the system on the optimality path; an example is the optimization of the energy smart grids.

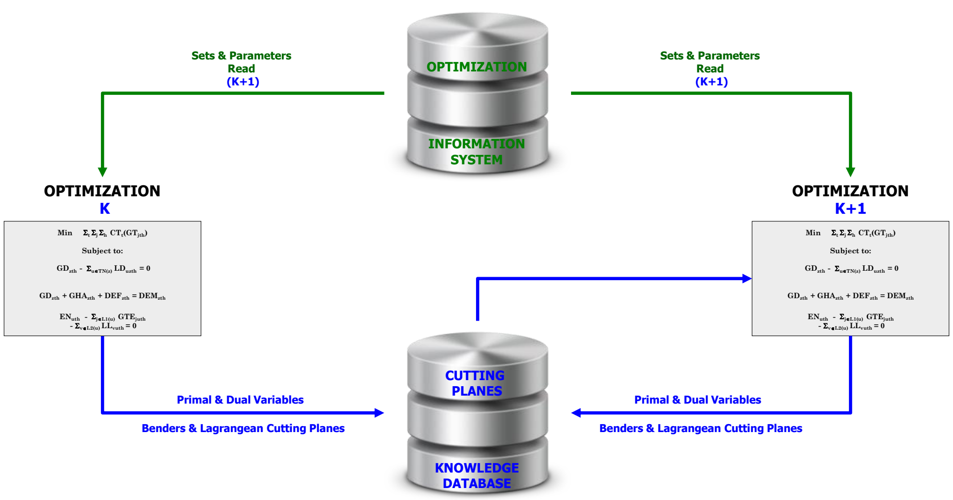
OPTIMIZATION OF DISTRIBUTE SYSTEMS
REAL-TIME DISTRIBUTED OPTIMIZATION



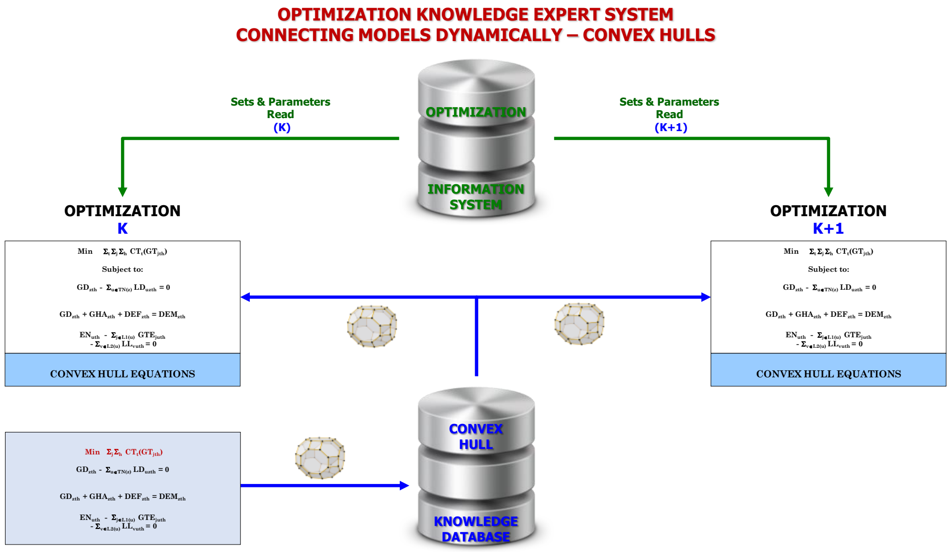
To implement the previous processes, mainly **RT-DO**, the management of multiple solutions of atomized-problems is necessary; this implies to introduce the concept of optimization expert systems oriented to:

- **Knowledge Accumulation** that exist in the multiple's solutions of problems. An example is to use the Benders cutting planes of a run (**k**) in the next runs (**k+1**, **k+2**, …). The management of databases of solutions (primal & dual) can be used to warm up the repetitive models and speed-up their solution. The next diagram describes the situation.

OPTIMIZATION KNOWLEDGE EXPERT SYSTEM
CONNECTING MODELS DYNAMICALLY – CUTTING PLANES

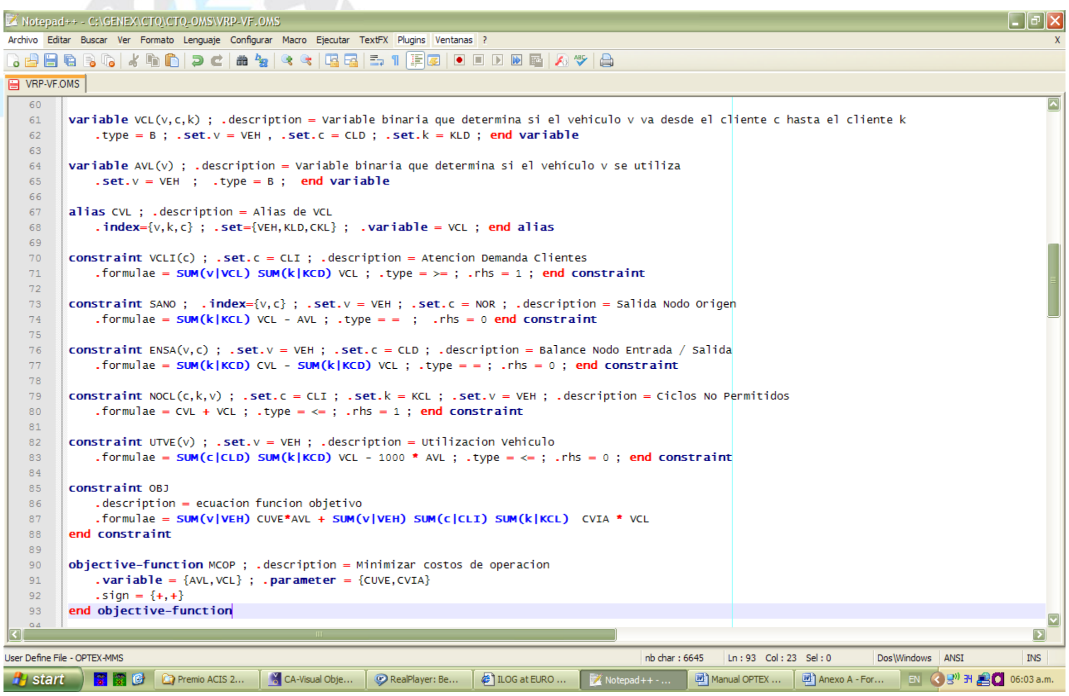


- **Knowledge Generation** during the idle time of the computers pre-solving the complex part of a large/complex mathematical models. This may be get representing the complex part as follow: i) using the convex-hull of optimal solutions, that may be solved when the computer is idle and ii) including the equations that represent the convex hull (normally a grid) in the integrated model. The next diagram describes the situation.



2.7. OPTEX ALGEBRAIC LANGUAGE

OPTEX has an algebraic programming language, like **GAMS** or **AMPL**. The compilation process works in double pass: first analyzes the program syntax and second analyzes the logical content of the program; if everything is correct it is linked with **OPTEX-EXE**. Since from an **OPTEX** program is possible to fill the tables of **MMIS**. For programs editions the modeler can use **NOTEPAD^{++}**, a customized free software.



3. OPTEX PROCESSORS

OPTEX works like an integral system that offers to the modeler a range of possibilities that guarantees efficiency and flexibility to face the implementation process of a decisions support system oriented to be launched in an end-user. The modules that integrates **OPTEX** are presented below.

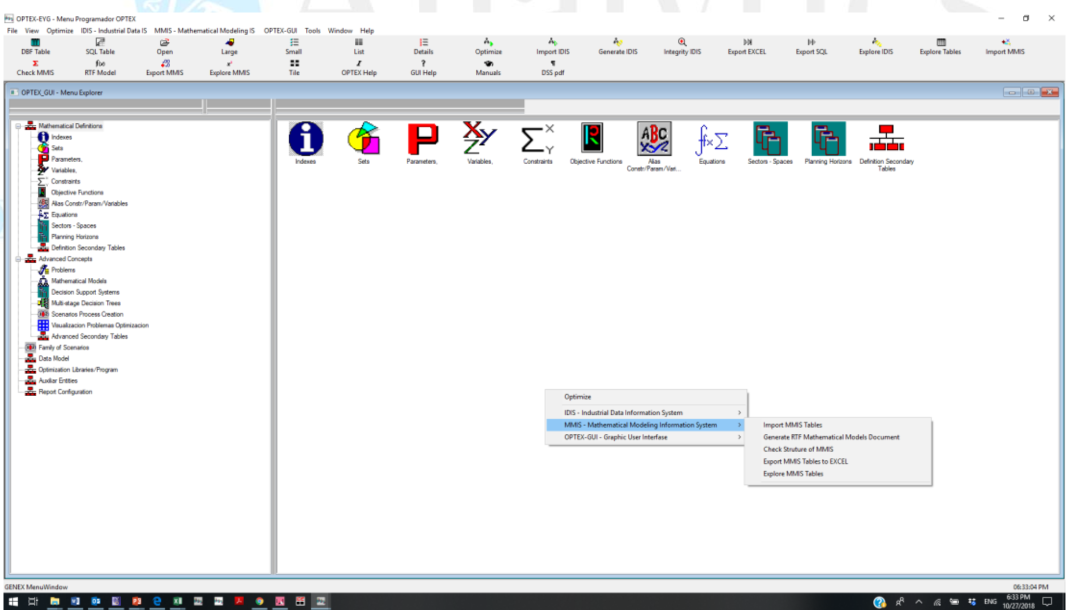
3.1. OPTEX-GUI: INTEGRATED DEVELOPMENT ENVIRONMENT

OPTEX-GUI corresponds to the **IDE** interface (**I**ntegrated **D**evelopment **E**nvironment) used by the modeler and its objective is to facilitate the access to all tables that integrated the **DSS**, this means **MMIS** or **IDIS**.

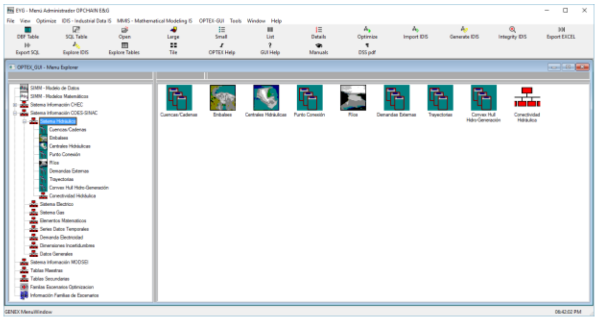
The algebraic formulation stored in databases allows the mathematical modelers to work simultaneously as users of LANs and/or WANs; this is one of the most important characteristics of **OPTEX**, not possible in the optimization technologies based in computer programs. **OPTEX-GUI** is a client application that works in **MS-WINDOWS** available for those who has installed **OPTEX** in their computers.

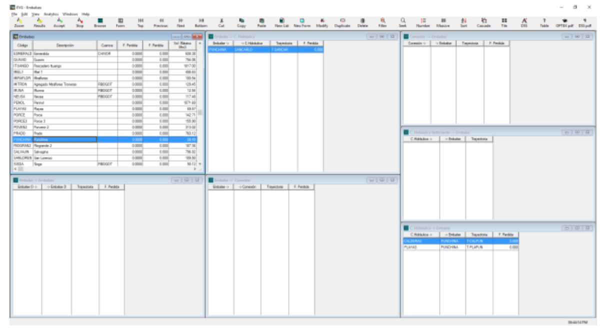
OPTEX-GUI is based on a browser like "windows explorer" that allows the user to access all tables of **MMIS** and of **IDIS**; also, it has processes services which can be accessed through menus application. The connection to the tables is performed without programming tasks, in this way the modeler parametrize the way used by the end-user to access to the **IDIS** tables.

OPTEX-GUI allows to the modeler interact with the **MMIS** in such a way that he can update the model equations as the changes are required. **OPTEX-GUI** includes an online help system, providing to the modeler the necessary information about different aspects of the application that is being developed.



The next images show the explore window of final user and the shell window to see a master table and all related tables.

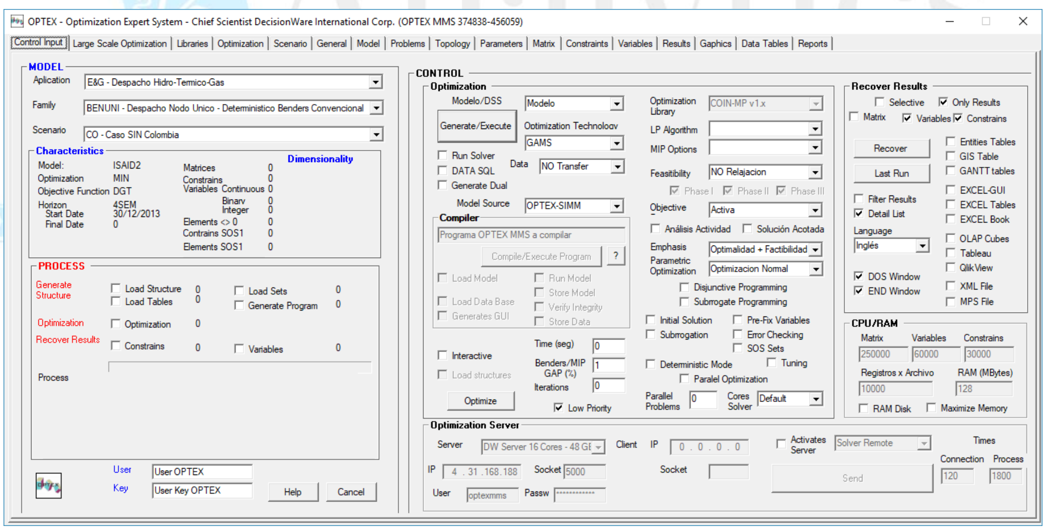




3.2. OPTEX-EXE: INTERACTIVE SOLVER

OPTEX-EXE processor is responsible of perform all tasks related to the optimization services offered by **OPTEX**. **OPTEX-EXE** has an interactive control interface allowing the modeler to conduct, step by step, the optimization processes; also, it can be executed as a task in the back-end for automatic processing, controlled by a configuration file. This is only available for users with **OPTEX** installed on their computer. This interface can be activated from **OPTEX-GUI** and it works on **MS-WINDOWS** environments.

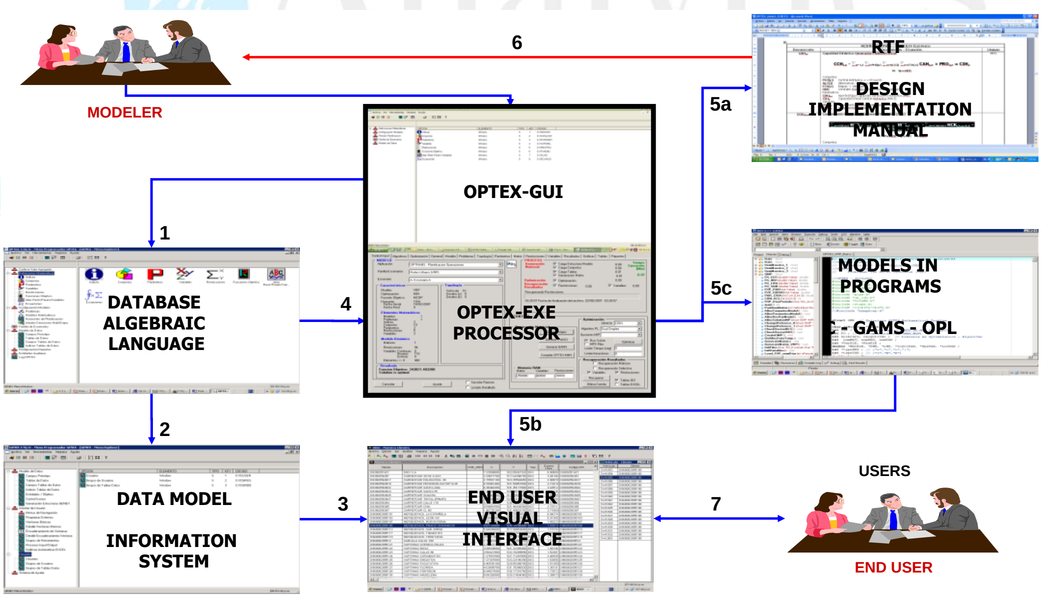
OPTEX-EXE is designed to act as client and as optimization server, in this way the implementation of a "cloud" environment solution using a remote server focuses on the implementation of **OPTEX-EXE** in both computers with its corresponding parameterization.



The next table describes the steps to work with **OPTEX-GUI** and **OPTEX-EXE**

STEPS IN THE IMPLEMENTATION OF OPTEX APPLICATIONS	
STEP	**DESCRIPTION**
1	**ALGEBRAIC MODEL LOAD** The process begins with the load of the algebraic model by the responsible administrator/modeler of the model being implemented. This process implies to fill the corresponding database to the **MMIS**, this process must follow general guidelines describe bellow and it is performed through the access to **OPTEX-GUI** or to **OPTEX-EXCEL-MMS.**
2	**MODEL DATA LOAD** The process of defining the data model of **IDIS** is a process that is generated simultaneously with the loading of mathematical models so, as relations between the two models are strong so that the table structures are determined by the structure of the mathematical model, primarily by the relation between sets, parameters, variables and constraints. This process is performed through access to **OPTEX-GUI** or to **OPTEX-EXCEL-MMS.**

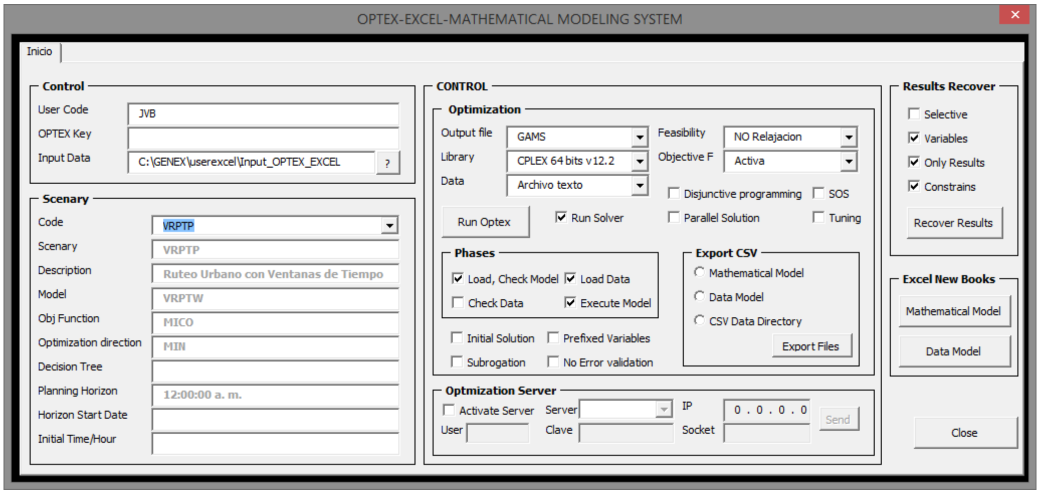
STEPS IN THE IMPLEMENTATION OF OPTEX APPLICATIONS	
STEP	**DESCRIPTION**
3	**GENERATION OF THE VISUAL USER INTERFACE** **OPTEX GUI** provides services to generate a user interface without programming tasks, this involves organizing the shell windows in tables associated with a main table and the related secondary tables. This query is performed through the administrator who must built menus to provide access to end-users. This process is performed through access to **OPTEX-GUI**.
4	**USING OPTEX-EXE** Once the database is loaded into **MMIS**, the next step is to interact with **OPTEX-EXE** in order to begin the process of adjustment of the formulation of algebraic models.
5	**ANALYSIS ALGEBRAIC MODEL** The analysis of the algebraic model involves interaction coordinating two simultaneous activities : ▪ Review loaded algebraic formulation into **MMIS**; and ▪ Review the results obtained with the models.
5a	**REVIEW ALGEBRAIC MODEL FORMULATION** This activity is carried out mainly with the **RTF** document generated by **OPTEX,** where the user can see the exact formulation loaded in **MMIS**, and find errors in it and/or the needs for adjustments due to imperfections in modeling.
5b	**STORAGE ALGEBRAIC MODEL RESULTS** This activity is performed automatically by **OPTEX-EXE** and/or by the programs generated with **OPTEX**.
5c	**REVIEWING THE RESULTS OF THE ALGEBRAIC MODEL** This activity is mainly observing the results produced by the algebraic model that is being implemented as a result, the user can found errors in the data loaded in **IDIS** and/or the need for adjustments due to imperfections in modeling. This process is performed through access to **OPTEX-GUI**.
6	**SETTING THE ALGEBRAIC MODEL** Following the analysis of the development and results in the early stages of implementation, it is necessary to make changes to the **MMIS** and **IDIS**. This cyclic process ended when the modeler considers that the implemented model produces the correct results and it is ready to be delivered to the end-user.
7	**DATA ACCESS BY THE END-USER** Finally, the end-user can access to use the model, which is made based on the data stored in the **IDIS** and results generated by the models.



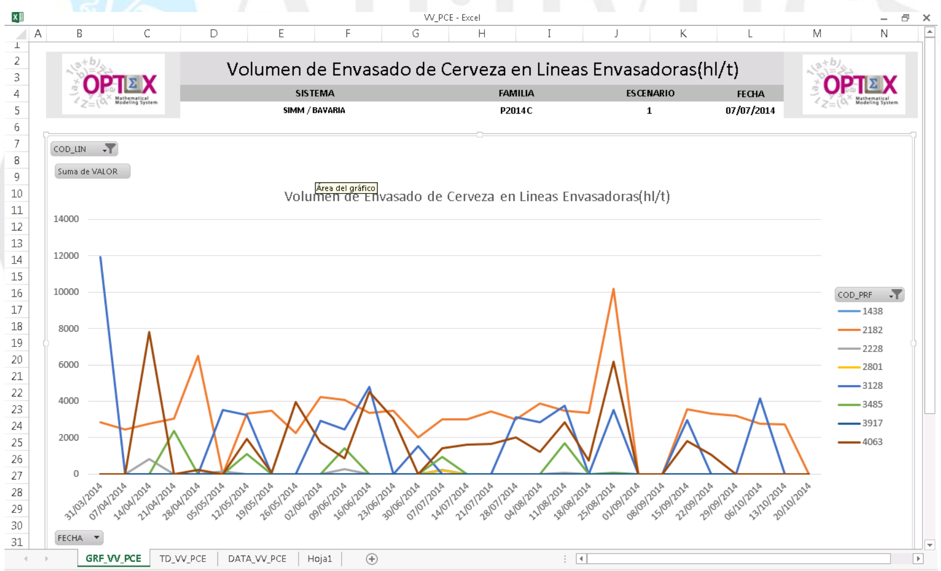
3.3. OPTEX-EXCEL-MMS: EXCEL OPTIMIZATION EXPERT SYSTEM

As already indicated, the data corresponding to the formulation of mathematical models is stored in the **MMIS** and therefore the information system can be loaded for any valid mechanism for loading database, with **EXCEL** one of the most popular tools for processing tables.

The advantage of loading the mathematical models through tables is that the modeler does not require to know programming languages to implement the mathematical models**.** After load the mathematical model in **EXCEL**, the tables can be loaded into the database **OPTEX** or kept in **EXCEL**; in any case **OPTEX** is responsible for generating the code associated to the programming language that the modeler has selected.

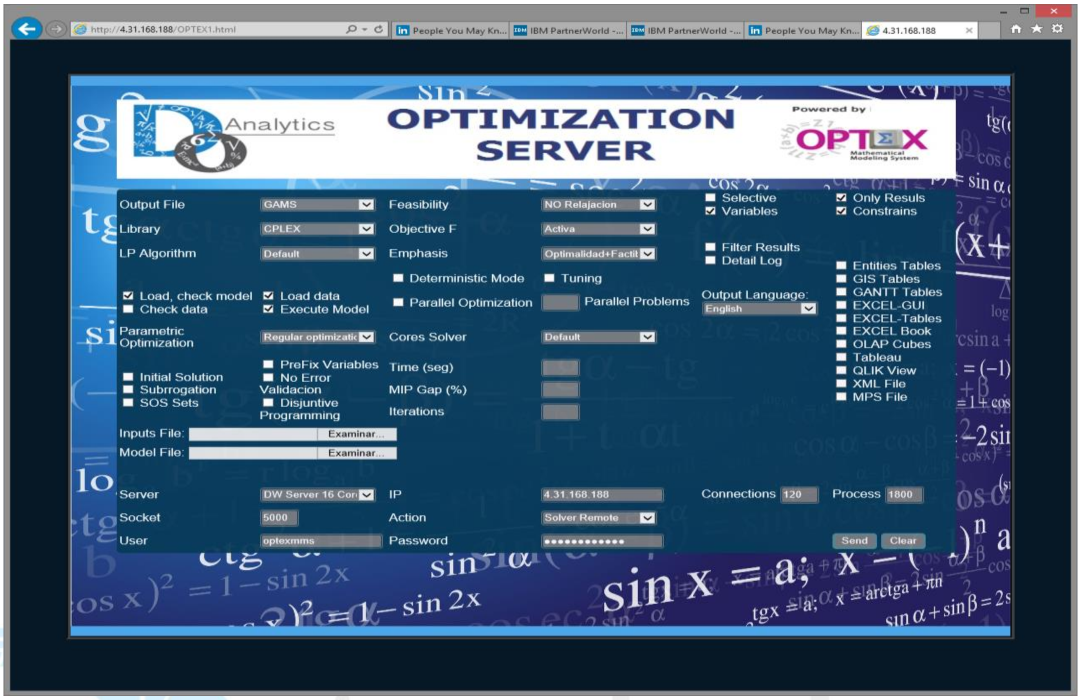


OPTEX-EXCEL-MMS controls the processes to be performed with **OPTEX** from **EXCEL** when the user has installed **OPTEX** on his computer or when the user access to **OPTEX** optimization server. The process was described previously. The following figure shows the results in the **OPTEX-EXCEL-GUI**, part **OPTEX-EXCEL-MMS**.



3.4. OPTEX-WEB: OPTEX WEB ACCESS SERVICE

OPTEX-WEB: Modeler interface oriented to using **EXCEL** as a way to develop models. Available on a website controlled by **DO ANALYTICS** or by an **OPTEX** user.



4. IDIS: INDUSTRIAL DATA INFORMATION SYSTEM

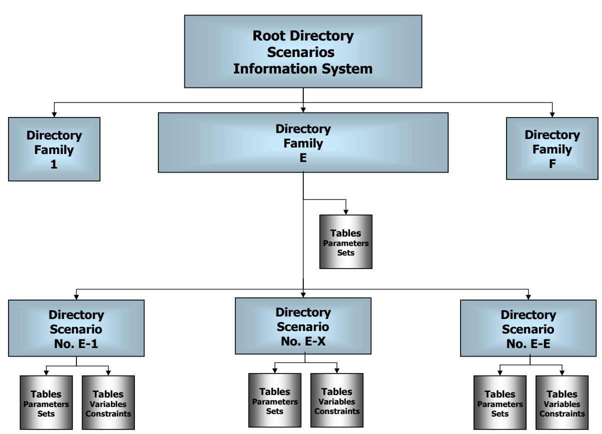
The data that represents the technical and socio-economic information of the industrial system are stored in the **IDIS**, classified into two types:

- **IIS:** Permanent **I**ndustrial **I**nformation **S**ystem, corresponding to the tables of the information system that are independent of any scenario (case study); and
- **SIS: S**cenarios **I**nformation **S**ystem, corresponding to the tables that represents the variability of scenario.

The **IDIS** data model depends on mathematical models; the content stored in tables depends on the physical system modelled and on the scenarios that the user wants to analyze. **OPTEX-GUI** provides services to configure the **IDIS** data model and its user interface; both **IIS** and **SIS** are relational information systems whose data models depend on mathematical models.

The scenarios are grouped under the concept of scenario families, so that the user can perform cross analysis of all scenarios that belong to a family. **SIS** corresponds to the union of information systems of each scenario.

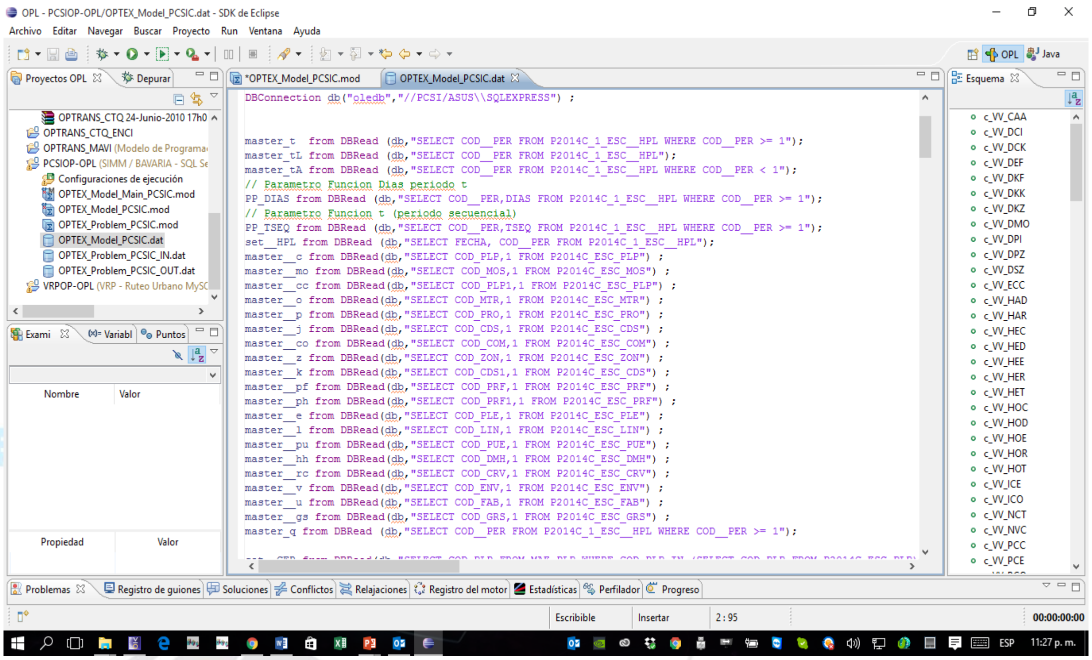
SCENARIOS INFORMATION SYSTEM



OPTEX provides services for the development and implementation of the data model and corresponding user interface; thus the development of mathematical models of the corresponding system information and the visual interface is limited to a process of filling tables.

4.1. SQL CONNECTIVITY SERVICES

To support the **IDIS** information system, **OPTEX** provides connectivity services with tables stored in **EXCEL, CSV, DBF** and **SQL** server type, connected via **ODBCs** (**O**pen **D**ata**B**ase **C**onnectivity). The following picture shows the **SQL** connection for loading data into a **IBM ILOG OPL** program



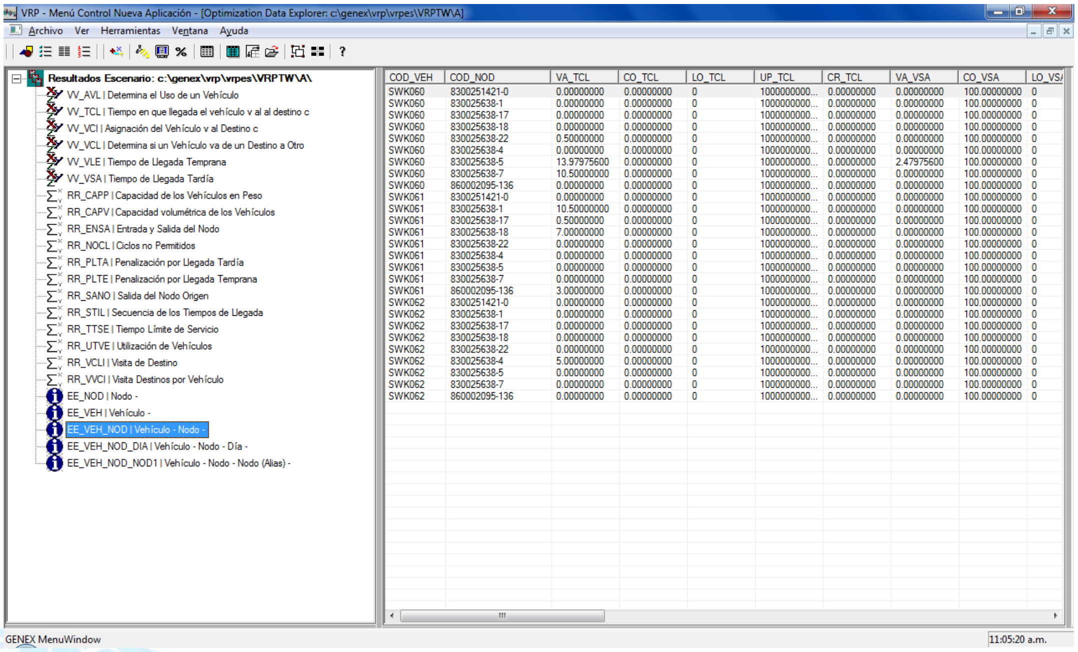
OPTEX provides the following services to support **IDIS**:

- Structuring the data model
- Generation user interface for access to **IDIS** tables.
- Check the integrity of the database
- Generation of derived tables for integration between **OPTEX** models and other computer systems.
- Generation of **SQL** statements for connection with optimization technologies
- Automatic mapping with other information systems (**ERP, WMS, TMS, GIS**, ...)
- Import/Export Data
- Structured query of **IDIS** tables.

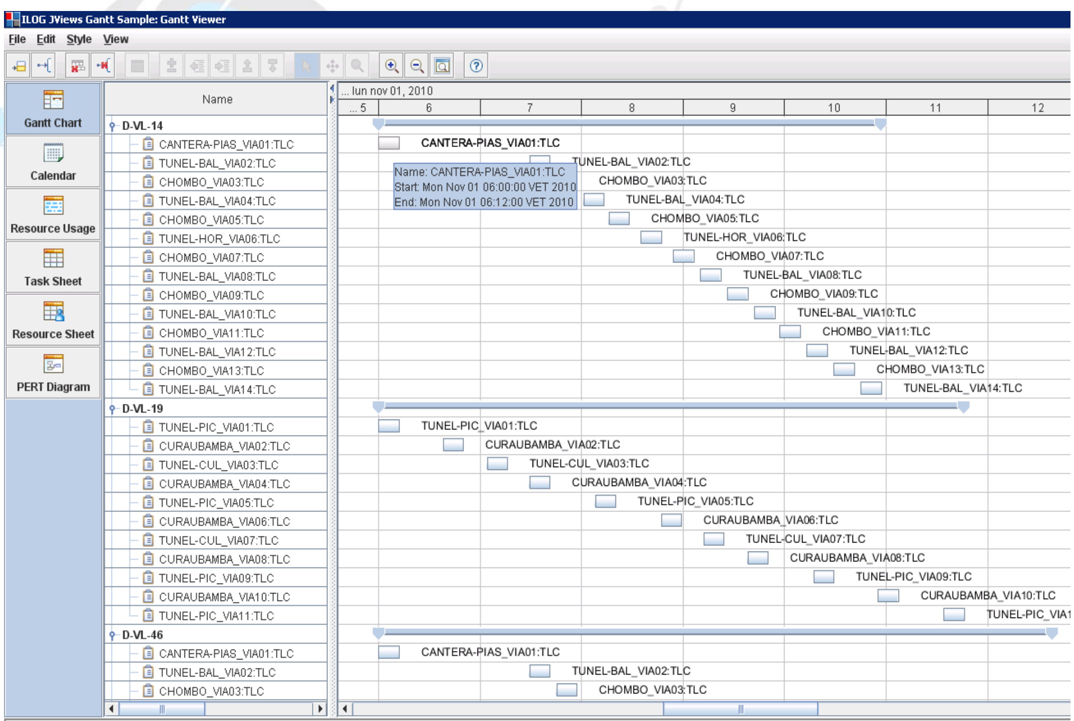
4.2. RESULTS STORE & DISPLAY

In **OPTEX -GUI** the modeler has access to tables that contains the results of variables and constraints for each specific scenario.

A fundamental part in the implementation of a decision support system is its ability to display the results associated to mathematical models that produce millions of data (big data). **OPTEX** approach facilitates the linking of results with information technology tools aimed at the exploration and visualization of large data volumes. All results of mathematical models, primary and dual variables, independent of optimization platform. Data is stored in relational tables that can be consulted by the user through **OPTEX-GUI.**



Based on this approach **OPTEX** can generate **XML** interfaces with **EXCEL, MS-Project, IBM-Jviews, TABLEAU, QLIKVIEW** and **Mondrian OLAP Server**. The following image shows an example of displaying a routing program in **IBM-Jviews.**



5. DOCUMENTATION

OPTEX generates **RTF** documents (**R**ich **T**ext **F**ormat), visible and editable with text editors' programs like **MS-WORD**. The **RTF** contains all the mathematical formulation included in a mathematical model. Thus, it guarantees proper documentation of the implemented models. Following, an example of the generated documentation.

RESTRICTIONS – MODULO:		
RESTRICTION	**DESCRIPTION – EQUATION**	**DISJUNCTIVE VARIABLE**
$BIEV_{t,j,hh}$ DECx1000	**Existencias Máximas de Producto Final más Envase en Centros de Distribución** $$\Sigma_{p\in PT(j)}\ \Sigma_{v\in PVJ(p\ j)}\ ICE_{t,j,p,v,hh} + \Sigma_{v\in JV(j)}\ EVJ_{t,j,v,hh} \le ACE_j$$ $$\forall t \quad \forall j\in PUN \quad \forall hh\in\_DIM\_hh(*)$$ Índices: **t** Período **j** Centro Distribución **hh** Escenario Demanda **p** Producto **v** Envase Conjuntos: **p∈PT(j)** Productos Cerveceros x Centro de Distribución j **v∈PVJ(p,j)** Envases x Producto x Centro de Distribución j **v∈JV(j)** Envases x Centro de Distribución j **j∈PUN** Centros de Distribución (j) **hh∈_DIM_hh(*)** Dimension hh <- Escenario Aleatorio Parámetros: **ACE_j** Capacidad Almancenamiento del Centro de Distribución (UNDx100) Variables: **$ICE_{t,j,p,v,hh}$** Existencias de Producto Finalizado en Centros de Distribución (DECx10) **$EVJ_{t,j,v,hh}$** Existencias Envase Vacío en Centros de Distribución (DECx10)	
...	...	...
$WHE_{t,l,hh}$ Hrs	**Tiempo Trabajado en Línea de Empacado. NO incluye tiempo preparación Línea** $$HOE_{t,l,hh} + HEE_{t,l,hh} - \Sigma_{p\in LP(l)}\ \Sigma_{v\in LTV(l\ p)}\ KWE_{l,v} \times PCE_{t,l,p,v,hh} = 0$$ $$\forall t \quad \forall l\in LN \quad \forall hh\in\_DIM\_hh(*)$$ Índices: **t** Período **l** Línea Envasadora **hh** Escenario Demanda **p** Producto **v** Envase Conjuntos: **p∈LP(l)** Productos x Línea de Envase **v∈LTV(l,p)** Envases x Línea de Envase x Producto **l∈LN** Línea de Envase **hh∈_DIM_hh(*)** Dimensión hh <- Escenario Aleatorio Parámetros: **$KWE_{l,v}$** Velocidad de Producción de Línea Envasadora (Hrs/UNDx100) Variables: **$HOE_{t,l,hh}$** Horas Ordinarias de Producción en Líneas de Envasado (Hrs) **$HEE_{t,l,hh}$** Horas Extras de Producción en Líneas de Envasado (Hrs) **$PCE_{t,l,p,v,hh}$** Volumen de Envasado de Cerveza en Líneas Envasadoras (DECx10)	

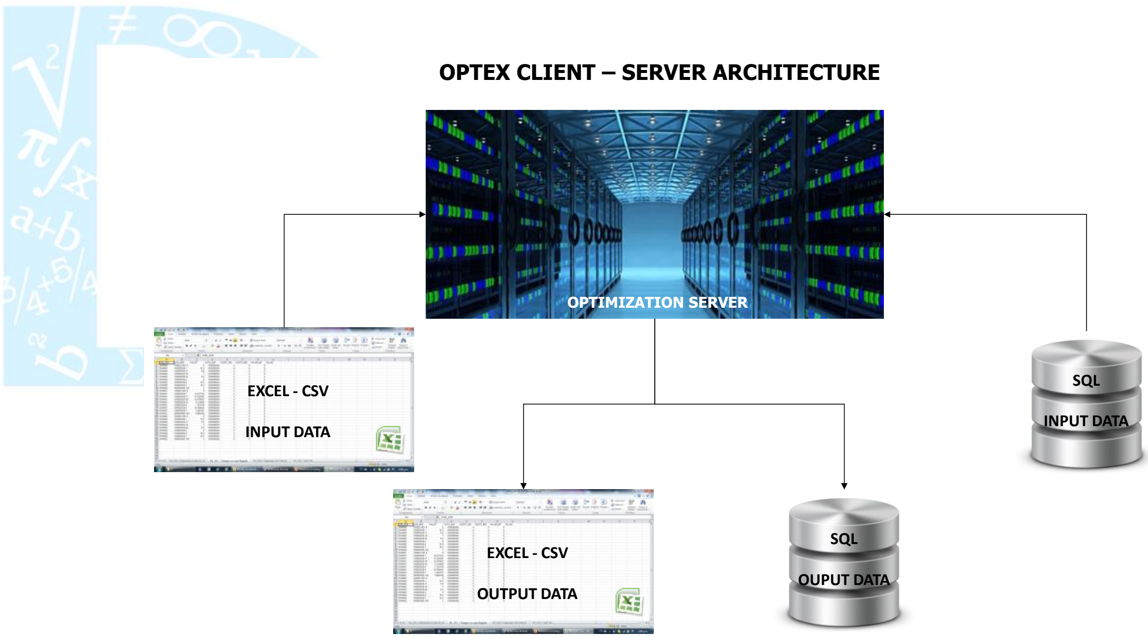
Reports include the description of the data model and the link between the fields of each table and the sets and the parameters of the models that are read as input data.

6. OPTEX OPTIMIZATION SERVER

Following the actual trend of cloud solutions, **OPTEX** allows the development of applications oriented to solve optimization problems, using services provided on the Internet (cloud services). For client-server applications **OPTEX** considers four roles that interact between them, allowing multiple architectures configured according to user needs:

- **OPTEX-GUI:** Graphical interface that allows to the administrator and users to view **OPTEX** information system.
- **OPTEX-CLIENT**: Processor oriented to provide **OPTEX** services on a client computer that uses a model locally or establishing a connection to a remote server that provides services to solve optimization problems. This role can be assumed by **OPTEX-EXE**, **OPTEX-EXCEL-MMS** and **OPTEX-WEB**. The final user can build his own **OPTEX-CLIENT**.
- **OPTEX-CONTROL-SERVER**: Task dedicated to manage the connections from a remote server with multiple clients requesting **OPTEX** services optimization.
- **OPTEX-SERVER**: Remote processor aimed at solving mathematical problems associated with an optimization model that has established a connection to apply the solution to a problem. **OPTEX-EXE** assumes this role.

Transferring files can be performed under any of the following ways: **EXCEL** books; **CSV** files or data stored on a **SQL** server to which access **OPTEX-SERVER**.



7. OPTEX DOWNLOADING

You can download a BETA version of **OPTEX** following the instructions included in the following presentation: https://goo.gl/Y9zMHD. If you need more information or are interested in **OPTEX** please contact us via jesus.velasquez@doanalytics.net