OPTΣX
Optimization Expert System

Making High Complexity Large-Scale Mathematical Models without Programming

RCADT
Research Center for
Advanced Decision Technologies

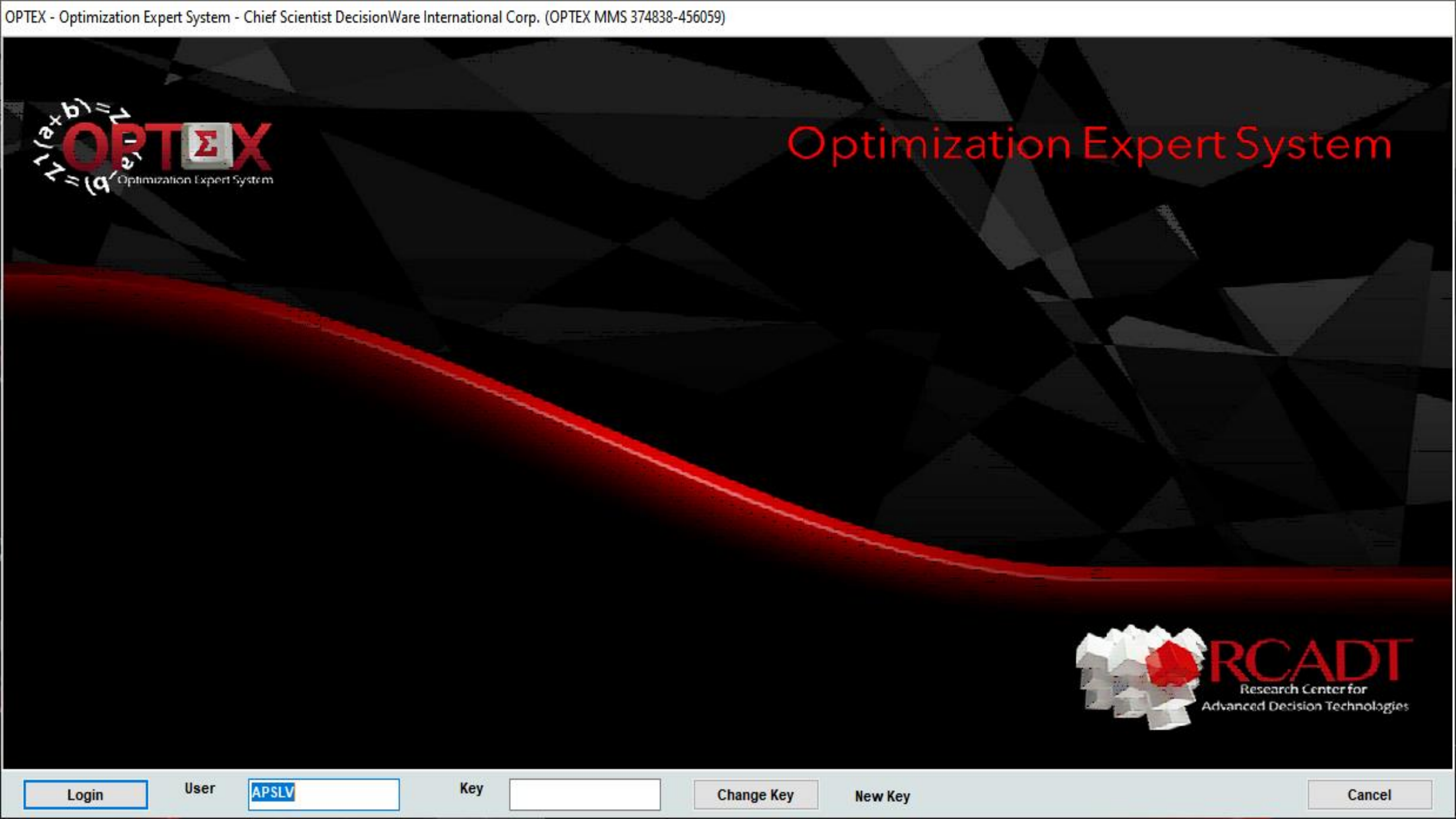
OPTΣX Optimization Expert System

Optimization Expert System

Imagination is the beginning of creation. You imagine what you desire, you will what you imagine and at last you create what you will.

George Bernard Shaw

RCADT Research Center for Advanced Decision Technologies


OPTEX - Optimization Expert System - Chief Scientist DecisionWare International Corp. (OPTEX MMS 374838-456059)
OPTΣX
Optimization Expert System
Optimization Expert System
RCADT
Research Center for
Advanced Decision Technologies
Login
User
APSLV
Key
Change Key
New Key
Cancel

OPTEX

Optimization Expert System
General Framework

OPTΣX
Optimization Expert System

Optimization Expert System

The best way to make software
is to haven't to do it.

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Robots for Mathematical Modeling

A robot is an artificial agent, meaning it acts instead of a person, doing things it is designed for.

Robots are usually machines controlled by a computer program or by electronic circuitry.

The robot can be a physical mechanical mechanism and/or a virtual software system.

A robot for mathematical modeling is aimed at replacing all the systematic activities the must perform:

i) The mathematical modeler during the development, testing and start-up of a mathematical modelling system

ii) The end user in the day-to-day use of mathematical models, either directly controlled by humans or automatically controlled based on the principles of artificial hypothalamus.

Optimization Expert System

In artificial intelligence, an expert system is a computer system that emulates the decision-making ability of a human expert.

Expert systems are designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as if–then rules rather than through conventional procedural code.

An expert system is a knowledge-based system that uses a knowledge-based architecture where the knowledge base represents facts about the world.

The inference engine is an automated reasoning system that evaluates the current state of the knowledge-base, applies relevant rules, and then asserts new knowledge into the knowledge base. The inference engine may also include abilities for explanation, so that it can explain to a user the chain of reasoning used to arrive at a particular conclusion by tracing back over the firing of rules that resulted in the assertion

The Modern Optimization Requirements

1. Standardization & Normalization
   (Easy connection of multiple mathematical models)

2. Expert Optimization Systems
   (Capitalization of the knowledge in optimization)

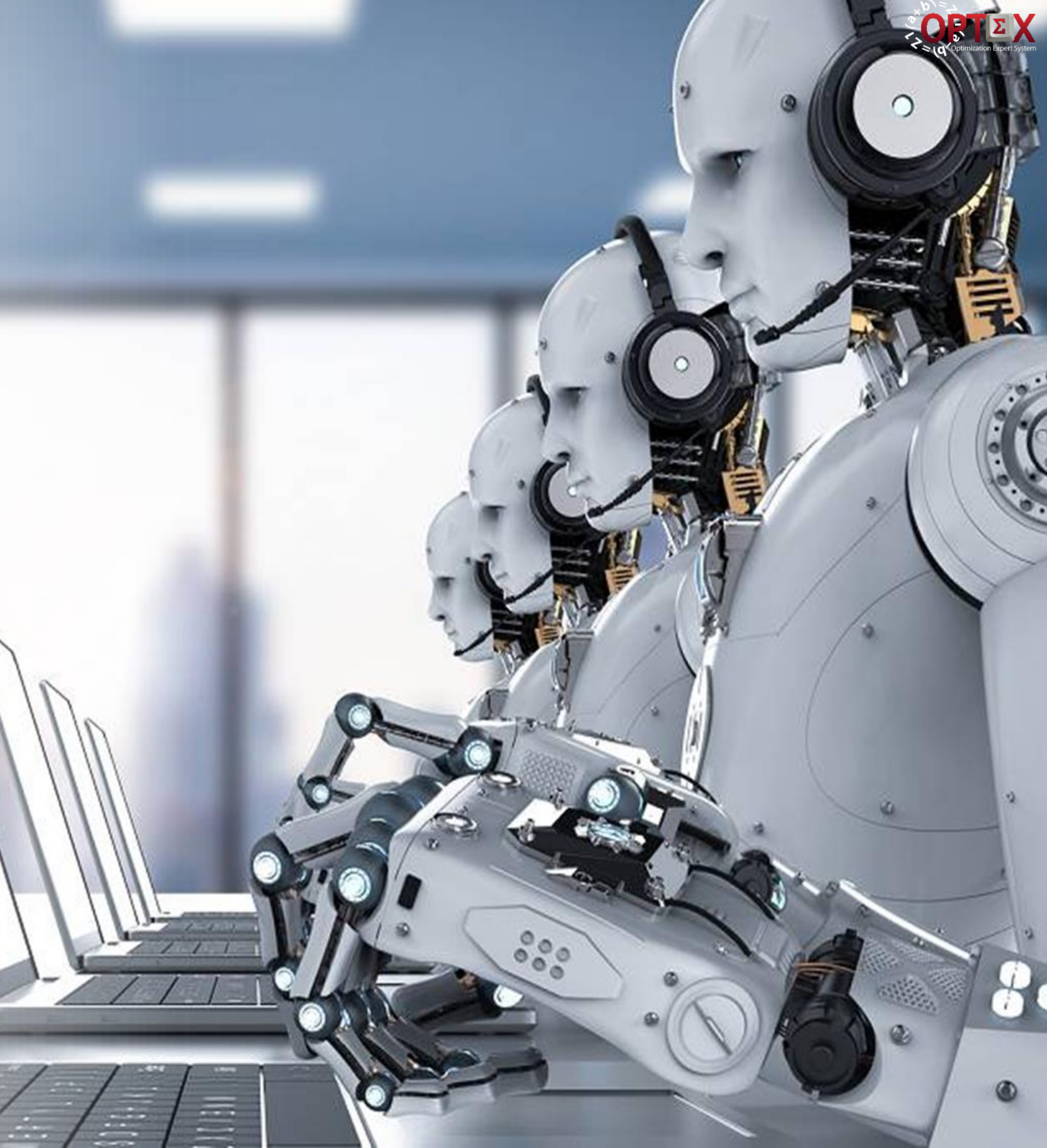
3. Socialization of basic optimization in final users
   (Commercially, optimization in LATAM isn't real part of Advanced Analytics)

4. Make easy the implementation of complex mathematical models

5. Socialization of large-scale technologies to the community of mathematical modelers.

6. The large-scale methodologies must be connected in a similar way that we connect actually the basic solvers using parametrization.

7. A new look of optimization according to the actual real-world technologies:
   - Internet of Things (IoT)
   - Industrial Internet of Things (IIoT)
   - Smart Metering
   - Big Data



Optimization for the Future

MATHEMATICAL MODELING

RCADT is working in automatic generation of systems of models oriented to build Artificial Hypothalamuses, that implies:

- Asynchronous Parallel Optimization (solving complex model using parallelization)
- Real-time Distributed Optimization (optimization distributed in many agents that must work coordinated in real time).

INFORMATION TECHNOLOGIES

- Automatic generation and maintenance of the data model of the information system (metadata) of the input/output data of the models.
- Automatic generation of a "smart" graphic user interface to link the user with de information system, in any type of SQL (Standard Query Language) server.
- All the SQL statement are generated by OPTEX (in the mathematical then the modeler doesn't need to know about information systems.

REMOTE SERVER

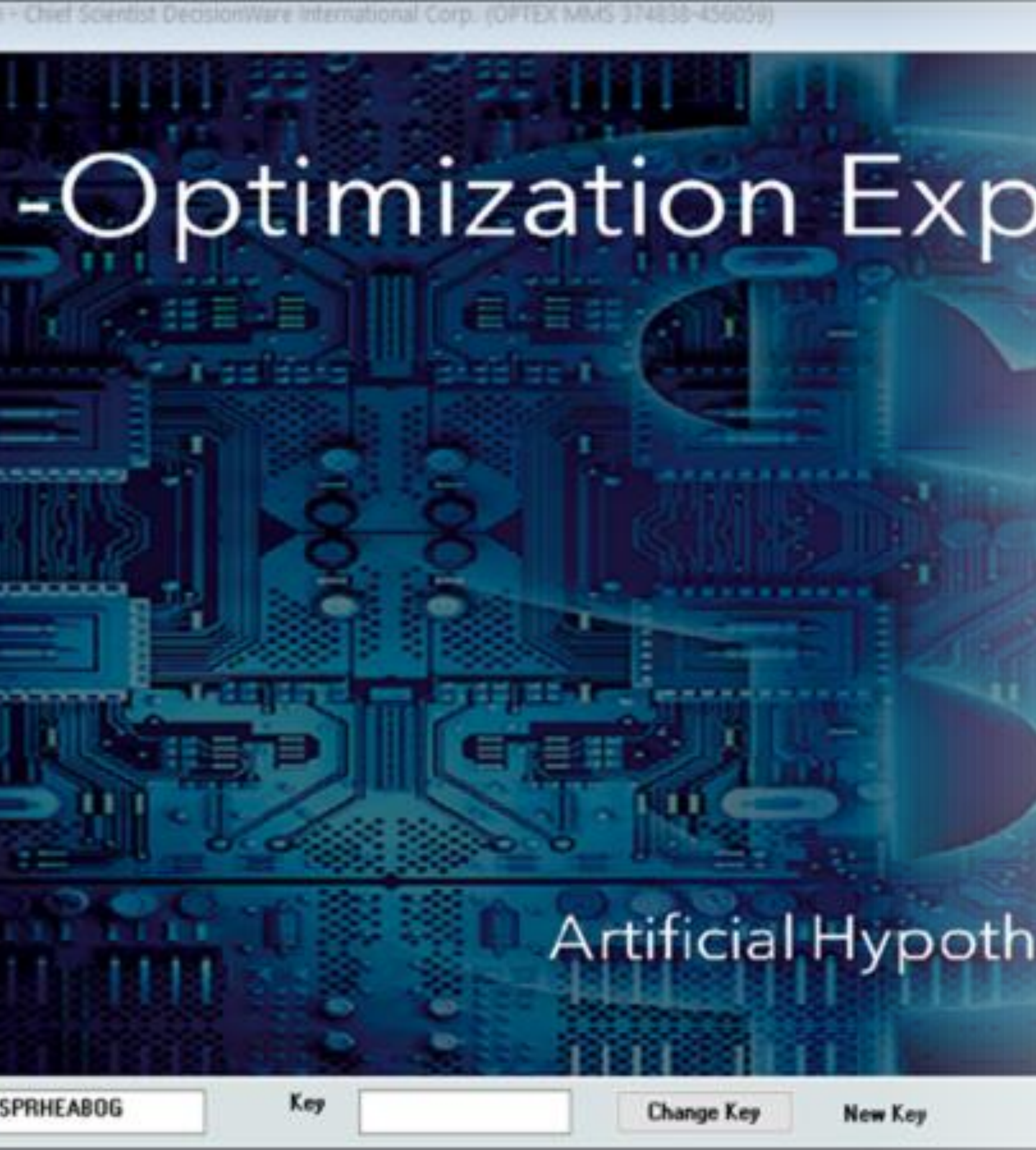
- Make easy to the users to send the models to a remote optimization server where the mathematical problem is solved

Where was OPTEX ?

OPTEX is the result of more than thirty (30) years of experience in multiple optimization projects applied to real life problems, developed in several countries, economical sectors and cultures;

Now RCADT share the benefits of OPTEX with the Mathematical Programming Community.

What is New with OPTEX ?



OPTEX supports all stages of the mathematical modeling process:

- Designing Mathematical Models: From MS-WORD (the "natural technology" for writing algebraic formulation) the mathematical modeler can obtain computer programs in multiple optimization technologies (like C ANSI, GAMS, IBM OPL, XPRESS/MOSEL, AMPL, AIMMS, among others) without carrying out programming activities.

- Large-Scale Optimization Algorithms: Only by “filling the blanks” and activating check-box controls the modeler can generate programs based on large-scale optimization methodologies. This includes the automatic generation of stochastic programming models.

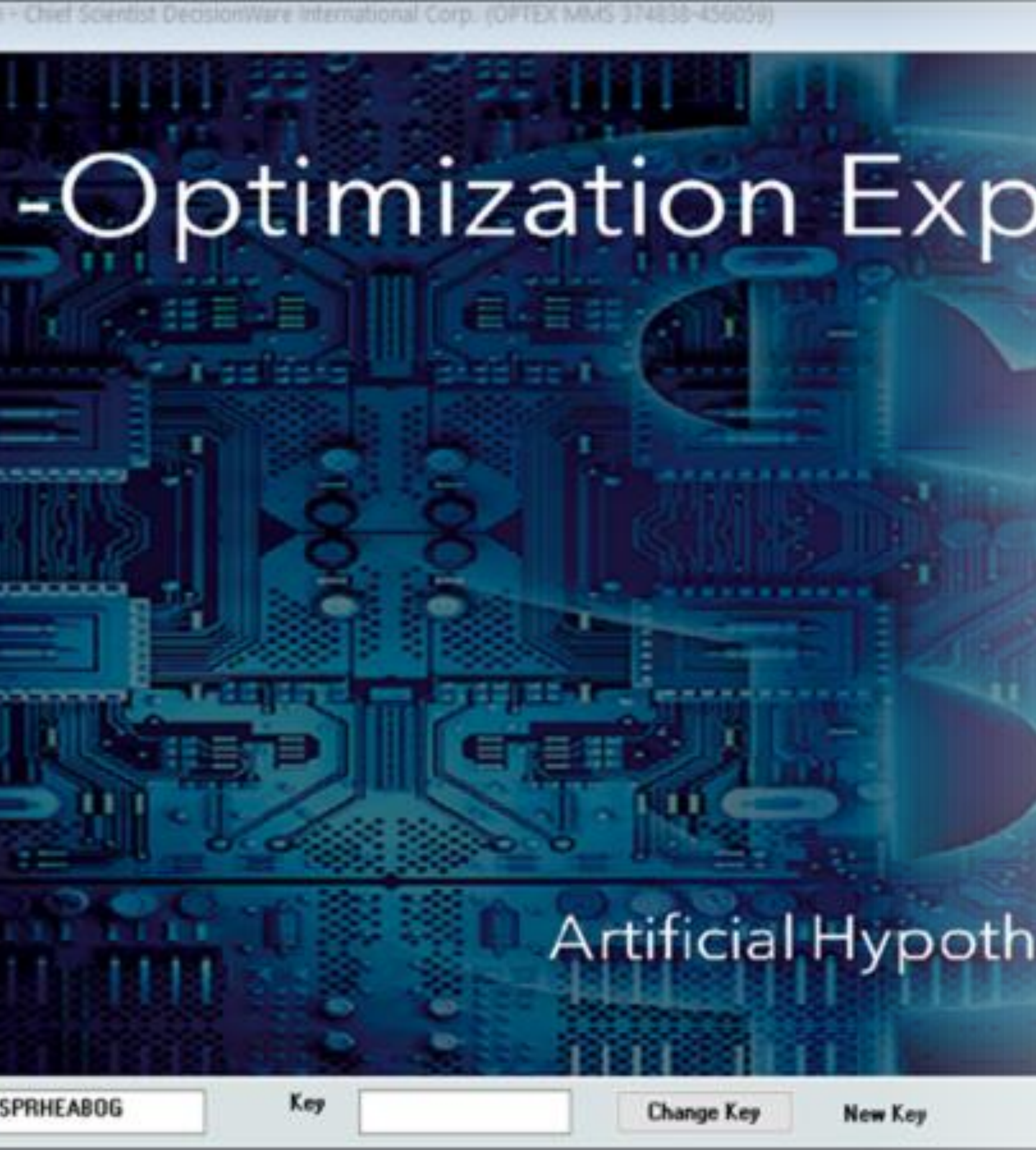
- Information Systems: As part of the implementation process OPTEX handles the automatic generation of a common data- model that allows the off-line integration of all models. Additionally, without programming tasks, OPTEX generates the screens for data manipulation.

- Mathematical Models Store: Based on the vision of mathematical models as a collection of objects, the modelers can develop their own “equation store” from which they can build (as a LEGO process) multiple problems that are used to build the models that integrate the enterprise decision support system.

- Artificial Hypothalamus: OPTEX generates automatically, following the business rules and the modeler rules, artificial hypothalamuses algorithms to support Autonomous Real-Time Distributed Optimization (ARTDO).

Using OPTEX the mathematical modelers can think the model and OPTEX will make the software and guarantees the portability of the mathematical models between optimization technologies

OPTEX Mathematical Modeling Framework



- Optimization Information Systems (the components of the model are stored in tables of an optimization information system). As any relational information its management is organized, standardized and normalized. This ensures control of models developed for companies.

- Optimization Expert System:
  - Capture of knowledge and experience that store the mathematical components that work correctly in the information system, so that it is not necessary to rewrite them. The mathematical model is built as a "LEGO" selecting the proper components (the constraints).
  - Capture the knowledge of a series of runs using:
    - Benders cutting planes that constraint the optimal-feasible zone based on previous runs of a model
    - Optimal convex hull that resume the optimum response of the complex components of a system, making the model more "light".

- Robotization: OPTEX writes programs ("millions" of instructions of source code) free of errors in the optimization technology selected by the user. This means shorter development times; changes to a model that works properly are implemented in minutes/hours.

- Freedom: OPTEX approach frees the mathematical model (algebraic formulation) of the optimization software, which is directly related to optimization technology like GAMS, AMPL, GMPL, ILOG OPL, MOSEL, C++, R, PYTHON, … .

- Easy to Use: complex models, using large-scale technologies, may be developed in MS-EXCEL or MS-WORD, filling templates.

Large Scale Optimization Technologies

- Large Scale Oriented: OPTEX can write models to be solved using large scale partition and decomposition methodologies, like Benders & Lagrangean Relaxation & Cross Decomposition.

- Benders Theory: OPTEX incorporates the "main" variation of Benders Theory (Generalized Benders Decomposition, Combinatorial Benders Cuts, Strongest cuts, Nested Benders, and so on). The implementation of Benders' Theory is parametrized, it implies that the user can selected (customize) the enhancements of Benders that she/he considered convenient (the options are based in an extended bibliographical research of real applications using Benders).

- Dual Models: OPTEX writes the models (primal and/or dual) and applied the enhancements or variations of the technologies.

- Dynamic Modeling: for Dynamic Systems, DecisionWare developed the GDDP (Generalized Dual Dynamic Programing) methodology that speed-up the dynamic Benders applications; Dynamic Benders modeling, from 1969, it is based on the concept of L-Shape linear models (known as Nested Benders). GDDP is applicable to any dynamic model (LP, MIP, NLP, MINLP, NLP).

- Cutting Planes Management: Automatic generation and management of databases of solutions (primal & dual) to generate cutting planes to warm up the repetitive models and speed-up their solution.

- Parallel Optimization: Automatic generation of statements for parallel optimization (asynchronous or synchronous).

This approach implies that a modeler can change the solution methodology of large-scale models according to results, in minutes.

TRADITIONAL WAY
(LARGE-SCALE IMPOSSIBLE WAY)

AN EXPERT COMPUTER PROGRAMMER

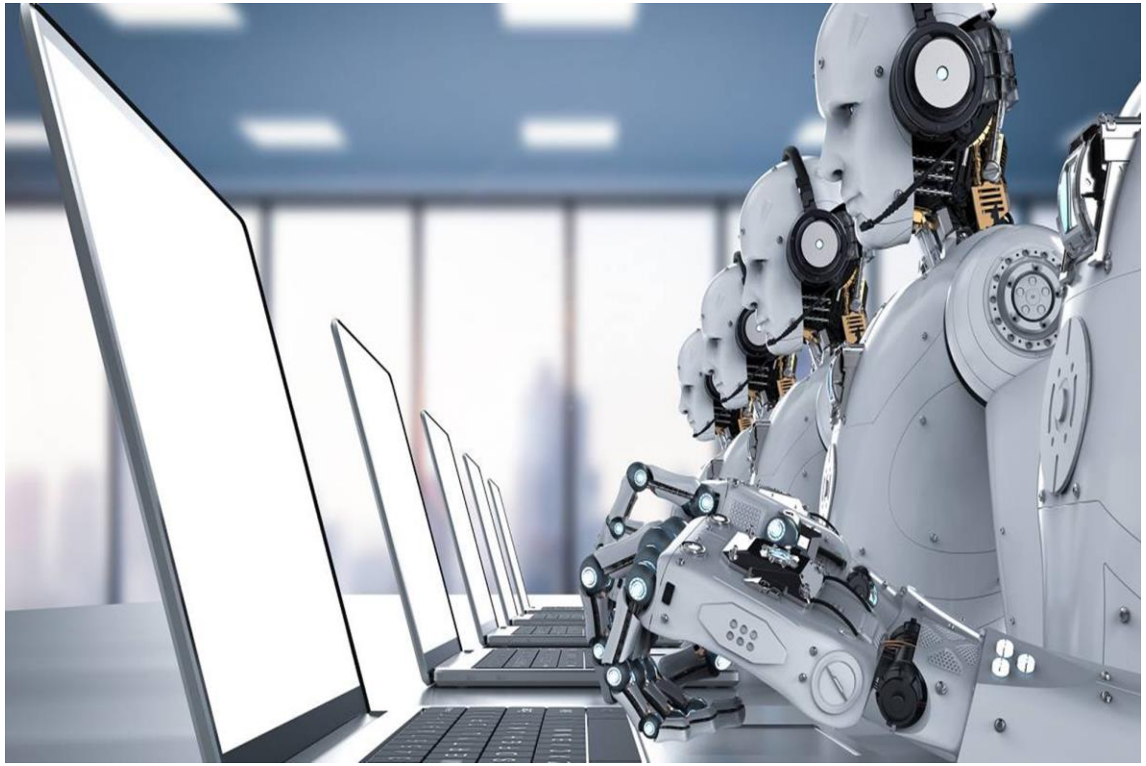
OPTEX WAY

COGNITIVE ROBOT

TRADITIONAL WAY
(SOFTWARE CONTROL IS A BIG PROBLEM)

MULTIPLE
COMPUTER PROGRAMMERS

OPTEX WAY



COGNITIVE ROBOT

TRADITIONAL WAY

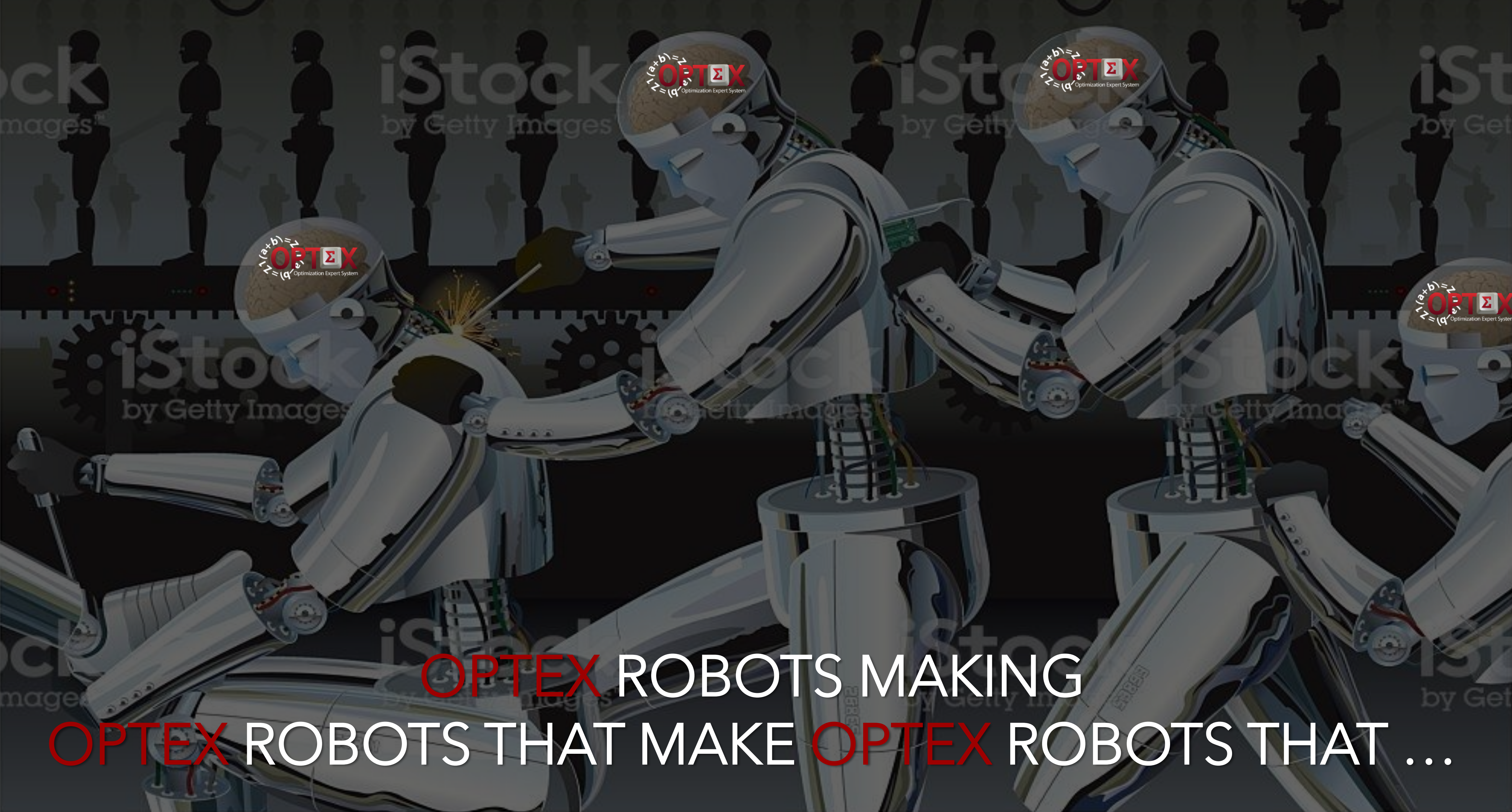
(THE COST OF LABOR CAN BECOME VERY HIGH)

EXPERT
COMPUTER PROGRAMMERS

OPTEX WAY

COGNITIVE ROBOT

THE FUTURE: MATHEMATICAL PROGRAMMING 4.0



OPTEX ROBOTS MAKING
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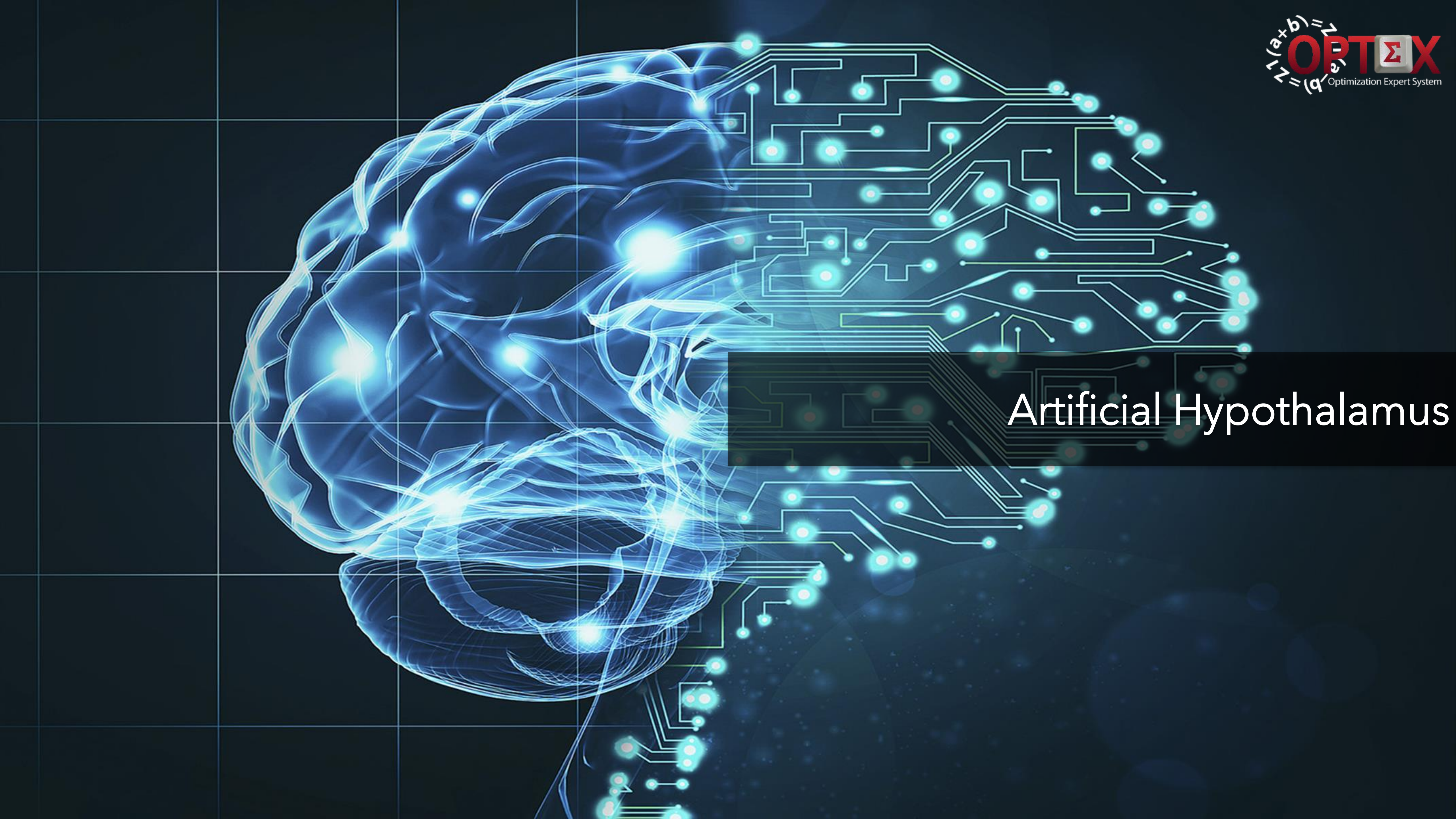

Artificial Hypothalamus

Optimization Expert System

Mathematics may be the language with which God has written the Human Brain

Mathematics must be the language with which humans can write the Organization Brain

Artificial Hypothalamus

"Most of the things and processes that the humans use have been totally affected by technology, which has opened up to the human imagination producing previously unsuspected results; mathematical modeling should not escape this process; starting from discovering the mathematical foundations that serve to establish the laws governing physical, industrial, economic, biological, health, social, … processes and with them to build mathematical models and increasingly powerful calculation algorithms; today all the knowledge and the technology is available to develop an upper level artificial intelligence that emulates the human intelligence in any type of human organization, it may be call the organization artificial hypothalamus.

The power of today's technology is not in the mathematical calculations that it allows to perform it is in the mathematical calculations that we can imagine that we can perform."

Velasquez-Bermudez, Jesus.
Artificial Hypothalamus: Artificial Intelligence and Mathematical Programming Integration.
(Available at SSRN: https://ssrn.com/abstract=3767763)

Video: https://youtu.be/tqMm6svjnPY

Artificial Hypothalamus: Artificial Intelligence and Mathematical Programming Integration

32 Pages • Posted: 11 Mar 2021

Jesus Velasquez
DecisionWare

Date Written: January 17, 2021

Abstract

In the industrial environment, the hypothalamus of the enterprise must be based on the knowledge of the process of serving the final services/products of its end customers from the supply of raw materials and inputs that are required for this transformation (the supply chain). The construction of the hypothalamus, such as the construction of any product/service, must be the result of a design process and its subsequent implementation that is supported in a coherent guide whose purpose is to produce the hypothalamus according to the needs of the organization.

A cognitive robot is an artificial intelligence algorithm that is able to have a holistic view of a problem and solve it using high-complexity mathematical modeling. Examples of this type of intelligence are the algorithms capable of optimally planning and operating a supply chain or a hospital or factory, planning the location of facilities in a smart city, managing fleets of vehicles optimizing energy consumption, scheduling the staff plant (formal and informal) of a company, controlling the risk associated with the financial distribution of assets and liabilities of an organization. An artificial hypothalamus corresponds to the integration of multiple cognitive robots that operating simultaneously, in real-time, act as the human hypothalamus.

Keywords: Artificial Hypothalamus, Artificial Intelligence, Mathematical Programming Integration, Real-Time Distributed Optimization

JEL Classification: C, L

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Mathematics is the language with which God has written the Universe".
Galileo Galilei.

Mathematics may be the language with which God has written the Human Brain

Mathematics must be the language with which humans can write the Organization Brain

Velasquez-Bermudez, Jesus.
Artificial Brains (Augmented Artificial Intelligence):
Artificial Neocortex + Artificial Hypothalamus + Artificial Hippocampus.
(Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4064851)

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23 Pages • Posted:

Jesus Velasquez
DecisionWare; Hypothalamus Ai Inc.

Date Written: March 23, 2022

Abstract

"Mathematics is the language with which God has written the Universe".
Galileo Galilei.

Mathematics may be the language with which God has written the Human Brain

Mathematics must be the language with which humans can write the Organization Brain

Three types of intelligence may be associated with the production of knowledge on which humanity develops: mental, mathematical, and analytical.

All human beings manage mental models (very quick to solve) and, in their absence, easily copy themselves from a more influential individual, and more recently, are implanted in human beings through the ochlocracy of mental models distributed by social networks. When intelligence works under this model, we will call it "Mental" Intelligence.

"Mathematical" Intelligence is oriented to use in real-time the mathematical models that describe or explain the portion of reality that is of particular interest. The mathematical models are the result of the research carried out by certain human individuals and are growing as analytical "tools" are providing greater processing speed to the investigation. For its understanding requires formal training in mathematics and in the science being modeled

Integrated Vision of Multiple Optimization Models

Board of Directors

Business Management

Decoupled Vision f Multiple Optimization Models

Board of Directors

Decomposing a system in the atoms that component it is a definitive step to understand the operation of the system based on the exchange of data that is generated within the components

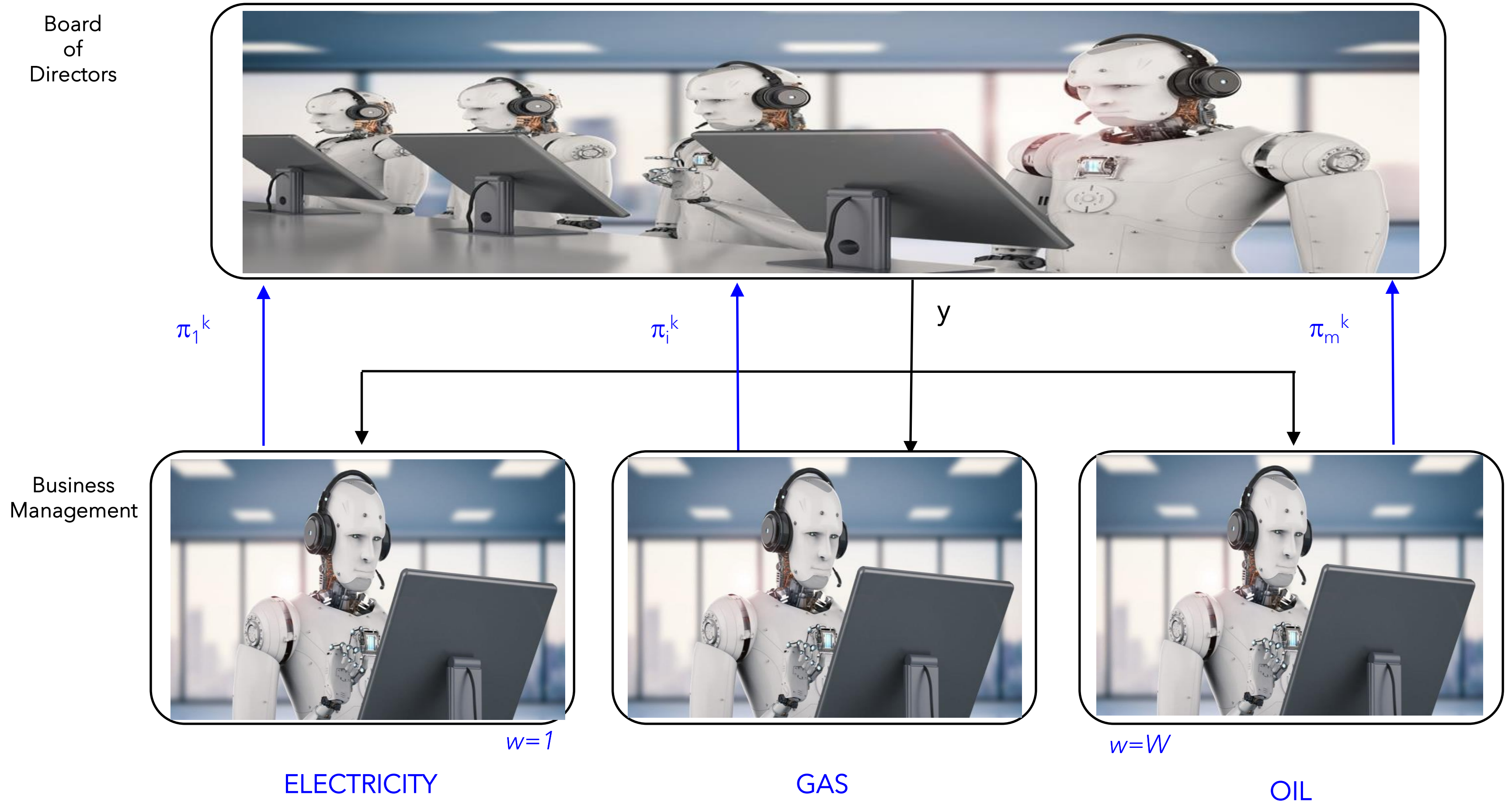
Business Management

ELECTRICITY

GAS

OIL

Enterprise Artificial Hypothalamus



To visualize the real-time operation of an organization, similar to how the human being operates, it must be accepted that the different models that represent the parts of the organization must act permanently among them, so that the organization operates as a whole.

To do this, a language for robots must be established between the models (algorithms) that involved in the organization's decision support system.

Communications Between Mathematical Problems (Algorithms, Robots, Agents, …)

The artificial hypothalamus is the algorithm that control the workflow of the models of the decision support system.

It includes the constraints that guaranties that the system is in the optimal path; these are based on duality theory.

In real time the concept of a point/trajectory must be replaced by that of "optimal path"

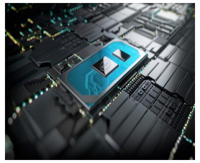
ROBOT A

OUTPT VARIABLES

$\{x^k_A, \pi^k_A\} = \Phi_A(\Theta^k)$

Θ^k

INPUT VARIABLES



$\Theta^k = \Theta^{k-1} \cup \{x^k_A, \pi^k_A\} \cup \{x^k_B, \pi^k_B\}$

$\Theta^0 = \{\}$

ROBOT B

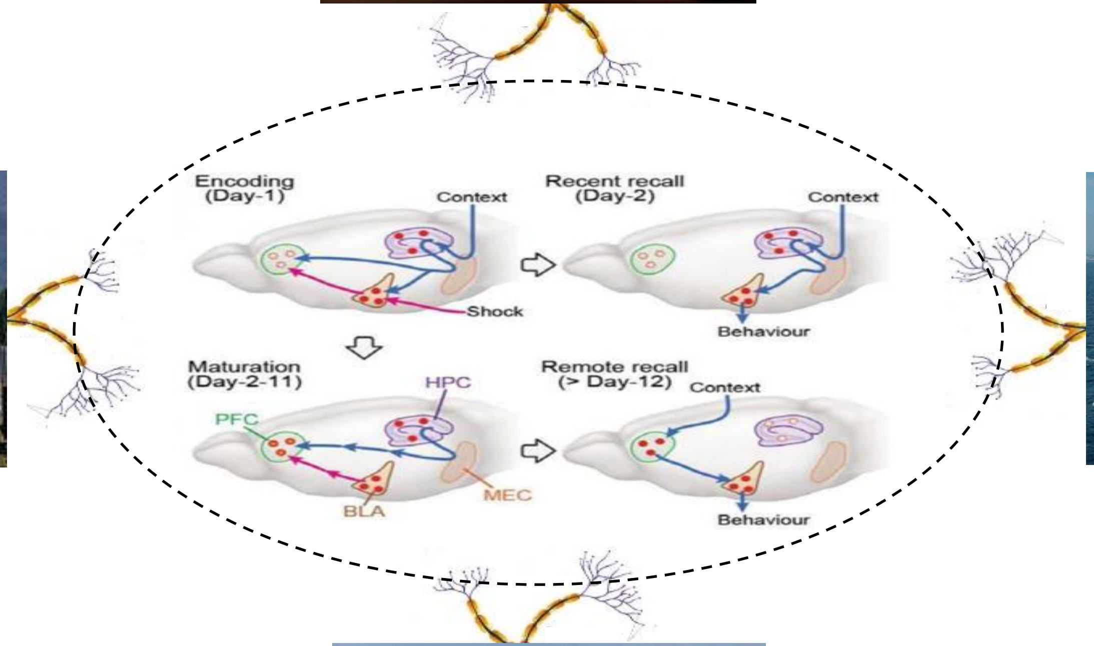
OUTPT VARIABLES

$\{x^k_B, \pi^k_B\} = \Phi_B(\Theta^k)$

The Hypothalamus of An Oil Organization

OIL
PRODUCTION

PIPES TRANSPORT



MULTI-MODE TRANSPORT

OIL
REFINING

The Hypothalamus of An Oil Organization

$$\text{Min} \quad \Sigma_t \Sigma_j \Sigma_h \, CT_t(GT_{jth})$$

sujeto a:

$$GD_{zth} - \Sigma_{u \in TN(z)} LD_{uzth} = 0$$

$$GD_{zth} + GHA_{zth} + DEF_{zth} = DEM_{zth}$$

$$EN_{uth} - \Sigma_{j \in L1(u)} GTE_{juth} - \Sigma_{v \in L2(u)} LL_{vuth} = 0$$

OIL PRODUCTION MODEL

PIPES TRANSPORT MODEL

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OIL REFINING MODEL

The Hypothalamus of An Oil Organization

OIL PRODUCTION MODEL

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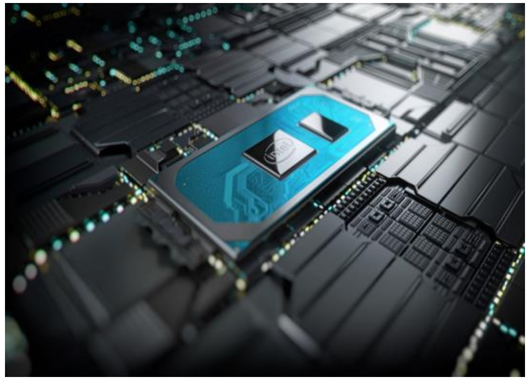

MULTI-MODE TRANSPORT MODEL

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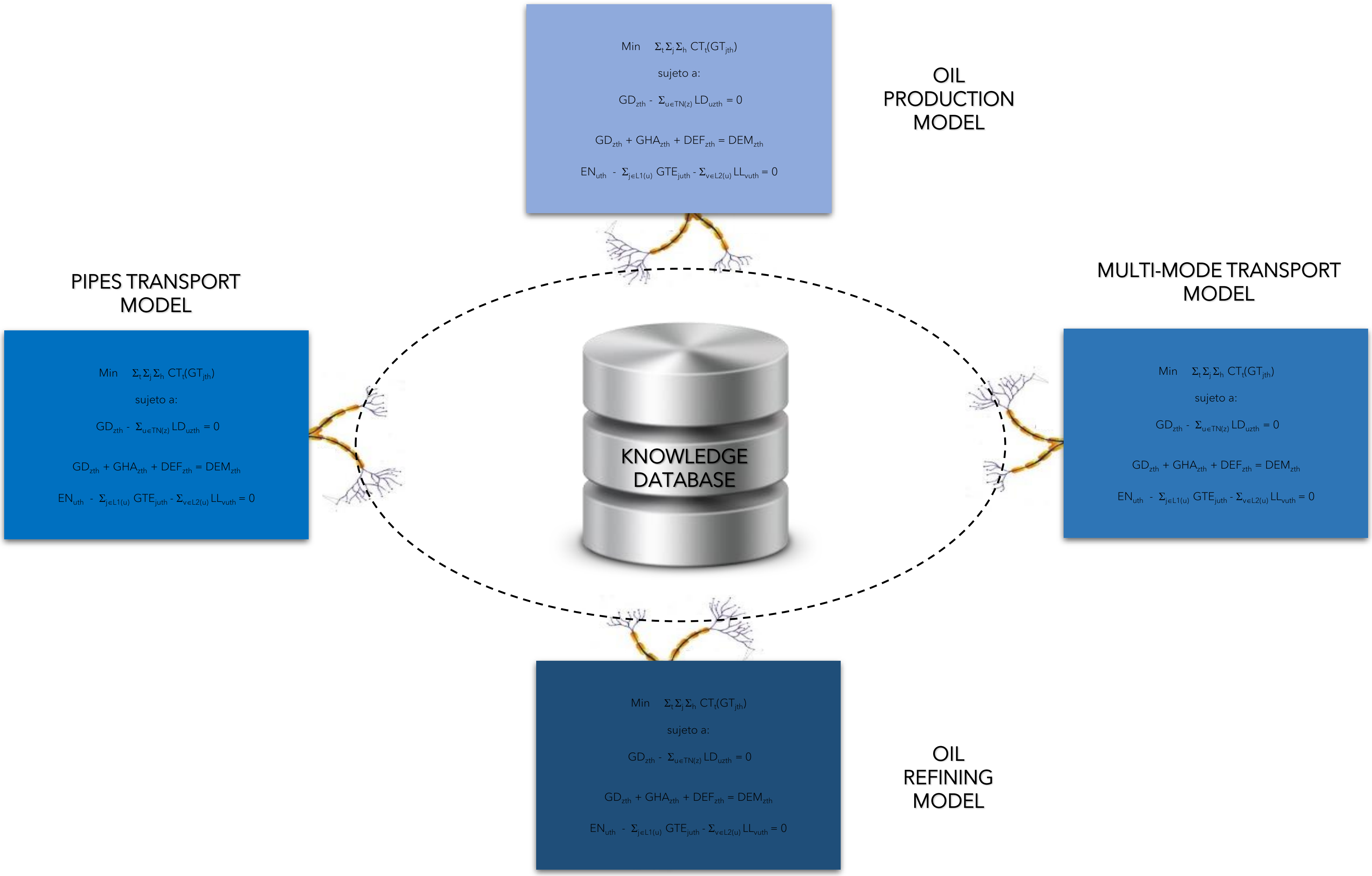
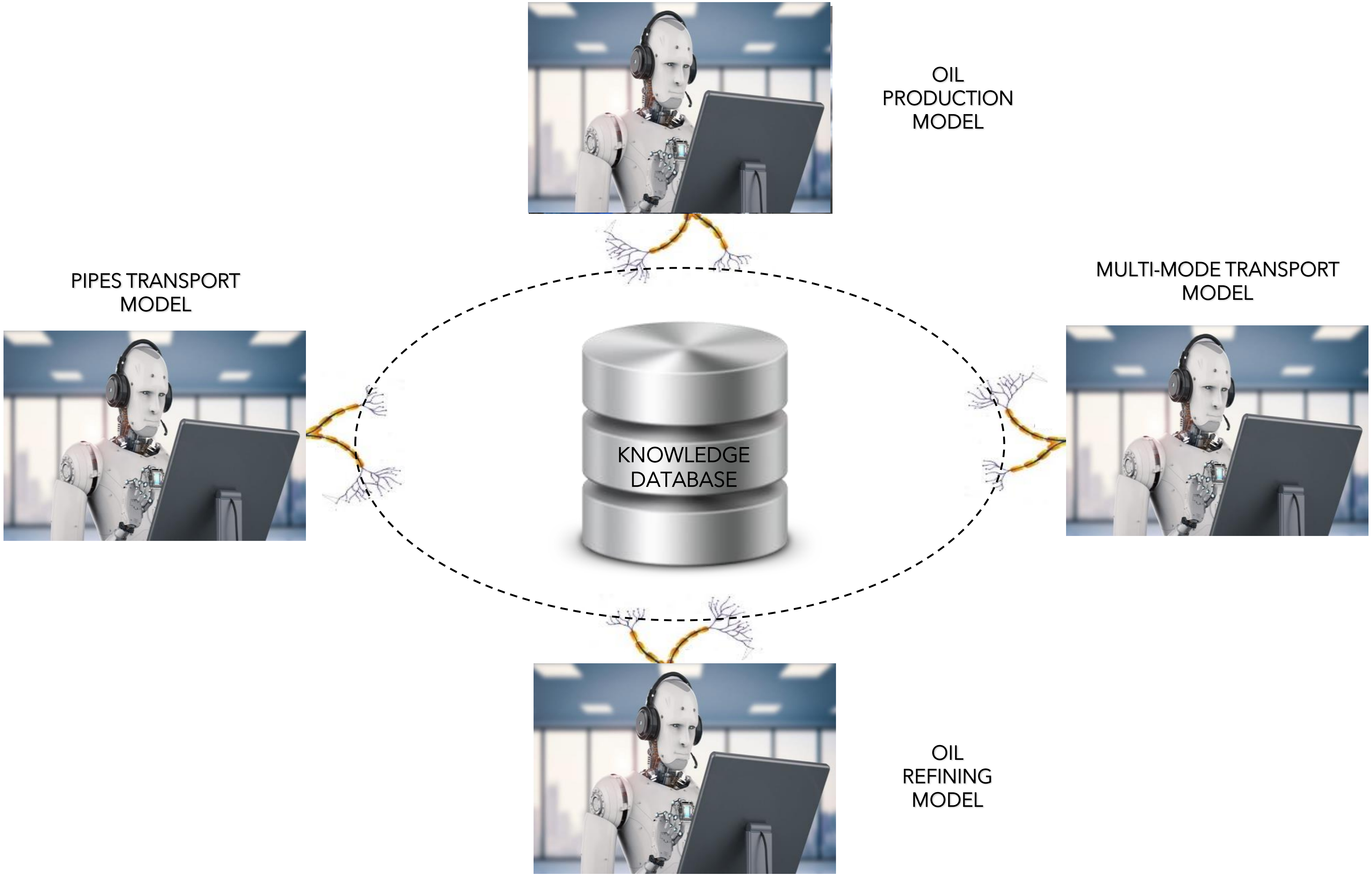
THE HYPOTHALAMUS OF AN OIL ORGANIZATION

OPTΣX



The Hypothalamus of A Multi-business Energy Enterprise



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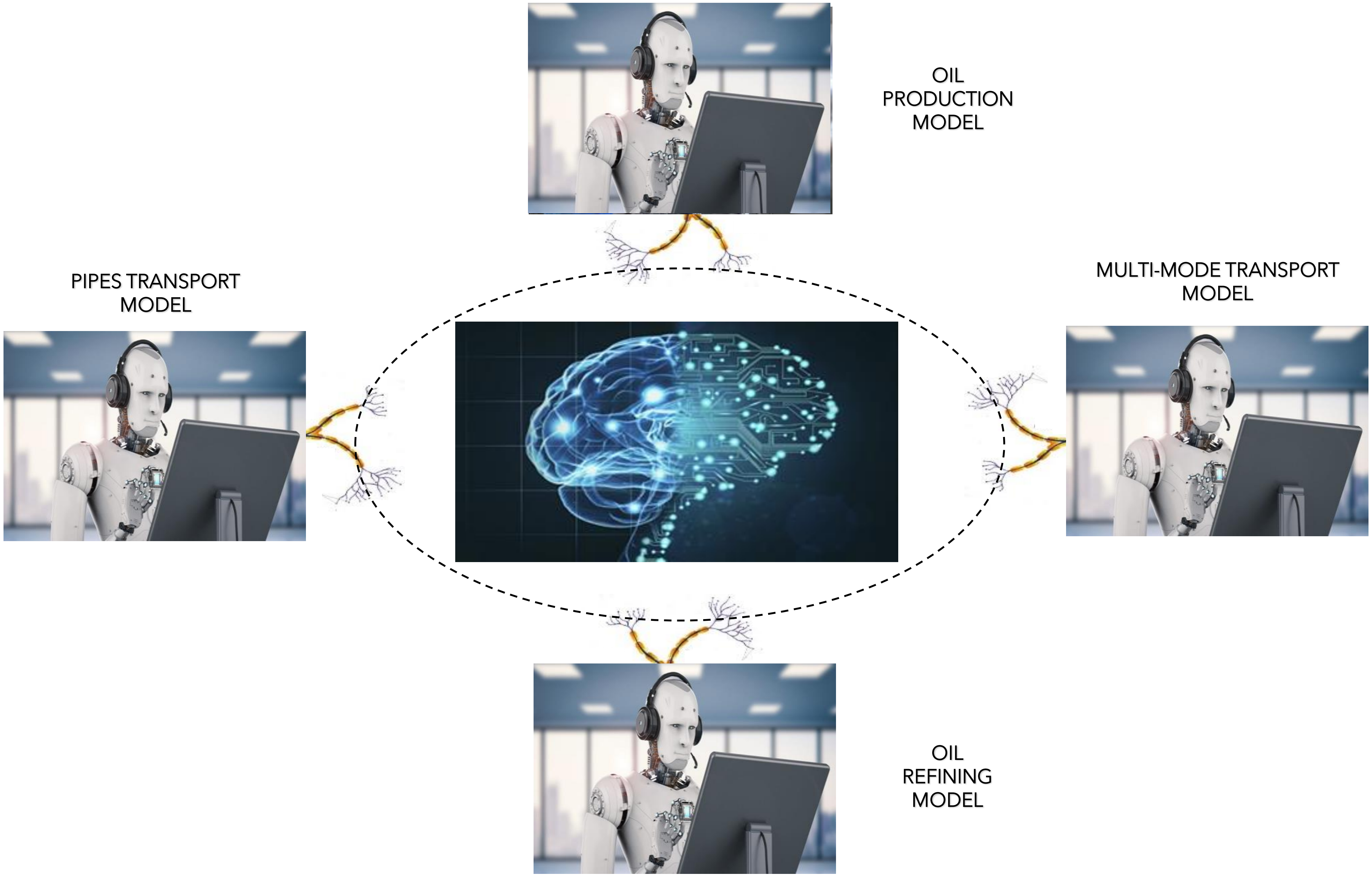
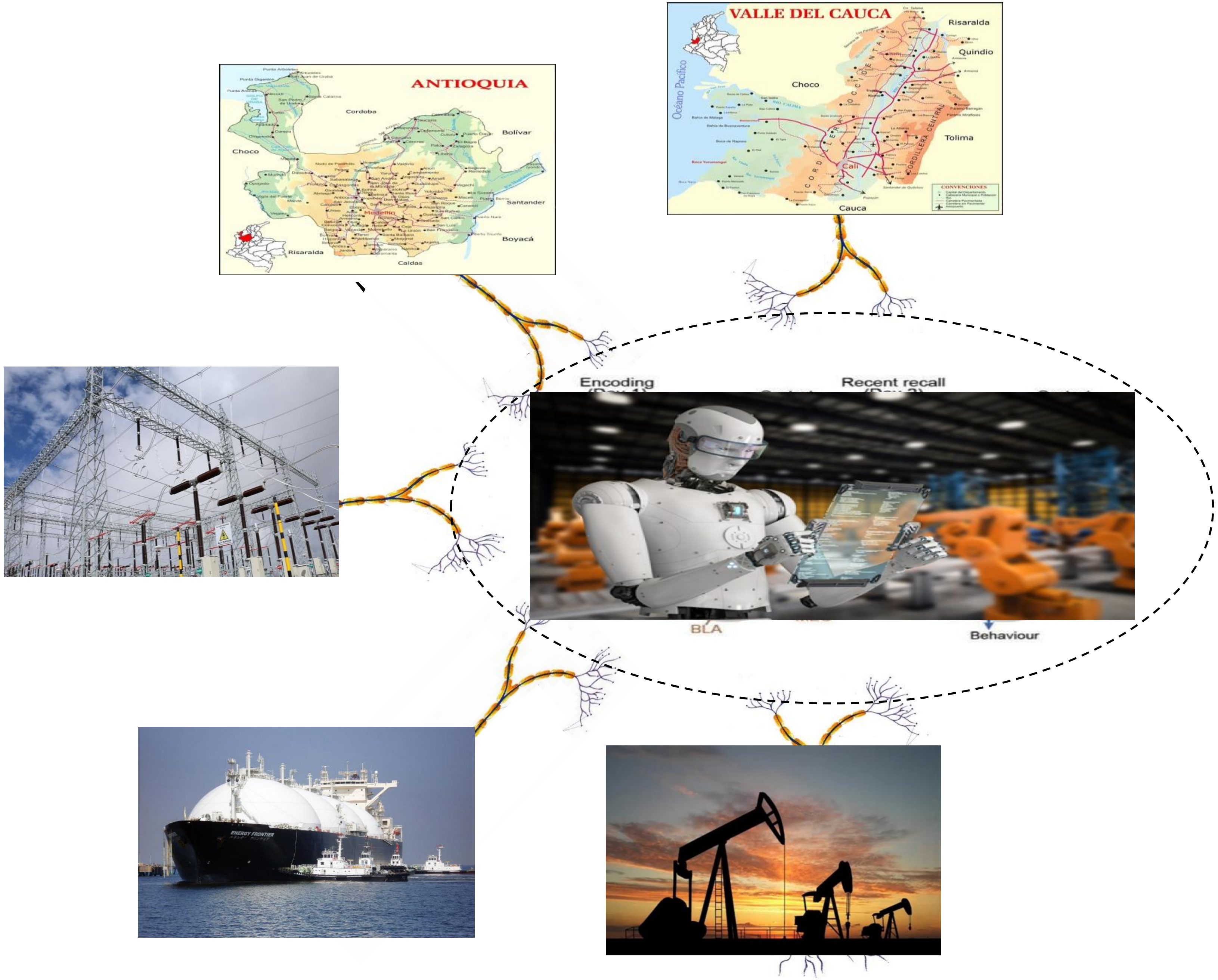


Artificial Hypothalamus: Net of Artificial Neural Nets

Artificial Hypothalamus: Net of Artificial Neural Nets



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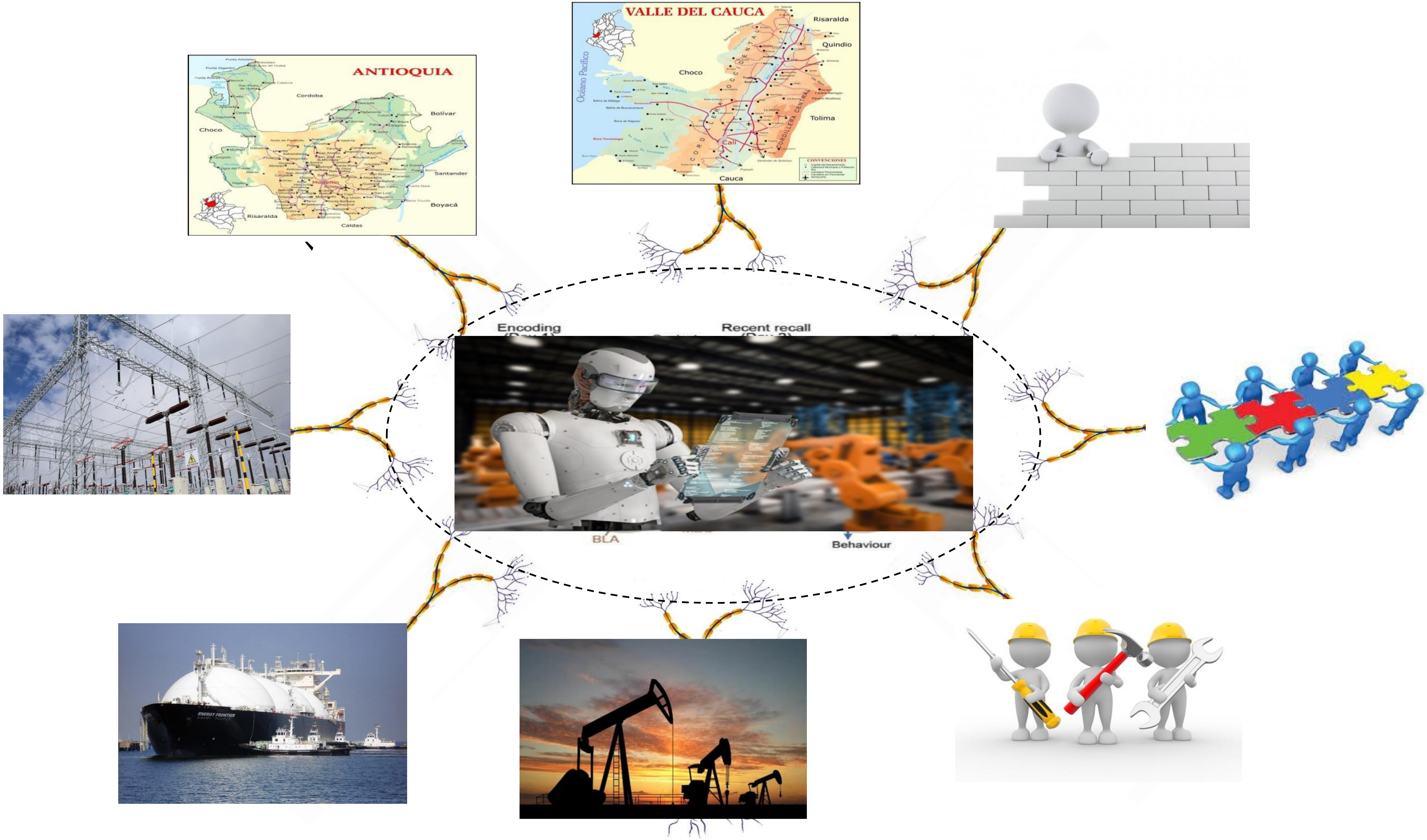


Electricity System and Market Modeling

Independent System and Market Operator (ISO)

PRIMAL VARIABLES

DUAL VARIABLES

Agents Generators

HYDROPOWER

NUCLEAR

RENEWABLES

The Hypothalamus of An Electricity Enterprise

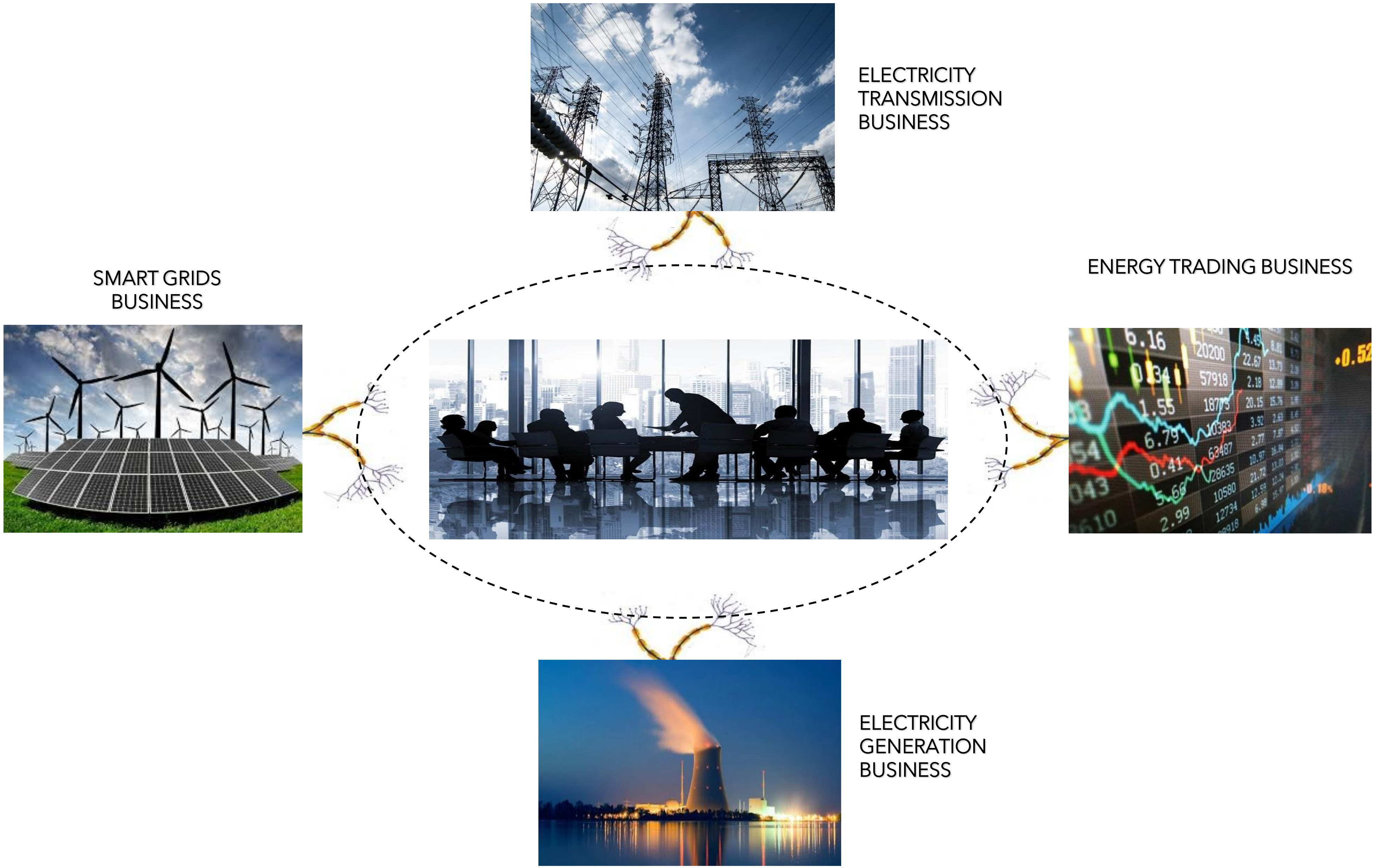
INDUSTRIAL
ASSET
MAINTENANCE

GAS
ECONOMIC DISPATCH

ETRM
ENERGY TRADING AND RISK
MANAGEMENT

ELECTRICITY
ECONOMIC
DISPATCH

The Hypothalamus of A Multi-Business Electricity Enterprise



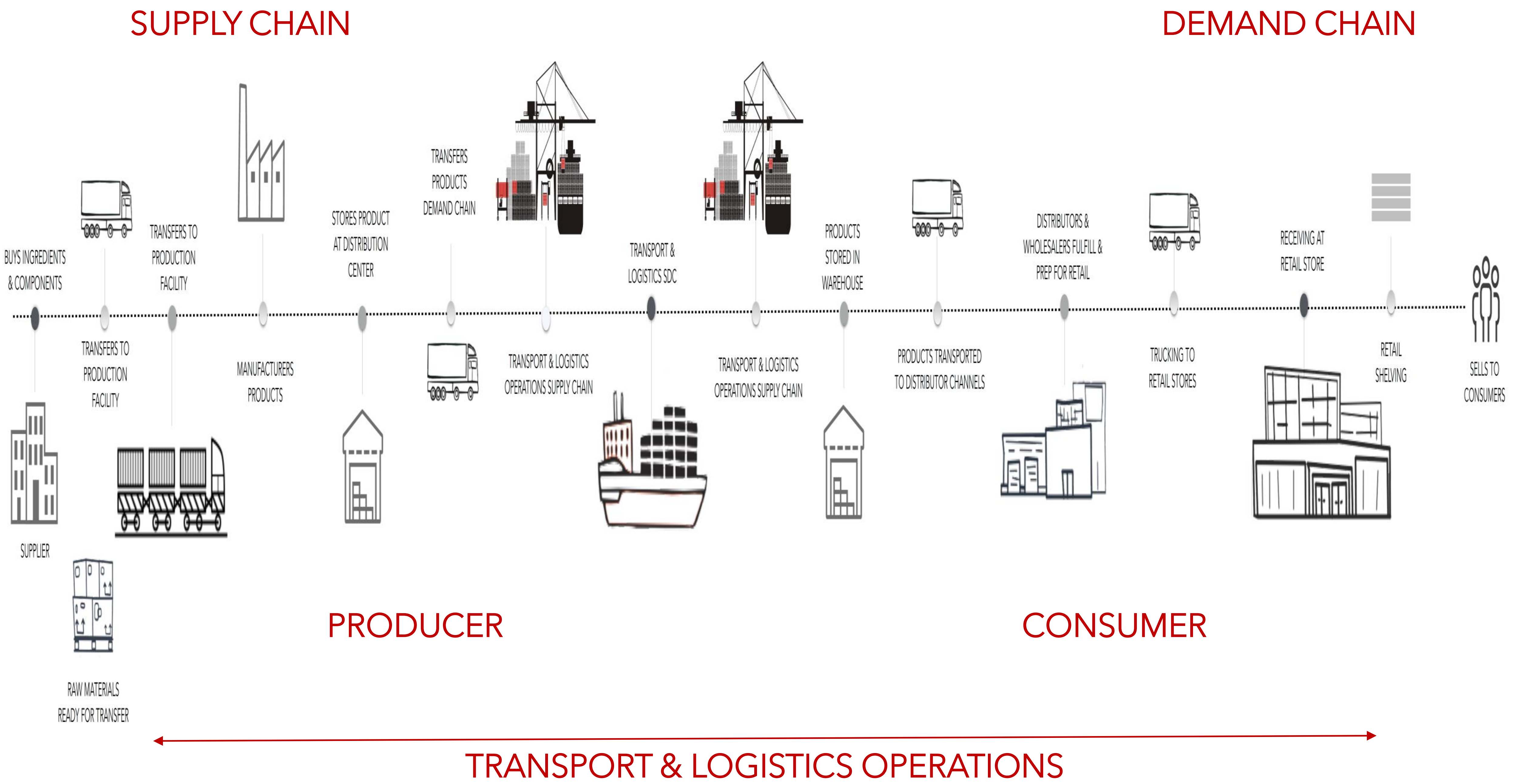

OPTΣX
Optimization Expert System
Enterprise Wide-Optimization
&
Enterprise Artificial Hypothalamus

Connection Between Models

The connection between models is given in multiple dimensions:

- **Temporal:** linking two consecutive levels of planning in the time domain: planning & scheduling and scheduling & real-time.
- **Functional:** linking two or more models associated with different functions. For example: traditional S&OP model that integrates sales and production.
- **Geographic/Regional:** linking the models of multiple regions of the subsidiaries that make up a global chain.
- **Multi-business:** linking the models that integrate the multi-business supply chain of an organization. Example: Oil companies made up of exploration, production, raw transfer, refining, refining and distribution businesses.
- **Multisectoral:** uniting the models of the multiple sectors that make up a macro-sector of the economy: Example: Energy sector composed of the sectors: electricity, gas, oil and biofuels.

Transport & Logistics Chain Optimization



Hierarchical Coordination of Planning Tools

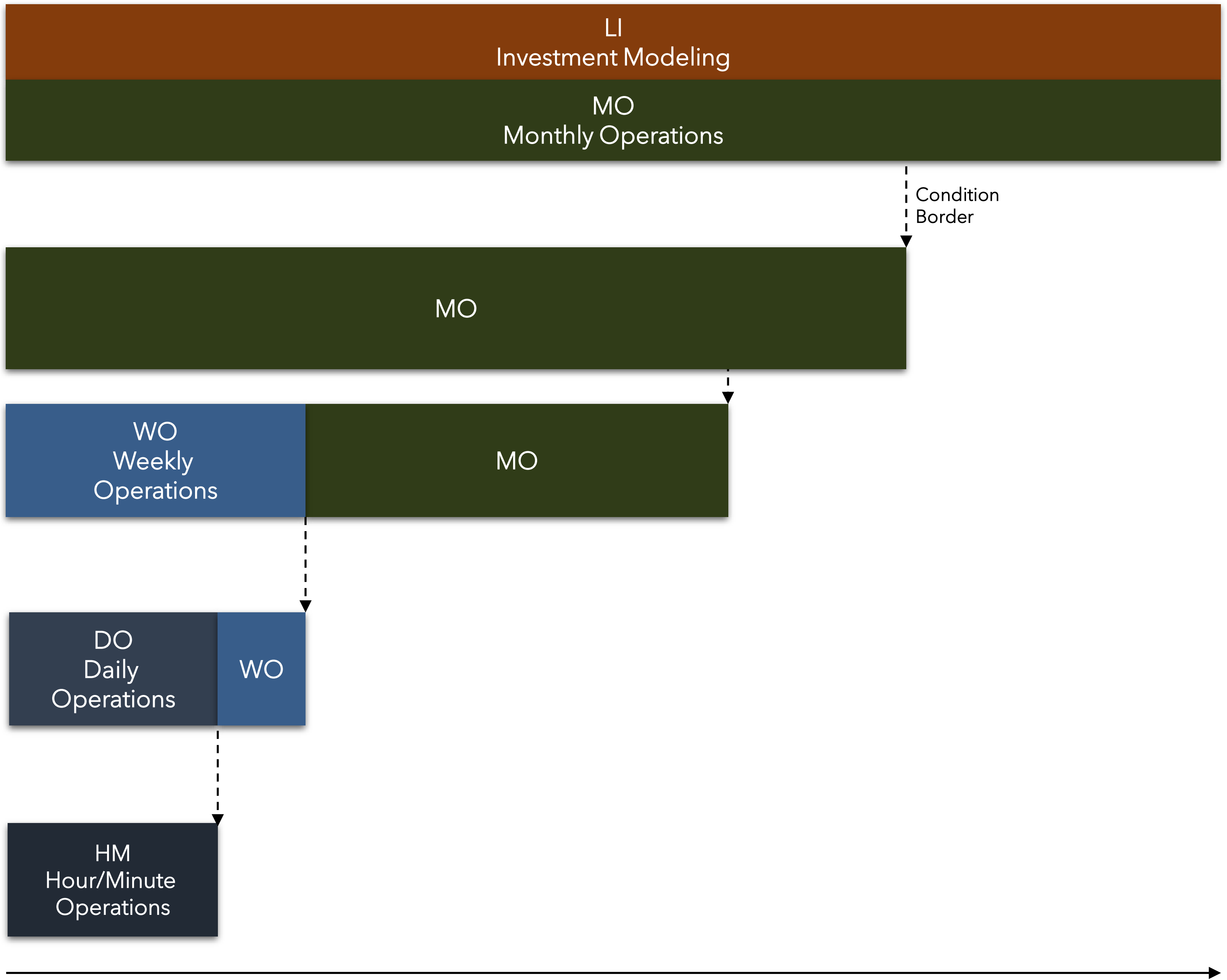
STRATEGY
LONG-TERM INVESTMENT

MEDIUM-TERM TACTICS
SHORT-TERM TACTICS
SHORT/MEDIUM TERM
OPERATIONAL GOALS

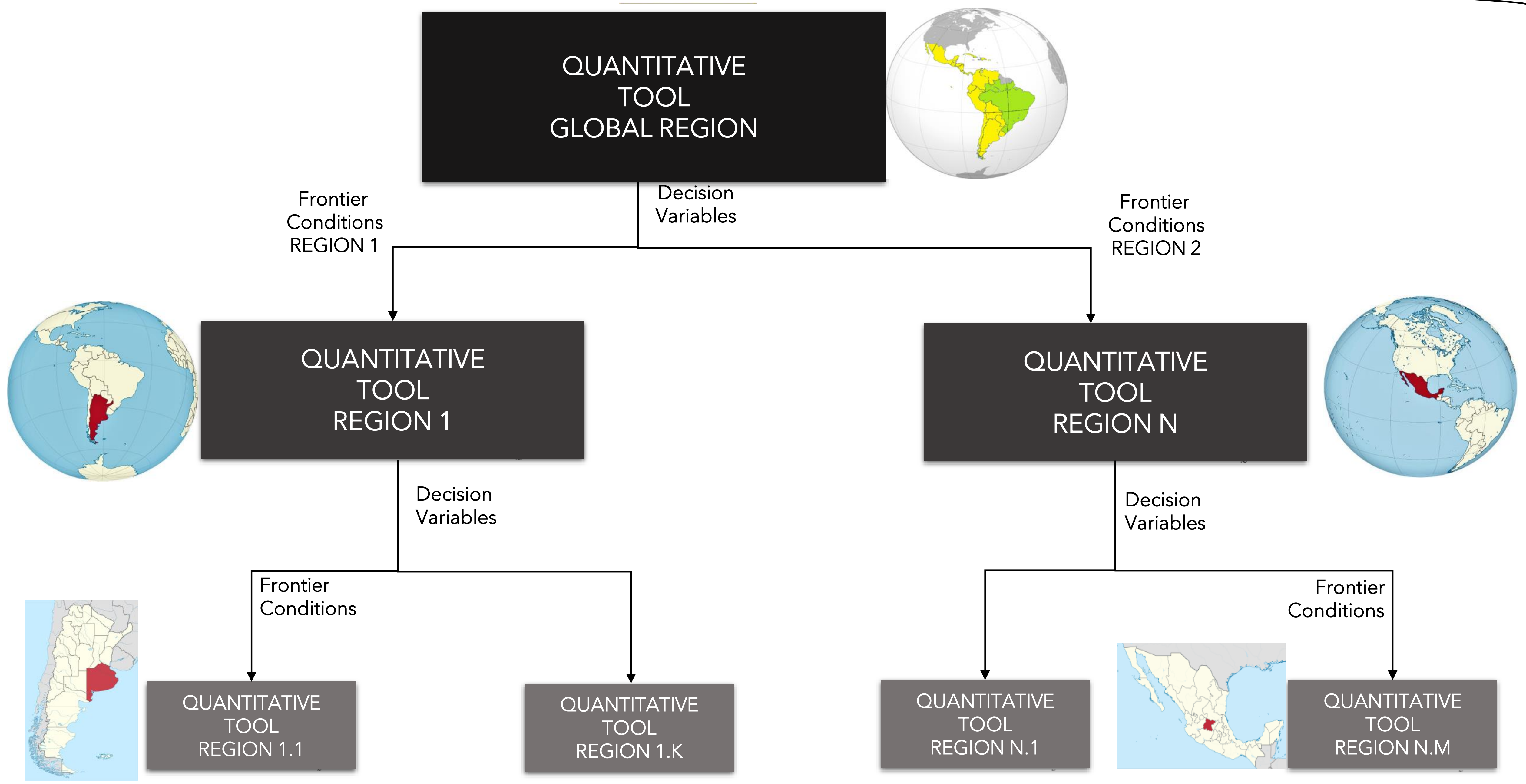
SCHEDULING OPERATIONS
OPERATION COMMANDS/ORDERS

REAL-TIME – OPTIMIZATION
ADVANCED OPTIMAL CONTROL

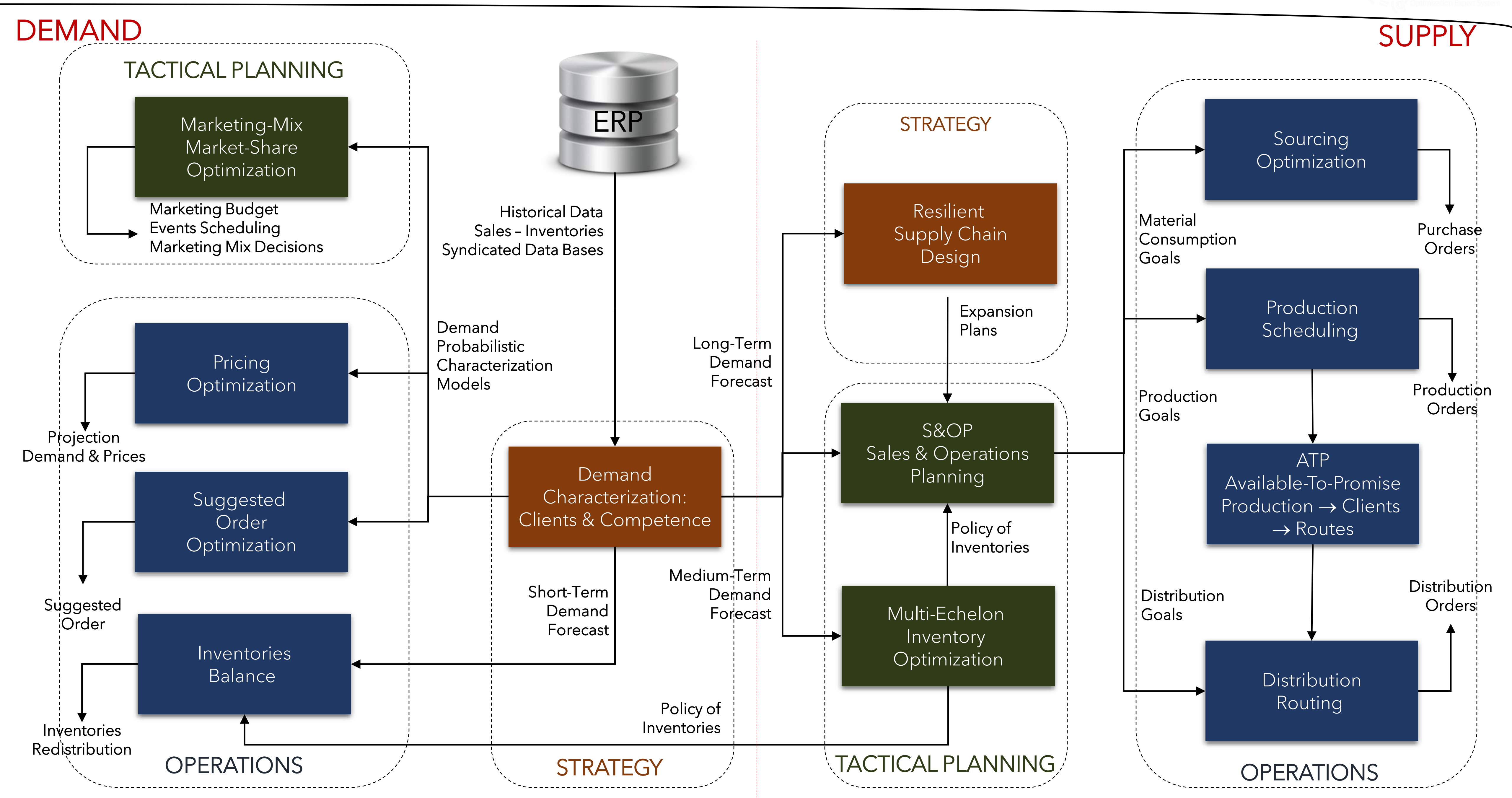
REAL-TIME – DISTRIBUTED OPTIMIZATION
INDUSTRY 4.0 OPTIMAL CONTROL



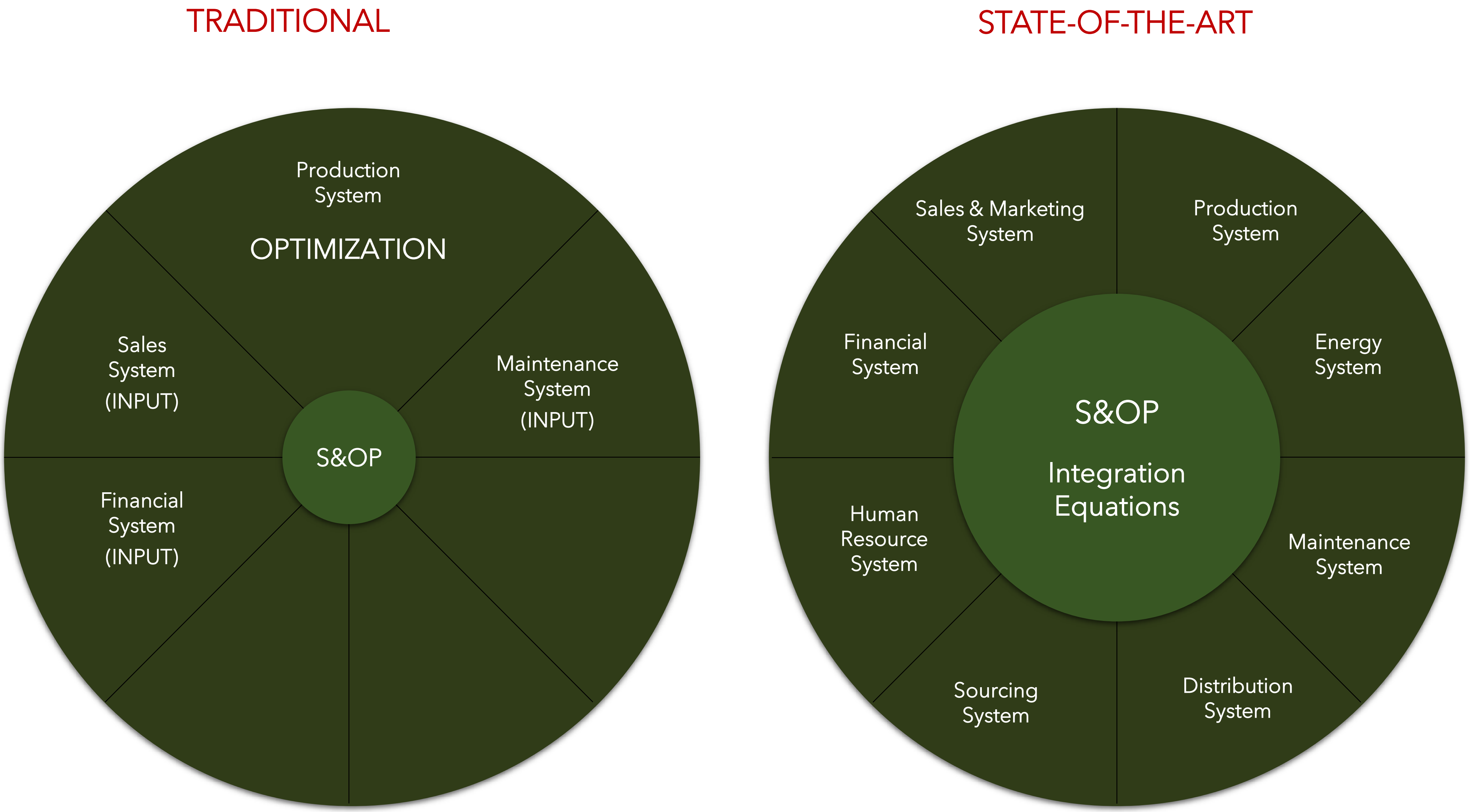
Global Supply Chain Optimization



Optimization Models for Industrial Value Chains

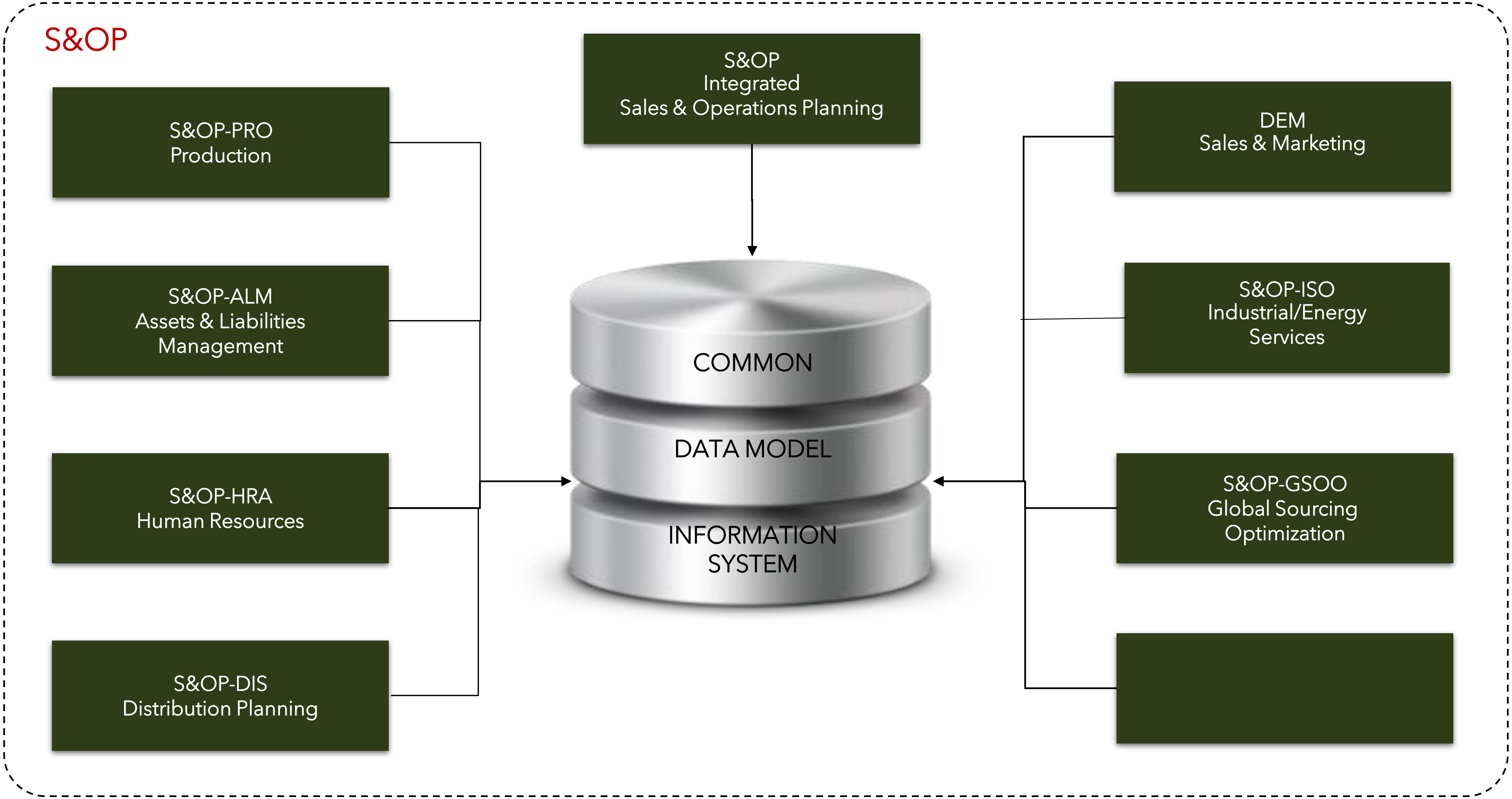


S&OP: Sales & Operations Planning

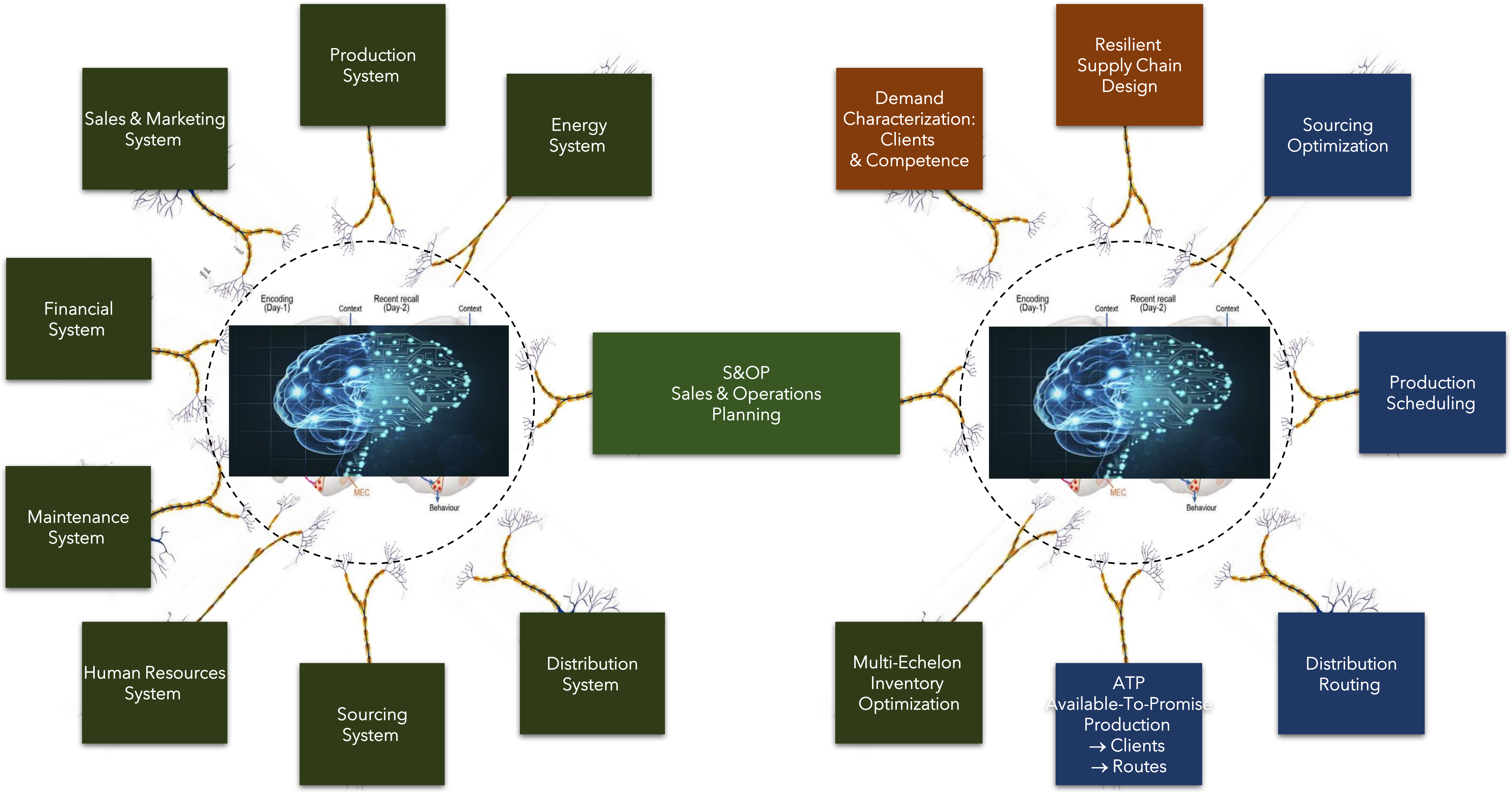


S&OP: Sales & Operations Planning - Models Integration

OPTΣX



Enterprise-Wide Artificial Hypothalamus



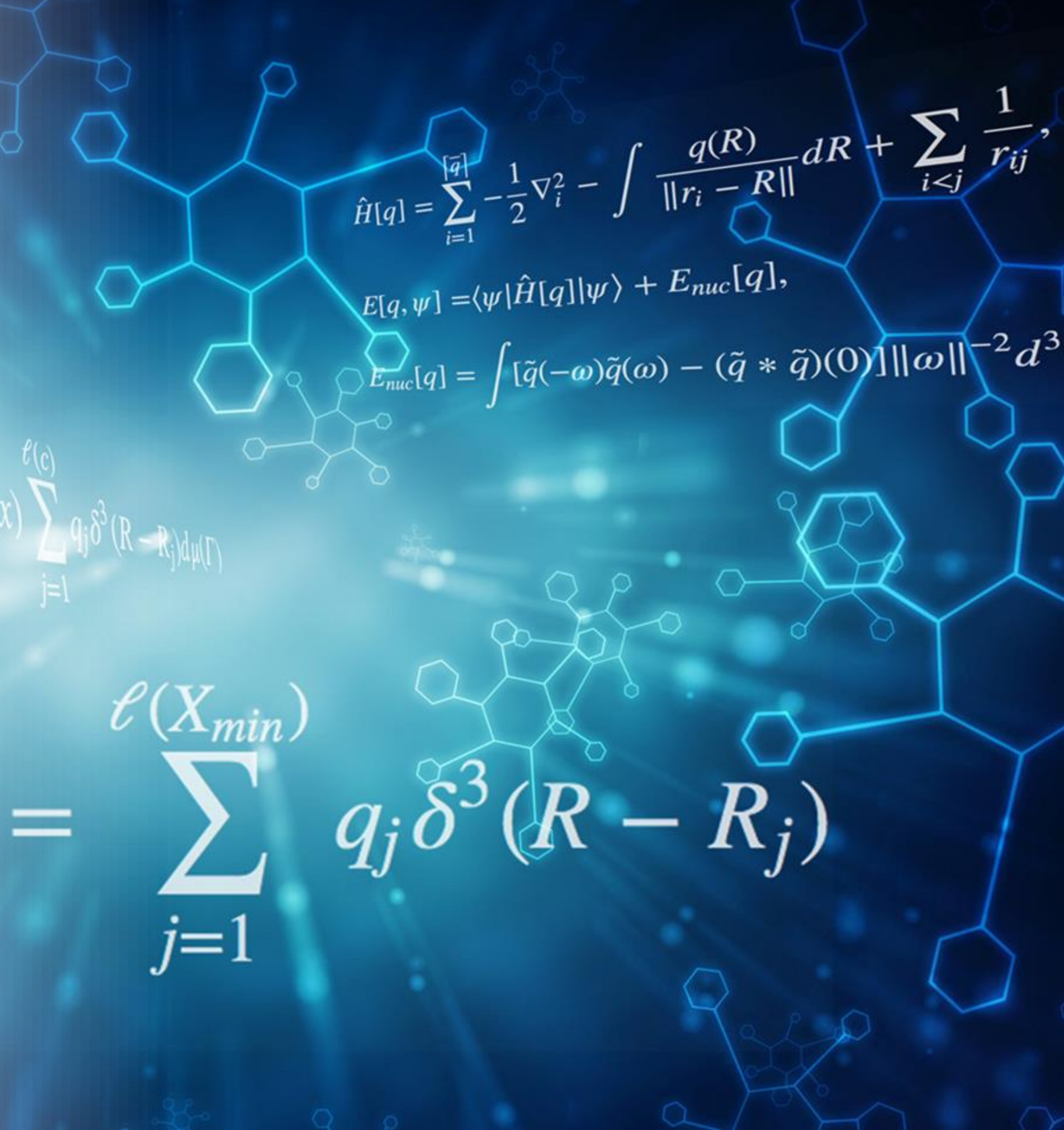
Mathematical Programming
A Standard for Mathematical Modeling

If the formulation of algebraic expressions is normalized, it is possible to have a standard way of representing a mathematical model that can be understood by another mathematical modeler, making mathematical programming a standard for formulating this type of problem.

Additionally, the combination/division of mathematical programming problems generates new mathematical programming problems, which can be solved in multiple ways using the same computer technology.

Therefore, to facilitate the development of models, and take advantage of modern computer technologies, it is convenient to establish basic principles of modeling (norms, standards) in order to enhance the use of models and ensure that they, and their technological platform, remain in force over time, thanks to conceiving as a dynamic structure that adapts to changes in computer technologies.

This implies, prior to the implementation of mathematical models, establishing a standardization manual that guarantees the understanding of the mathematical model, by any professional knowledgeable about the subject. This fact will result in the portability of mathematical models and the significant decrease in the implementation time of mathematical models.



HAVING IN THE MIND THAT A MATHEMATICAL PROGRAMING (MP) STORED IN AN INFORMATION SYSTEM IS AN STANDARD; THEN IT IS POSSIBLE TO JOIN TWO MP PROBLEMS TO OBTAIN A NEW MODEL.

$$Min\ \Psi = \sum_{t=1}^{T}\sum_{i=1}^{N_T}\psi_{(i,t)}$$

s.a.

MATHEMATICAL PROGRAMMING

$$\psi_{(i,t)} = \frac{c_{(i,t)}}{2}\cdot P_{(i,t)}^{2} + e_{(i,t)}\cdot P_{(i,t)}$$

$$V_{(j,t+1)} = V_{(j,t)} + \tau\cdot\left(A_{(j,t)} - Q_{(j,t)} - S_{(j,t)}\right)$$

$$P_{(j,t)} = \rho_{(j)}\cdot Q_{(j,t)}$$

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THE UNION OF MATHEMATICAL PROGRAMMING PROBLEMS GENERATES
A NEW MODEL OR A VARIATION OF AN ALREADY EXISTING MODEL

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ELECTRICITY

$$V_{(j,t+1)} = V_{(j,t)} + \tau \cdot \left(A_{(j,t)} - Q_{(j,t)} - S_{(j,t)}\right)$$

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GAS

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=

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ELECTRICITY

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GAS

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THE UNION OF MATHEMATICAL PROGRAMMING PROBLEMS GENERATES
A NEW MODEL OR A VARIATION OF AN ALREADY EXISTING MODEL

ELECTRICITY

+

=

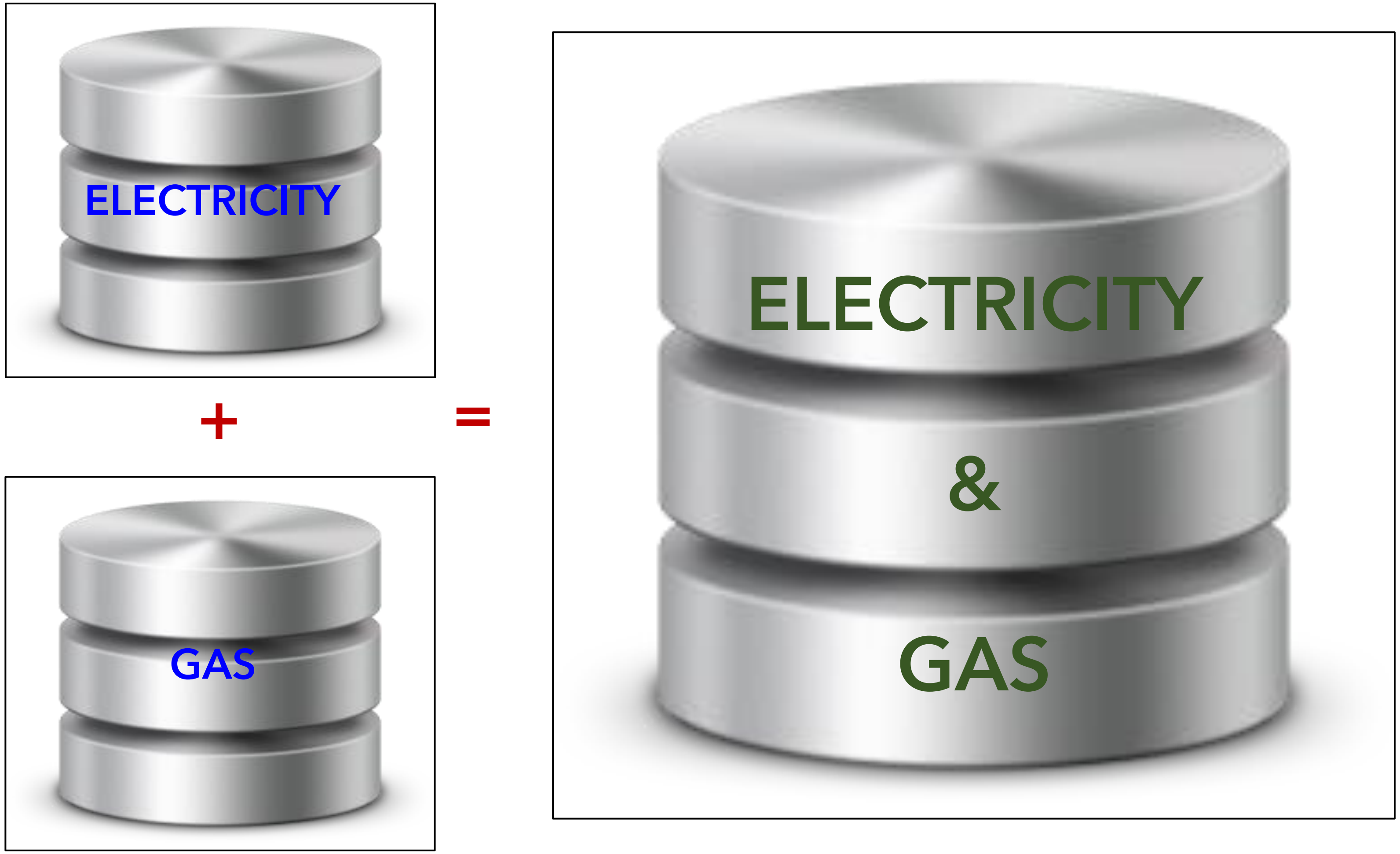
ELECTRICITY

&

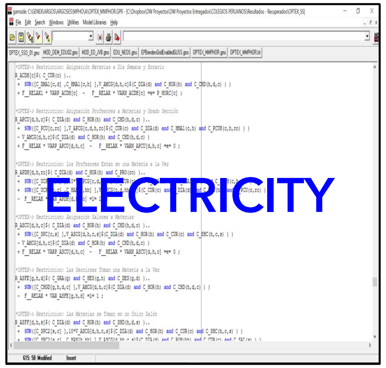
GAS

GAS

THE UNION OF COMPONENTS OF AN INFORMATION SYSTEM GENERATES
A NEW CORRECT INFORMATION SYSTEM



THE UNION OF COMPUTER PROGRAMS DOESN'T GENERATE
A NEW CORRECT COMPUTER PROGRAM



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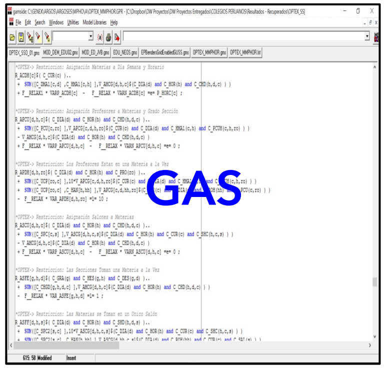

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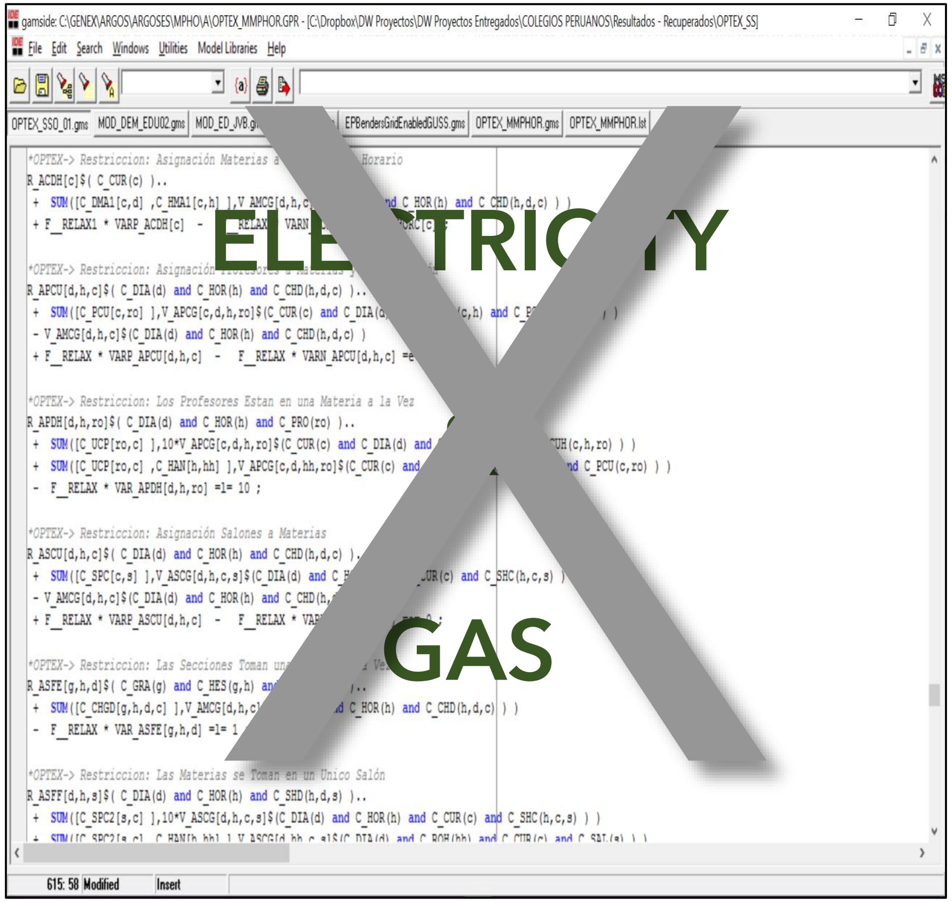
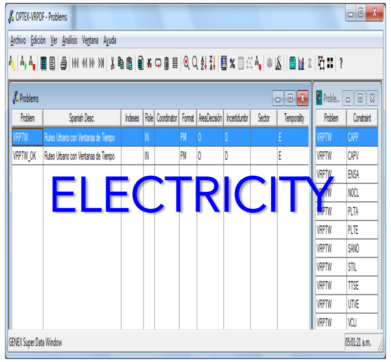


MATHEMATICAL PROGRAMING AS STANDARD

OPTEX CAN GENERATE EASILY A NEW MODEL AS THE ADDITION OF TWO OR MORE MP MODELS
OR AS VARIATION OF AN ALREADY EXISTING ONE



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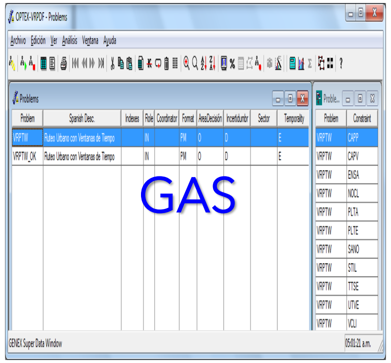

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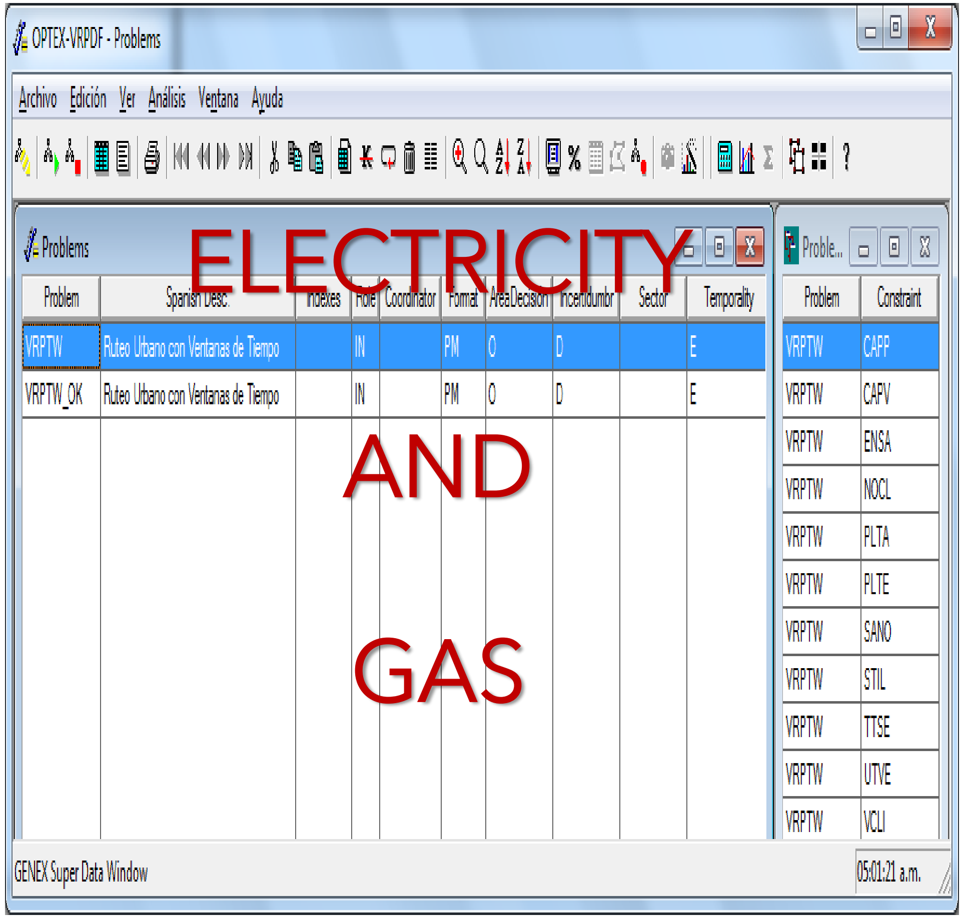
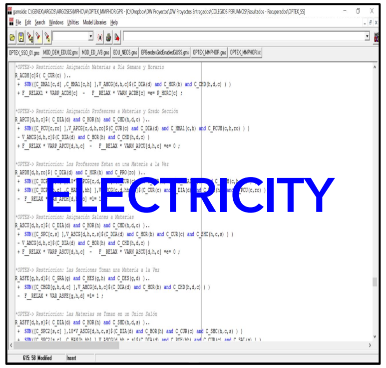


THE UNION OF COMPUTER PROGRAMS DOESN'T GENERATE A NEW CORRECT COMPUTER PROGRAM

BUT WE CAN MAKE THE PROCESS IN THE DATABASE AND THEN GO TO GENERATE THE NEW PROGRAM



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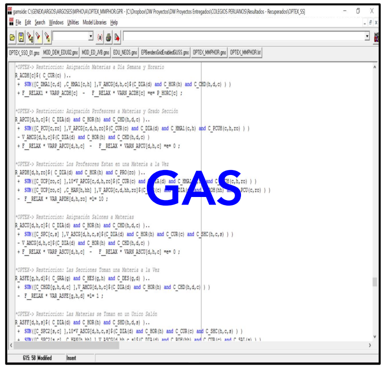

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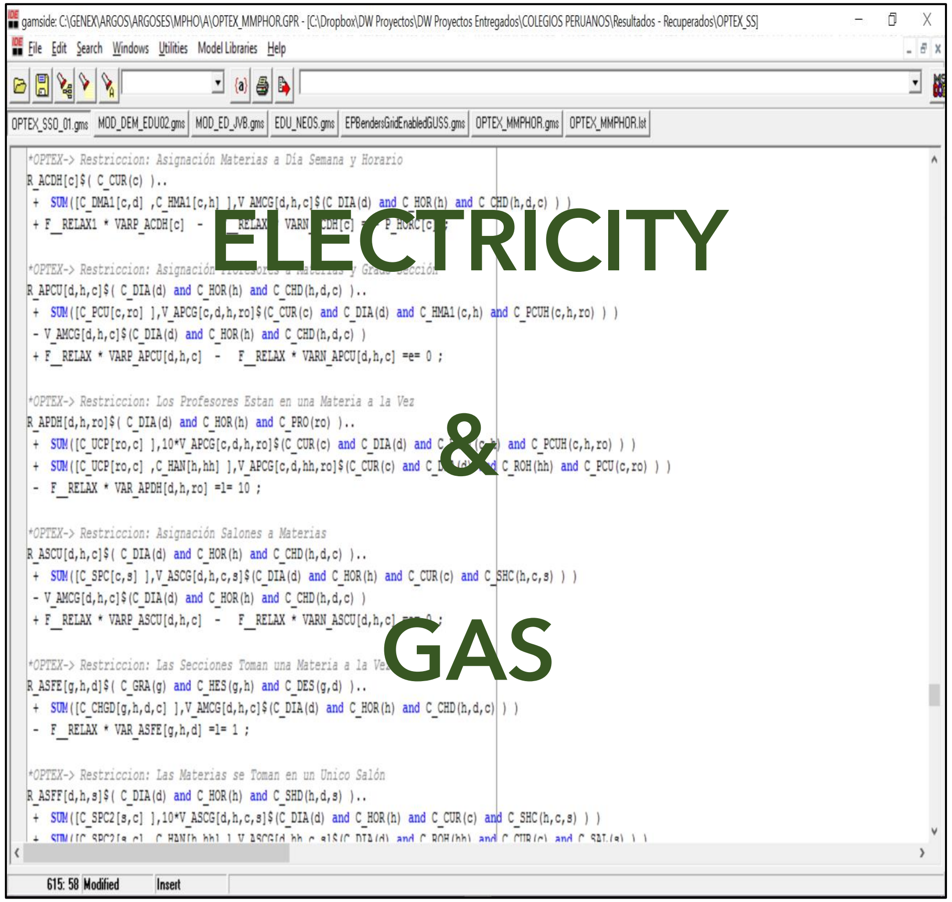

OPTEX Structured Mathematical Modeling

(Making Mathematical Models as LEGO Models)

Optimization Expert System

Making Mathematical Models
as
LEGO Models

Research Center for Advanced Decision Technologies

OPTEX Structured Mathematical Modeling

A mathematical model can be conceived as the union of mathematical components harmoniously integrated.

There are two types of components (objects):

1. Basic Mathematical Definitions:
   i. Index
   ii. Sets,
   iii. Parameter,
   iv. Equations (Constraints)

2. Advanced Concepts:
   i. Problems
   ii. Models
   iii. Decision Support Systems
   iv. Artificial Hypothalamus

These components can be stored in a relational information system, it permits their handling in a modular way, following the principles of relational information systems and use Structured Query Language (SQL) to manipulate the mathematical objects.

This conceptualization is independent of optimization technologies, which allows to separate the formulation of the mathematical models from their implementation using a specific optimization technology.

Constraints: The Molecule of a Mathematical Model

The nuclear unit ("the molecule") of a mathematical model is the constraint (equqtions), which is the result of integrating various types of atoms:

1. Indexes
2. Sets
3. Parameters

Based on the constraints, more complex mathematical structures are built:

i. Problems: sets of equations and/or set of problems
ii. Models: sets of problems and/or set of models
iii. Decision Support System: set of models
iv. Artificial Hypothalamus

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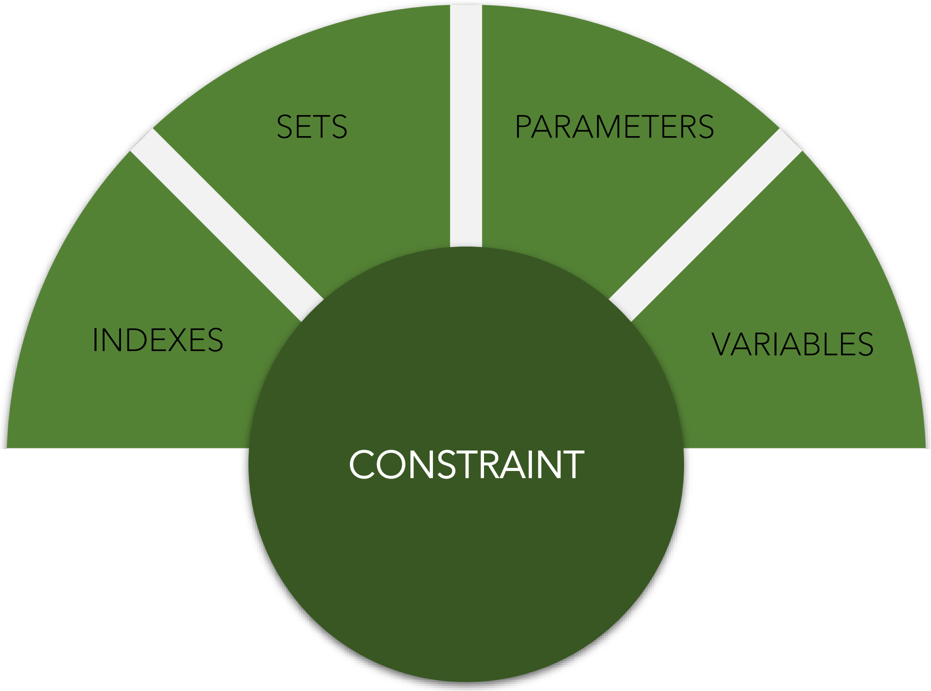


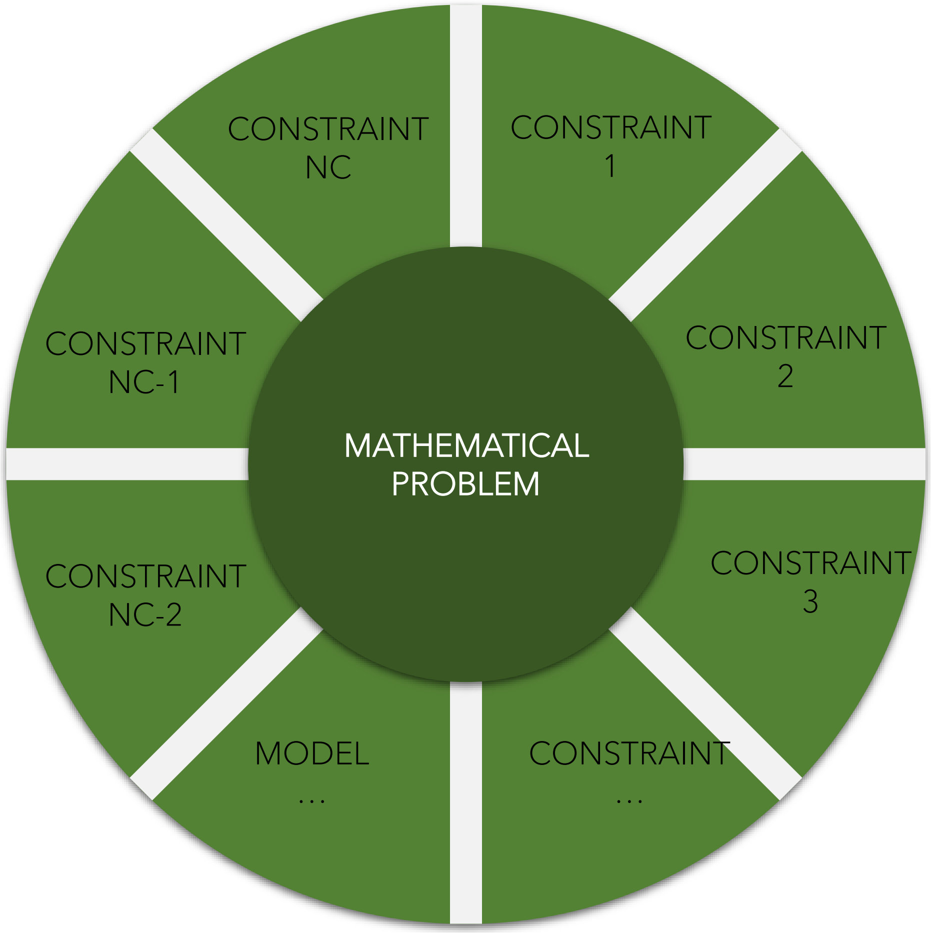
Mathematical Problem: A Set of Constraints

Based on the constraints, more complex mathematical structures are built:

i. Problems
ii. Models
iii. Decision Support Systems
iv. Artificial Hypothalamus

Problems are defined based on the set of constraints that integrate it.

If the modeler has built a database of equations (equations store) he can assemble as many mathematical problems as the combinatorics of the constraints that can be assembled.



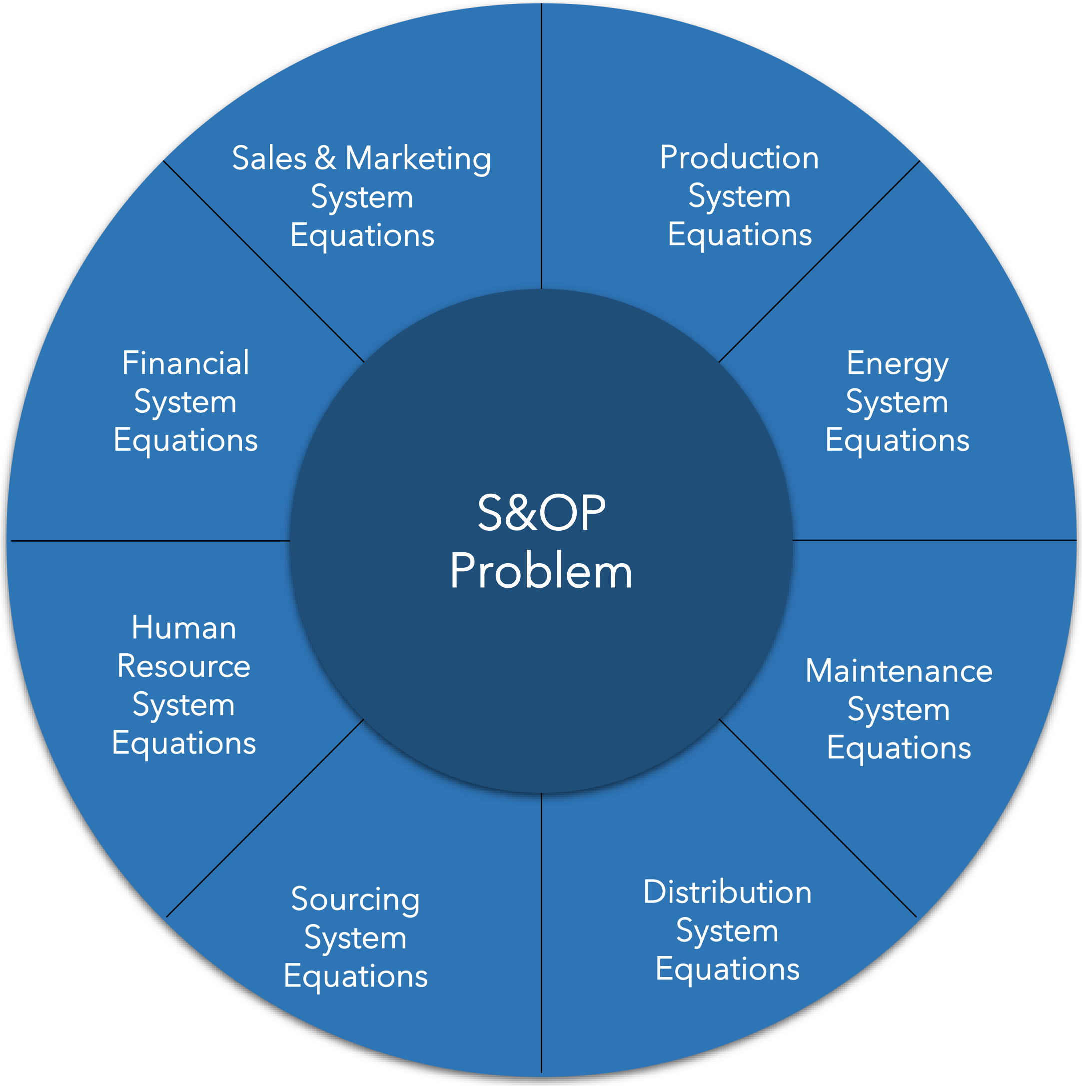
S&OP: Sales & Operations Planning Problem

For example, the figure represents a mathematical problem related to the S&OP (Sales & Operations Planning) that may be constructed based on eight groups of equations.

1. Production System
2. Energy System
3. Maintenance System
4. Distribution System
5. Sourcing System
6. Human Resources System
7. Financial Systems
8. Sales & Marketing System

The view the systems (groups of equations) that must be included in the S&OP mathematical problem depends on many factors, so that there is no "revealed truth" regarding what the S&OP problem is.

Since the equations are defined in a database, the configuration of a problem is limited to selecting from the "equation store" which are the ones that the modeler want to consider in the model.



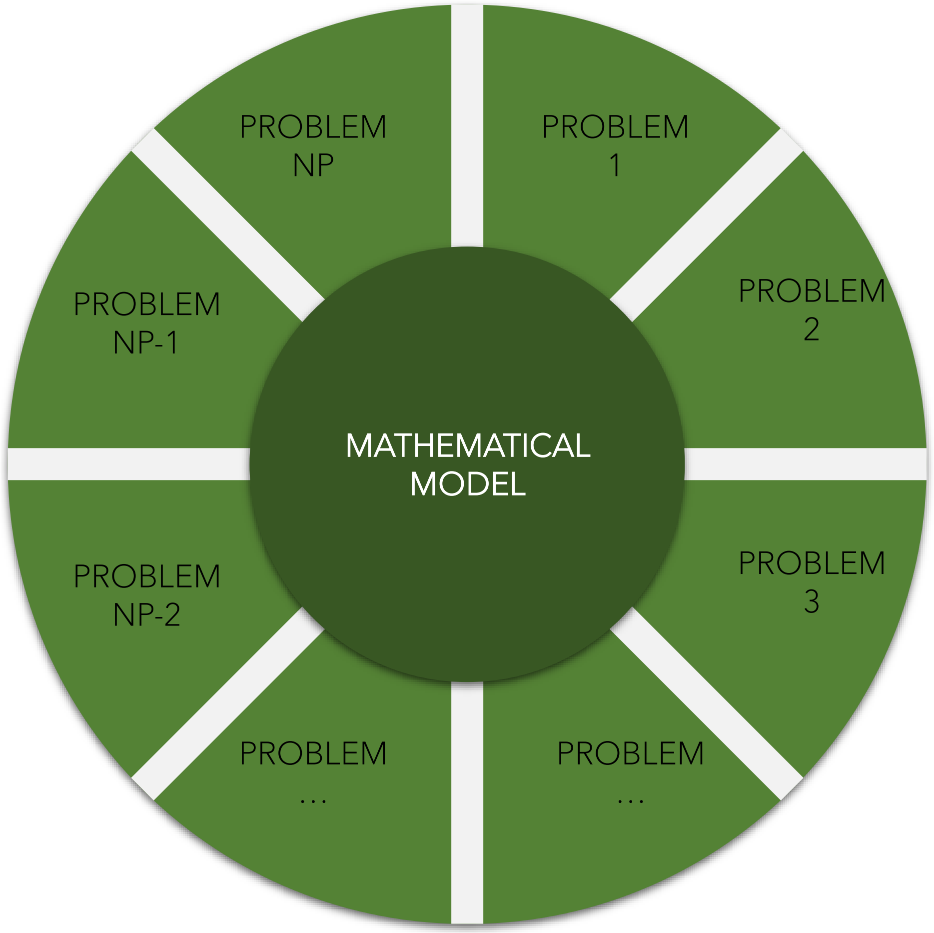
Mathematical Model: A Set of Problems

Under the traditional approach (the basic) a mathematical model is defined based on a single mathematical problem that is solved in an integrated way using an optimization :solver".

This approach is easy to implement, however it does not allow the use of large-scale optimization methodologies that allow solving problems of high complexity using parallel optimization.

If you want to use high-performance computing technologies, based on parallel processing, you need to divide the mathematical model into multiple problems. The model may be divided to the most elementary components (atoms) of the physical system, there will be a significant gain in the solution time and in the understanding of the inner operation of the system.

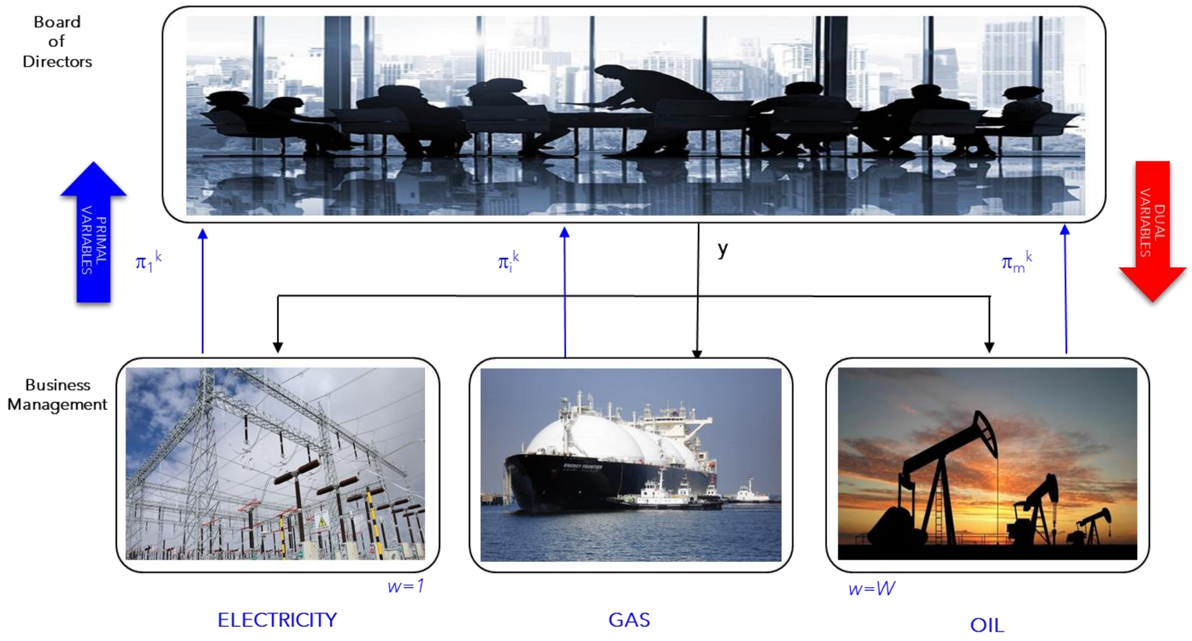
To solve the model, it is necessary to define a large-scale optimization methodology that defines the processing of information in each problem.

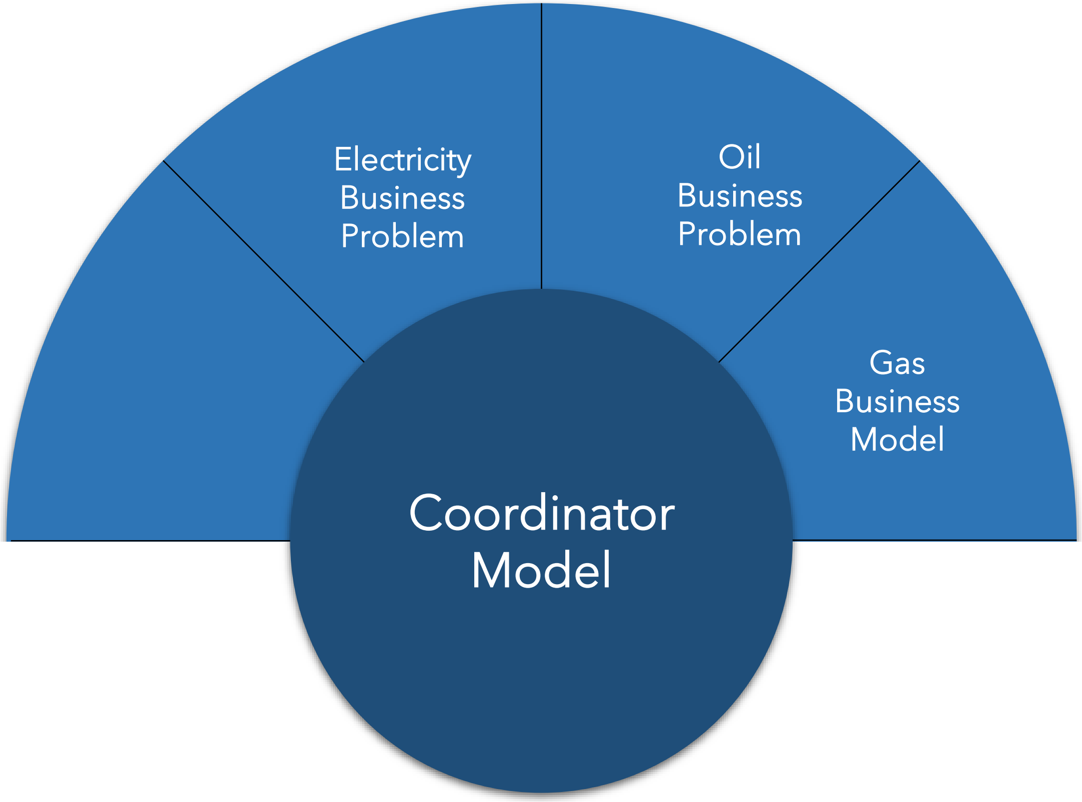


For example, the figure represents a mathematical model for a multi-business enterprise, that operates three business: electricity, oil and gas.

The integrated model of the company will be the union of the three problems. However, the modularity of the modeling, allows to have individual models for each business.

In this case, the data communication for the Lagrangean relaxation methodology is presented.



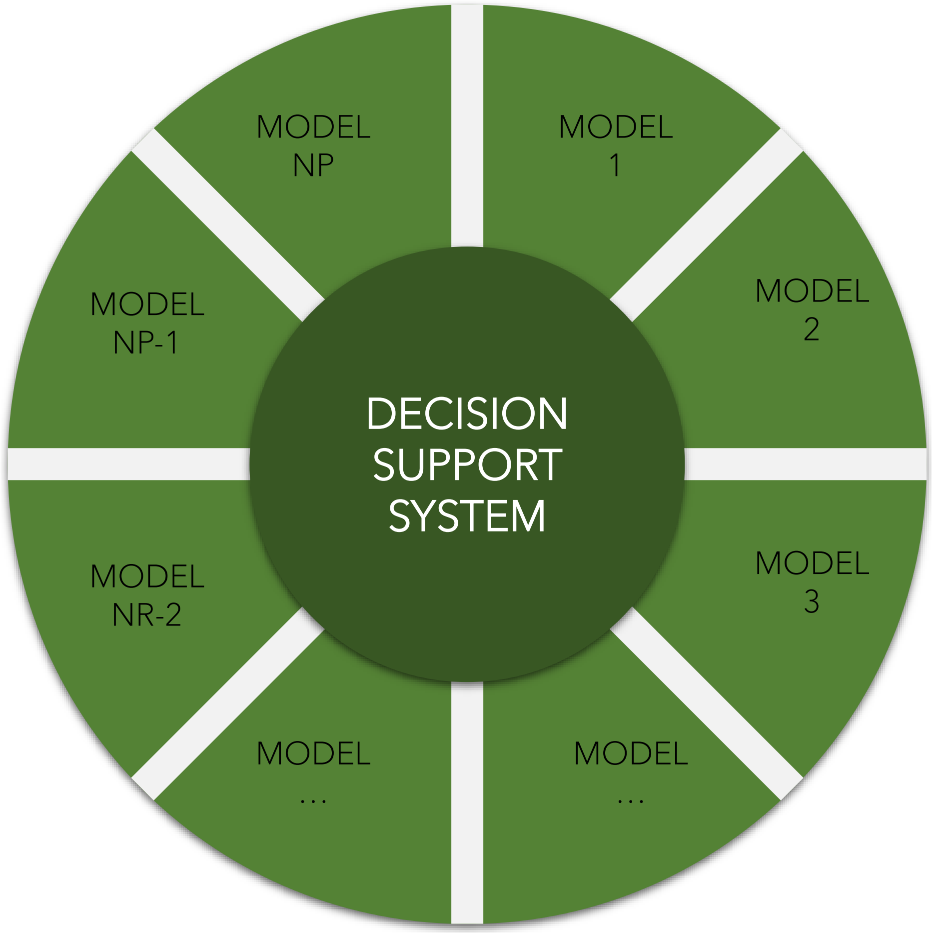


Decision Support System: A Set of Models

A Decision Support System (DSS) must group all mathematical models, predictive and prescriptive. that uses an organization.

Therefore, a DSS can be defined by the set of models that it integrated. Associated with the DSS must be the flow of information between the models, since it is appropriate that the output of one model is used as the input of another models.

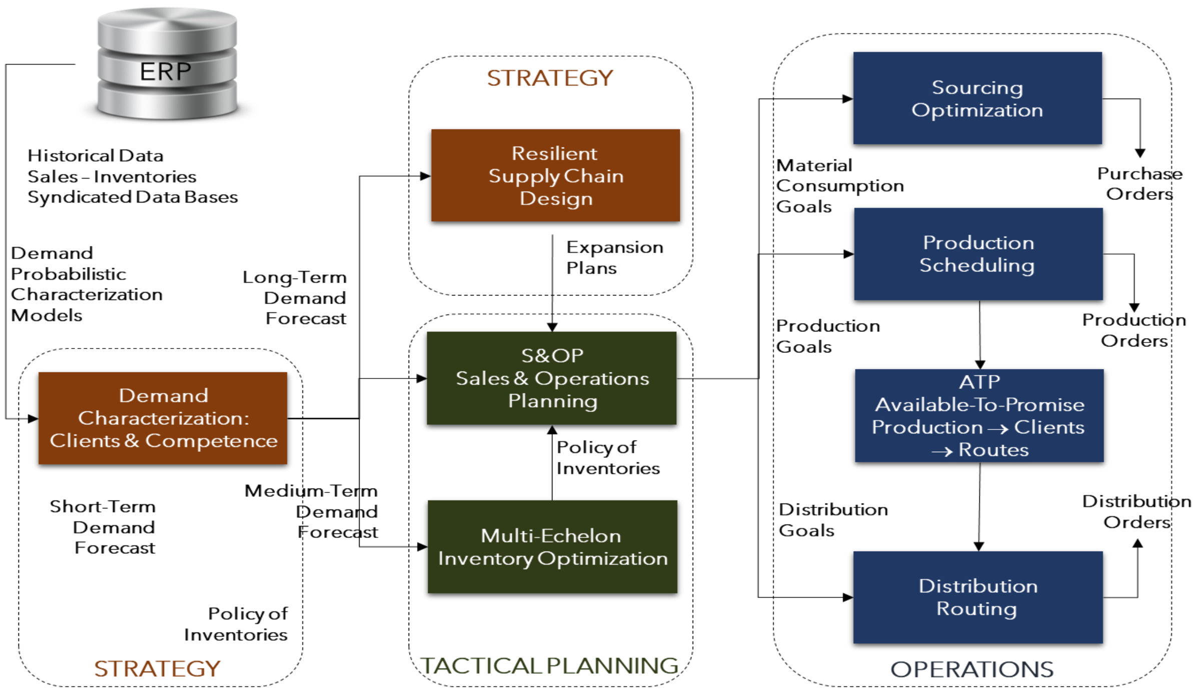
The traditional is that these models are used by users in a "manual" way, except in cases of advanced optimal control in which the models can run permanently (real-time) in an infinite cycle of predictive models and prescriptive models.

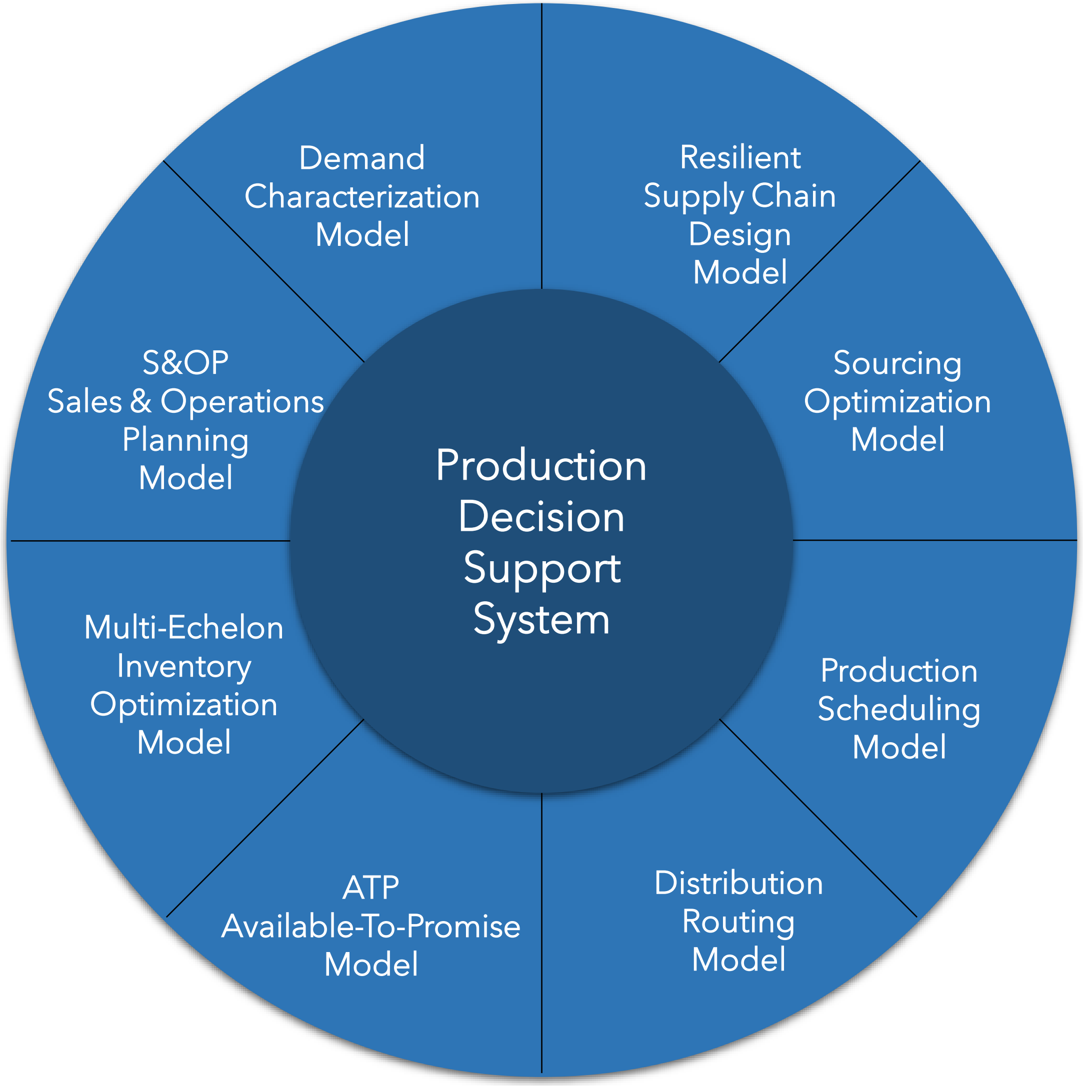


Supply Decision Support System

The architecture of a production DSS in an organization is presented below. It is made up of eight (8) models and the diagram describes the data flow between models.

Traditionally these models are run with a certain frequency (daily, weekly, biweekly, monthly, ...) and the implementation of the decisions depends on the professionals who must validate the results. In some cases, this validation is automatic.





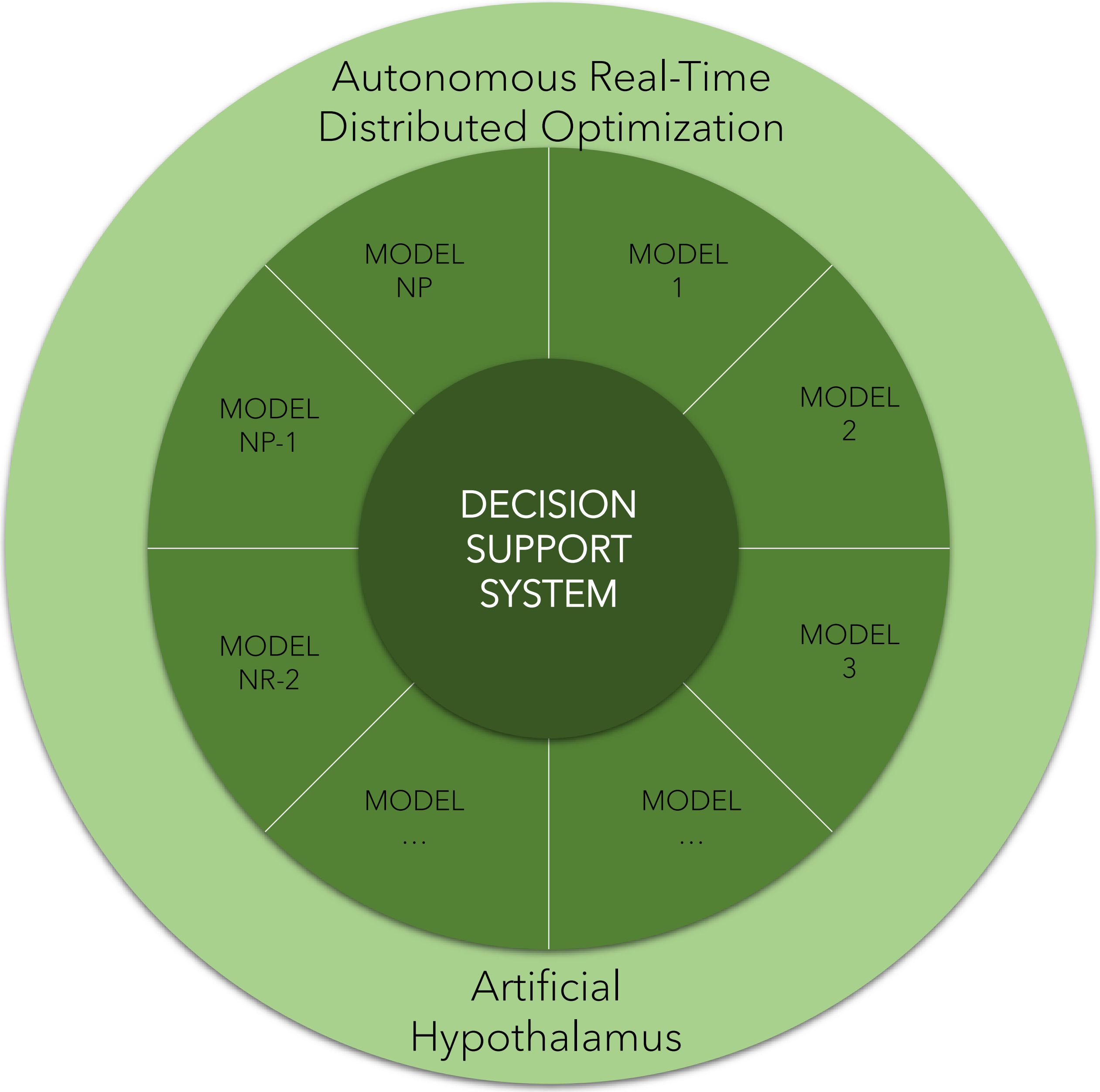
Industry 4.0, intensive in data acquisition (big data) extends the concept of real-time to "any hierarchy" of decision making. Generating the concept of Autonomous Real-time. Distributed Optimization, in which multiple agents (distributed) cooperate to solve an integral problem of the organization.

An agent may be a country, a region, a business, an administrative department.

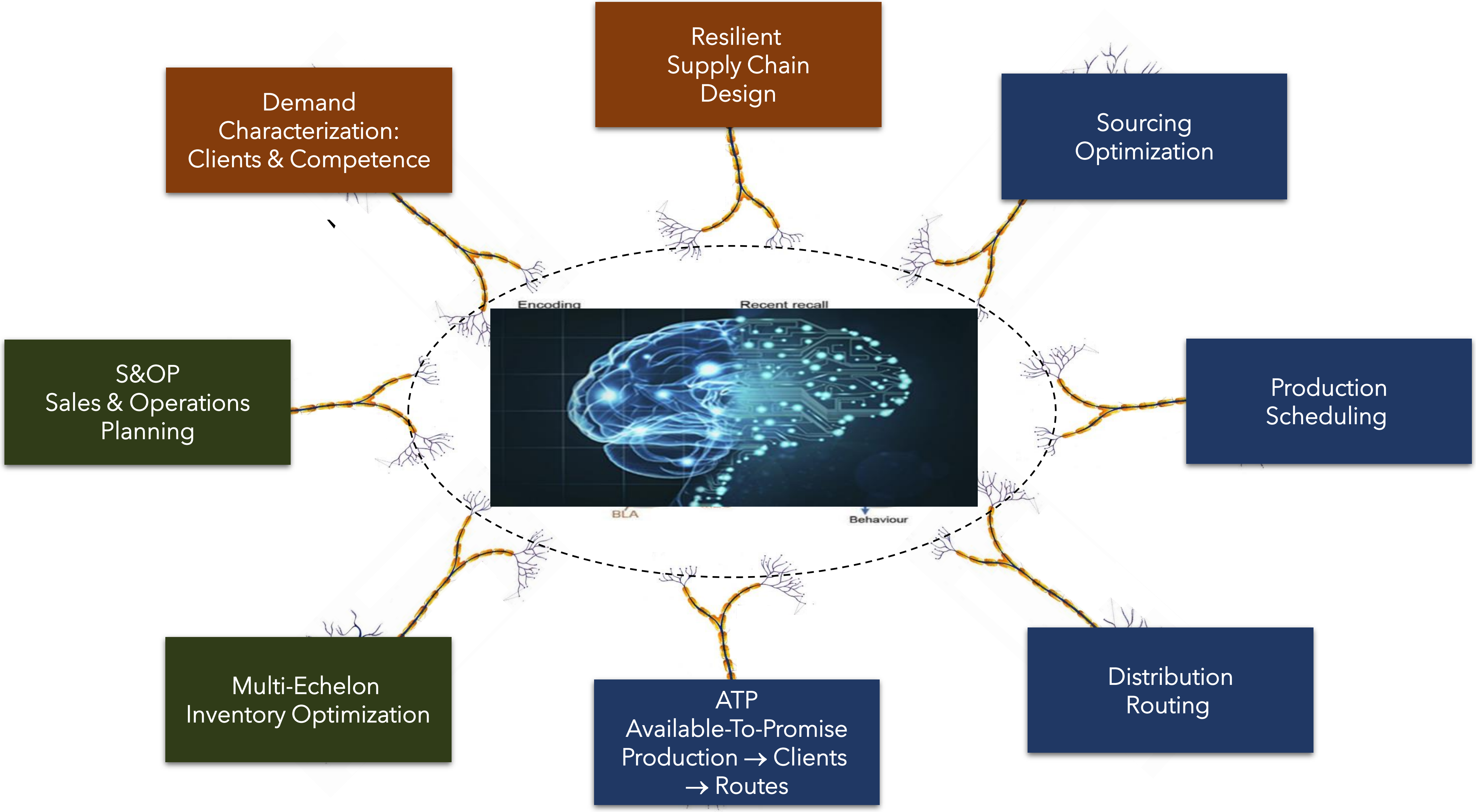
The models correspond to the same models that are included in the DSS, but they must be organized following the principles of the Artificial Hypothalamus, in which models can run autonomously, activated by an exogenous event (for example, an earthquake, the failure of an industrial equipment, …) or by another model that requires processing their data.

The Artificial Hypothalamus corresponds to a macro-algorithm (generated by OPTEX) that coordinates the activation and solution of the models defined by the mathematical modeler and by the users of the system.

The models correspond to a set of micro-services (algorithms) that solve problems/models and produce the required information, acting simultaneously and cooperatively.



Artificial Hypothalamus: Net of Supply Models

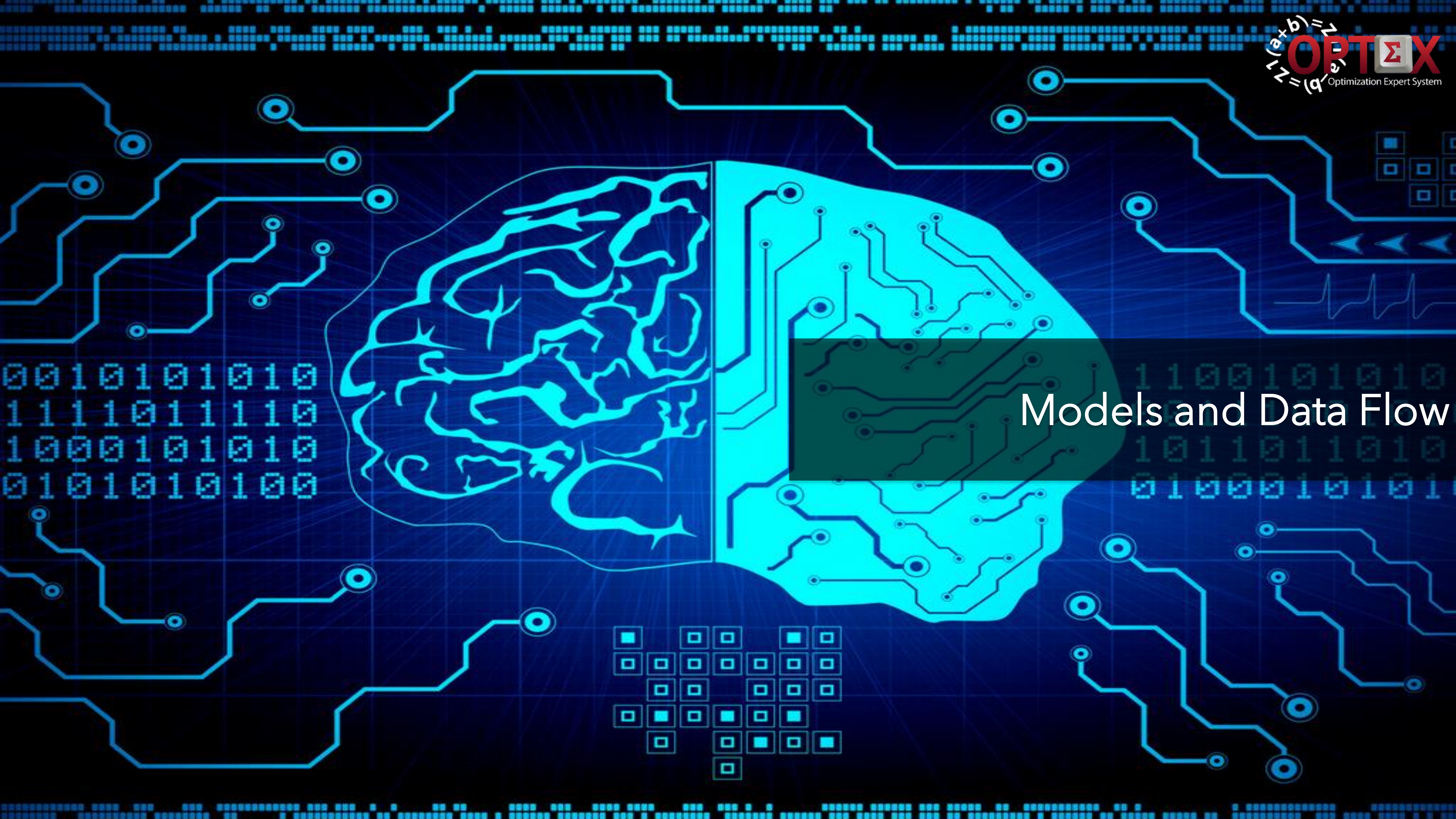


If an application is defined, such as the set of tables that make up the mathematical models database, since it can contain multiple decision support systems, the next level of integration is to define an integrated application (super application) by the joint of multiple basic applications.

This process can be enhanced by joining the tables of the two applications and ensuring that the integrity rules of the relational information systems are met.

In the example, HEALTH integrates with HRPO, this implies that all models of the two systems can be integrated through the database (common data model) and / or by means of equations that integrate a unique holistic model, this following the principles of structured mathematical modeling.

This integration is since the management of public health problem corresponds to regional planning problem, as experienced during the COVID-19 pandemic.



Models and Data Flow

Mathematical Problems – Inputs & Outputs

OPTΣX

INDEX

SETS

PARAMETERS

$$\text{Min} \quad \Sigma_t \Sigma_j \Sigma_h \; CT_t(GT_{jth})$$

sujeto a:

$$GD_{zth} - \Sigma_{u \varepsilon TN(z)} LD_{uzth} = 0$$

$$GD_{zth} + GHA_{zth} + DEF_{zth} = DEM_{zth}$$

$$EN_{uth} - \Sigma_{j \varepsilon L1(u)} GTE_{juth} - \Sigma_{v \varepsilon L2(u)} LL_{vuth} = 0$$

PRIMAL VARIABLES

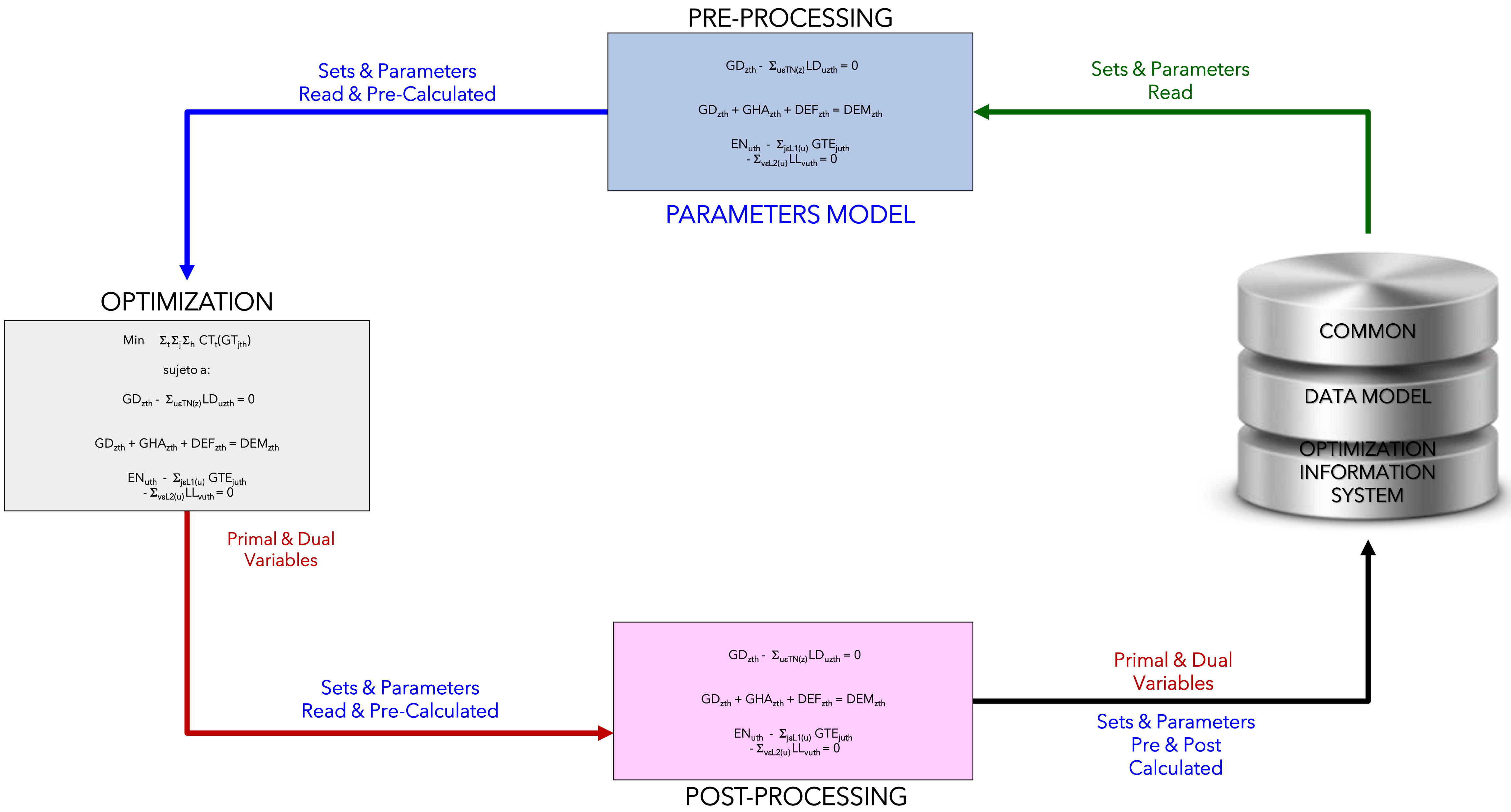
DUAL VARIABLES

CONSTRAINTS

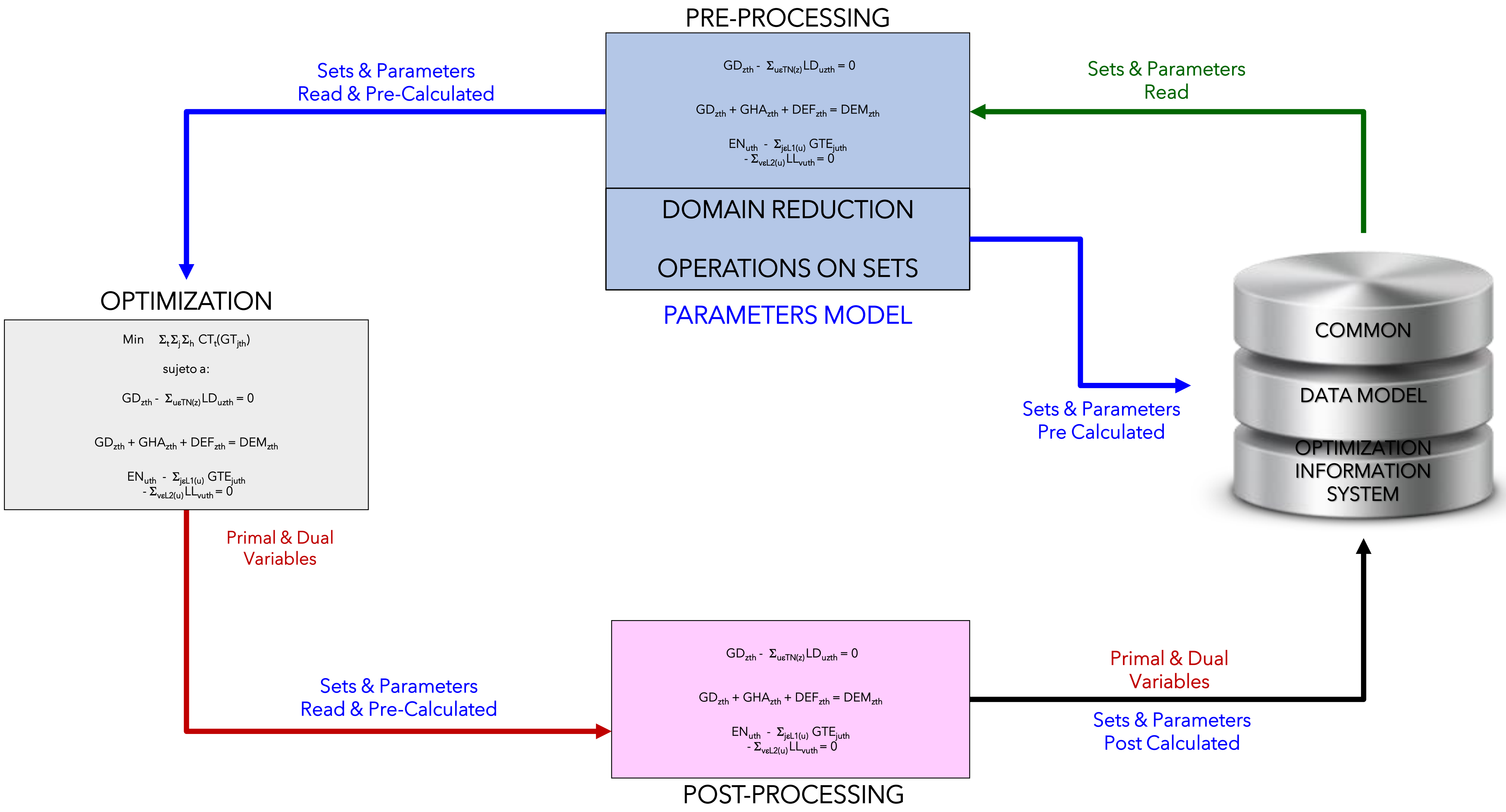
EXISTENCE CONDITIONS

OBJECTIVE FUNCTION

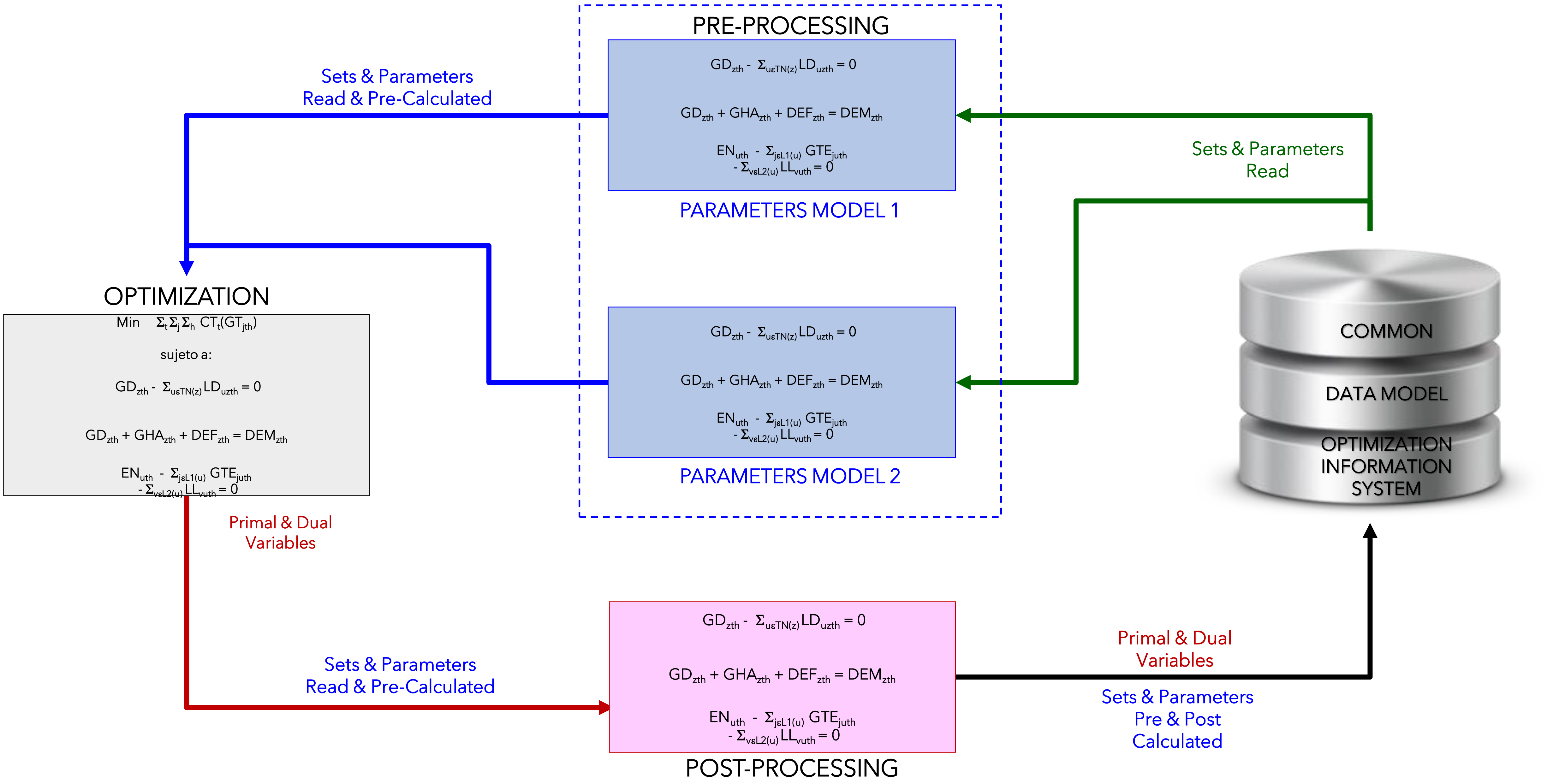
Standard Implementation



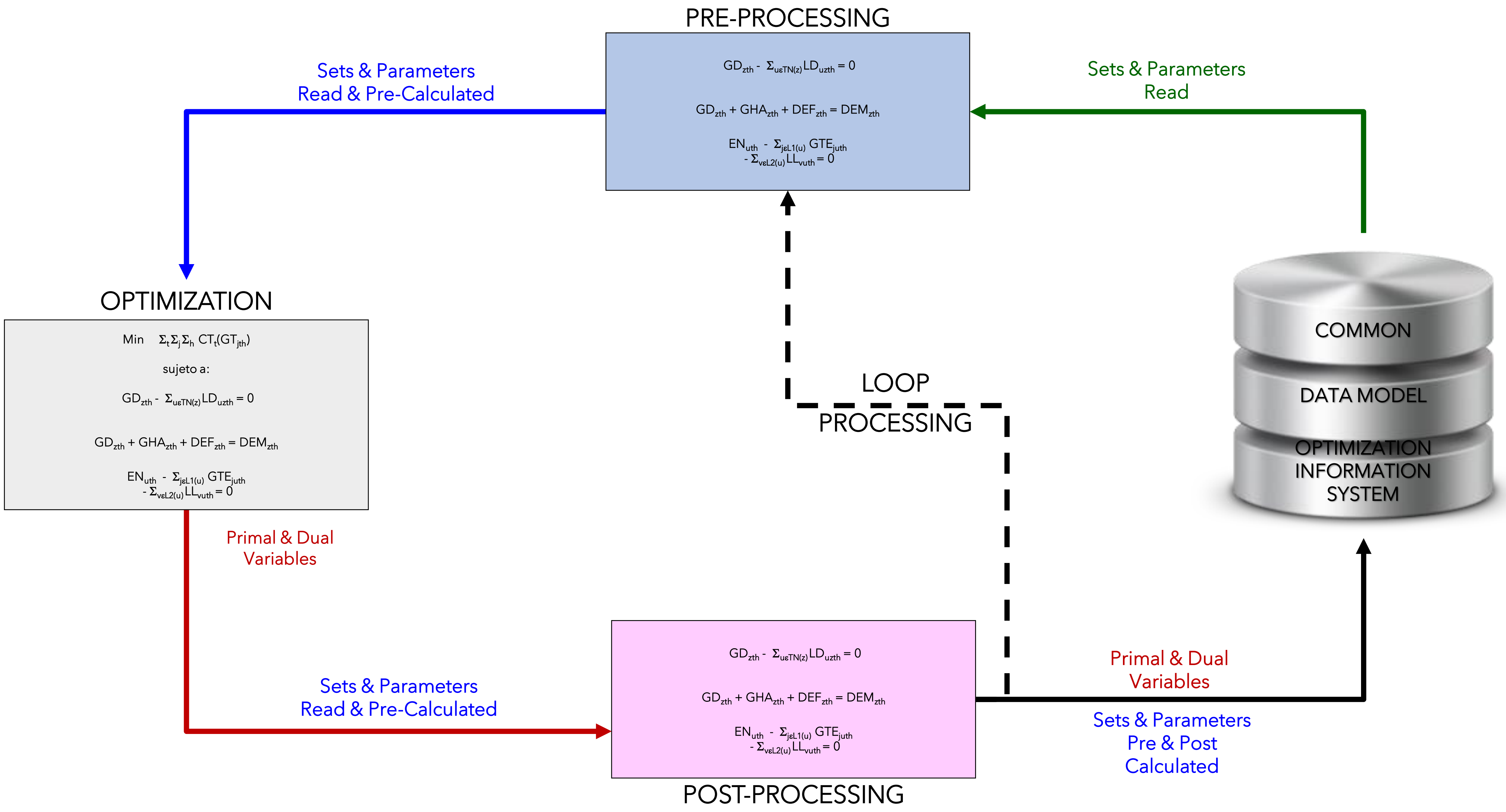
Standard Implementation - Domain Reduction



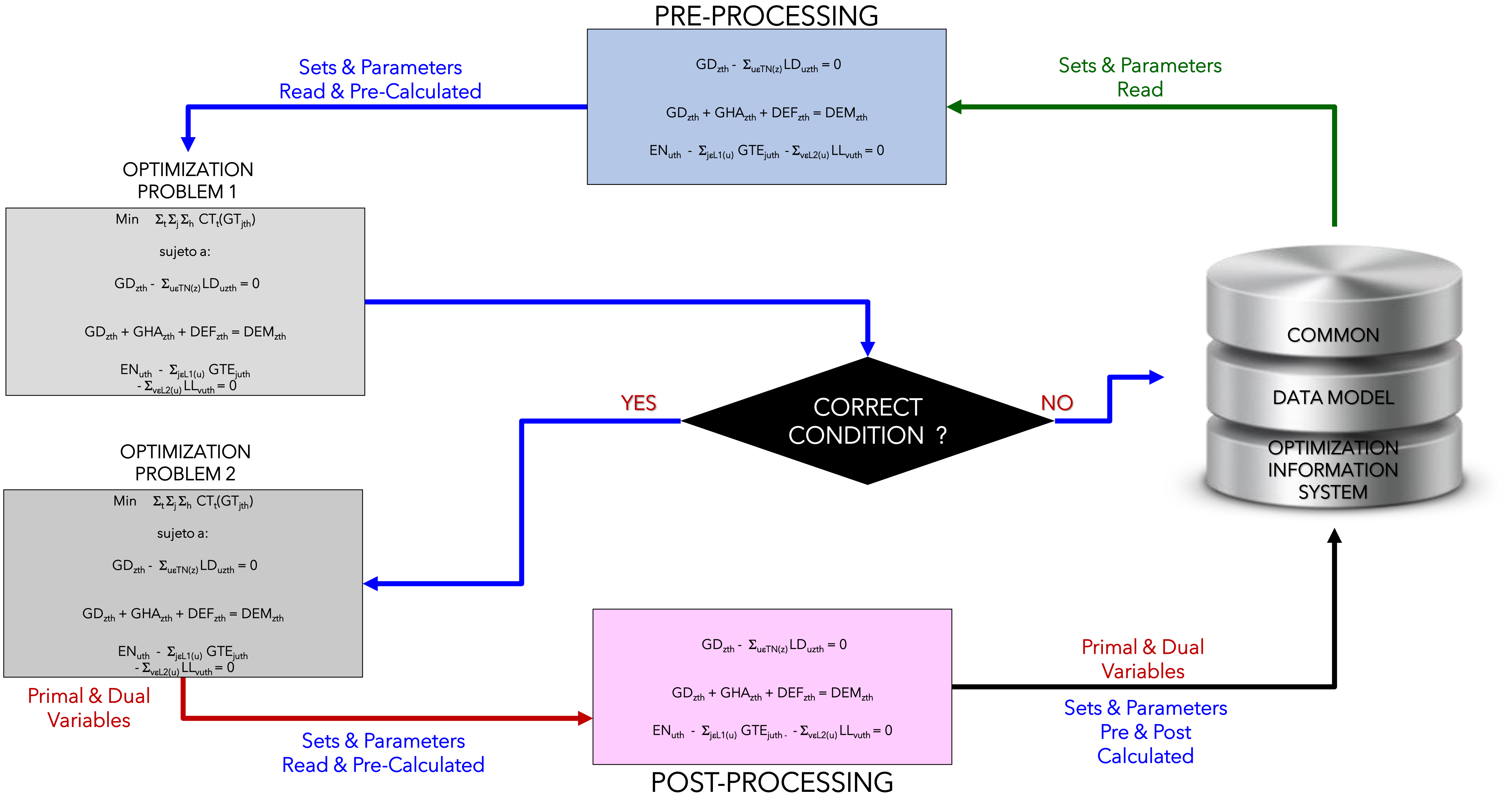
Standard Implementation – Multiple Models Parameter

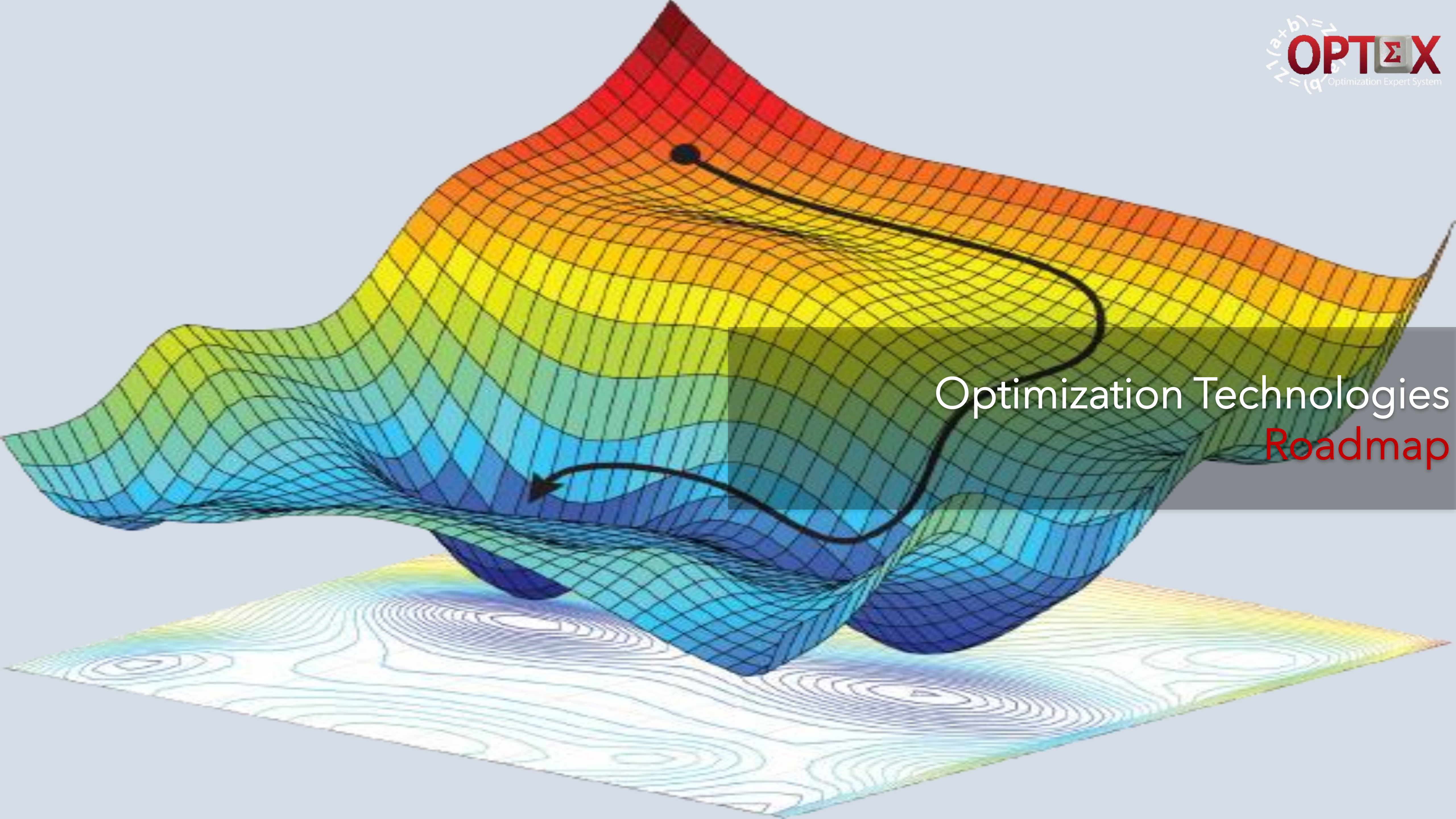


Loop Implementation – Multiple Model Loops



Two Stage Optimization – Multiple Model Loops





Optimization Technologies
Roadmap

There are multiple types of models based on Mathematical Programming (MP) that can be required by an organization, each of them for specific and complementary purposes; they can be named:

- Optimization
- Computable General Equilibrium
- Statistical and/or Econometric Models
- System Dynamics
- Synthetic Random Variable Generators
- Stochastic Process Modeling
- Machine Leaarning Algorithms

Despite their diversity, the different types of models meet a common characteristic: they can be formulated by means of algebraic expressions typical of mathematical programming, that is, they can all be solved using:

- A solver based on the mathematical laws of optimization
- A low-level programming language in which the interface between algebraic formulation and mathematical programming solver is programmed
- A high-level programming language oriented to handle algebraic formulations and interface with the solver

MATHEMATICAL PROGRAMMING SOLVER

GUROBI OPTIMIZATION, FICO Xpress, IBM CPLEX, KNITRO, LINDO, COIN OR, LPS

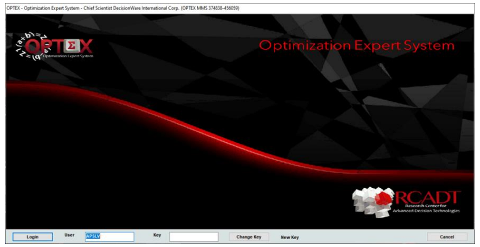
LOW-LEVEL PROGRAMMING LANGUAGE

julia, R, python, Java, C++

HIGH-LEVEL ALGEBRAIC LANGUAGE

GAMS, IBM OPL, AMPL, GMPL, FICO Mosel, LINGO, AIMMS

Optimization Technologies



OPTIMIZATION INFORMATIC PLATFORM

IBM Decision Optimization on Cloud – Optimization Modeling – IBM Analytics Services

AIMMS Prescriptive Analytics Platform

FICO Xpress Optimization Suite

SAS Optimization

LOW-LEVEL PROGRAMMING LANGUAGE

julia, R, C++, Java, python PYOMO, python GEKKO Dynamic Optimization

HIGH-LEVEL ALGEBRAIC LANGUAGE

AMPL, GAMS, GMPL, IBM OPL, FICO Mosel, AIMMS, SAS Optimization, LINGO, TOMLAB Optimization

OPTIMIZATION SOLVERS

GLPK, COIN|OR, IPOPT, LPS, GLOP, KNITRO, LINDO, IBM CPLEX, FICO Xpress 8.1, LocalSolver, GUROBI OPTIMIZATION

OPTIMIZATION EXPERT SYSTEM

Expert systems and cognitive robots that generate algorithms in multiple optimization technologies, simplifying the process of implementing complex and integrated solutions.

OPTIMIZATION INFORMATIC PLATFORM.

Computer platforms that integrate all the computer aspects required for the implementation of Decision Support Systems (DSS). They facilitate the commissioning and maintenance of DSSs for an organization, integrating multiple mathematical models, databases and visualization interfaces.

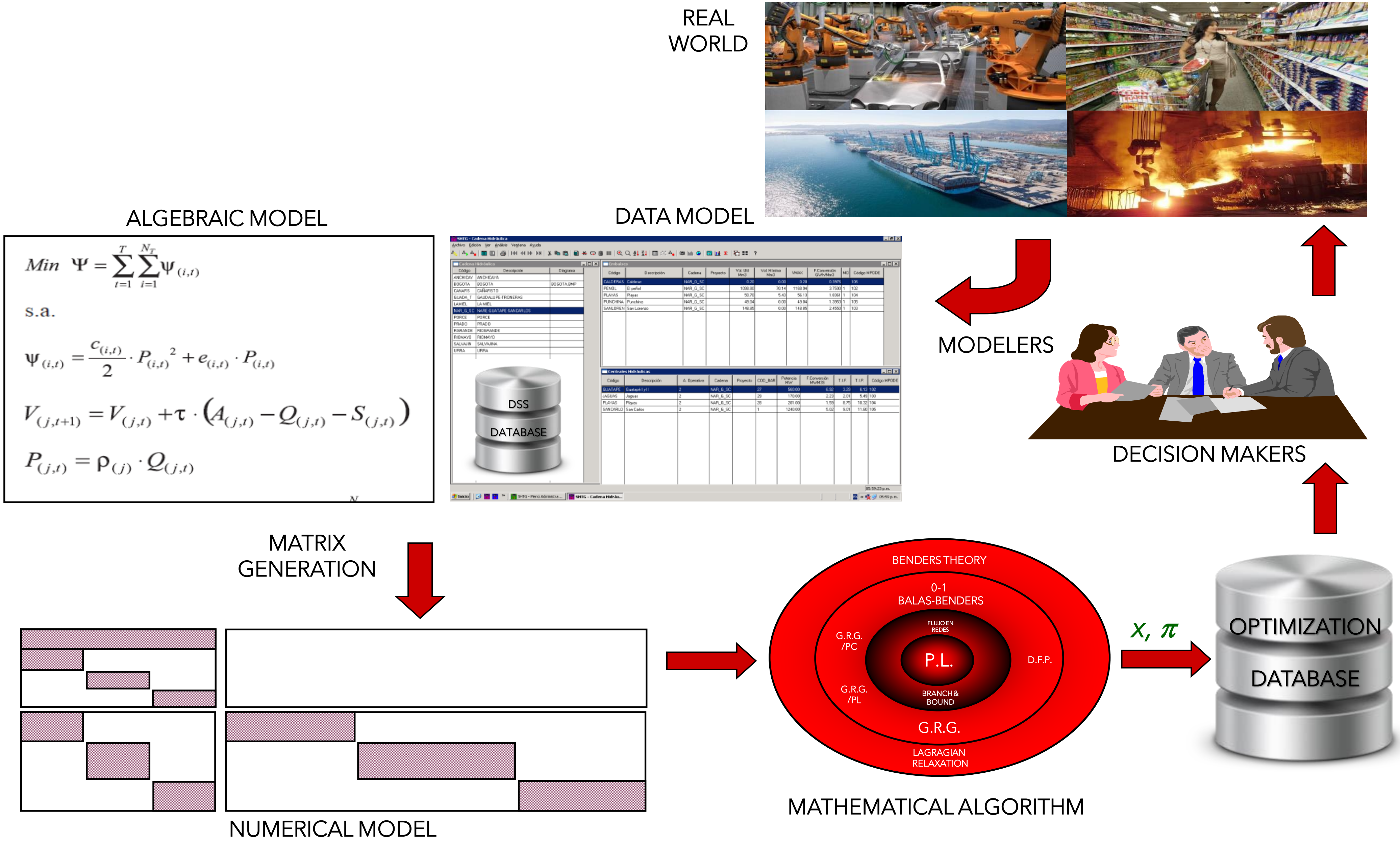
PROGRAMMING LANGUAGE.

Products oriented to the development of optimization models, focused on providing the mathematical modeler with a means to implement specialized algorithms in certain types of mathematical problems (linear, non-linear, ...). To beat them, large-scale optimization methodologies are implemented.

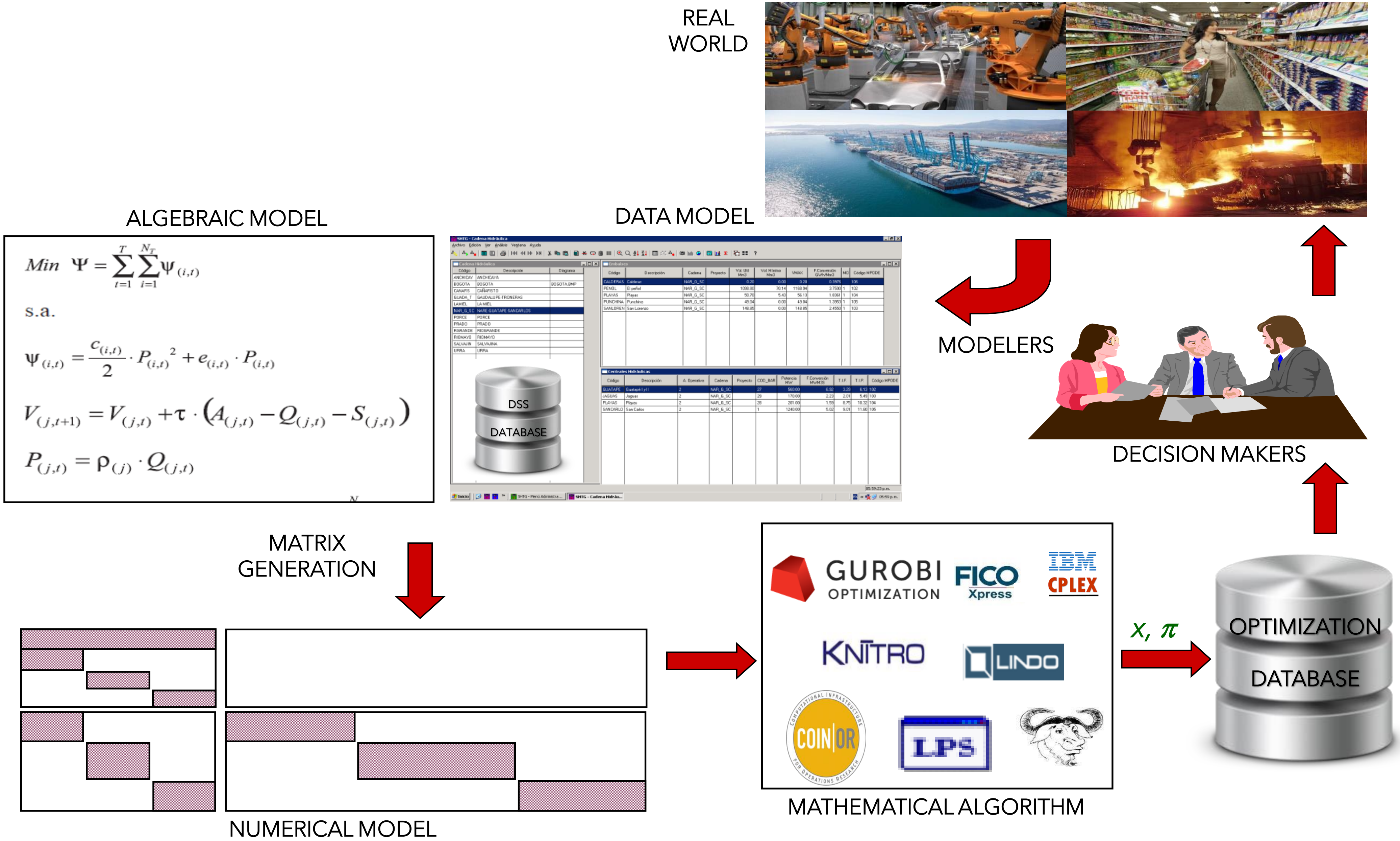
OPTIMIZATION SOLVERS.

They are highly specialized products based on the mathematical laws of optimization. They are the basis of all mathematical optimization of high complexity.

Mathematical Modeling Process

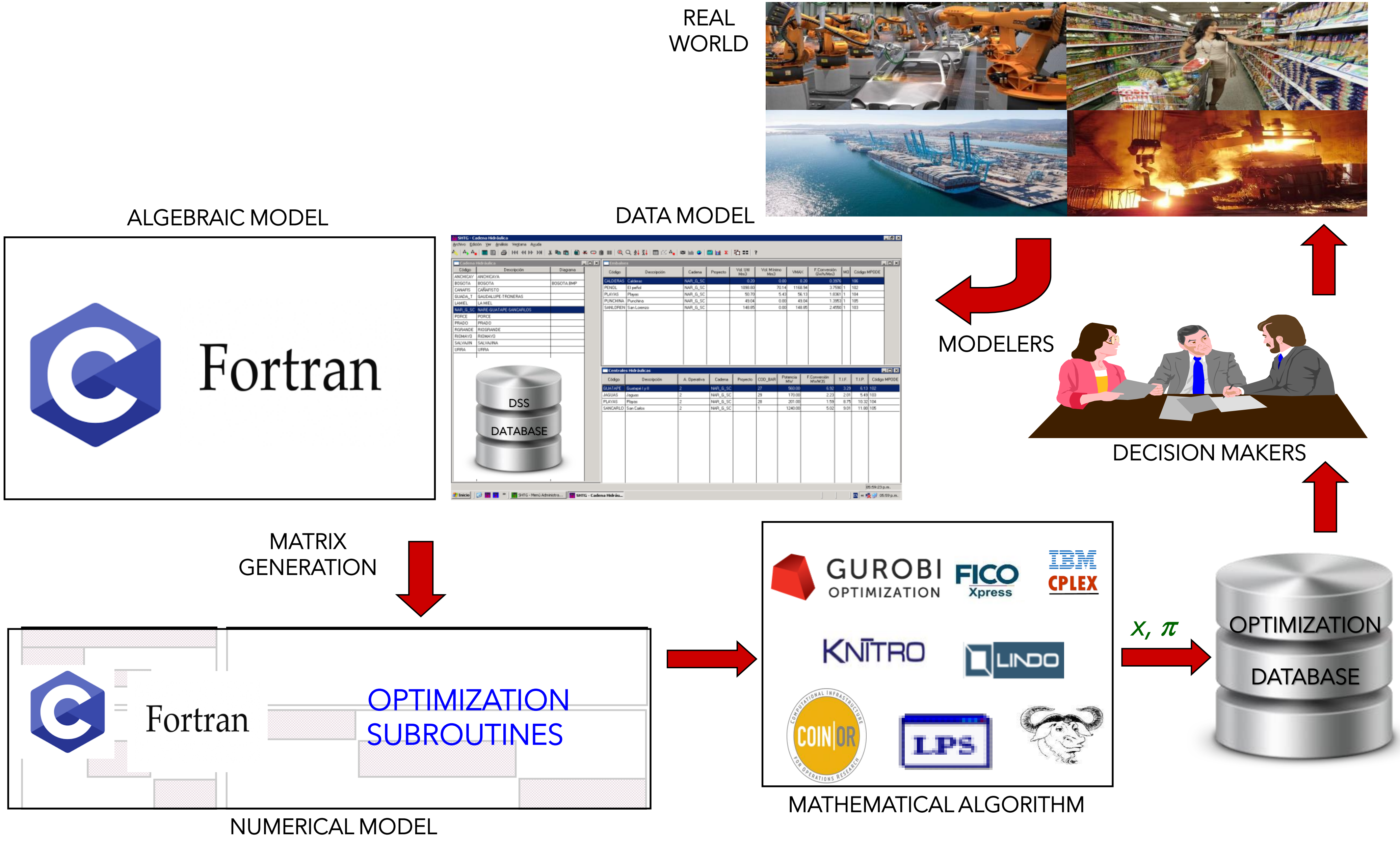


Mathematical Modeling Process

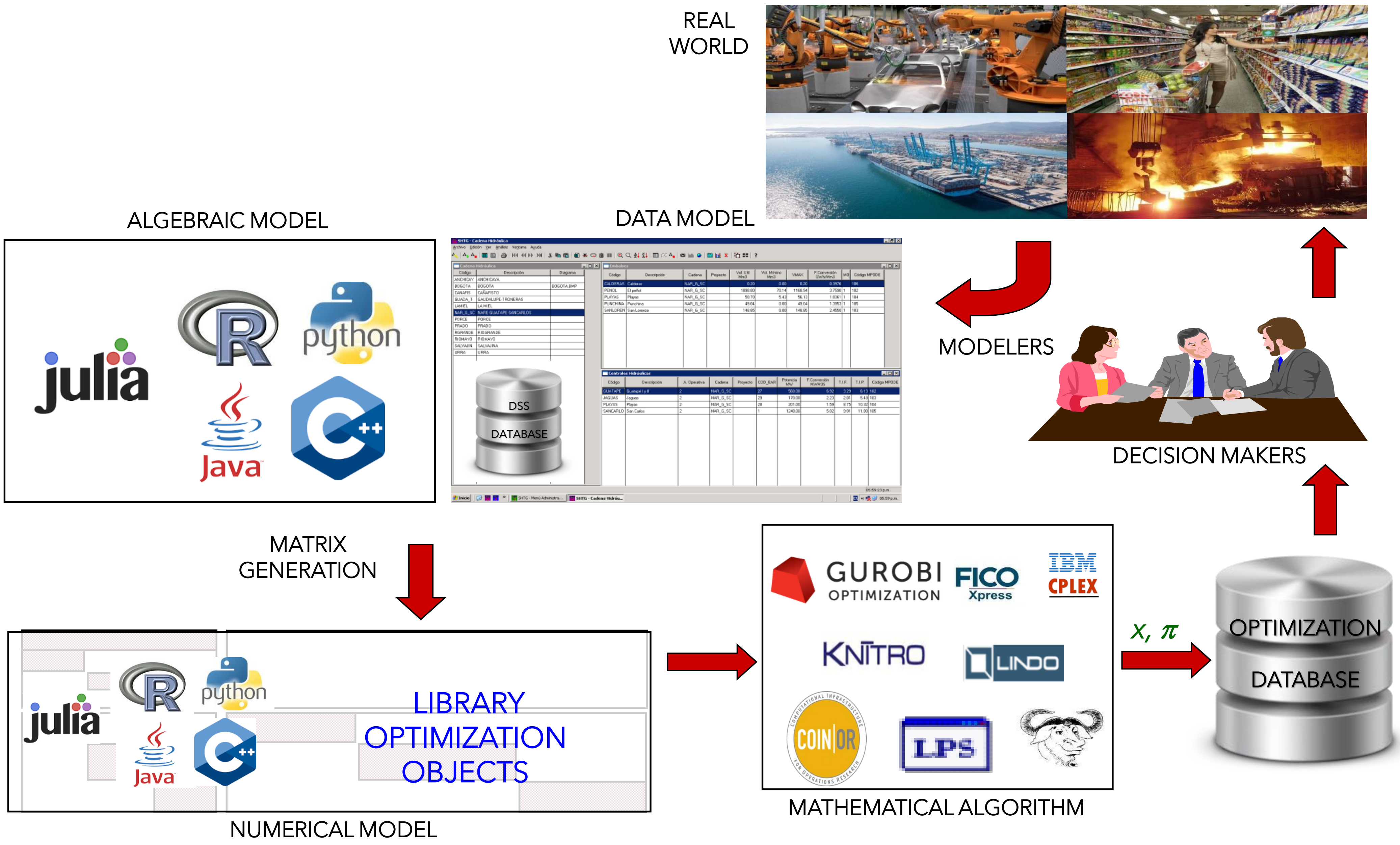


Mathematical Modeling Process

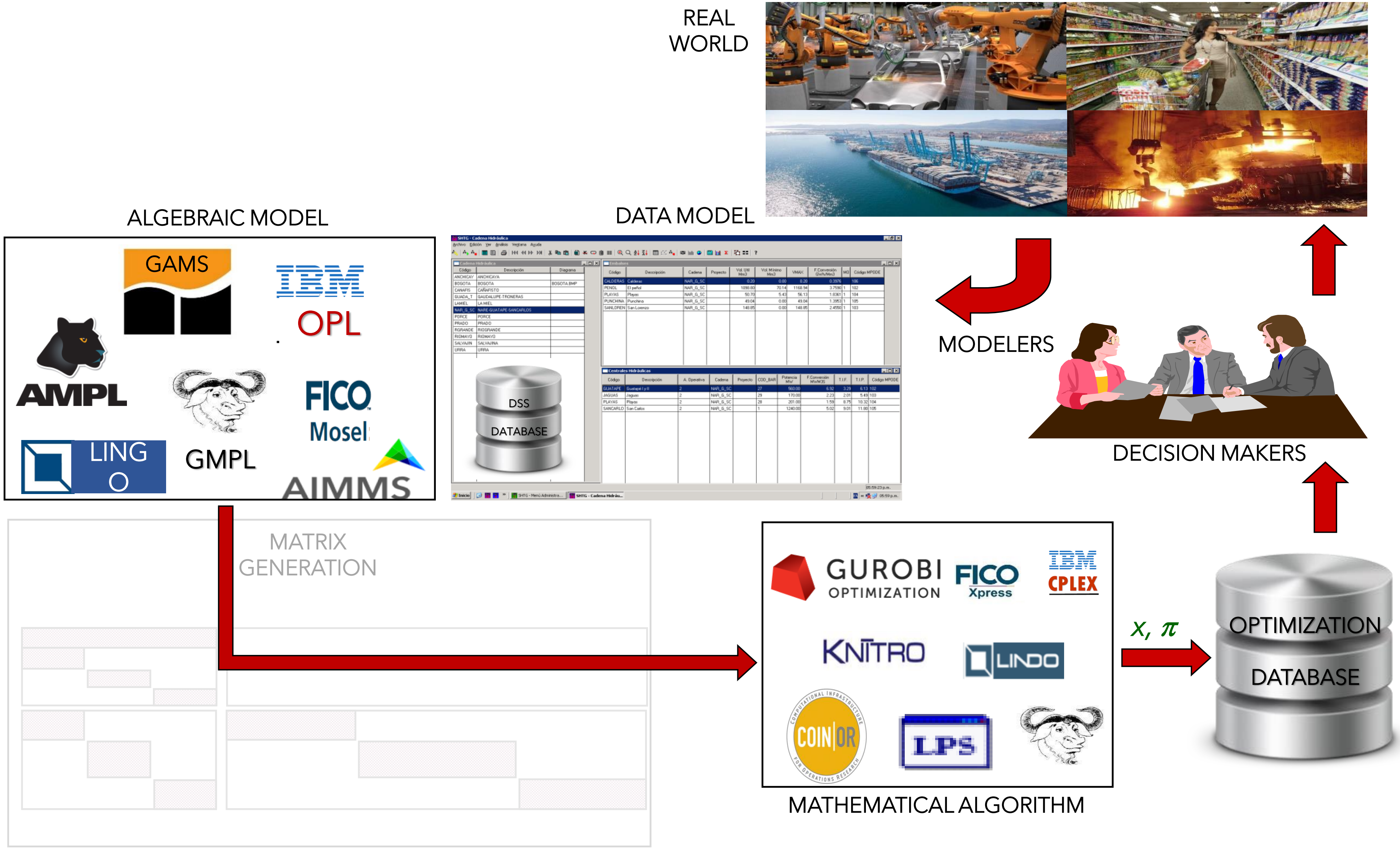
OPTEX



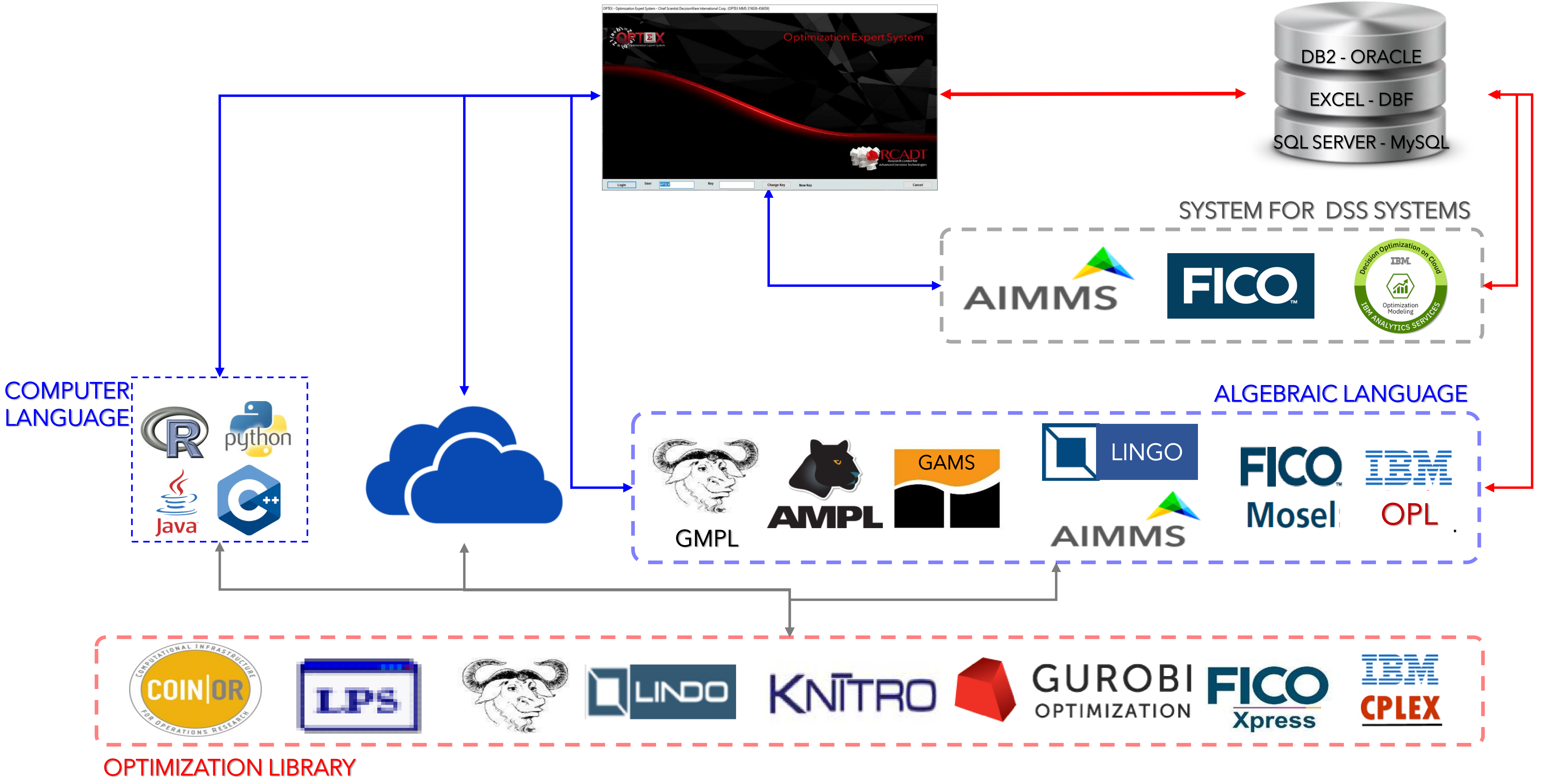
Mathematical Modeling Process

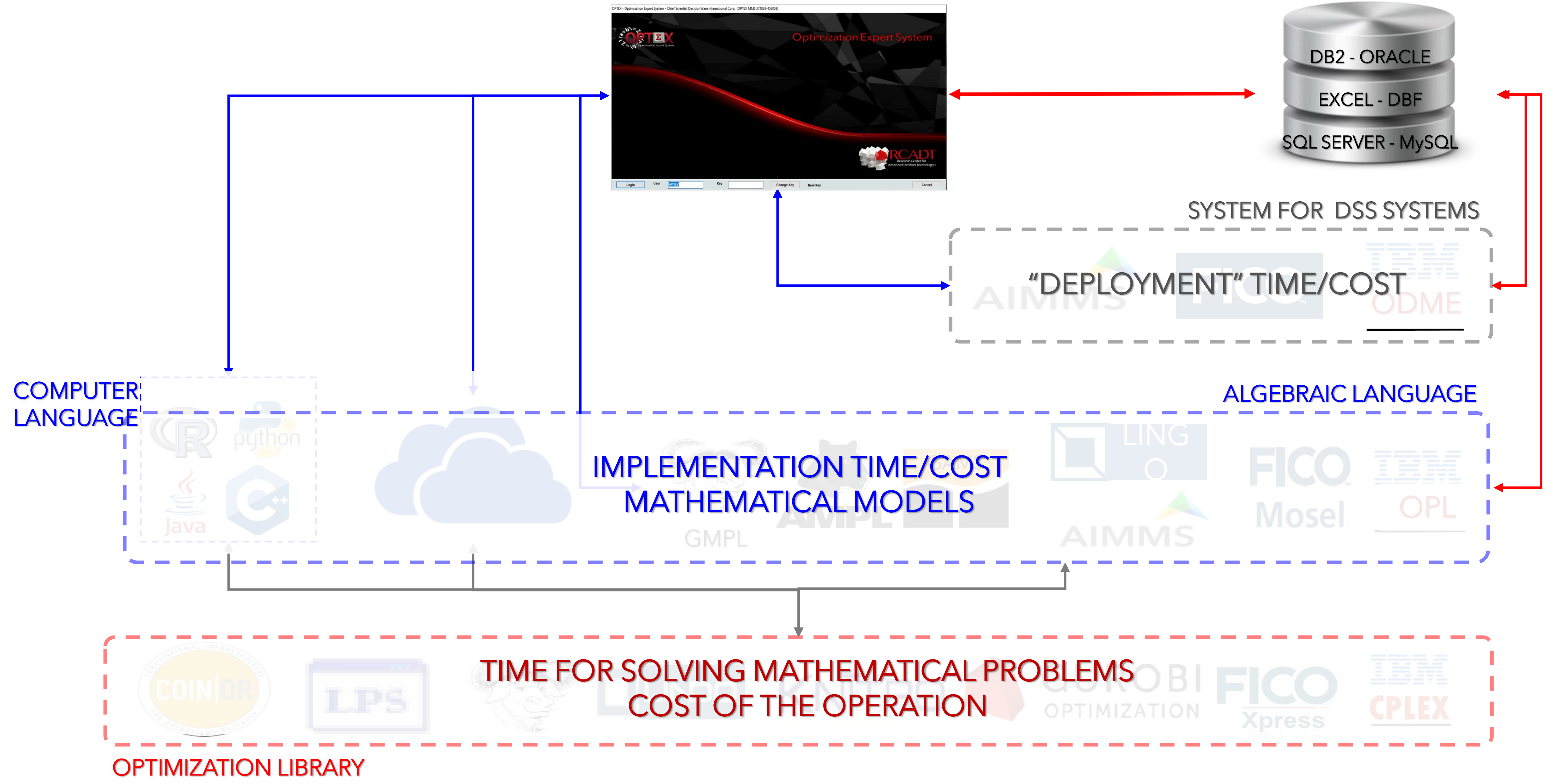


Mathematical Modeling Process



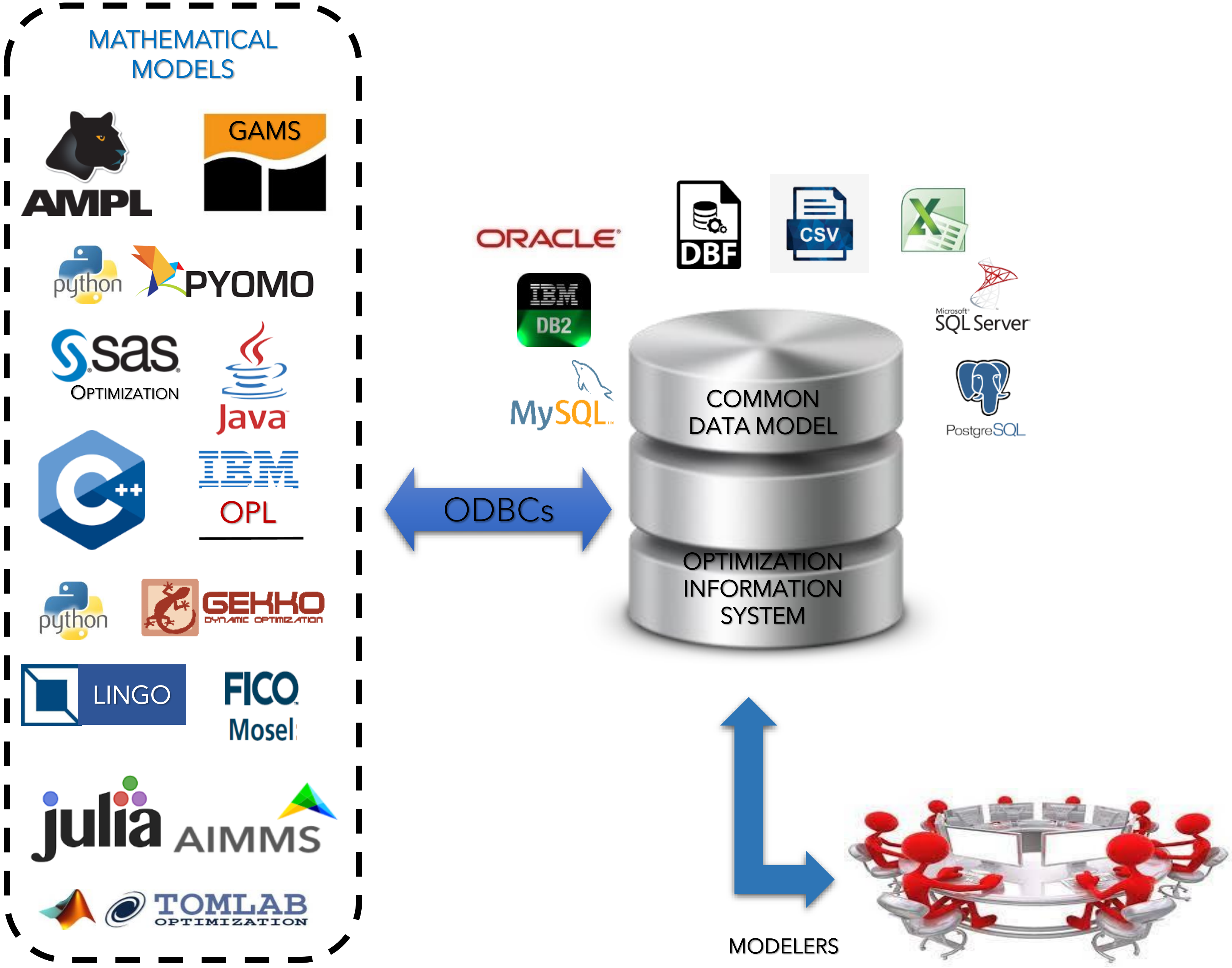
Optimization Technologies



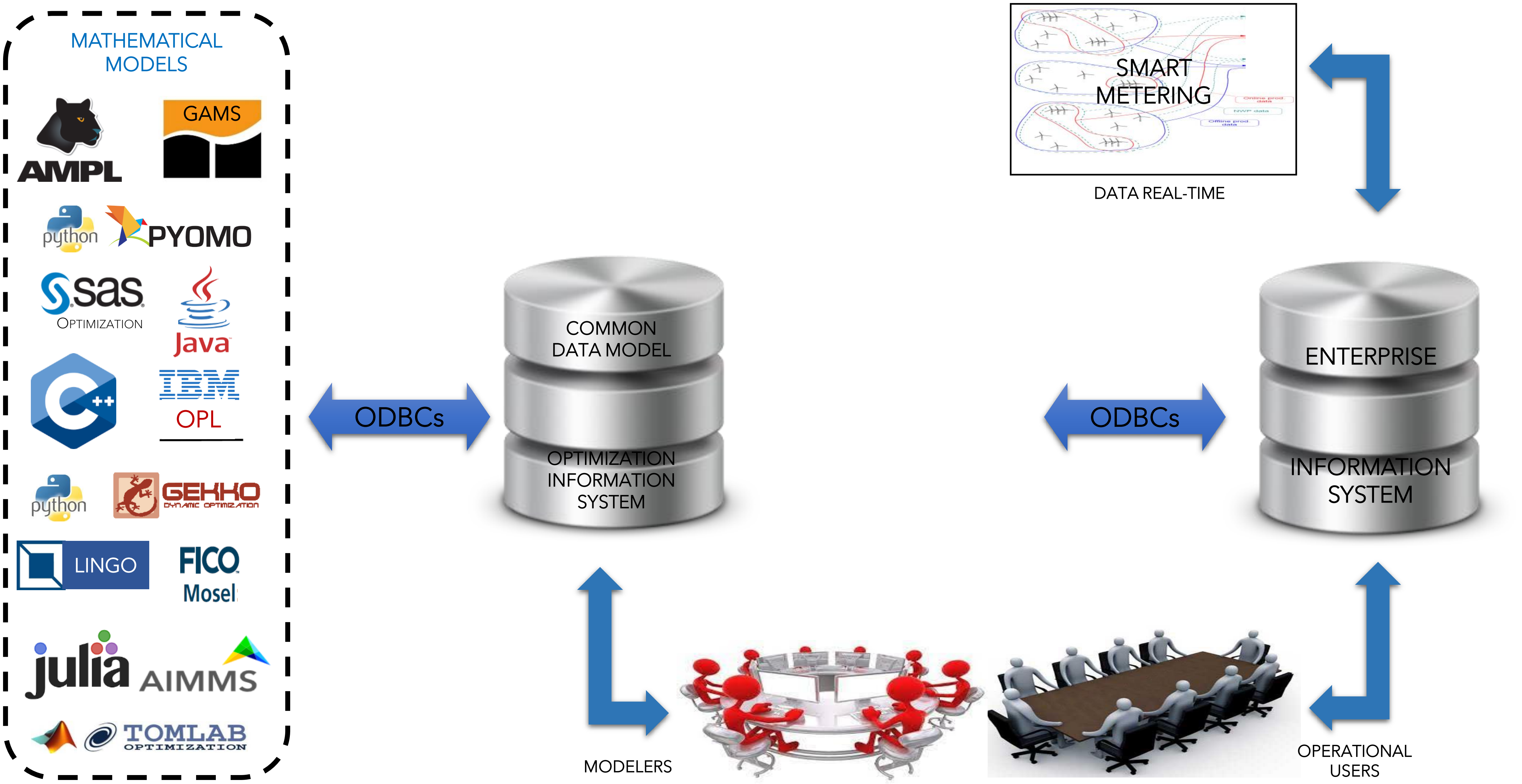


Optimization Expert System
RCADT
DB2 - ORACLE
EXCEL - DBF
SQL SERVER - MySQL
SYSTEM FOR DSS SYSTEMS
"DEPLOYMENT" TIME/COST
AIMMS
FICO
IBM
ODME
COMPUTER LANGUAGE
ALGEBRAIC LANGUAGE
python
Java
IMPLEMENTATION TIME/COST
MATHEMATICAL MODELS
GMPL
AMPL
LINGO
AIMMS
FICO
Mosel
IBM
OPL
TIME FOR SOLVING MATHEMATICAL PROBLEMS
COST OF THE OPERATION
COIN|OR
LPS
OPTIMIZATION
FICO
Xpress
IBM
CPLEX
OPTIMIZATION LIBRARY

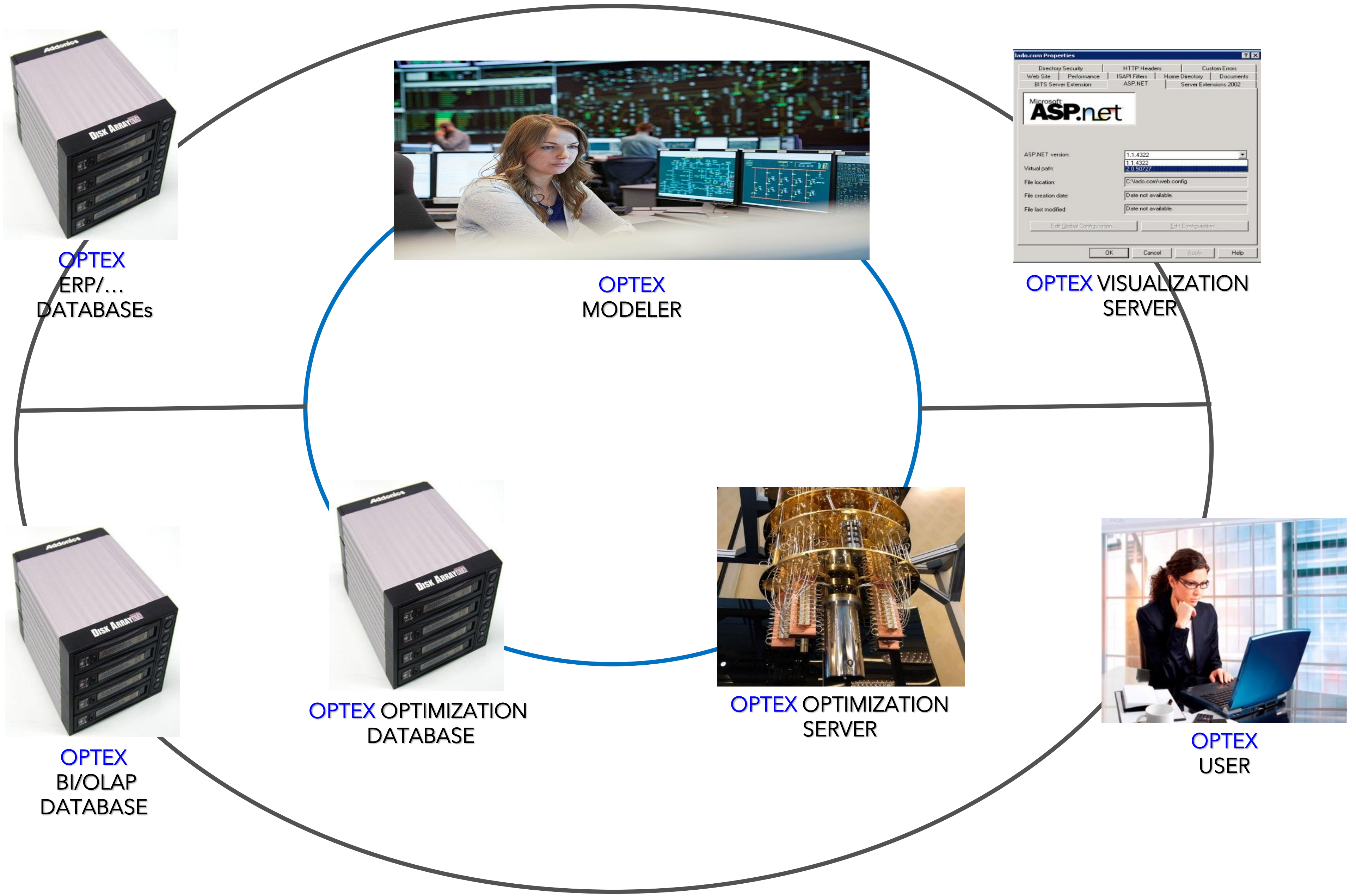
OPTEX – Information System Connectivity



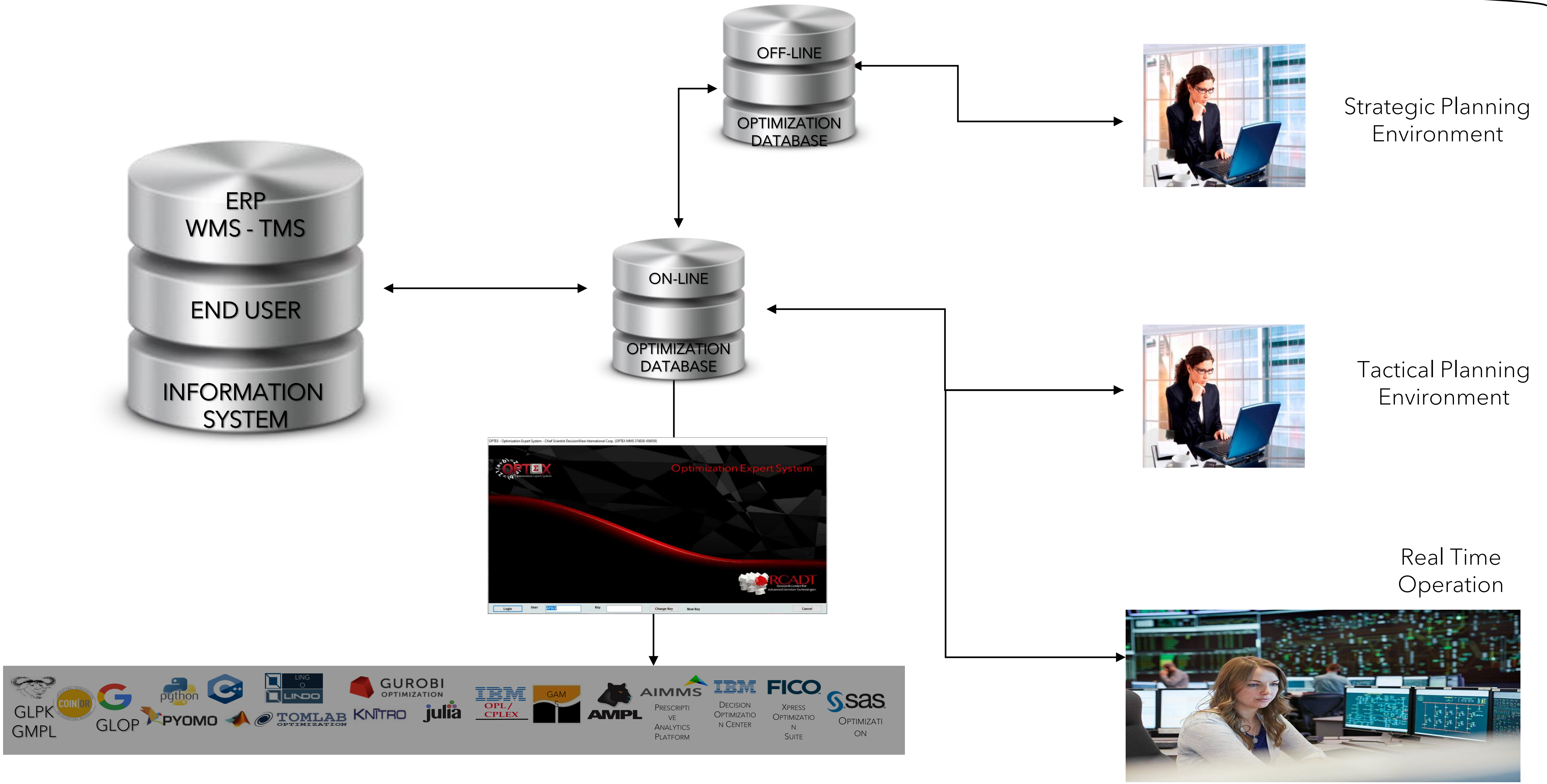
OPTEX – Information System Connectivity



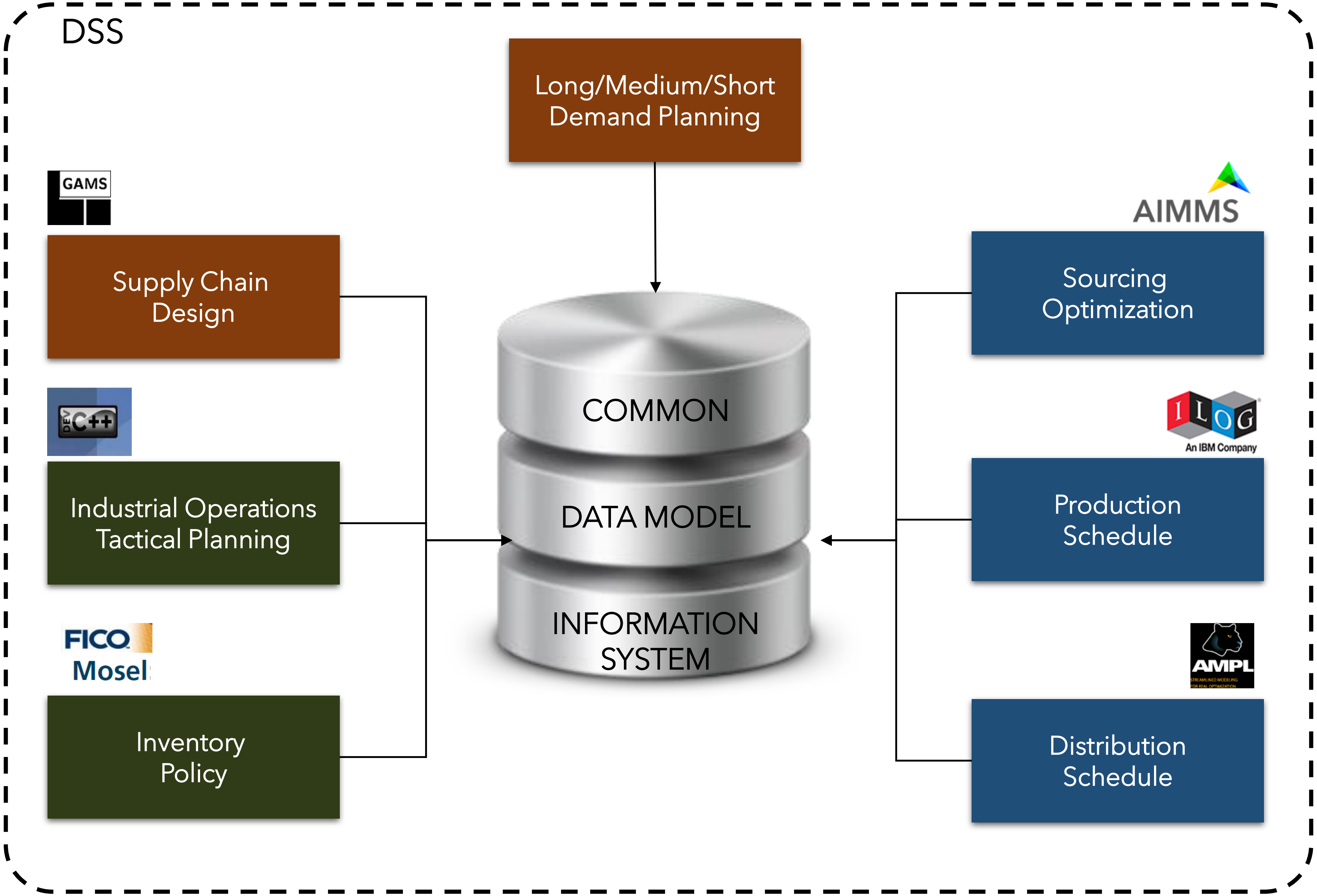
OPTEX – Client-Server Architecture

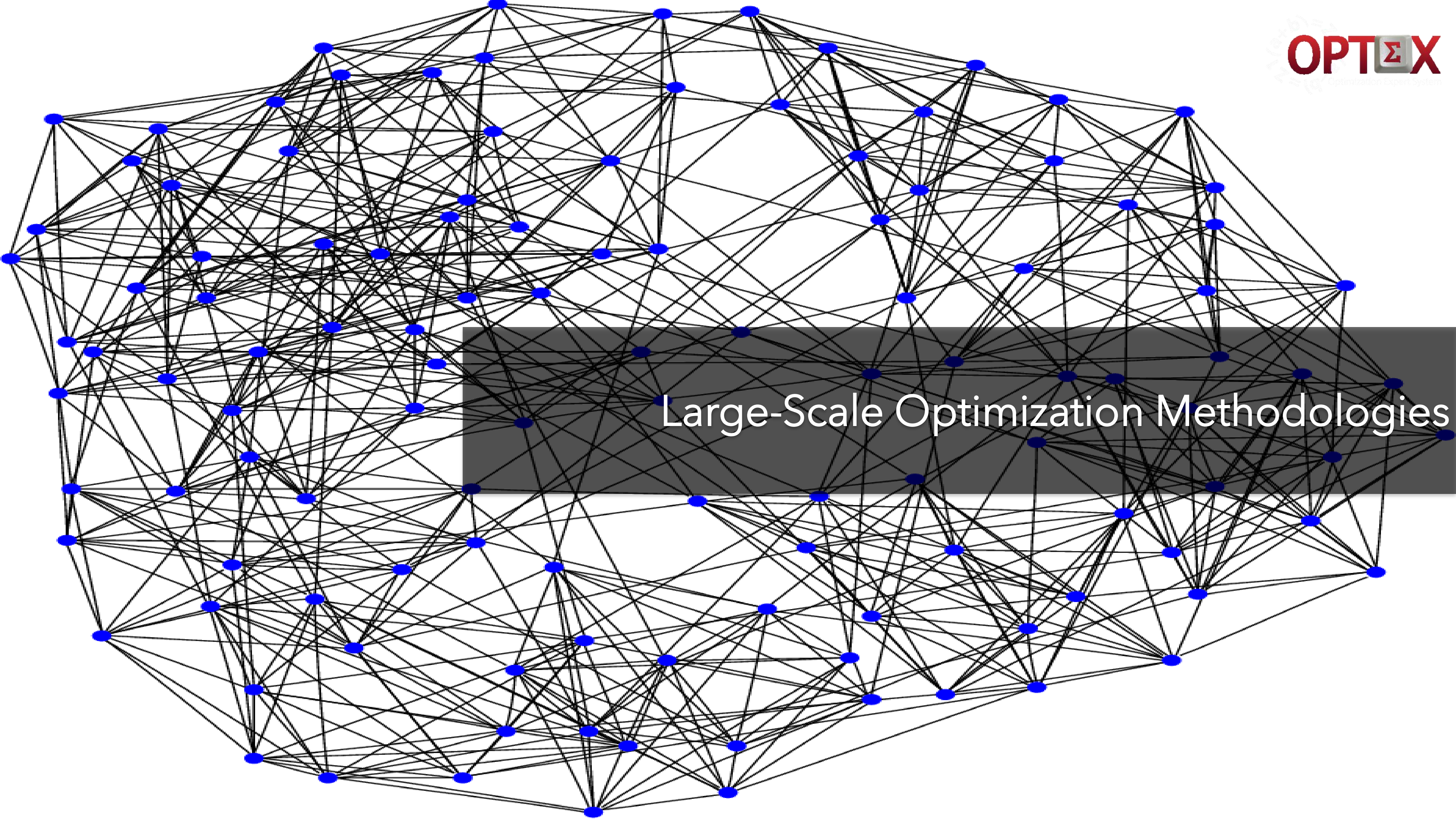


OPTEX – Functional Architecture



Common Data Model - Multi Optimization Technologies Platform



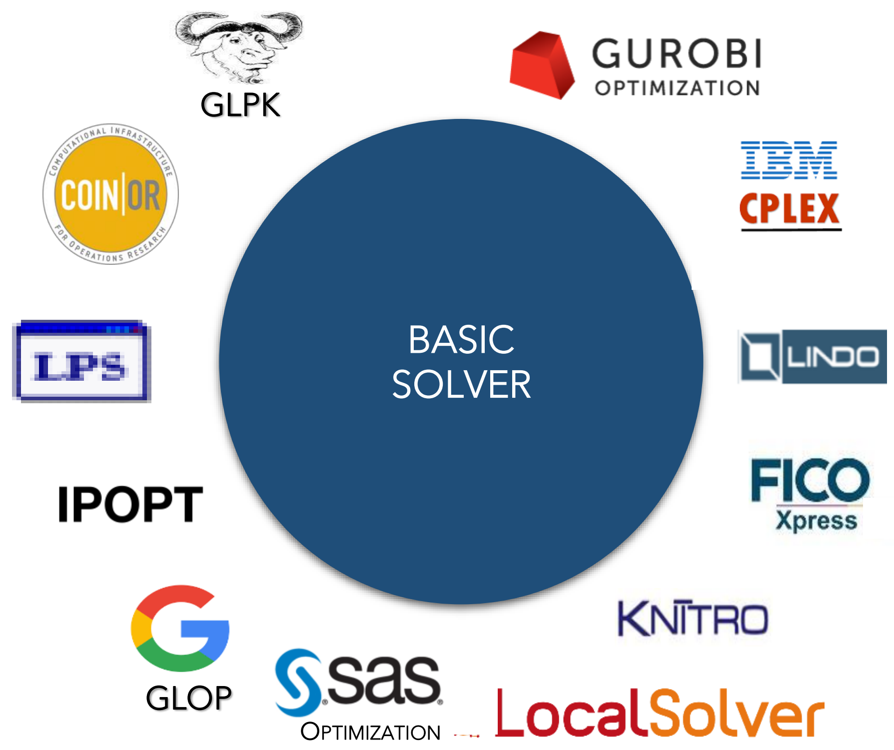


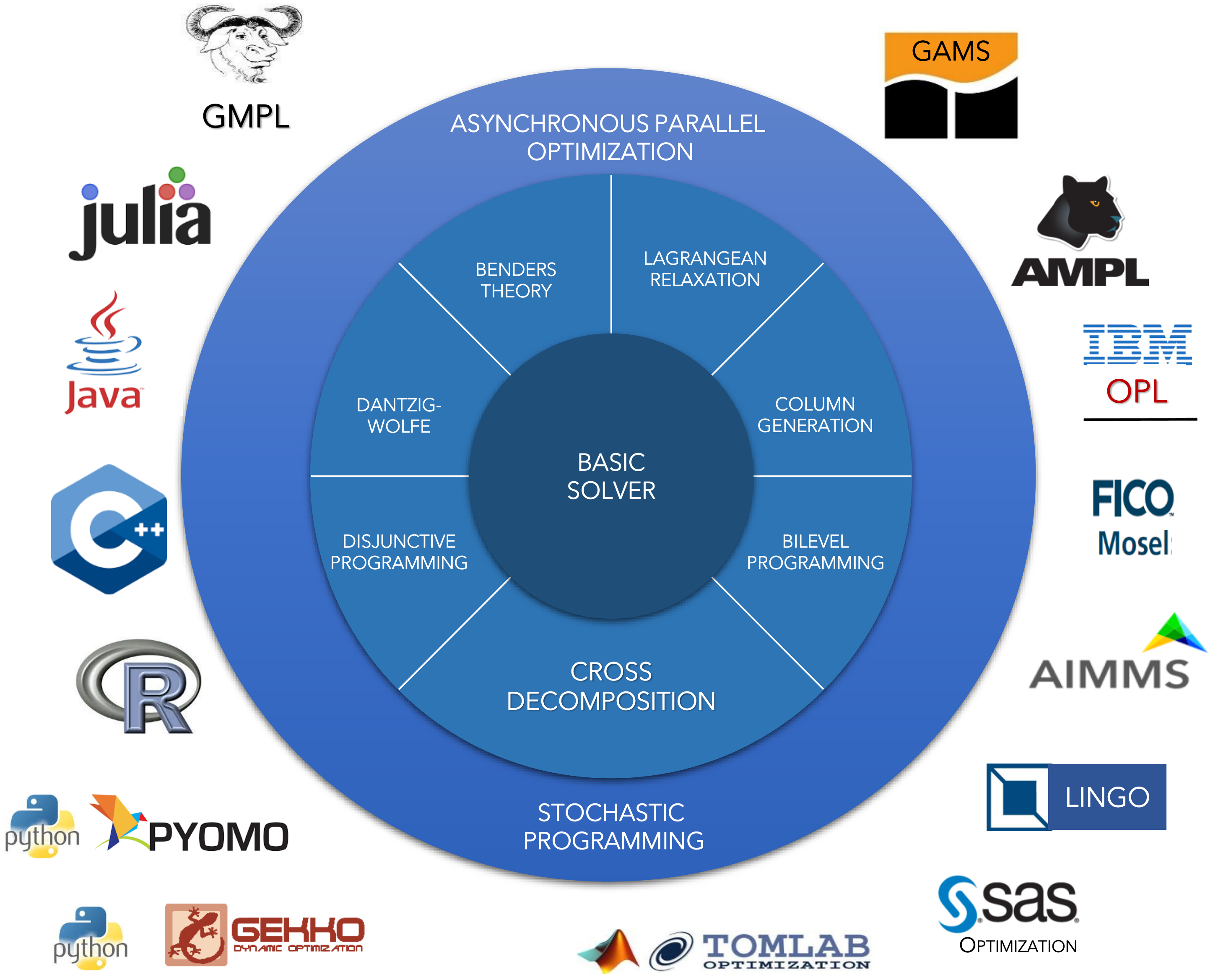
Large-Scale Optimization Methodologies

Optimization Technologies

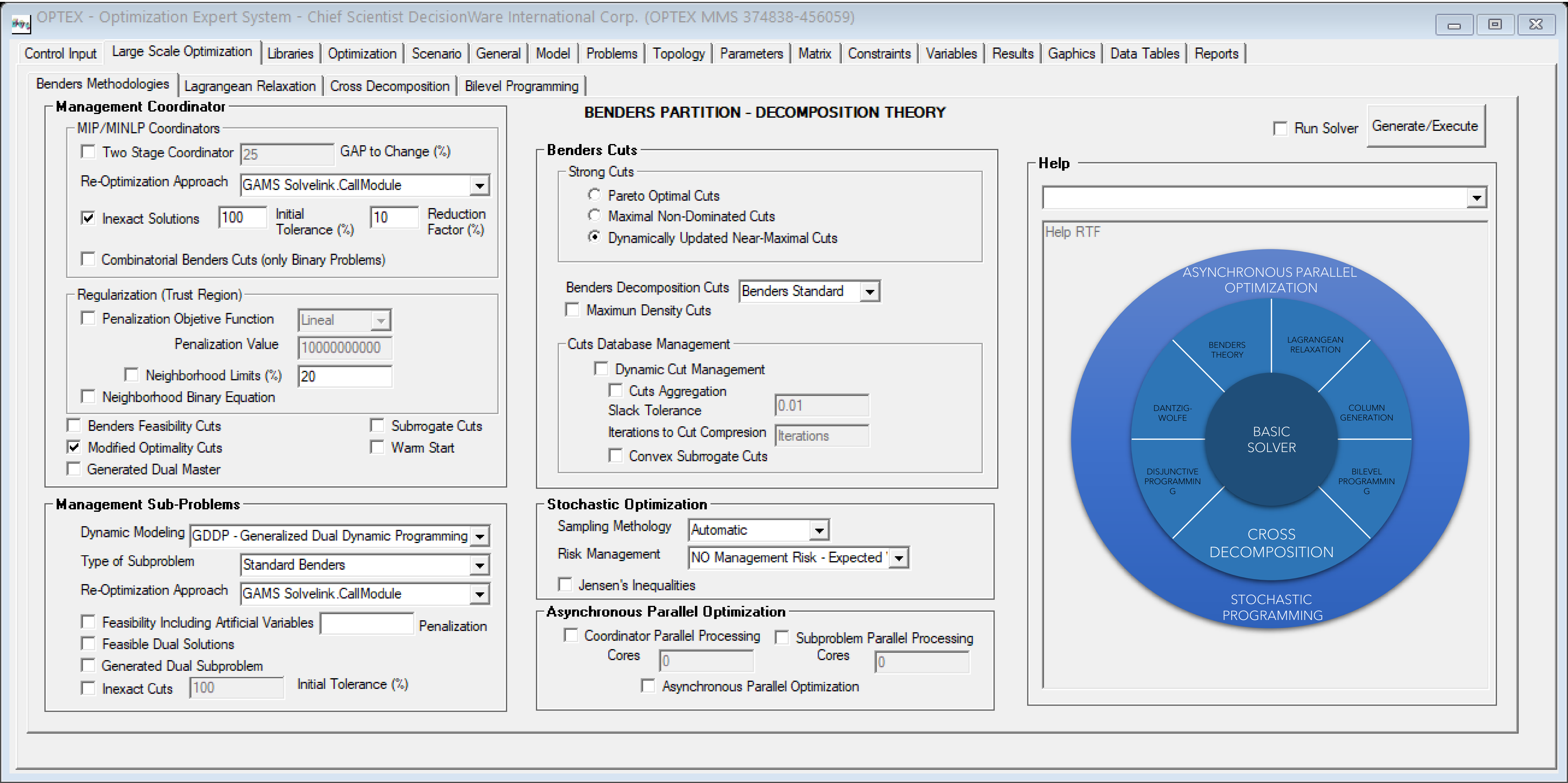
Optimization Technologies – Large Scale Optimization Technologies

OPTΣX





OPTEX – Large Scale Optimization Technologies



OPTEX – G-SDDP GAMS PROGRAM

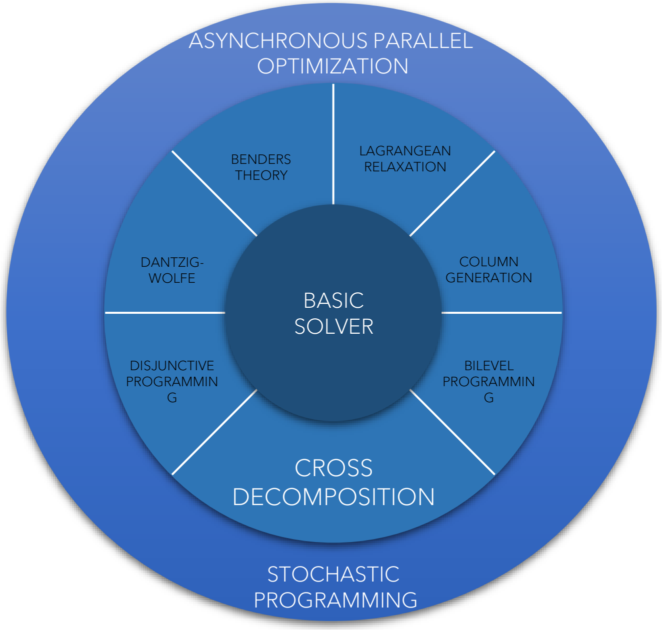
Gamside: C:\GENEX\SHTG\SHTGES\GDDP-C\CO\OPTEX_GDDPUNI.GPR - [c:\GENEX\SHTG\SHTGES\GDDP-C\CO\OPTEX_GDDPUNI.gms]

File Edit Search Windows Utilities Model Libraries Help

RSPH_

OPTEX_GDDPUNI.gms

```
* OPTEX-> File creation date: 02/10/2017 - 10:59:05-->
* GAMS Program Code generated by OPTEX Mathematical Modeling System copyright  DO ANALYTICS LLC.
* This code can be legally used only with write or digital license of DO ANALYTICS LLC.
* User License ID: Chief Scientist DecisionWare International Corp. (OPTEX MMS 374838-456059)

* OPTEX-> Modelo: GDDPUNI - GDDP - Nodo Unico - Deterministico

* OPTEX-> Problema(s):
*     Problema: BENUNICO Despacho Ideal Nodo Unico - Coordinador Benders
*     Problema: BENUNISP Despacho Ideal Nodo Unico - SubProblema Benders


*Tipo Modelo: Normal

$title OPTEX - Modelo: GDDPUNI GDDP - Nodo Unico - Deterministico
*OPTEX-> Include MOD ##INIT##

*OPTEX-> Include PRO BENUNICO ##INIT##

*OPTEX-> Include PRO BENUNISP ##INIT##


$onempty
*OPTEX-> Maestros Indices

SET t(*)  Tiempo
/
$include I_t.opt
/ ;
* SET C__TTT(t) Periodos  Modelo

SET C__TTT(t) Periodos  Modelo
```



GAMS

1: 1 Insert

Making Complex Mathematical Models

Filling the Blanks

OPTEX

Optimization Expert System

OPTEX

Database Algebraic Language
Computer Algebraic Language

RCADT

Research Center for Advanced Decision Technologies

Database Algebraic “Language”

OPTEX interprets the implementation of a Decision Support System as a load of a Relational Information System converting the mathematical modeling and the software production in a “filling the blanks” process.

The Lan-Wan environment makes easy this simultaneous work of several modelers, using the power of internet and the database servers.

Database Algebraic "Language"

OPTEX use the same structure to storage all the mathematical components that define a Decision Support System.

Then the mathematical modeler can use EXCEL or WORD to fill the tables that integrate the input of the Mathematical Modeling Information System (MMIS)

Database Algebraic "Language"

OPTEX Mathematical Modeling Information System (MMIS) is a data warehouse that contains mathematical objects, that have been proven in real models, and that can be used to built new models .

This works in the same way that in object programing, where to make the software, the programmer can use objects that work correctly.

Database Algebraic "Language"

OPTEX generates structured programs for each model, it is error free and easy to understand, because all description that exists in the data base are translated to the program.

The multilingual capacity of OPTEX permits description in multiple languages, then is possible to have the same model in different idioms.

OPTEX Structured Mathematical Modeling

A mathematical model can be conceived as the union of mathematical components harmoniously integrated.

There are two types of components (objects):

1. Basic Mathematical Definitions:
   i. Index
   ii. Sets,
   iii. Parameter,
   iv. Equations (Constraints)

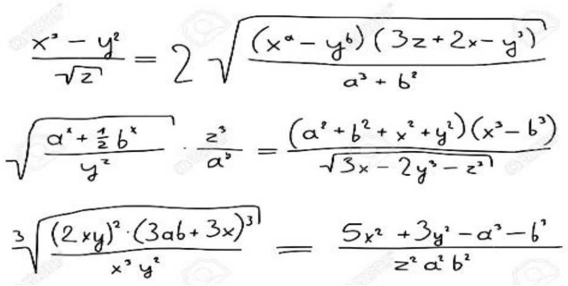
2. Advanced Concepts:
   i. Problems
   ii. Models
   iii. Decision Support Systems
   iv. Artificial Hypothalamus

These components can be stored in a relational information system, it permits their handling in a modular way, following the principles of relational information systems and use Structured Query Language (SQL) to manipulate the mathematical objects.

This conceptualization is independent of optimization technologies, which allows to separate the formulation of the mathematical models from their implementation using a specific optimization technology.

Implementing complex Mathematical Models from MS-Word

ALGEBRAIC MODEL



FILLING TABLES

MODEL IN MS-WORD

PARÁMETROS				
Parámetro	**Descripción**	**Unidad**	**Tabla Referencia**	**Campo**
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$\mathbf{CAMI}_{td}$	Capacidad de procesamiento mínima de un biodigestor con tecnología **td**.	m^3-día	MAE_TBD	CAMI
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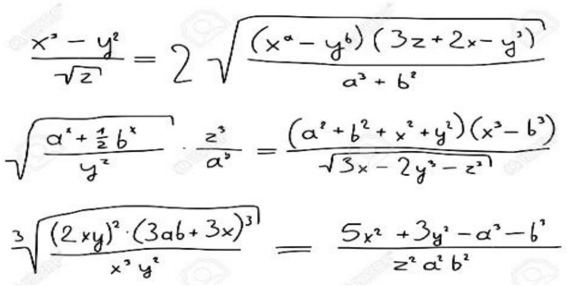
Implementing complex Mathematical Models from MS-Word

ALGEBRAIC MODEL



FILLING TABLES

MODEL IN MS-WORD

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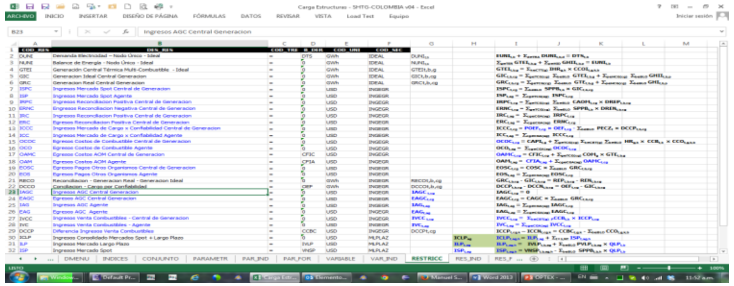
LOAD EXCEL



MODEL IN EXCEL

Implementing complex Mathematical Models from MS-Word

ALGEBRAIC MODEL

$$\frac{x^3 - y^2}{\sqrt{z}} = 2\sqrt{\frac{(x^a - y^b)(3z + 2x - y^3)}{a^3 + b^2}}$$

$$\sqrt{\frac{a^2 + \frac{1}{2}b^x}{y^2}} \cdot \frac{z^3}{a^3} = \frac{(a^2 + b^2 + x^2 + y^2)(x^3 - b^3)}{\sqrt{3x - 2y^3 - z^2}}$$

$$\sqrt[3]{\frac{(2xy)^2 (3ab + 3x)^3}{x^3 y^2}} = \frac{5x^2 + 3y^2 - a^3 - b^3}{z^2 a^2 b^2}$$

FILLING TABLES

MODEL IN MS-WORD

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$CTVB_{ud,td,tr}$	Pendiente del tramo **tr** para el costo de inversión variable de un biodigestor con tecnología **td** en el sitio **ud**. Se calcula con base en la siguiente fórmula: $\mathbf{CIVB_{ud,td,tr} = FCTD_{ud,td} \times (CIFA_{td,tr+1} - CIFA_{td,tr}) / (CALT_{td,tr+1} - CALT_{td,tr})}$	\$/m³-día		
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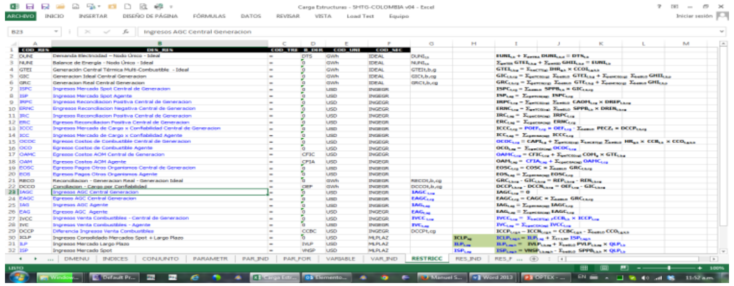
LOAD EXCEL



MODEL IN EXCEL

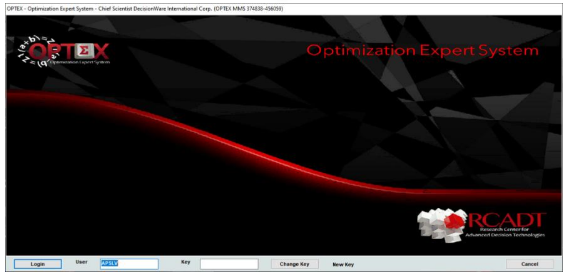
.CSV FILES

formula csv.csv - Notepad

File Edit Format View Help

```
"CIMIud,td","CIMIud,td = FCTDud,td × CTMItd"
"CTVBud,td,tr","CIVBud,td,tr = FCTDud,td × (CIFAtd,tr+1 – CIFAtd,tr) / (CALTtd,tr+1 – CALTtd,tr)"
"PBIRud,bm","PBIRud,bm = SgrÎGRE(rn)  PBIGgr,bm + SmuÎMRE(rn)  PBIMmu,bm"
"DIRSrn,ud","DIRSrn,ud  = FKMS × (DI2Xrn,ud  + DI2Yrn,ud)½"
"CTBIrn,ud,mt","CTBIrn,ud,mt = DIRSrn,ud  × FLTEmt × FACRrn  × FACSud  "
"PGBUud,td,bm","PGBUud,td,bm = PGTDtd,bm × FGUDud,td"
"PDBUud,td,bm","PDBUud,td,bm = PDTDtd,bm × FDUDud,td"
"CPBIud,td,bm","CPBIud,td,bm = CPUDtd,bm × FCUDud,td"
"DIRSrn,ud","DIRSrn,ud  = FKMS × (DI2Xrn,ud  + DI2Yrn,ud)½"
"DI2Xrn,ud  ","DI2Xrn,ud  = (CORXrn -  COSXrn)2"
"DI2Yrn,ud  ","DI2Yrn,ud  = (CORYrn -  COSYrn)2"
```

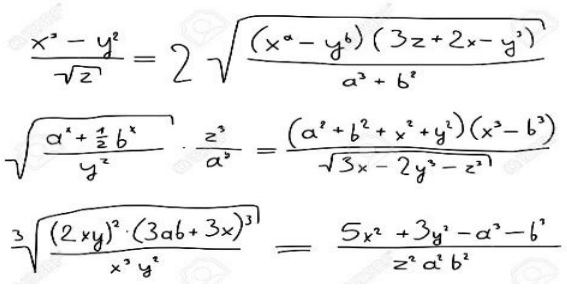
LOAD OPTEX



Implementing complex Mathematical Models from MS-Word

OPTΣX

ALGEBRAIC MODEL



FILLING TABLES

MODEL IN MS-WORD

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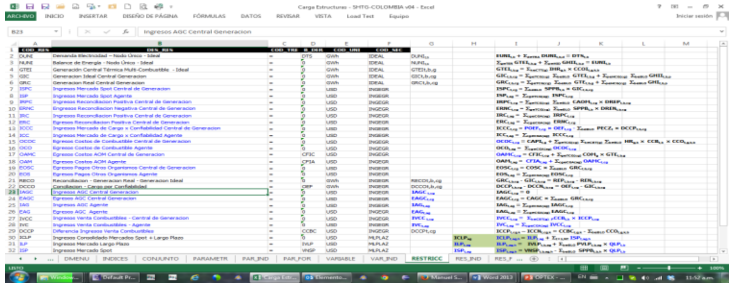
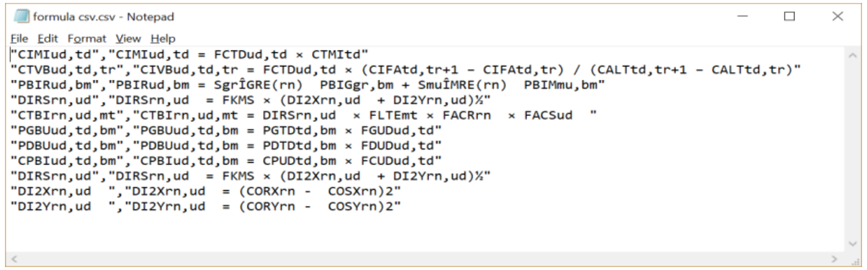


MODEL IN EXCEL

.CSV FILES



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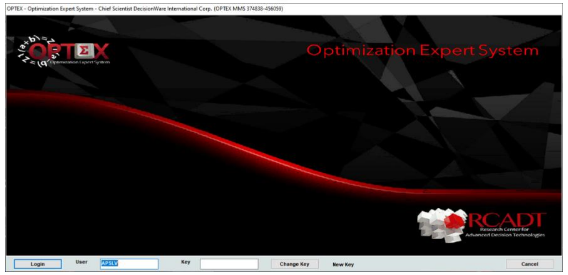


CODE GENERATION
INCLUDING LARGE SCALE METHODOLOGIES

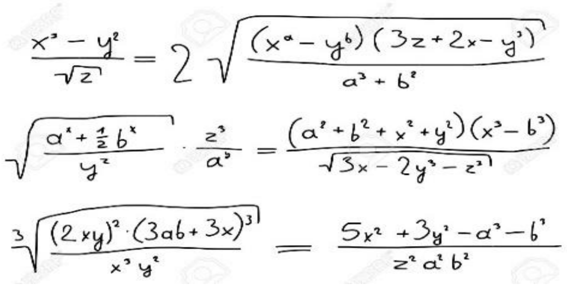
C++ python GAMS ILOG An IBM Company OPL FICO Mosel AIMMS AMPL

OPTIMIZATION TECHNOLOGY

MODEL IN A COMPUTER LANGUAGE

Implementing complex Mathematical Models from MS-Word

ALGEBRAIC MODEL



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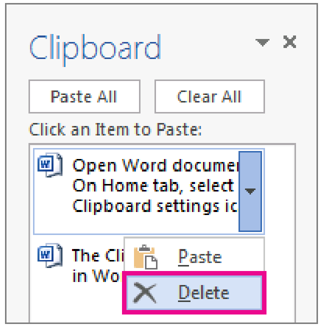
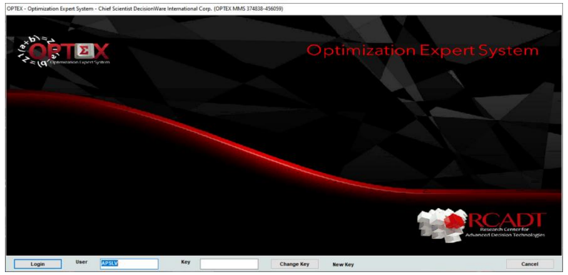


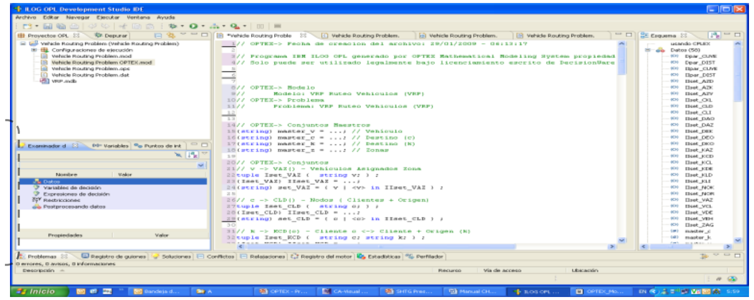
LOAD OPTEX



CODE GENERATION
INCLUDING LARGE SCALE METHODOLOGIES

OPL

OPTIMIZATION TECHNOLOGY



MODEL IN A COMPUTER LANGUAGE

Future OPTEX – Optimization Expert System - Optimization Expert System + Web Access

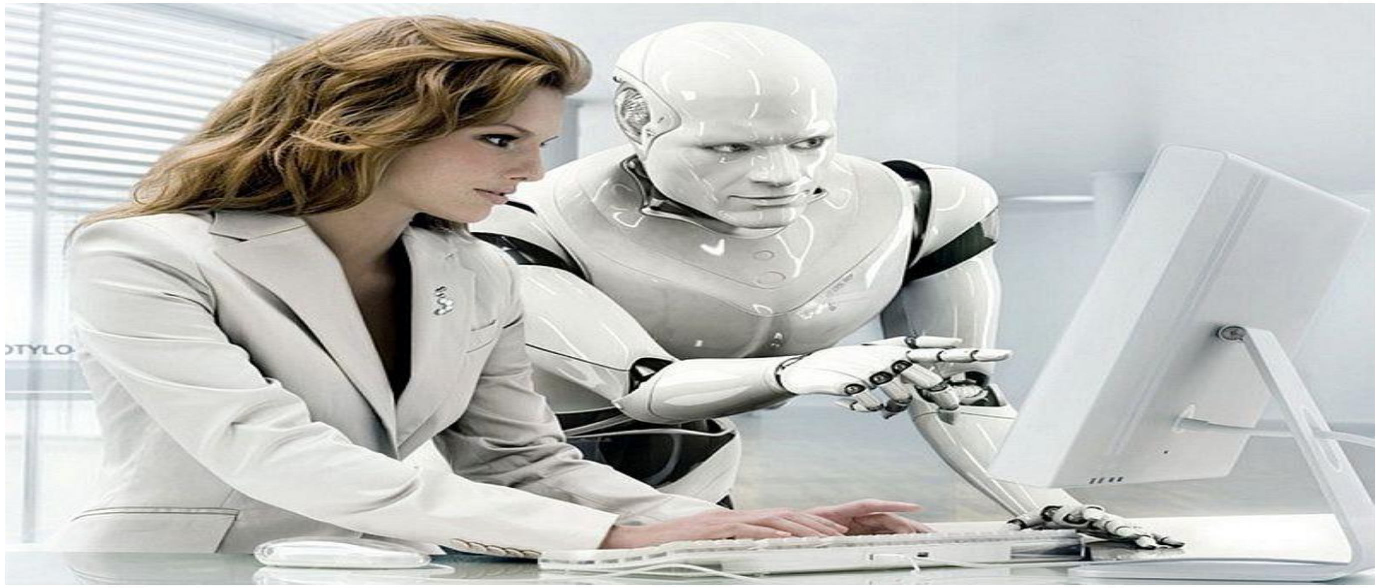
ALGEBRAIC MODEL

$$\frac{x^3 - y^2}{\sqrt{z}} = 2\sqrt{\frac{(x^a - y^b)(3z + 2x - y^3)}{a^3 + b^2}}$$

$$\sqrt{\frac{a^2 + \frac{1}{2}b^2}{y^2}} \cdot \frac{z^3}{a^3} = \frac{(a^2 + b^2 + x^2 + y^2)(x^3 - b^3)}{\sqrt{3x - 2y^3 - z^2}}$$

$$\sqrt[3]{\frac{(2xy)^2 \cdot (3ab + 3x)^3}{x^3 y^2}} = \frac{5x^2 + 3y^2 - a^3 - b^3}{z^2 a^2 b^2}$$

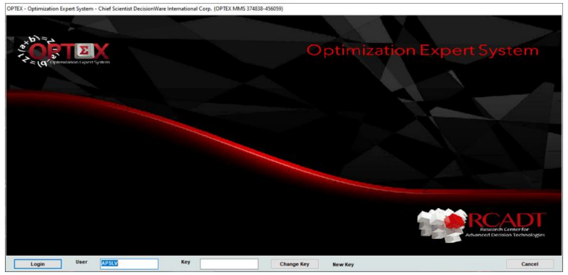
SPEAKING WITH OPTEX



HELPING THE MODELER

LOAD OPTEX

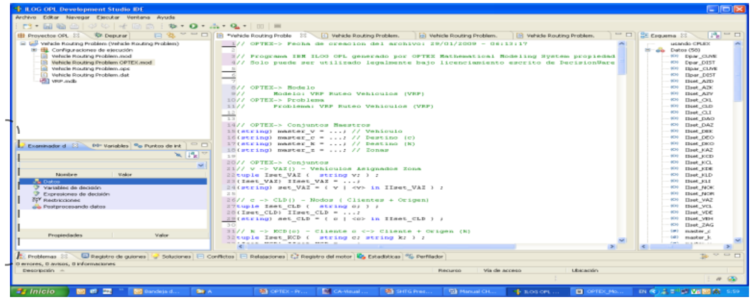
LOAD OPTEX



CODE GENERATION
INCLUDING LARGE SCALE METHODOLOGIES

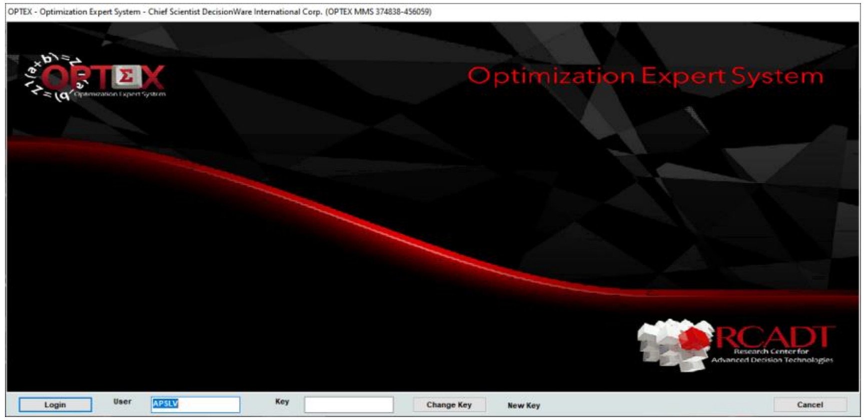
C++ python GAMS ILOG An IBM Company OPL FICO Mosel AIMMS AMPL

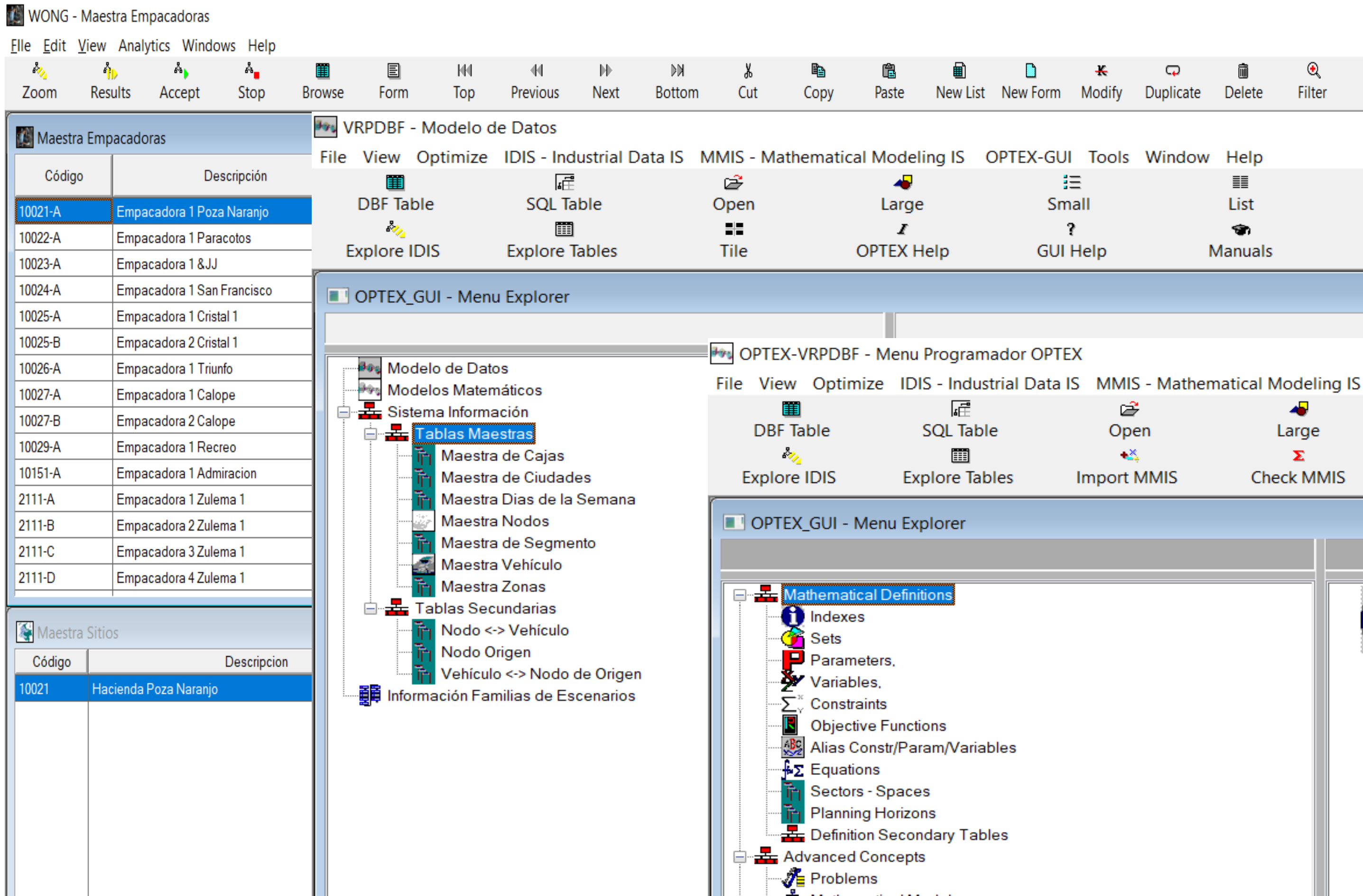
OPTIMIZATION TECHNOLOGY



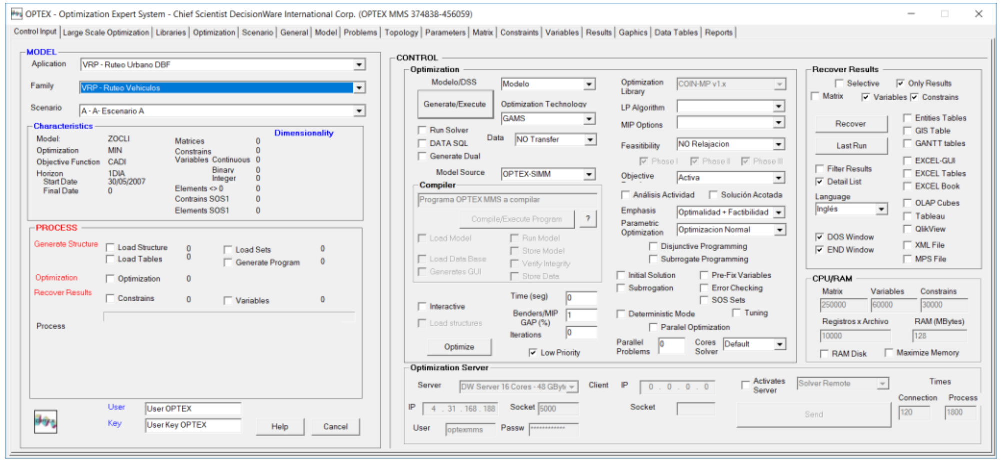
MODEL IN A COMPUTER LANGUAGE

OPTEX – Optimization Expert System - Automatic Generated User Interface





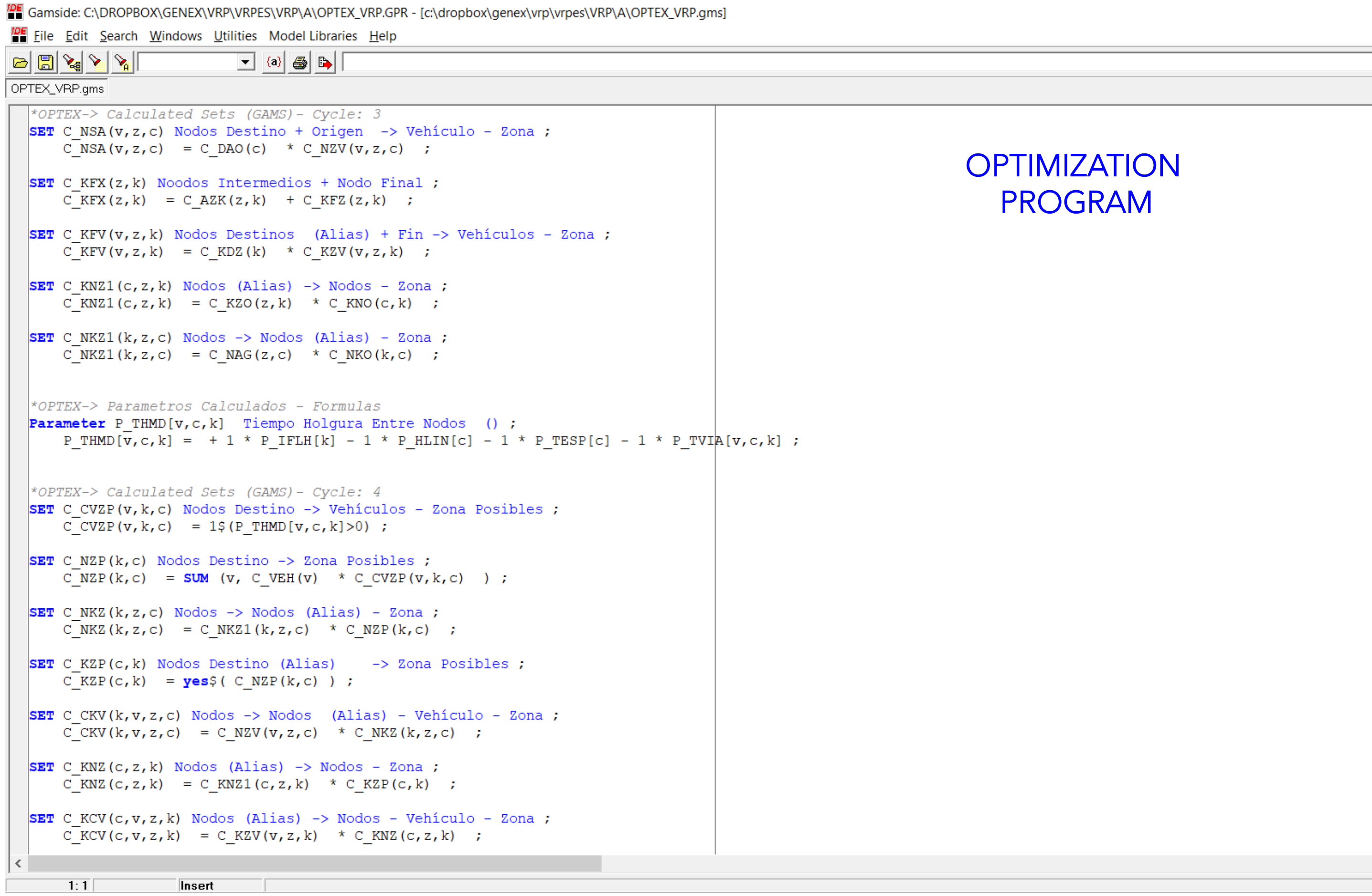
OPTEX – Optimization Expert System - Optimization Models Generator



CONTROL DIALOG WINDOW

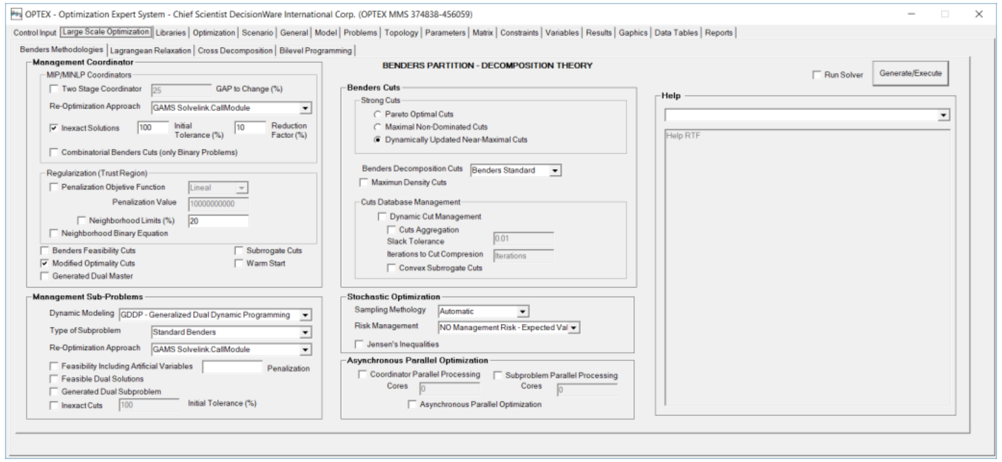
BASIC SOLVER

GUROBI
CPLEX
XPRESS
COINMP
GLPK

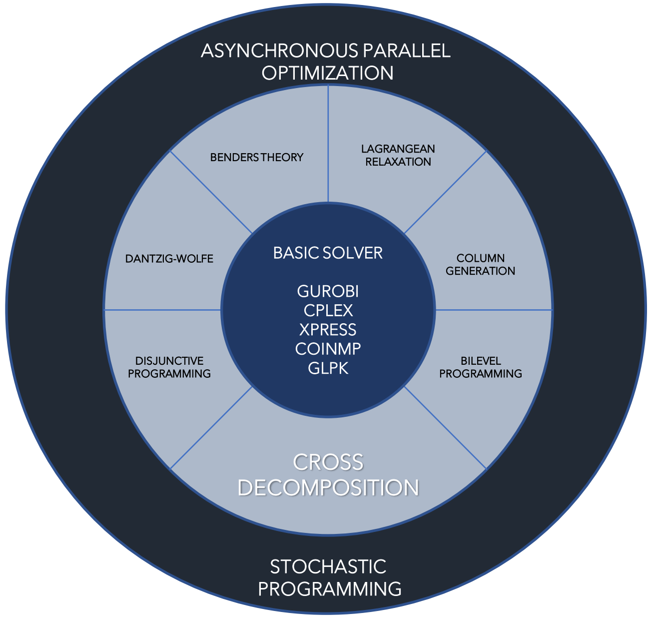


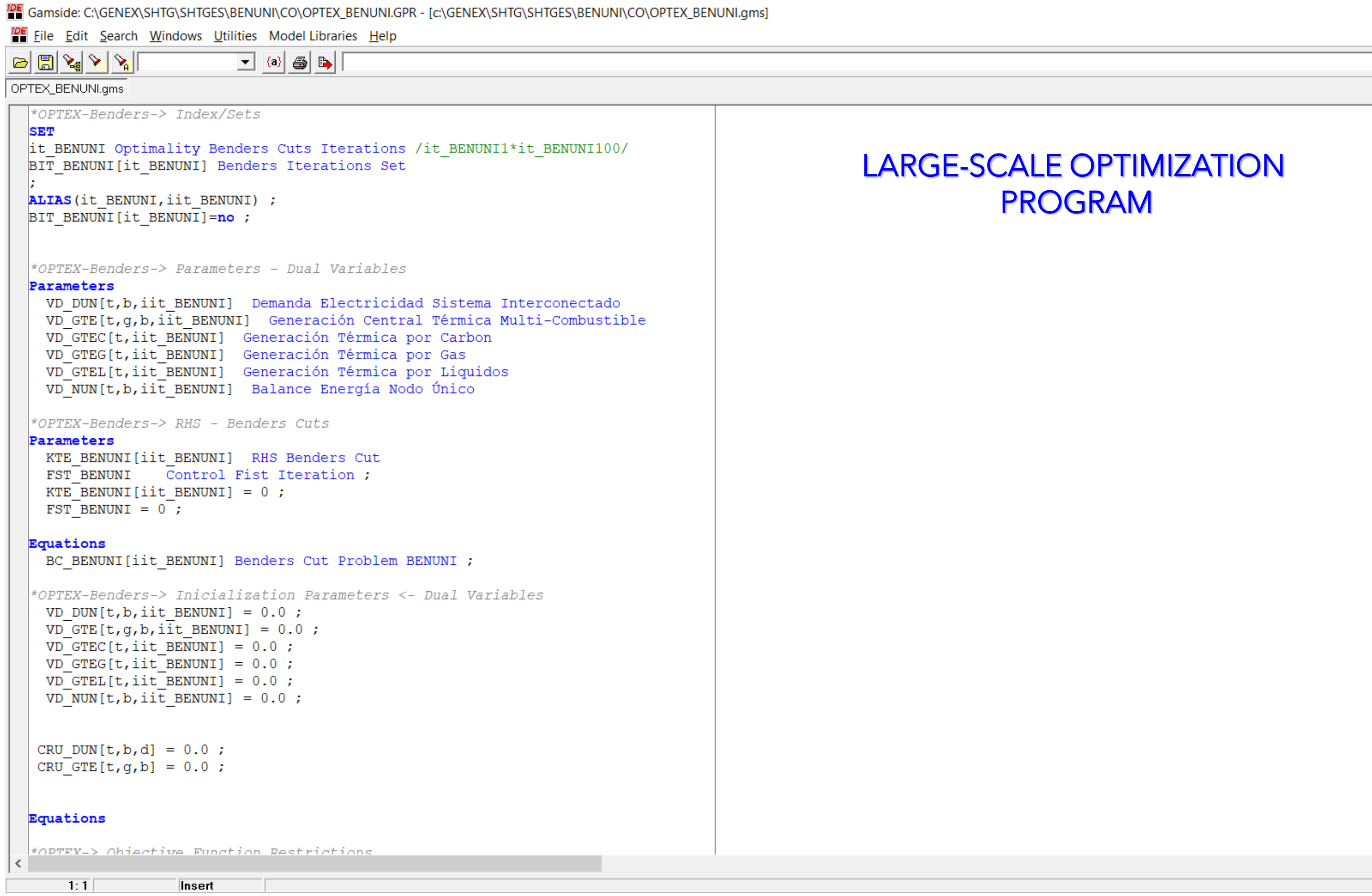
OPTIMIZATION PROGRAM

OPTEX – Optimization Expert System - Large-Scale Optimization Models Generator



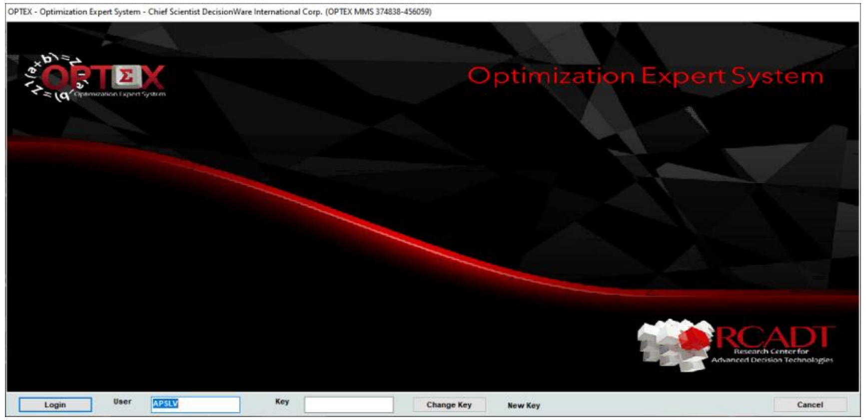
LARGE-SCALE CONTROL DIALOG WINDOW

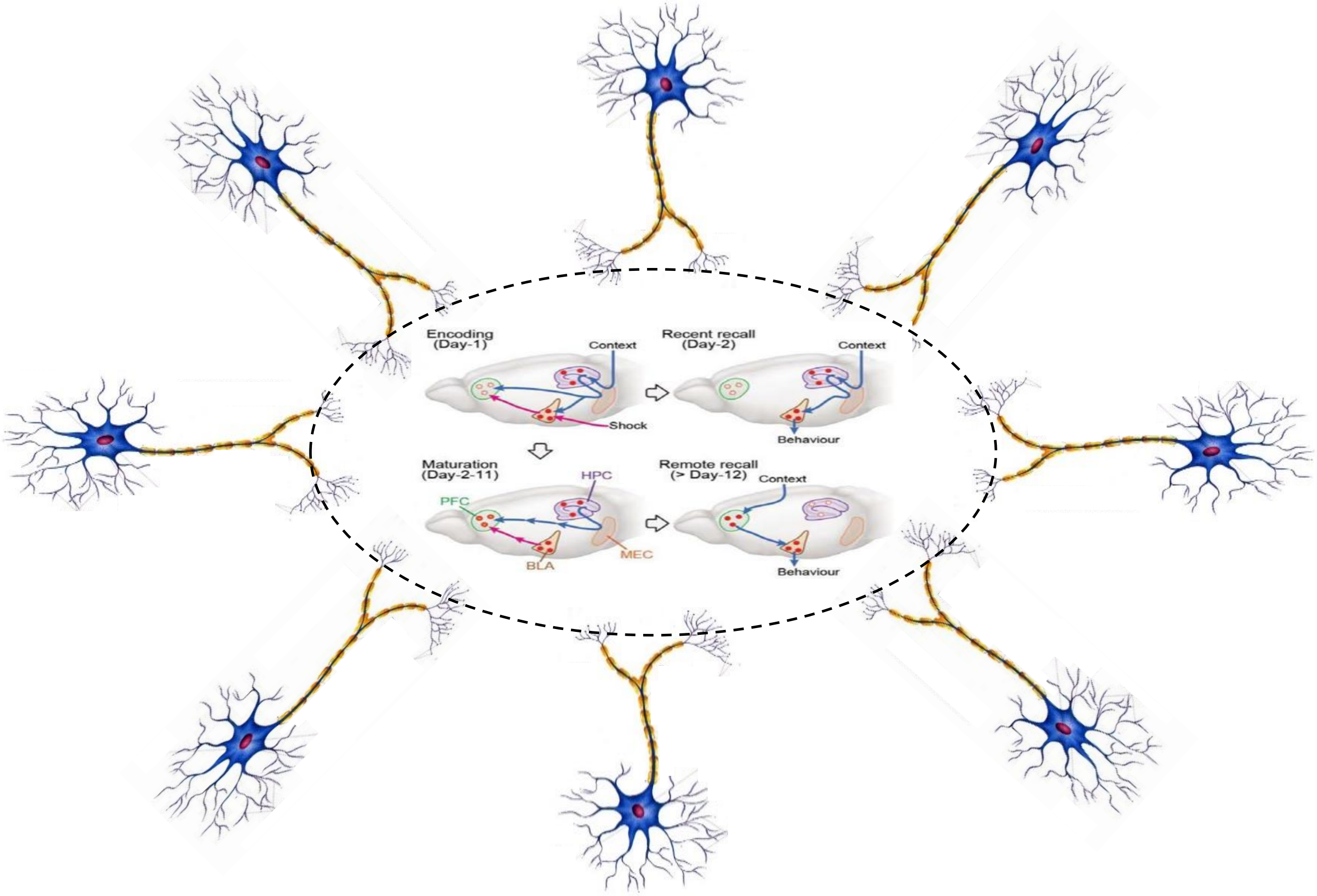





```
*OPTEX-Benders-> Index/Sets
SET
it_BENUNI Optimality Benders Cuts Iterations /it_BENUNI1*it_BENUNI100/
BIT_BENUNI[it_BENUNI] Benders Iterations Set
;
ALIAS(it_BENUNI,iit_BENUNI) ;
BIT_BENUNI[it_BENUNI]=no ;


*OPTEX-Benders-> Parameters - Dual Variables
Parameters
  VD_DUN[t,b,iit_BENUNI]  Demanda Electricidad Sistema Interconectado
  VD_GTE[t,g,b,iit_BENUNI]  Generación Central Térmica Multi-Combustible
  VD_GTEC[t,iit_BENUNI]  Generación Térmica por Carbon
  VD_GTEG[t,iit_BENUNI]  Generación Térmica por Gas
  VD_GTEL[t,iit_BENUNI]  Generación Térmica por Liquidos
  VD_NUN[t,b,iit_BENUNI]  Balance Energía Nodo Único

*OPTEX-Benders-> RHS - Benders Cuts
Parameters
  KTE_BENUNI[iit_BENUNI]  RHS Benders Cut
  FST_BENUNI     Control Fist Iteration ;
  KTE_BENUNI[iit_BENUNI] = 0 ;
  FST_BENUNI = 0 ;

Equations
  BC_BENUNI[iit_BENUNI] Benders Cut Problem BENUNI ;

*OPTEX-Benders-> Inicialization Parameters <- Dual Variables
  VD_DUN[t,b,iit_BENUNI] = 0.0 ;
  VD_GTE[t,g,b,iit_BENUNI] = 0.0 ;
  VD_GTEC[t,iit_BENUNI] = 0.0 ;
  VD_GTEG[t,iit_BENUNI] = 0.0 ;
  VD_GTEL[t,iit_BENUNI] = 0.0 ;
  VD_NUN[t,b,iit_BENUNI] = 0.0 ;


 CRU_DUN[t,b,d] = 0.0 ;
 CRU_GTE[t,g,b] = 0.0 ;


Equations

*OPTEX-> Objective Function Restrictions
```

LARGE-SCALE OPTIMIZATION PROGRAM


OPTEX - Optimization Expert System - Chief Scientist DecisionWare International Corp. (OPTEX MMS 374838-456059)
OPTΣX
Optimization Expert System
RCADT
Research Center for
Advanced Decision Technologies
Login
User
APSLV
Key
Change Key
New Key
Cancel


Encoding
(Day-1)
Context
Shock
Recent recall
(Day-2)
Context
Behaviour
Maturation
(Day-2-11)
HPC
PFC
MEC
BLA
Remote recall
(> Day-12)
Context
Behaviour

Optimization Technologies
OPTEX Implementation

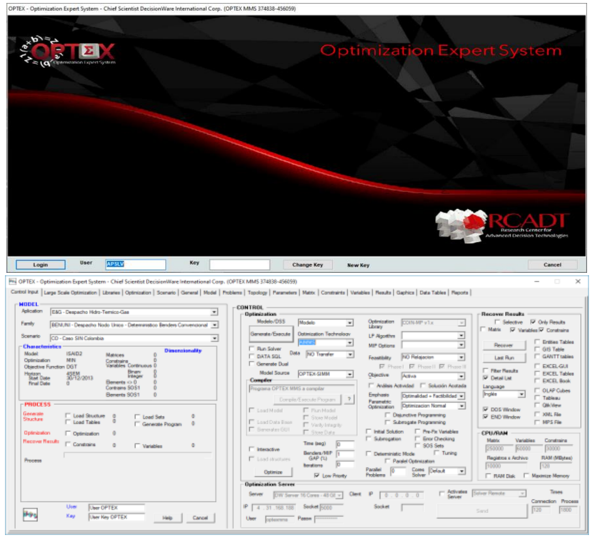
Optimization Expert System

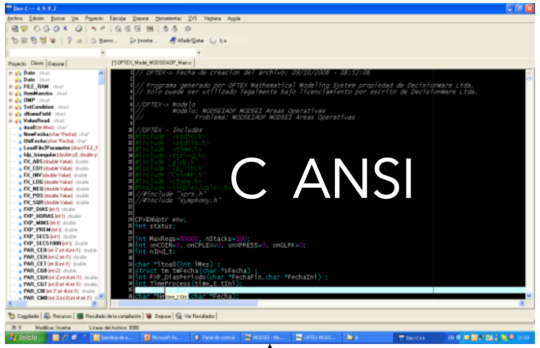
OPTEX supports all stages of the mathematical modeling process, designing Mathematical Models from MS-WORD (the "natural technology" for writing algebraic formulation) the mathematical modeler can obtain computer programs in multiple optimization technologies (like C ANSI, PYTHON, GAMS, IBM OPL, XPRESS/MOSEL, AMPL, AIMMS, among others) without carrying out programming activities.

RCADT
Research Center for Advanced Decision Technologies

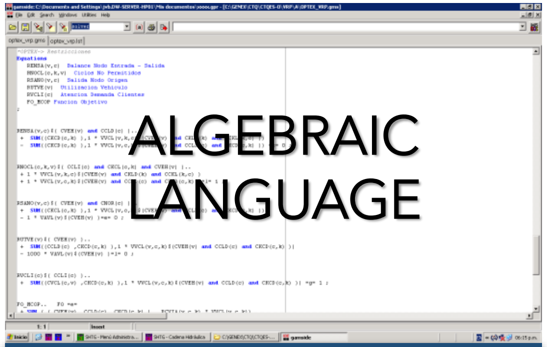
Developing Mathematical Models

OPTΣX





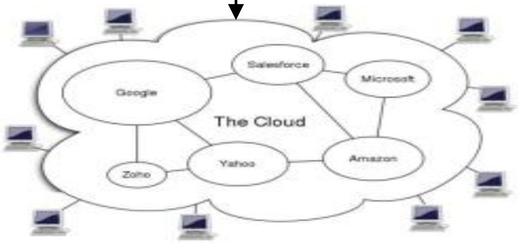
SOLVER



SOLVER

OPTΣX

CLOUD LINK

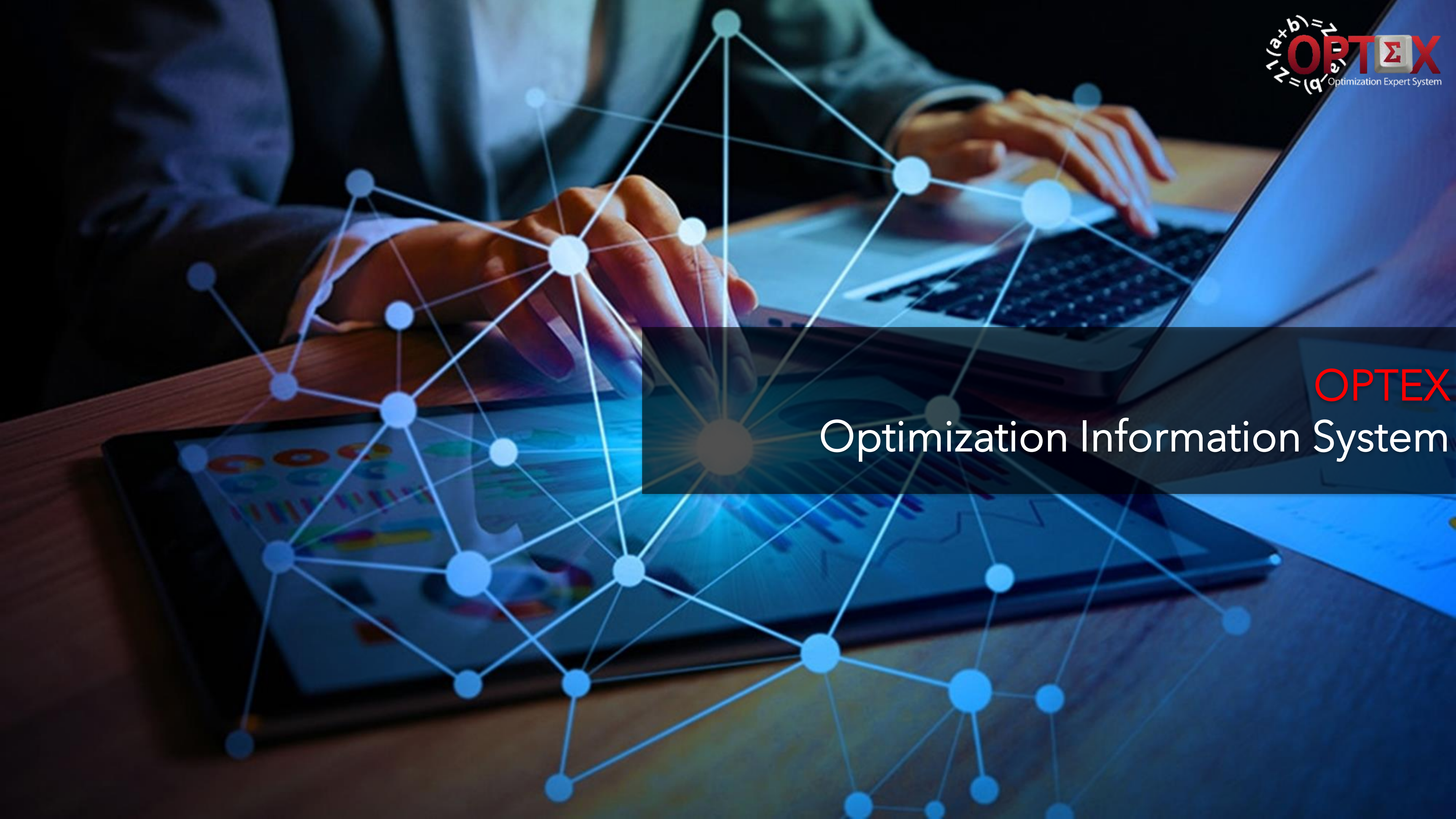


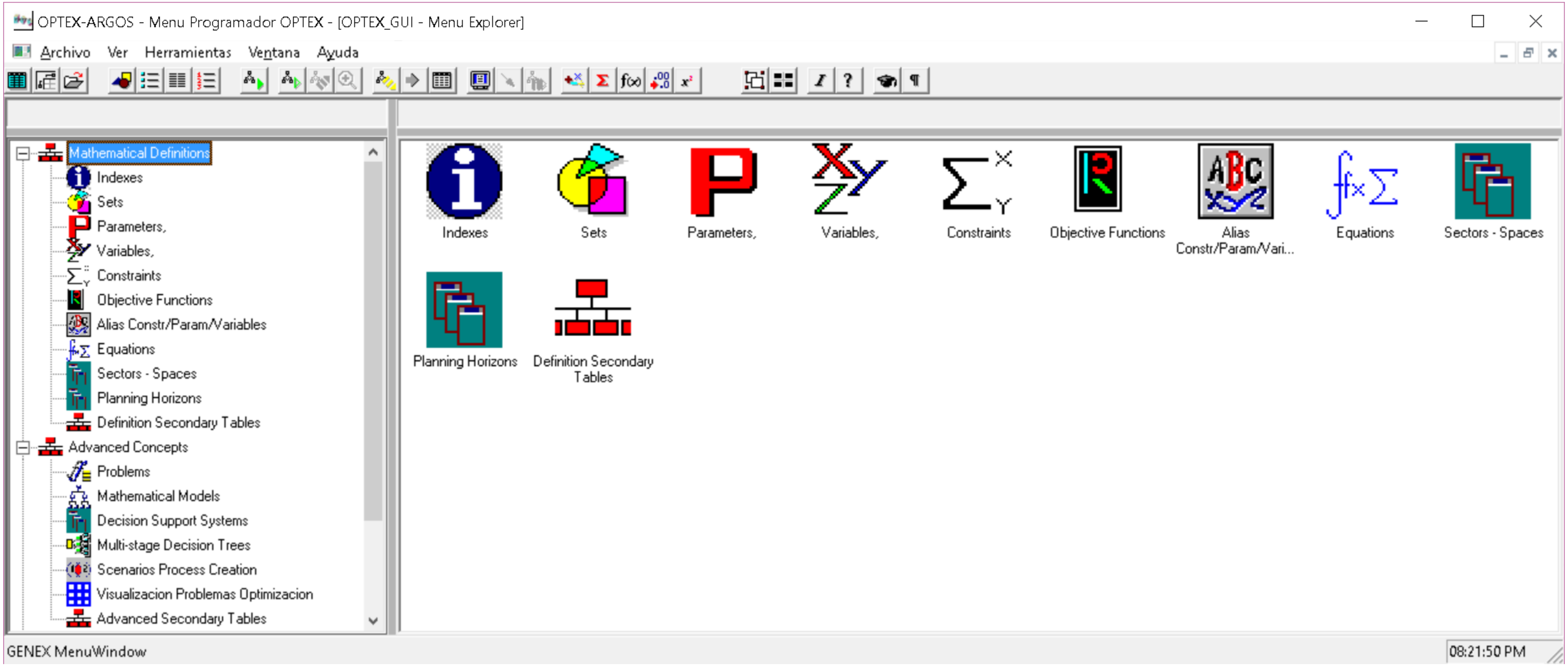
CLOUD SERVER

OPTEX
Optimization Expert System

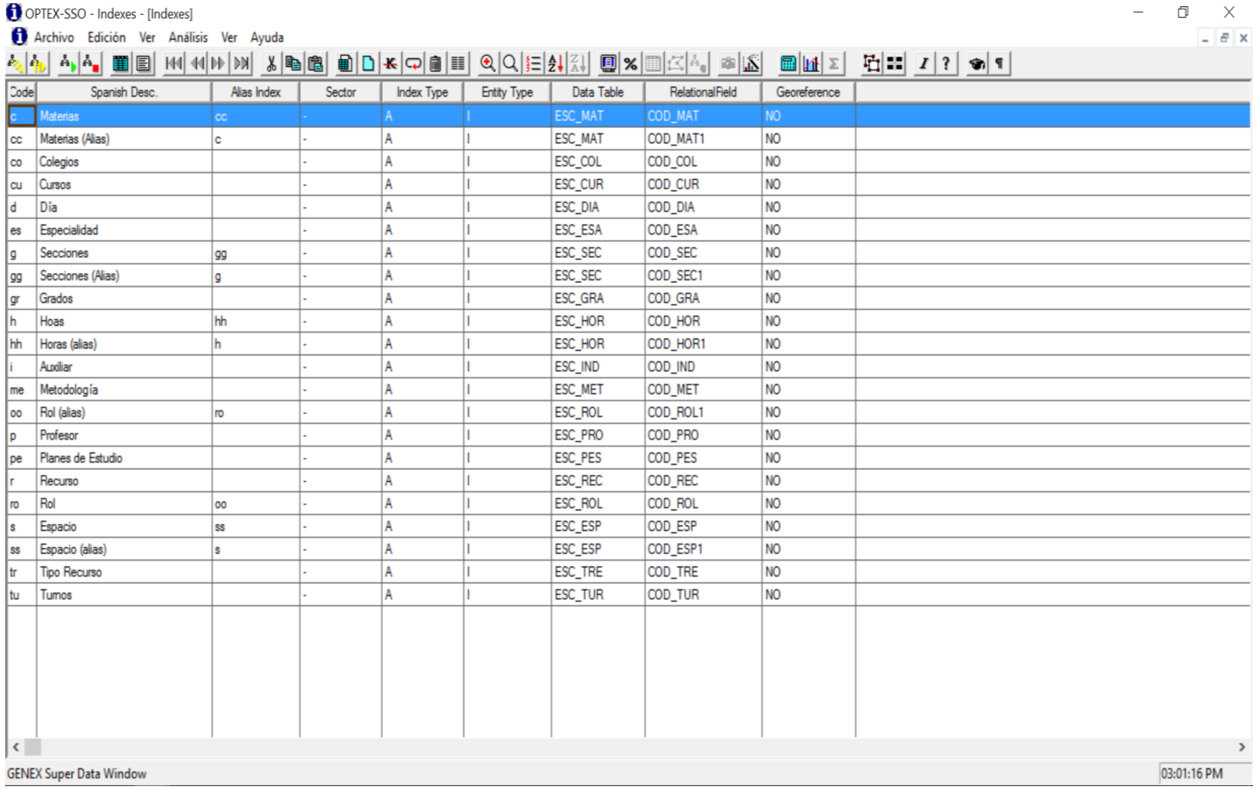
Optimization Technologies Connectivity

RCADT
Research Center for Advanced Decision Technologies


OPTEX
Optimization Expert System
OPTEX
Optimization Information System

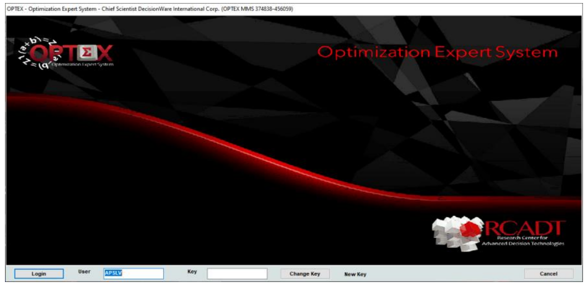

OPTEX-ARGOS - Menu Programador OPTEX - [OPTEX_GUI - Menu Explorer]
Archivo Ver Herramientas Ventana Ayuda
Mathematical Definitions
Indexes
Sets
Parameters,
Variables,
Constraints
Objective Functions
Alias Constr/Param/Variables
Equations
Sectors - Spaces
Planning Horizons
Definition Secondary Tables
Advanced Concepts
Problems
Mathematical Models
Decision Support Systems
Multi-stage Decision Trees
Scenarios Process Creation
Visualizacion Problemas Optimizacion
Advanced Secondary Tables
Indexes
Sets
Parameters,
Variables,
Constraints
Objective Functions
Alias Constr/Param/Vari...
Equations
Sectors - Spaces
Planning Horizons
Definition Secondary Tables
GENEX MenuWindow
08:21:50 PM

Structured Mathematical Modeling - Indexes



Code	Spanish Desc.	Alias Index	Sector	Index Type	Entity Type	Data Table	RelationalField	Georeference
c	Materias	cc	-	A	I	ESC_MAT	COD_MAT	NO
cc	Materias (Alias)	c	-	A	I	ESC_MAT	COD_MAT1	NO
co	Colegios		-	A	I	ESC_COL	COD_COL	NO
cu	Cursos		-	A	I	ESC_CUR	COD_CUR	NO
d	Día		-	A	I	ESC_DIA	COD_DIA	NO
es	Especialidad		-	A	I	ESC_ESA	COD_ESA	NO
g	Secciones	gg	-	A	I	ESC_SEC	COD_SEC	NO
gg	Secciones (Alias)	g	-	A	I	ESC_SEC	COD_SEC1	NO
gr	Grados		-	A	I	ESC_GRA	COD_GRA	NO
h	Hoas	hh	-	A	I	ESC_HOR	COD_HOR	NO
hh	Horas (alias)	h	-	A	I	ESC_HOR	COD_HOR1	NO
i	Auxiliar		-	A	I	ESC_IND	COD_IND	NO
me	Metodología		-	A	I	ESC_MET	COD_MET	NO
oo	Rol (alias)	ro	-	A	I	ESC_ROL	COD_ROL1	NO
p	Profesor		-	A	I	ESC_PRO	COD_PRO	NO
pe	Planes de Estudio		-	A	I	ESC_PES	COD_PES	NO
r	Recurso		-	A	I	ESC_REC	COD_REC	NO
ro	Rol	oo	-	A	I	ESC_ROL	COD_ROL	NO
s	Espacio	ss	-	A	I	ESC_ESP	COD_ESP	NO
ss	Espacio (alias)	s	-	A	I	ESC_ESP	COD_ESP1	NO
tr	Tipo Recurso		-	A	I	ESC_TRE	COD_TRE	NO
tu	Turnos		-	A	I	ESC_TUR	COD_TUR	NO

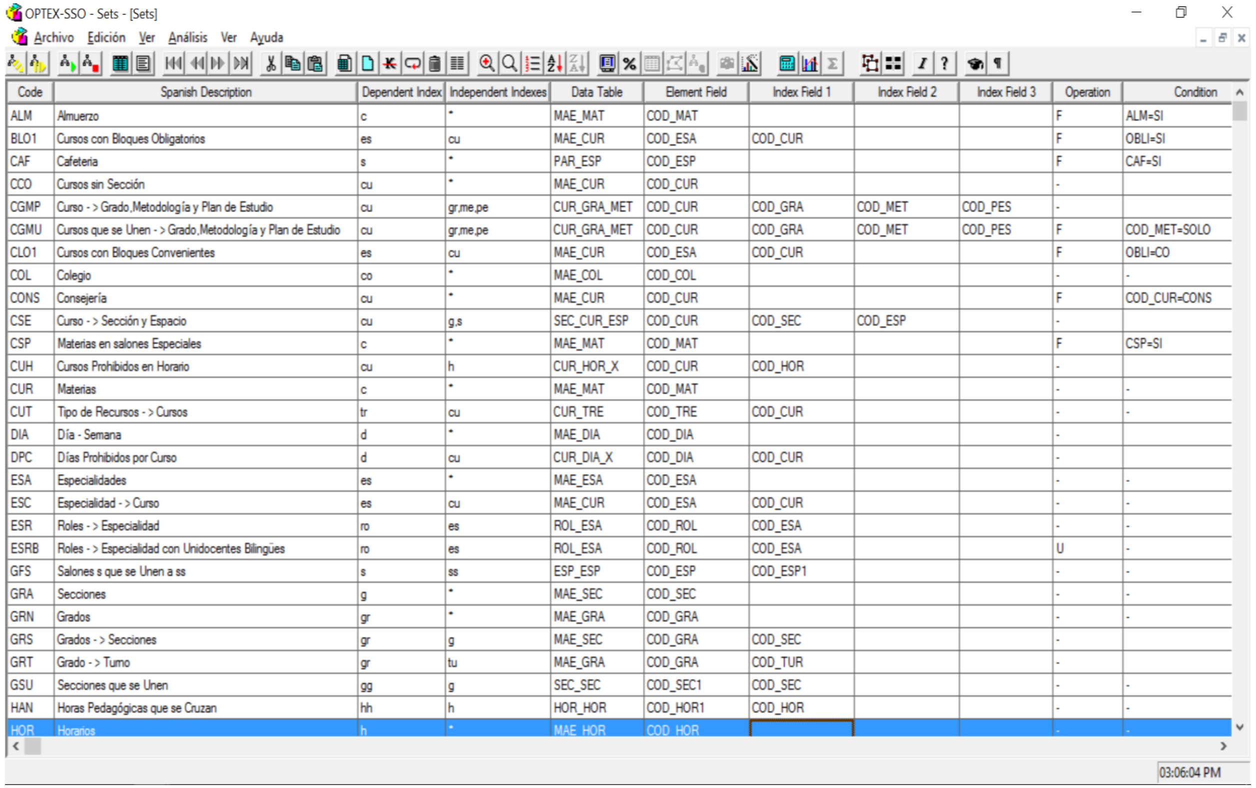
ENTIDADES COLEGIOS PERUANOS					
ÍNDICE	**CÓDIGO**	**ENTIDAD OBJETO**	**TABLA MAESTRA**	**TABLA ESCENARIO**	**CAMPO RELACIONAL**
cu	CUR	Curso	MAE_CUR	ESC_CUR	COD_CUR
d	DIA	Día	MAE_DIA	ESC_DIA	COD_DIA
se	SEC	Sección	MAE_SEC	ESC_SEC	COD_SEC
g	GRA	Grado	MAE_GRA	ESC_GRA	COD_GRA
co	COL	Sede	MAE_COL	ESC_COL	COD_COL
h	HOR	Hora escolar	MAE_HOR	ESC_HOR	COD_HOR
p	PRO	Profesor	MAE_PRO	ESC_PRO	COD_PRO
r	REC	Recurso	MAE_REC	ESC_REC	COD_REC
tr	TRE	Tipo de Recurso	MAE_TRE	ESC_TRE	COD_TRE
s	ESP	Espacio	MAE_ESP	ESC_ESP	COD_ESP
me	MET	Metodología	MAE_MET	ESC_MET	COD_MET
te	TES	Tipo espacio	MAE_TES	ESC_TES	COD_TES
ro	ROL	Rol	MAE_ROL	ESC_ROL	COD_ROL
sd	SED	Macro sedes	MAE_SED	ESC_SED	COD_SED
al	ALU	Alumnos	MAE_ALU	ESC_ALU	COD_ALU
n	NIV	Niveles	MAE_NIV	ESC_NIV	COD_NIV
tu	TUR	Turnos	MAE_TUR	ESC_TUR	COD_TUR
pa	PES	Plan de estudios	MAE_PES	ESC_PES	COD_PES
es	ESA	Especialidad	MAE_ESA	ESC_ESA	COD_ESA
rg	REG	Región	MAE_REG	ESC_REG	COD_REG



Structured Mathematical Modeling – Basic Sets (Read)

CONJUNTOS BÁSICOS				
Conjunto	**Descripción**	**Tabla**	**Campo Elemento**	**Filtro**
es∊BLO1(cu)	Cursos con Bloques Obligatorios	MAE_CUR	COD_ESA	OBLI=SI
cu∊CCO	Cursos sin Sección	MAE_CUR	COD_CUR	
cu∊CGMU(gr,me,pe)	Cursos Unificados -> Grado, Metodología, Plan Estudio	CUR_GRA_MET	COD_CUR	COD_MET=SOLO
cu∊CONS	Consejería	MAE_CUR	COD_CUR	COD_CUR=CONS
cu∊CUH(h)	Cursos Prohibidos en Horario	CUR_HOR_X	COD_CUR	
c∊CUR	Materias	MAE_MAT	COD_MAT	
d∊DIA	Día - Semana	MAE_DIA	COD_DIA	
d∊DPC(cu)	Días Prohibidos por Curso	CUR_DIA_X	COD_DIA	
es∊ESA	Especialidades	MAE_ESA	COD_ESA	
es∊ESC(cu)	Especialidad - > Curso	MAE_CUR	COD_ESA	
ro∊ESR(es)	Roles - > Especialidad	ROL_ESA	COD_ROL	
g∊GRA	Secciones	MAE_SEC	COD_SEC	
gr∊GRS(g)	Grados - > Secciones	MAE_SEC	COD_GRA	
gr∊GRT(tu)	Grado - > Turno	MAE_GRA	COD_GRA	
hh∊HAN(h)	Horas Pedagógicas que se Cruzan	HOR_HOR	COD_HOR1	
h∊HOR	Horarios	MAE_HOR	COD_HOR	
hh∊HSG(h)	Horas Seguidas	HOR_SEG	COD_HOR1	
cu∊MAC(c)	Materia - > Curso	MAE_MAT	COD_CUR	
c∊MSC(cu,g)	Materia - > Curso y Sección	MAE_MAT	COD_MAT	
oo∊ORP	Roles (alias)	ROL_ROL	COD_ROL1	
s∊PAT	Patio	MAE_ESP	COD_ESP	COD_TES=PAT
pe∊PES1	Planes de Estudio	MAE_PES	COD_PES	
ro∊PRO	Roles	MAE_ROL	COD_ROL	
ro∊RGP2(g)	Roles - > Secciones Prohibidas	ROL_SEC_X	COD_ROL	
ro∊RGR(gr)	Roles - > Grados	ROL_GRA	COD_ROL	
r∊RTR(tr)	Recursos - > Tipo de Recursos	MAE_REC	COD_REC	
s∊SAL	Espacios	MAE_ESP	COD_ESP	
g∊SCE(cu,s)	Sección - > Curso y Espacio	SEC_CUR_ESP	COD_SEC	
ss∊SFG(s)	Espacios ss que Pertenecen a s	ESP_ESP	COD_ESP1	
g∊SMC(cu,c)	Sección - > Materia y Curso	MAE_MAT	COD_SEC	
s∊SPH(h)	Salones Prohibidos Horario	ESP_HOR_X	COD_ESP	
ro∊SRO(oo)	Secuencia de Roles	ROL_ROL	COD_ROL	
me∊SUN	Metodología Secciones Unidas	MAE_MET	COD_MET	SUN=SI
tr∊TRE	Tipo de Recurso	ESC_TRE	COD_TRE	
tu∊TUD(d)	Turno - > Día	TUR_DIA	COD_TUR	
tu∊TUH(h)	Turno - > Hora	TUR_HOR	COD_TUR	
cu∊TUT	Tutoría	MAE_CUR	COD_CUR	COD_CUR=TUTO

Structured Mathematical Modeling – Basic Sets (Read)

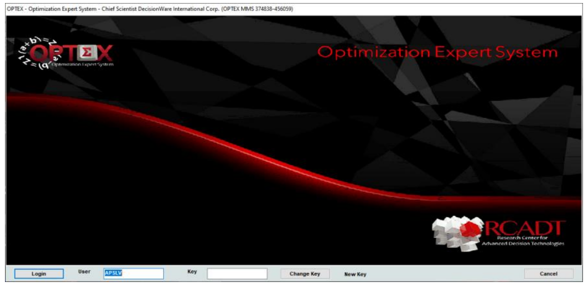


OPTEX-SSO - Sets - [Sets]

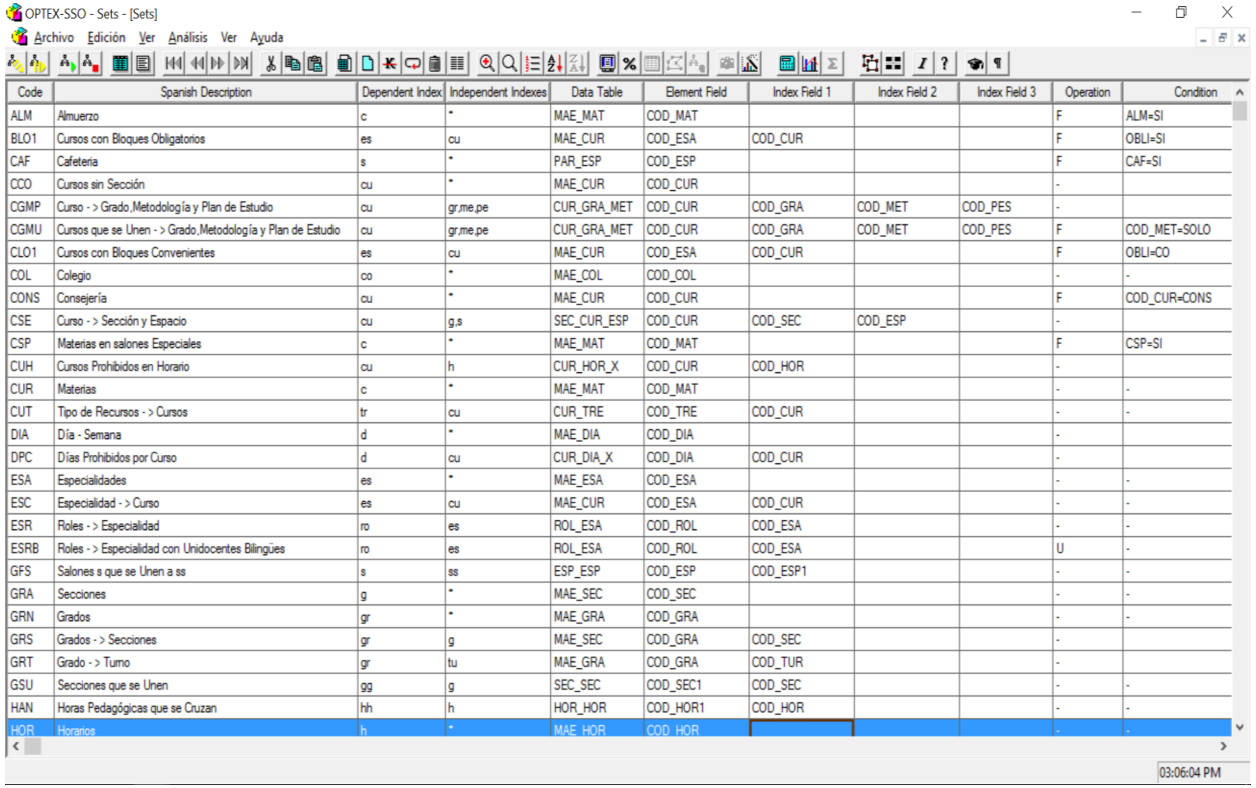
Code	Spanish Description	Dependent Index	Independent Indexes	Data Table	Element Field	Index Field 1	Index Field 2	Index Field 3	Operation	Condition
ALM	Almuerzo	c	*	MAE_MAT	COD_MAT				F	ALM=SI
BLO1	Cursos con Bloques Obligatorios	es	cu	MAE_CUR	COD_ESA	COD_CUR			F	OBLI=SI
CAF	Cafeteria	s	*	PAR_ESP	COD_ESP				F	CAF=SI
CCO	Cursos sin Sección	cu	*	MAE_CUR	COD_CUR				-	
CGMP	Curso - > Grado,Metodología y Plan de Estudio	cu	gr,me,pe	CUR_GRA_MET	COD_CUR	COD_GRA	COD_MET	COD_PES	-	
CGMU	Cursos que se Unen - > Grado,Metodología y Plan de Estudio	cu	gr,me,pe	CUR_GRA_MET	COD_CUR	COD_GRA	COD_MET	COD_PES	F	COD_MET=SOLO
CLO1	Cursos con Bloques Convenientes	es	cu	MAE_CUR	COD_ESA	COD_CUR			F	OBLI=CO
COL	Colegio	co	*	MAE_COL	COD_COL				-	-
CONS	Consejería	cu	*	MAE_CUR	COD_CUR				F	COD_CUR=CONS
CSE	Curso - > Sección y Espacio	cu	g,s	SEC_CUR_ESP	COD_CUR	COD_SEC	COD_ESP		-	
CSP	Materias en salones Especiales	c	*	MAE_MAT	COD_MAT				F	CSP=SI
CUH	Cursos Prohibidos en Horario	cu	h	CUR_HOR_X	COD_CUR	COD_HOR			-	
CUR	Materias	c	*	MAE_MAT	COD_MAT				-	-
CUT	Tipo de Recursos - > Cursos	tr	cu	CUR_TRE	COD_TRE	COD_CUR			-	-
DIA	Día - Semana	d	*	MAE_DIA	COD_DIA				-	
DPC	Días Prohibidos por Curso	d	cu	CUR_DIA_X	COD_DIA	COD_CUR			-	
ESA	Especialidades	es	*	MAE_ESA	COD_ESA				-	-
ESC	Especialidad - > Curso	es	cu	MAE_CUR	COD_ESA	COD_CUR			-	-
ESR	Roles - > Especialidad	ro	es	ROL_ESA	COD_ROL	COD_ESA			-	-
ESRB	Roles - > Especialidad con Unidocentes Bilingües	ro	es	ROL_ESA	COD_ROL	COD_ESA			U	-
GFS	Salones s que se Unen a ss	s	ss	ESP_ESP	COD_ESP	COD_ESP1			-	-
GRA	Secciones	g	*	MAE_SEC	COD_SEC				-	-
GRN	Grados	gr	*	MAE_GRA	COD_GRA				-	-
GRS	Grados - > Secciones	gr	g	MAE_SEC	COD_GRA	COD_SEC			-	
GRT	Grado - > Turno	gr	tu	MAE_GRA	COD_GRA	COD_TUR			-	
GSU	Secciones que se Unen	gg	g	SEC_SEC	COD_SEC1	COD_SEC			-	-
HAN	Horas Pedagógicas que se Cruzan	hh	h	HOR_HOR	COD_HOR1	COD_HOR			-	-
HOR	Horarios	h	*	MAE_HOR	COD_HOR				-	-

03:06:04 PM

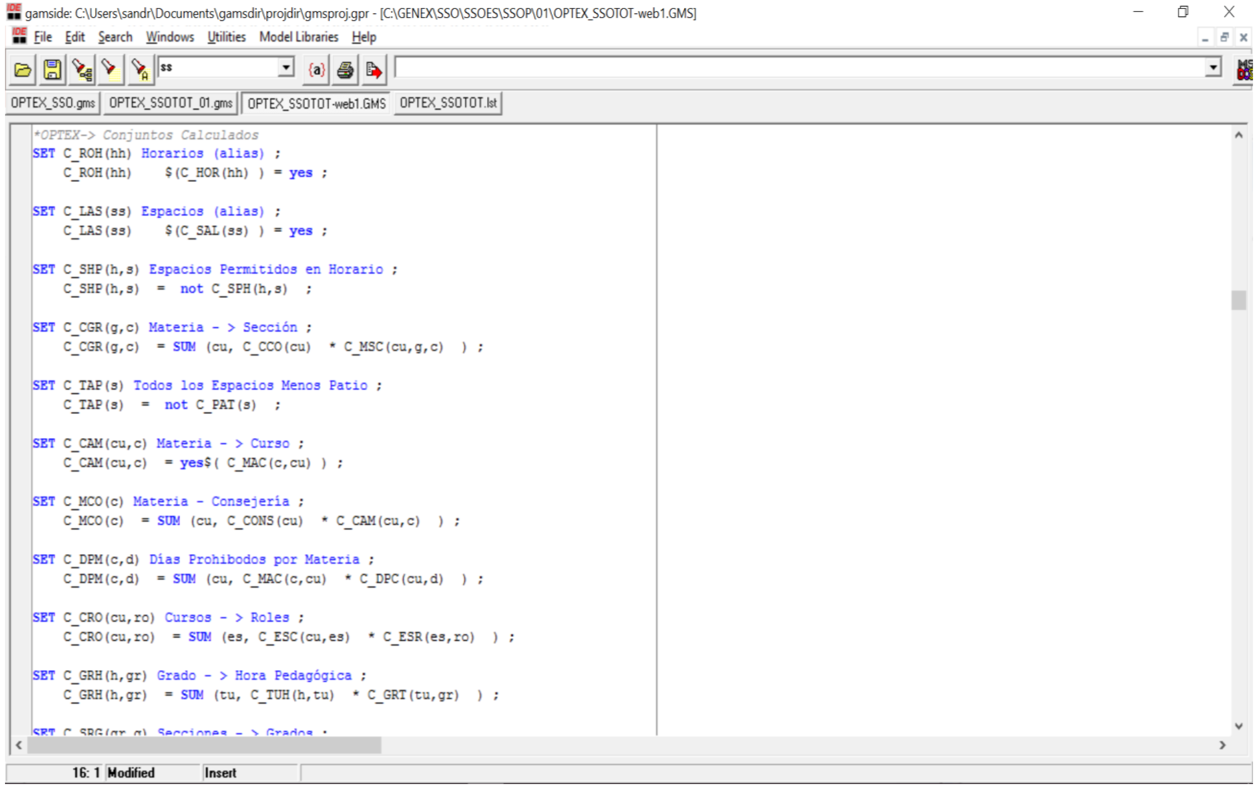
CONJUNTOS BÁSICOS				
Conjunto	**Descripción**	**Tabla**	**Campo Elemento**	**Filtro**
es∊BLO1(cu)	Cursos con Bloques Obligatorios	MAE_CUR	COD_ESA	OBLI=SI
cu∊CCO	Cursos sin Sección	MAE_CUR	COD_CUR	
cu∊CGMU(gr,me,pe)	Cursos Unificados -> Grado, Metodología, Plan Estudio	CUR_GRA_MET	COD_CUR	COD_MET=SOLO
cu∊CONS	Consejería	MAE_CUR	COD_CUR	COD_CUR=CONS
cu∊CUH(h)	Cursos Prohibidos en Horario	CUR_HOR_X	COD_CUR	
c∊CUR	Materias	MAE_MAT	COD_MAT	
d∊DIA	Día - Semana	MAE_DIA	COD_DIA	
d∊DPC(cu)	Días Prohibidos por Curso	CUR_DIA_X	COD_DIA	
es∊ESA	Especialidades	MAE_ESA	COD_ESA	
es∊ESC(cu)	Especialidad - > Curso	MAE_CUR	COD_ESA	
ro∊ESR(es)	Roles - > Especialidad	ROL_ESA	COD_ROL	
g∊GRA	Secciones	MAE_SEC	COD_SEC	
gr∊GRS(g)	Grados - > Secciones	MAE_SEC	COD_GRA	
gr∊GRT(tu)	Grado - > Turno	MAE_GRA	COD_GRA	
hh∊HAN(h)	Horas Pedagógicas que se Cruzan	HOR_HOR	COD_HOR1	
h∊HOR	Horarios	MAE_HOR	COD_HOR	
hh∊HSG(h)	Horas Seguidas	HOR_SEG	COD_HOR1	
cu∊MAC(c)	Materia - > Curso	MAE_MAT	COD_CUR	
c∊MSC(cu,g)	Materia - > Curso y Sección	MAE_MAT	COD_MAT	
oo∊ORP	Roles (alias)	ROL_ROL	COD_ROL1	
s∊PAT	Patio	MAE_ESP	COD_ESP	COD_TES=PAT
pe∊PES1	Planes de Estudio	MAE_PES	COD_PES	
ro∊PRO	Roles	MAE_ROL	COD_ROL	
ro∊RGP2(g)	Roles - > Secciones Prohibidas	ROL_SEC_X	COD_ROL	
ro∊RGR(gr)	Roles - > Grados	ROL_GRA	COD_ROL	
r∊RTR(tr)	Recursos - > Tipo de Recursos	MAE_REC	COD_REC	
s∊SAL	Espacios	MAE_ESP	COD_ESP	
g∊SCE(cu,s)	Sección - > Curso y Espacio	SEC_CUR_ESP	COD_SEC	
ss∊SFG(s)	Espacios ss que Pertenecen a s	ESP_ESP	COD_ESP1	
g∊SMC(cu,c)	Sección - > Materia y Curso	MAE_MAT	COD_SEC	
s∊SPH(h)	Salones Prohibidos Horario	ESP_HOR_X	COD_ESP	
ro∊SRO(oo)	Secuencia de Roles	ROL_ROL	COD_ROL	
me∊SUN	Metodología Secciones Unidas	MAE_MET	COD_MET	SUN=SI
tr∊TRE	Tipo de Recurso	ESC_TRE	COD_TRE	
tu∊TUD(d)	Turno - > Día	TUR_DIA	COD_TUR	
tu∊TUH(h)	Turno - > Hora	TUR_HOR	COD_TUR	
cu∊TUT	Tutoría	MAE_CUR	COD_CUR	COD_CUR=TUTO



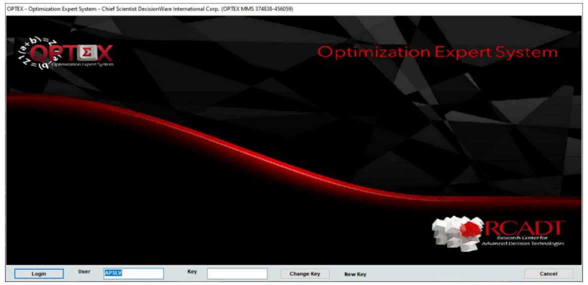
Structured Mathematical Modeling – Calculated Sets



Code	Spanish Description	Dependent Index	Independent Indexes	Data Table	Element Field	Index Field 1	Index Field 2	Index Field 3	Operation	Condition
ALM	Almuerzo	c	*	MAE_MAT	COD_MAT				F	ALM=SI
BLO1	Cursos con Bloques Obligatorios	es	cu	MAE_CUR	COD_ESA	COD_CUR			F	OBLI=SI
CAF	Cafeteria	s	*	PAR_ESP	COD_ESP				F	CAF=SI
CCO	Cursos sin Sección	cu	*	MAE_CUR	COD_CUR				-	
CGMP	Curso - > Grado,Metodología y Plan de Estudio	cu	gr,me,pe	CUR_GRA_MET	COD_CUR	COD_GRA	COD_MET	COD_PES	-	
CGMU	Cursos que se Unen - > Grado,Metodología y Plan de Estudio	cu	gr,me,pe	CUR_GRA_MET	COD_CUR	COD_GRA	COD_MET	COD_PES	F	COD_MET=SOLO
CLO1	Cursos con Bloques Convenientes	es	cu	MAE_CUR	COD_ESA	COD_CUR			F	OBLI=CO
COL	Colegio	co	*	MAE_COL	COD_COL				-	-
CONS	Consejería	cu	*	MAE_CUR	COD_CUR				F	COD_CUR=CONS
CSE	Curso - > Sección y Espacio	cu	g,s	SEC_CUR_ESP	COD_CUR	COD_SEC	COD_ESP		-	
CSP	Materias en salones Especiales	c	*	MAE_MAT	COD_MAT				F	CSP=SI
CUH	Cursos Prohibidos en Horario	cu	h	CUR_HOR_X	COD_CUR	COD_HOR			-	
CUR	Materias	c	*	MAE_MAT	COD_MAT				-	-
CUT	Tipo de Recursos - > Cursos	tr	cu	CUR_TRE	COD_TRE	COD_CUR			-	-
DIA	Día - Semana	d	*	MAE_DIA	COD_DIA				-	
DPC	Días Prohibidos por Curso	d	cu	CUR_DIA_X	COD_DIA	COD_CUR			-	
ESA	Especialidades	es	*	MAE_ESA	COD_ESA				-	-
ESC	Especialidad - > Curso	es	cu	MAE_CUR	COD_ESA	COD_CUR			-	-
ESR	Roles - > Especialidad	ro	es	ROL_ESA	COD_ROL	COD_ESA			-	-
ESRB	Roles - > Especialidad con Unidocentes Bilingües	ro	es	ROL_ESA	COD_ROL	COD_ESA			U	-
GFS	Salones s que se Unen a ss	s	ss	ESP_ESP	COD_ESP	COD_ESP1			-	-
GRA	Secciones	g	*	MAE_SEC	COD_SEC				-	-
GRN	Grados	gr	*	MAE_GRA	COD_GRA				-	-
GRS	Grados - > Secciones	gr	g	MAE_SEC	COD_GRA	COD_SEC			-	
GRT	Grado - > Turno	gr	tu	MAE_GRA	COD_GRA	COD_TUR			-	
GSU	Secciones que se Unen	gg	g	SEC_SEC	COD_SEC1	COD_SEC			-	-
HAN	Horas Pedagógicas que se Cruzan	hh	h	HOR_HOR	COD_HOR1	COD_HOR			-	-
HOR	Horarios	h	*	MAE_HOR	COD_HOR				-	-



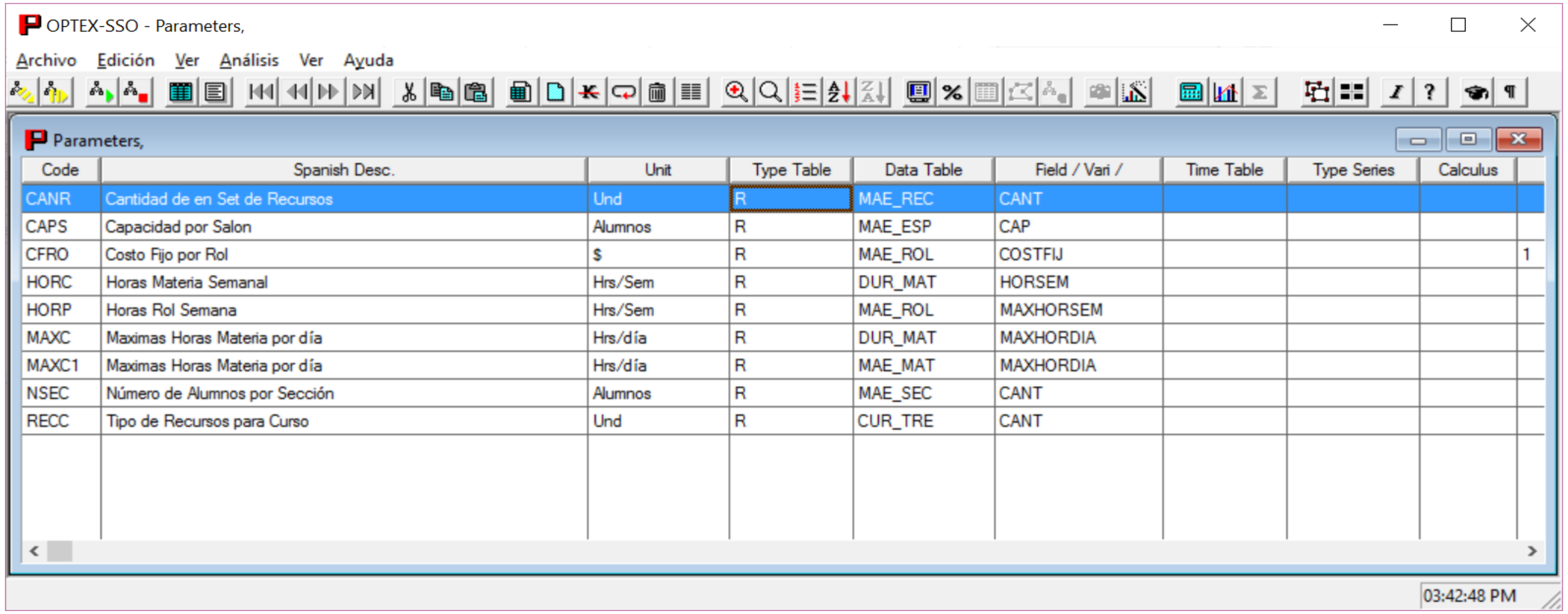

```
*OPTEX-> Conjuntos Calculados
SET C_ROH(hh) Horarios (alias) ;
    C_ROH(hh)    $(C_HOR(hh) ) = yes ;

SET C_LAS(ss) Espacios (alias) ;
    C_LAS(ss)    $(C_SAL(ss) ) = yes ;

SET C_SHP(h,s) Espacios Permitidos en Horario ;
    C_SHP(h,s)  =  not C_SPH(h,s)  ;

SET C_CGR(g,c) Materia - > Sección ;
    C_CGR(g,c)  = SUM (cu, C_CCO(cu)  * C_MSC(cu,g,c)  ) ;

SET C_TAP(s) Todos los Espacios Menos Patio ;
    C_TAP(s)  =  not C_PAT(s)  ;

SET C_CAM(cu,c) Materia - > Curso ;
    C_CAM(cu,c)  = yes$( C_MAC(c,cu) ) ;

SET C_MCO(c) Materia - Consejería ;
    C_MCO(c)  = SUM (cu, C_CONS(cu)  * C_CAM(cu,c)  ) ;

SET C_DPM(c,d) Días Prohibodos por Materia ;
    C_DPM(c,d)  = SUM (cu, C_MAC(c,cu)  * C_DPC(cu,d)  ) ;

SET C_CRO(cu,ro) Cursos - > Roles ;
    C_CRO(cu,ro)  = SUM (es, C_ESC(cu,es)  * C_ESR(es,ro)  ) ;

SET C_GRH(h,gr) Grado - > Hora Pedagógica ;
    C_GRH(h,gr)  = SUM (tu, C_TUH(h,tu)  * C_GRT(tu,gr)  ) ;

SET C_SRG(gr,g) Secciones - > Grados ;
```



GAMS

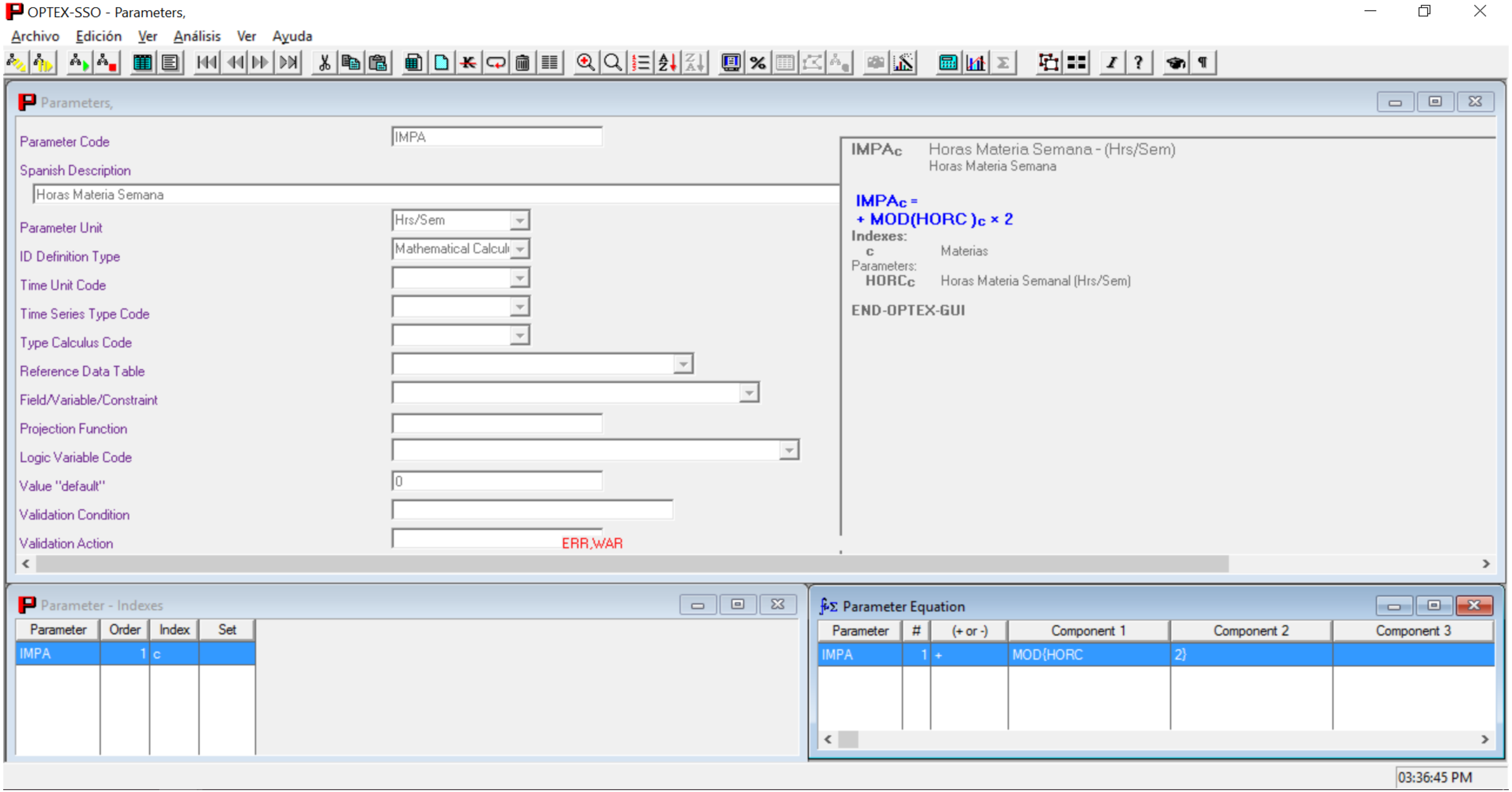
Structured Mathematical Modeling – Basic Parameters (Read)

BASIC PARAMETERS					
PARÁMETRO	DESCRIPCIÓN	FUNCIÓN	UNIDAD	TABLA	CAMPO
$CANR_{r}$	Cantidad de en Set de Recursos		Und	MAE_REC	CANT
$CAPS_{s}$	Capacidad por Salon		Alumnos	MAE_ESP	CAP
$CFRO_{ro}$	Costo Fijo por Rol	1	$	MAE_ROL	COSTFIJ
$HORC_{c}$	Horas Materia Semanal		Hrs/Sem	DUR_MAT	HORSEM
$HORP_{ro}$	Horas Rol Semana		Hrs/Sem	MAE_ROL	MAXHORSEM
$MAXC_{c}$	Maximas Horas Materia por día		Hrs/día	DUR_MAT	MAXHORDIA
$NSEC_{g}$	Número de Alumnos por Sección		Alumnos	MAE_SEC	CANT
$RECC_{tr,cu}$	Tipo de Recursos para Curso		Und	CUR_TRE	CANT

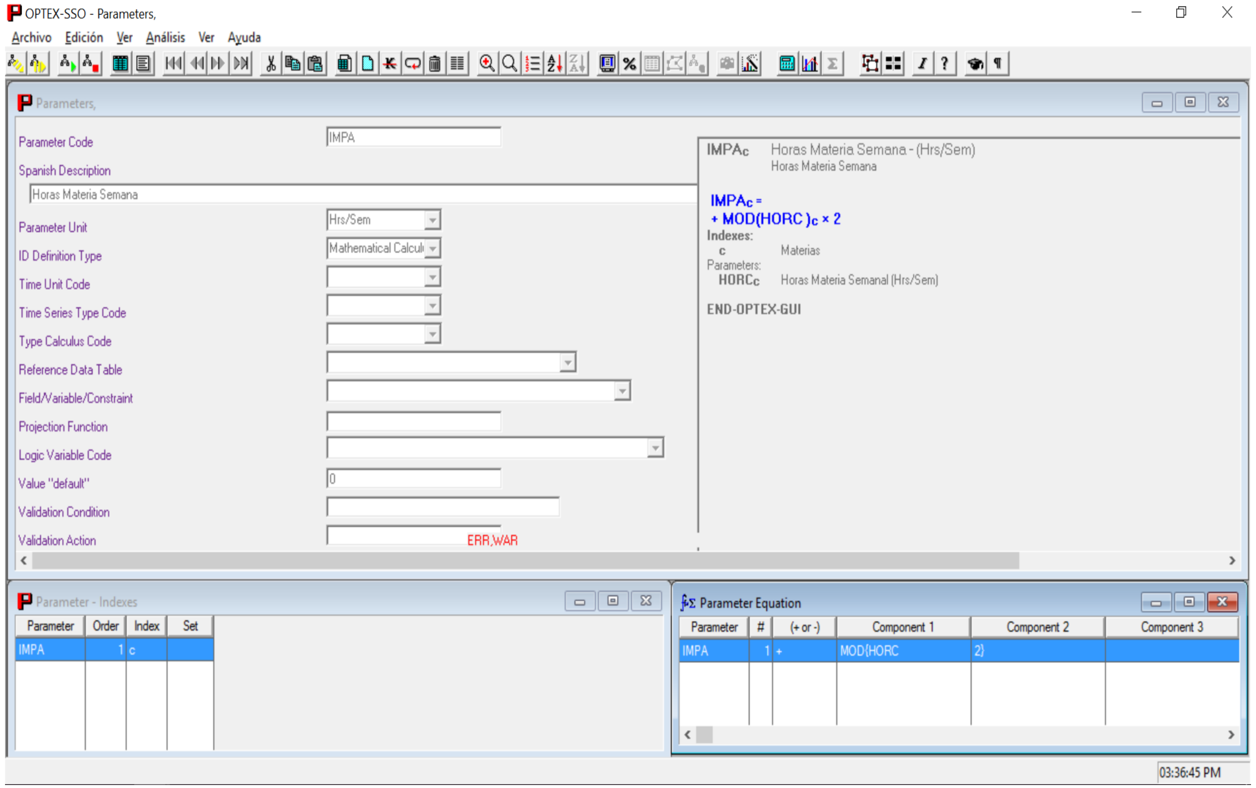


Code	Spanish Desc.	Unit	Type Table	Data Table	Field / Vari /	Time Table	Type Series	Calculus	
CANR	Cantidad de en Set de Recursos	Und	R	MAE_REC	CANT				
CAPS	Capacidad por Salon	Alumnos	R	MAE_ESP	CAP				
CFRO	Costo Fijo por Rol	$	R	MAE_ROL	COSTFIJ				1
HORC	Horas Materia Semanal	Hrs/Sem	R	DUR_MAT	HORSEM				
HORP	Horas Rol Semana	Hrs/Sem	R	MAE_ROL	MAXHORSEM				
MAXC	Maximas Horas Materia por día	Hrs/día	R	DUR_MAT	MAXHORDIA				
MAXC1	Maximas Horas Materia por día	Hrs/día	R	MAE_MAT	MAXHORDIA				
NSEC	Número de Alumnos por Sección	Alumnos	R	MAE_SEC	CANT				
RECC	Tipo de Recursos para Curso	Und	R	CUR_TRE	CANT				

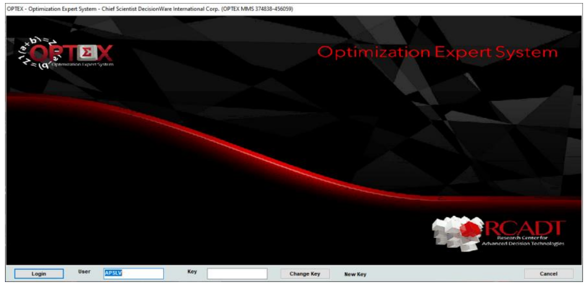
Structured Mathematical Modeling – Calculated Parameters



Structured Mathematical Modeling – Calculated Parameters



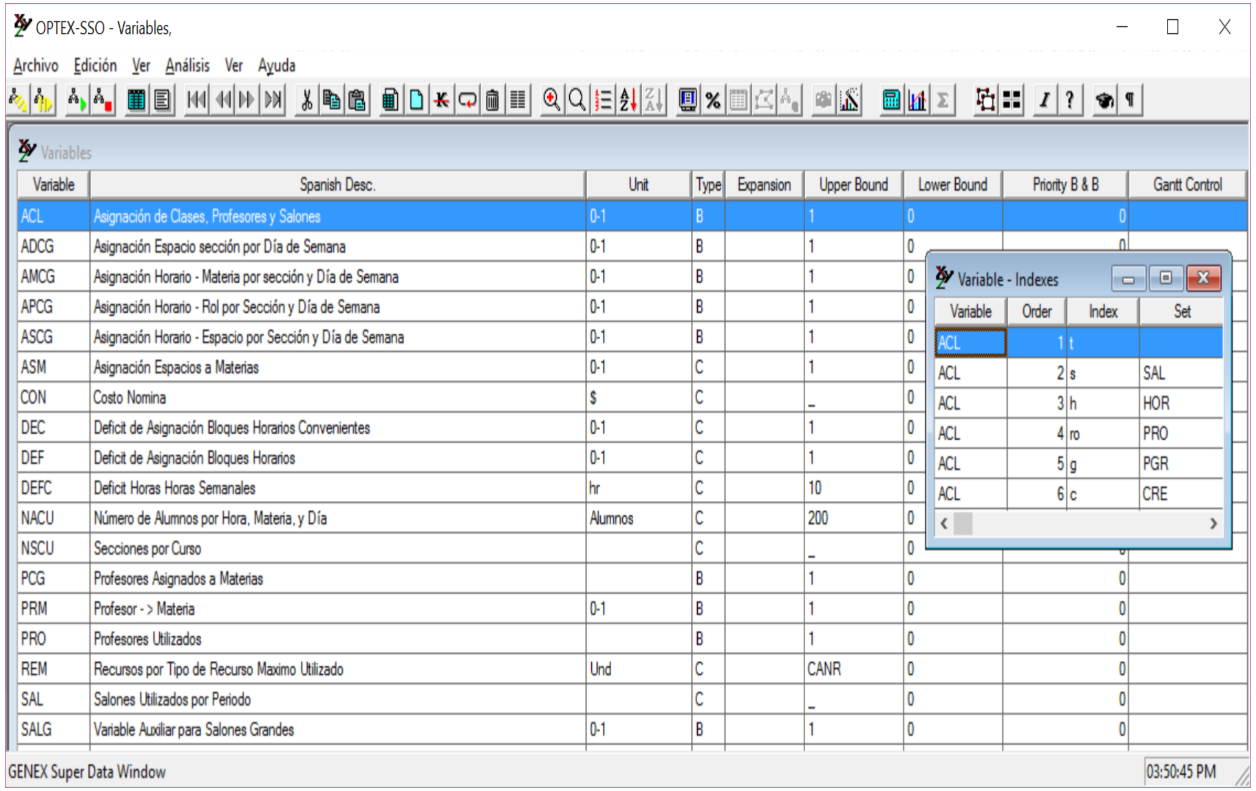
PARÁMETROS CALCULADOS		
PARÁMETRO	DESCRIPCIÓN	UNIDAD
$IMPA_c$	Horas Materia Semana Horas Materia Semana $IMPA_c = MOD(HORC_c , 2)$ Índices: c Materias Parámetros: $HORC_c$ Horas Materia Semanal (Hrs/Sem)	Hrs/Sem
$RECM_{tr,c,g}$	Cantidad Tipo de Recursos -> Materia y Sección Cantidad Tipo de Recursos -> Materia y Sección $RECM_{tr,c,g} = \Sigma_{cu \in MAC(c)} RECC_{tr,cu} \times NSEC_g$ Índices: tr Tipo Recurso c Materias g Secciones cu Cursos Conjuntos: $cu \in MAC(c)$ Materia - > Curso Parámetros: $RECC_{tr,cu}$ Tipo de Recursos para Curso (Und) $NSEC_g$ Número de Alumnos por Sección (Alumnos)	Und



PROBLEMAS	
RESTRICCIONES	**VARIABLES**
SSODU4 **SSO - SSODU3 + Espacios Iguales Horas Seguidas** **CONDICIONES DE EXISTENCIA:**	**ROL:** IN **TIPO:** PM
ACDH$_{c}$ - Asignación Materias a Día Semana y Horario **APCU**$_{d,h,c}$ - Asignación Profesores a Materias y Grado Sección **APDH**$_{d,h,ro}$ - Los Profesores Estan en una Materia a la Vez **ASCU**$_{d,h,c}$ - Asignación Salones a Materias **ASFE**$_{g,h,d}$ - Las Secciones Toman una Materia a la Vez **ASFF**$_{d,h,s}$ - Las Materias se Toman en un Unico Salón **ASFF1**$_{d,h,c}$ - Asignación de Salones Formato Pequeño **HOBL**$_{d,h,c}$ - Horas Asignadas por Bloques **HOPS**$_{ro}$ - Horas Máximas Profesores **MDEF**$_{c}$ - Maximo déficit Horas Seguidas por Materia **MHMD**$_{d,c}$ - Máximas Horas Materia Día **MTUS**$_{d,h,c,s}$ - Las Materias se Toman en un Único Espacio **MTUS1**$_{c}$ - Las Materias se Toman en un Único Espacio 1 **NATM**$_{d,h,c}$ - Número de Alumnos Por Materia **RECM**$_{d,h,tr}$ - Recursos Máximos **RPUN**$_{c,ro}$ - Profesor Único por Materia **RPUN1**$_{c}$ - Profesor Único por Materia 1 **RTUT**$_{ro}$ - Profesor Solo da una tutoría **RTUT2**$_{c,ro}$ - Profesor que da Tutoría También da Consejería **SERO**$_{oo,ro}$ - Secuencia de Roles **SUUB**$_{d,h,s}$ - Los Espacios no se Utilizan dos Veces	**AMCG**$_{d,h,c}$ - Asignación Horario - Materia por sección y Día de Semana **APCG**$_{c,d,h,ro}$ - Asignación Horario - Rol por Sección y Día de Semana **ASCG**$_{d,h,c,s}$ - Asignación Horario - Espacio por Sección y Día de Semana **NACU**$_{d,h,c}$ - Número de Alumnos por Hora, Materia, y Día **DEF**$_{d,h,c}$ - Deficit de Asignación Bloques Horarios **PRO**$_{ro}$ - Profesores Utilizados **ASM**$_{c,s}$ - Asignación Espacios a Materias **REM**$_{d,h,tr,r}$ - Recursos por Tipo de Recurso Maximo Utilizado **PRM**$_{c,ro}$ - Profesor - > Materia

21
Restricciones
Genéricas

9
Variables
Genéricas



OPTEX-SSO - Variables,

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Variables

Variable	Spanish Desc.	Unit	Type	Expansion	Upper Bound	Lower Bound	Priority B & B	Gantt Control
ACL	Asignación de Clases, Profesores y Salones	0-1	B		1	0	0	
ADCG	Asignación Espacio sección por Día de Semana	0-1	B		1	0	0	
AMCG	Asignación Horario - Materia por sección y Día de Semana	0-1	B		1	0		
APCG	Asignación Horario - Rol por Sección y Día de Semana	0-1	B		1	0		
ASCG	Asignación Horario - Espacio por Sección y Día de Semana	0-1	B		1	0		
ASM	Asignación Espacios a Materias	0-1	C		1	0		
CON	Costo Nomina	$	C		_	0		
DEC	Deficit de Asignación Bloques Horarios Convenientes	0-1	C		1	0		
DEF	Deficit de Asignación Bloques Horarios	0-1	C		1	0		
DEFC	Deficit Horas Horas Semanales	hr	C		10	0		
NACU	Número de Alumnos por Hora, Materia, y Día	Alumnos	C		200	0		
NSCU	Secciones por Curso		C		_	0		
PCG	Profesores Asignados a Materias		B		1	0	0	
PRM	Profesor - > Materia	0-1	B		1	0	0	
PRO	Profesores Utilizados		B		1	0	0	
REM	Recursos por Tipo de Recurso Maximo Utilizado	Und	C		CANR	0	0	
SAL	Salones Utilizados por Periodo		C		_	0	0	
SALG	Variable Auxiliar para Salones Grandes	0-1	B		1	0	0	

Variable - Indexes

Variable	Order	Index	Set
ACL	1	t	
ACL	2	s	SAL
ACL	3	h	HOR
ACL	4	ro	PRO
ACL	5	g	PGR
ACL	6	c	CRE

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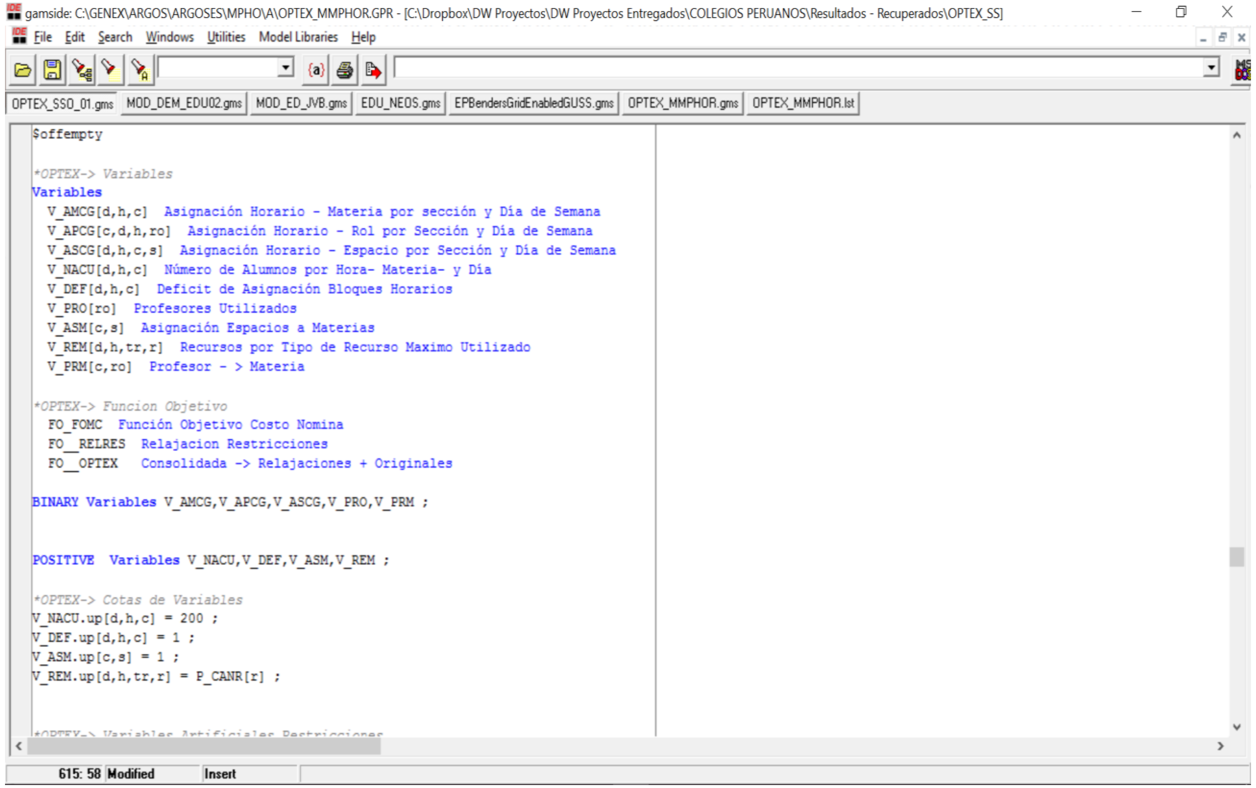


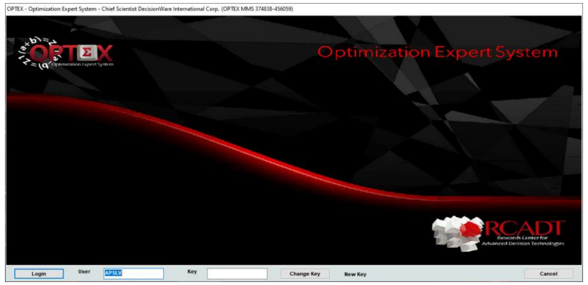
gamside: C:\GENEX\ARGOS\ARGOSES\MPHO\A\OPTEX_MMPHOR.GPR - [C:\Dropbox\DW Proyectos\DW Proyectos Entregados\COLEGIOS PERUANOS\Resultados - Recuperados\OPTEX_SS]

File Edit Search Windows Utilities Model Libraries Help

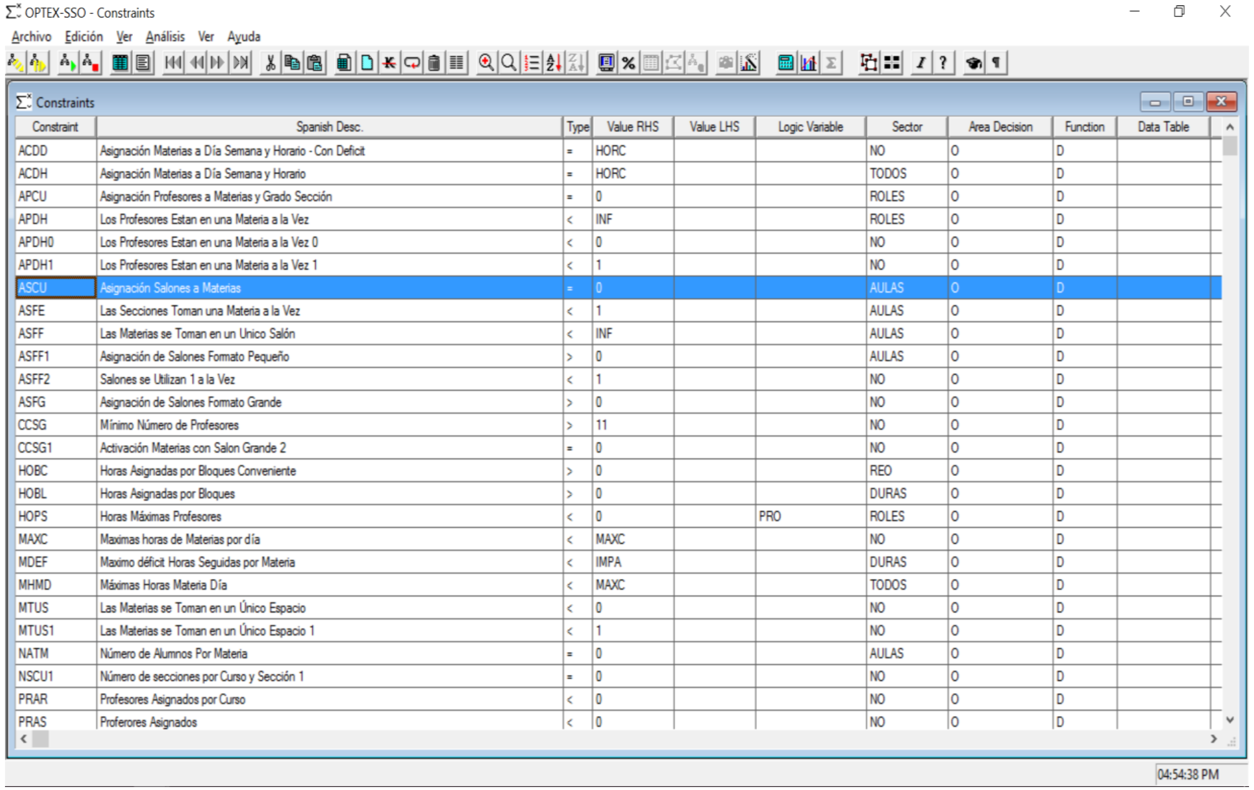
OPTEX_SSO_01.gms | MOD_DEM_EDU02.gms | MOD_ED_JVB.gms | EDU_NEOS.gms | EPBendersGridEnabledGUSS.gms | OPTEX_MMPHOR.gms | OPTEX_MMPHOR.lst

```
$offempty

*OPTEX-> Variables
Variables
  V_AMCG[d,h,c]  Asignación Horario - Materia por sección y Día de Semana
  V_APCG[c,d,h,ro]  Asignación Horario - Rol por Sección y Día de Semana
  V_ASCG[d,h,c,s]  Asignación Horario - Espacio por Sección y Día de Semana
  V_NACU[d,h,c]  Número de Alumnos por Hora- Materia- y Día
  V_DEF[d,h,c]  Deficit de Asignación Bloques Horarios
  V_PRO[ro]  Profesores Utilizados
  V_ASM[c,s]  Asignación Espacios a Materias
  V_REM[d,h,tr,r]  Recursos por Tipo de Recurso Maximo Utilizado
  V_PRM[c,ro]  Profesor - > Materia

*OPTEX-> Funcion Objetivo
  FO_FOMC  Función Objetivo Costo Nomina
  FO__RELRES  Relajacion Restricciones
  FO__OPTEX  Consolidada -> Relajaciones + Originales

BINARY Variables V_AMCG,V_APCG,V_ASCG,V_PRO,V_PRM ;

POSITIVE  Variables V_NACU,V_DEF,V_ASM,V_REM ;

*OPTEX-> Cotas de Variables
V_NACU.up[d,h,c] = 200 ;
V_DEF.up[d,h,c] = 1 ;
V_ASM.up[c,s] = 1 ;
V_REM.up[d,h,tr,r] = P_CANR[r] ;
```

615: 58 Modified Insert

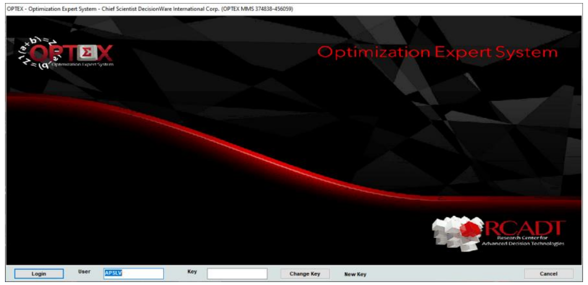


Structured Mathematical Modeling -Constraints

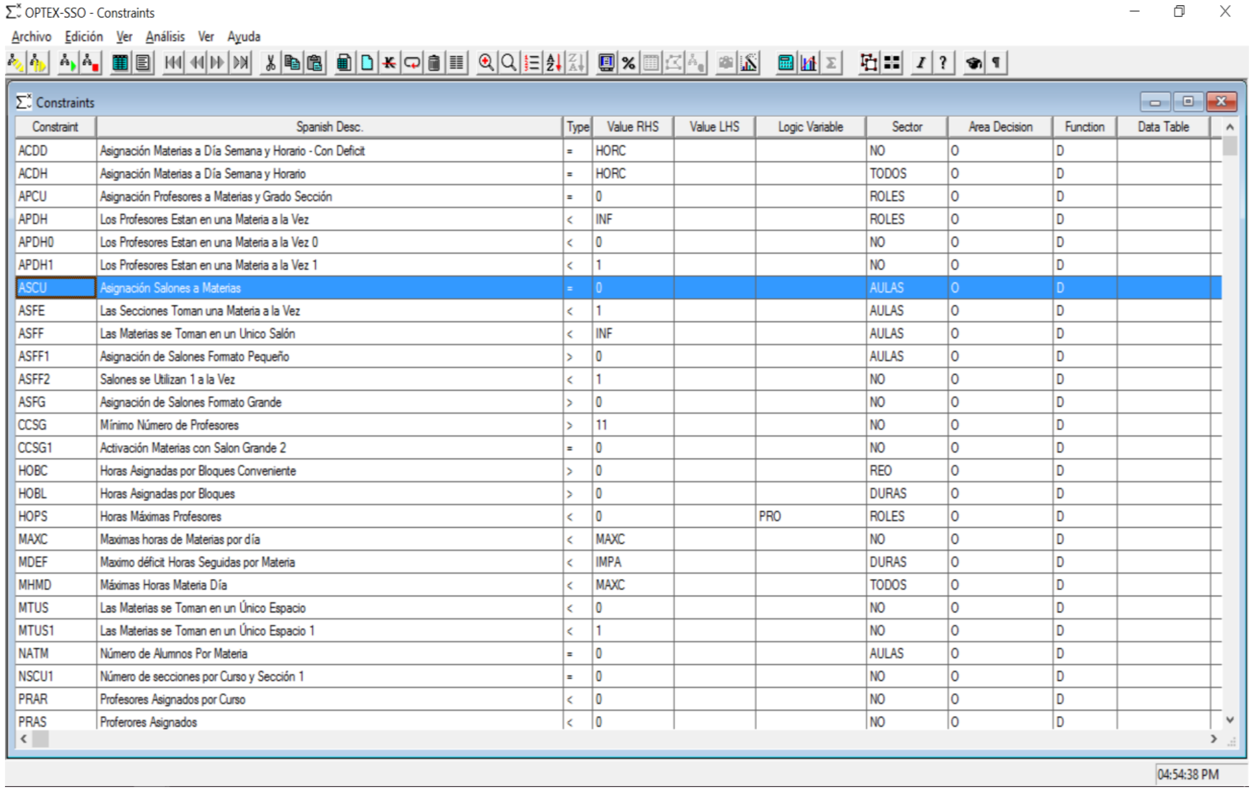


Constraint	Spanish Desc.	Type	Value RHS	Value LHS	Logic Variable	Sector	Area Decision	Function	Data Table
ACDD	Asignación Materias a Día Semana y Horario - Con Deficit	=	HORC			NO	O	D	
ACDH	Asignación Materias a Día Semana y Horario	=	HORC			TODOS	O	D	
APCU	Asignación Profesores a Materias y Grado Sección	=	0			ROLES	O	D	
APDH	Los Profesores Estan en una Materia a la Vez	<	INF			ROLES	O	D	
APDH0	Los Profesores Estan en una Materia a la Vez 0	<	0			NO	O	D	
APDH1	Los Profesores Estan en una Materia a la Vez 1	<	1			NO	O	D	
ASCU	Asignación Salones a Materias	=	0			AULAS	O	D	
ASFE	Las Secciones Toman una Materia a la Vez	<	1			AULAS	O	D	
ASFF	Las Materias se Toman en un Unico Salón	<	INF			AULAS	O	D	
ASFF1	Asignación de Salones Formato Pequeño	>	0			AULAS	O	D	
ASFF2	Salones se Utilizan 1 a la Vez	<	1			NO	O	D	
ASFG	Asignación de Salones Formato Grande	>	0			NO	O	D	
CCSG	Mínimo Número de Profesores	>	11			NO	O	D	
CCSG1	Activación Materias con Salon Grande 2	=	0			NO	O	D	
HOBC	Horas Asignadas por Bloques Conveniente	>	0			REO	O	D	
HOBL	Horas Asignadas por Bloques	>	0			DURAS	O	D	
HOPS	Horas Máximas Profesores	<	0		PRO	ROLES	O	D	
MAXC	Maximas horas de Materias por día	<	MAXC			NO	O	D	
MDEF	Maximo déficit Horas Seguidas por Materia	<	IMPA			DURAS	O	D	
MHMD	Máximas Horas Materia Día	<	MAXC			TODOS	O	D	
MTUS	Las Materias se Toman en un Único Espacio	<	0			NO	O	D	
MTUS1	Las Materias se Toman en un Único Espacio 1	<	1			NO	O	D	
NATM	Número de Alumnos Por Materia	=	0			AULAS	O	D	
NSCU1	Número de secciones por Curso y Sección 1	=	0			NO	O	D	
PRAR	Profesores Asignados por Curso	<	0			NO	O	D	
PRAS	Proferores Asignados	<	0			NO	O	D	

RESTRICCIONES – MODULO: AULAS		
RESTRICCIÓN	**DESCRIPCIÓN – ECUACIÓN**	**VARIABLE DISYUNTIVA**
$ASCU_{d,h,c}$	**Asignación Salones a Materias** Asignación Salones a Materias $\sum_{s \in SPC(c)} ASCG_{d,h,c,s} - AMCG_{d,h,c} = 0$ $\forall d \in DIA \quad \forall h \in HOR \quad \forall c \in CHD(h,d)$ Índices: d — Día h — Hoas c — Materias s — Espacio Conjuntos: $s \in SPC(c)$ — Espacio - > Materia $d \in DIA$ — Día - Semana $h \in HOR$ — Horarios $c \in CHD(h,d)$ — Materias - > Hora, Día Variables: $ASCG_{d,h,c,s}$ — Asignación Horario - Espacio por Sección y Día de Semana (0-1) $AMCG_{d,h,c}$ — Asignación Horario - Materia por sección y Día de Semana (0-1)	



MODELAMIENTO MATEMÁTICO ESTRUCTURADO


OPTEX-SSO - Constraints

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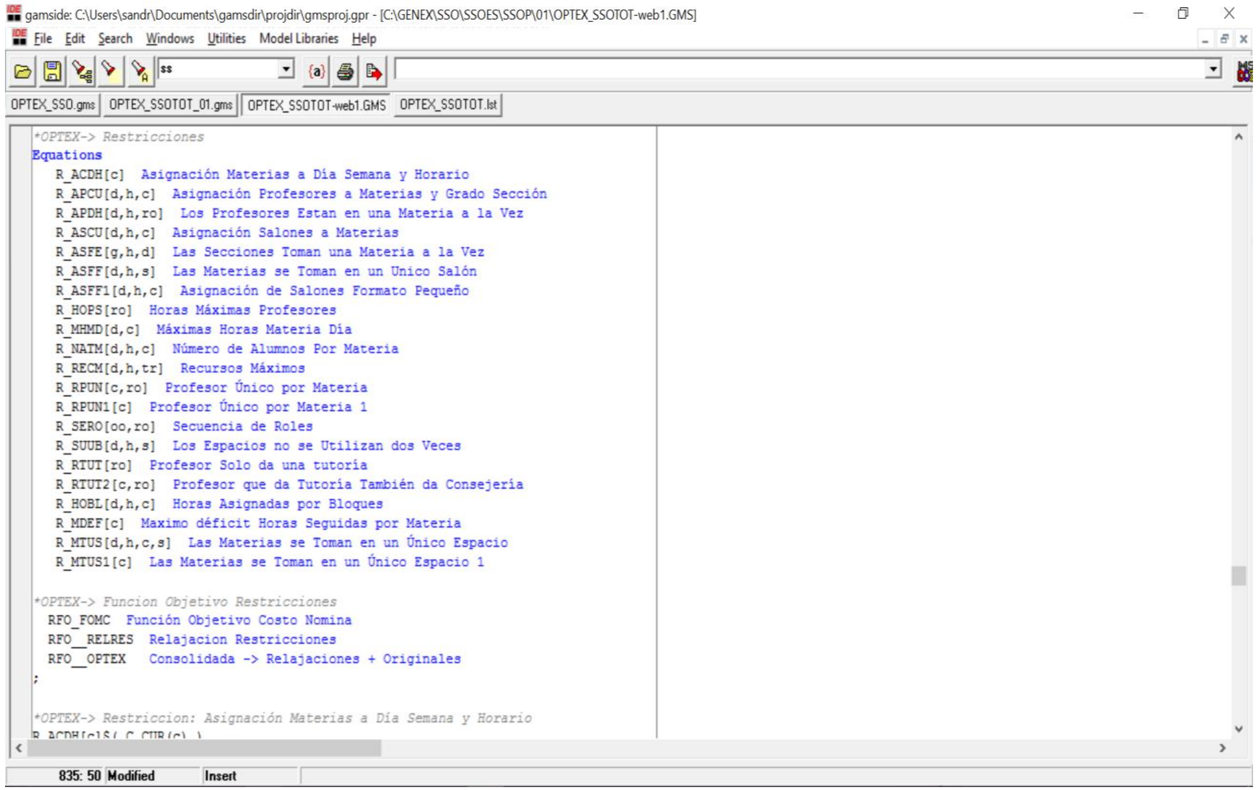
Constraints

Constraint	Spanish Desc.	Type	Value RHS	Value LHS	Logic Variable	Sector	Area Decision	Function	Data Table
ACDD	Asignación Materias a Día Semana y Horario - Con Deficit	=	HORC			NO	0	D	
ACDH	Asignación Materias a Día Semana y Horario	=	HORC			TODOS	0	D	
APCU	Asignación Profesores a Materias y Grado Sección	=	0			ROLES	0	D	
APDH	Los Profesores Estan en una Materia a la Vez	<	INF			ROLES	0	D	
APDH0	Los Profesores Estan en una Materia a la Vez 0	<	0			NO	0	D	
APDH1	Los Profesores Estan en una Materia a la Vez 1	<	1			NO	0	D	
ASCU	Asignación Salones a Materias	=	0			AULAS	0	D	
ASFE	Las Secciones Toman una Materia a la Vez	<	1			AULAS	0	D	
ASFF	Las Materias se Toman en un Unico Salón	<	INF			AULAS	0	D	
ASFF1	Asignación de Salones Formato Pequeño	>	0			AULAS	0	D	
ASFF2	Salones se Utilizan 1 a la Vez	<	1			NO	0	D	
ASFG	Asignación de Salones Formato Grande	>	0			NO	0	D	
CCSG	Mínimo Número de Profesores	>	11			NO	0	D	
CCSG1	Activación Materias con Salon Grande 2	=	0			NO	0	D	
HOBC	Horas Asignadas por Bloques Conveniente	>	0			REO	0	D	
HOBL	Horas Asignadas por Bloques	>	0			DURAS	0	D	
HOPS	Horas Máximas Profesores	<	0		PRO	ROLES	0	D	
MAXC	Maximas horas de Materias por día	<	MAXC			NO	0	D	
MDEF	Maximo déficit Horas Seguidas por Materia	<	IMPA			DURAS	0	D	
MHMD	Máximas Horas Materia Día	<	MAXC			TODOS	0	D	
MTUS	Las Materias se Toman en un Único Espacio	<	0			NO	0	D	
MTUS1	Las Materias se Toman en un Único Espacio 1	<	1			NO	0	D	
NATM	Número de Alumnos Por Materia	=	0			AULAS	0	D	
NSCU1	Número de secciones por Curso y Sección 1	=	0			NO	0	D	
PRAR	Profesores Asignados por Curso	<	0			NO	0	D	
PRAS	Proferores Asignados	<	0			NO	0	D	

04:54:38 PM

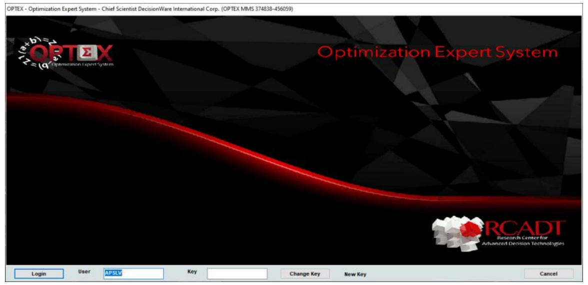

gamside: C:\Users\sandr\Documents\gamsdir\projdir\gmsproj.gpr - [C:\GENEX\SSO\SSOES\SSOP\01\OPTEX_SSOTOT-web1.GMS]

File Edit Search Windows Utilities Model Libraries Help

OPTEX_SSO.gms | OPTEX_SSOTOT_01.gms | OPTEX_SSOTOT-web1.GMS | OPTEX_SSOTOT.lst

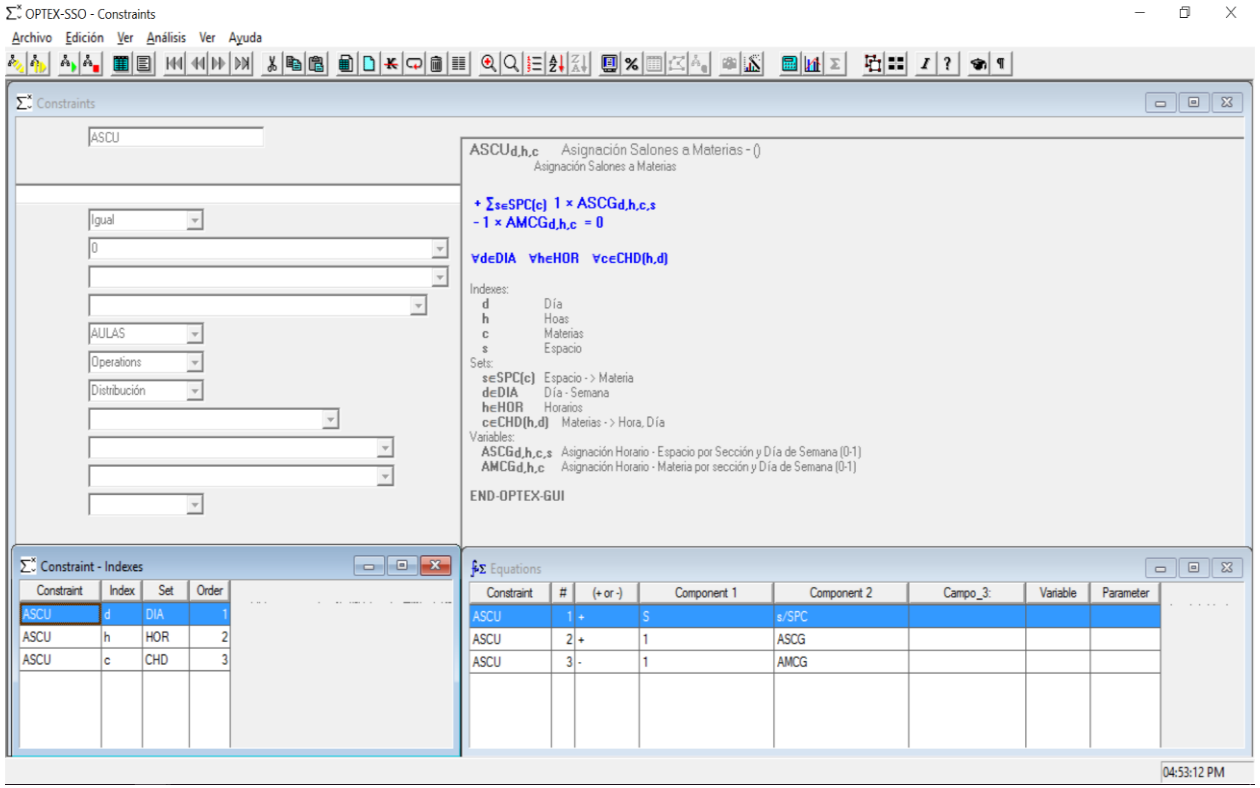
```
*OPTEX-> Restricciones
Equations
   R_ACDH[c]  Asignación Materias a Día Semana y Horario
   R_APCU[d,h,c]  Asignación Profesores a Materias y Grado Sección
   R_APDH[d,h,ro]  Los Profesores Estan en una Materia a la Vez
   R_ASCU[d,h,c]  Asignación Salones a Materias
   R_ASFE[g,h,d]  Las Secciones Toman una Materia a la Vez
   R_ASFF[d,h,s]  Las Materias se Toman en un Unico Salón
   R_ASFF1[d,h,c]  Asignación de Salones Formato Pequeño
   R_HOPS[ro]  Horas Máximas Profesores
   R_MHMD[d,c]  Máximas Horas Materia Día
   R_NATM[d,h,c]  Número de Alumnos Por Materia
   R_RECM[d,h,tr]  Recursos Máximos
   R_RPUN[c,ro]  Profesor Único por Materia
   R_RPUN1[c]  Profesor Único por Materia 1
   R_SERO[oo,ro]  Secuencia de Roles
   R_SUUB[d,h,s]  Los Espacios no se Utilizan dos Veces
   R_RTUT[ro]  Profesor Solo da una tutoría
   R_RTUT2[c,ro]  Profesor que da Tutoría También da Consejería
   R_HOBL[d,h,c]  Horas Asignadas por Bloques
   R_MDEF[c]  Maximo déficit Horas Seguidas por Materia
   R_MTUS[d,h,c,s]  Las Materias se Toman en un Único Espacio
   R_MTUS1[c]  Las Materias se Toman en un Único Espacio 1

*OPTEX-> Funcion Objetivo Restricciones
  RFO_FOMC  Función Objetivo Costo Nomina
  RFO__RELRES  Relajacion Restricciones
  RFO__OPTEX  Consolidada -> Relajaciones + Originales
;

*OPTEX-> Restriccion: Asignación Materias a Día Semana y Horario
```

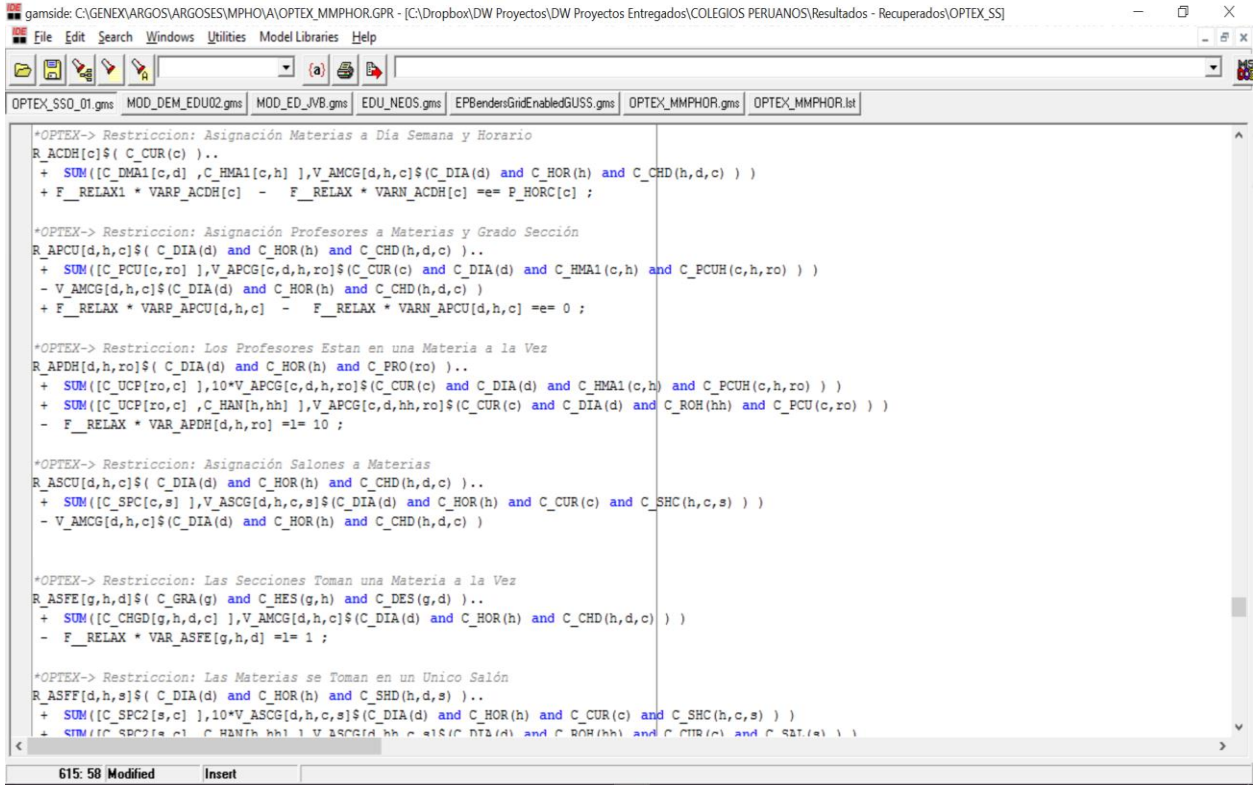
835: 50 Modified Insert

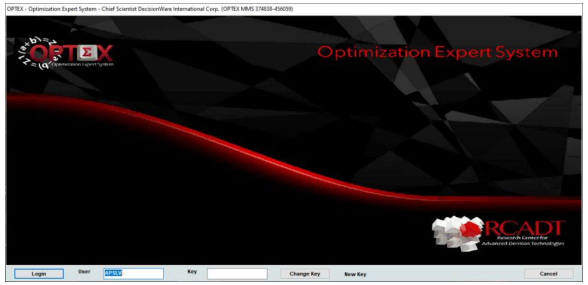


GAMS

Structured Mathematical Modeling – Automatic Program Generation

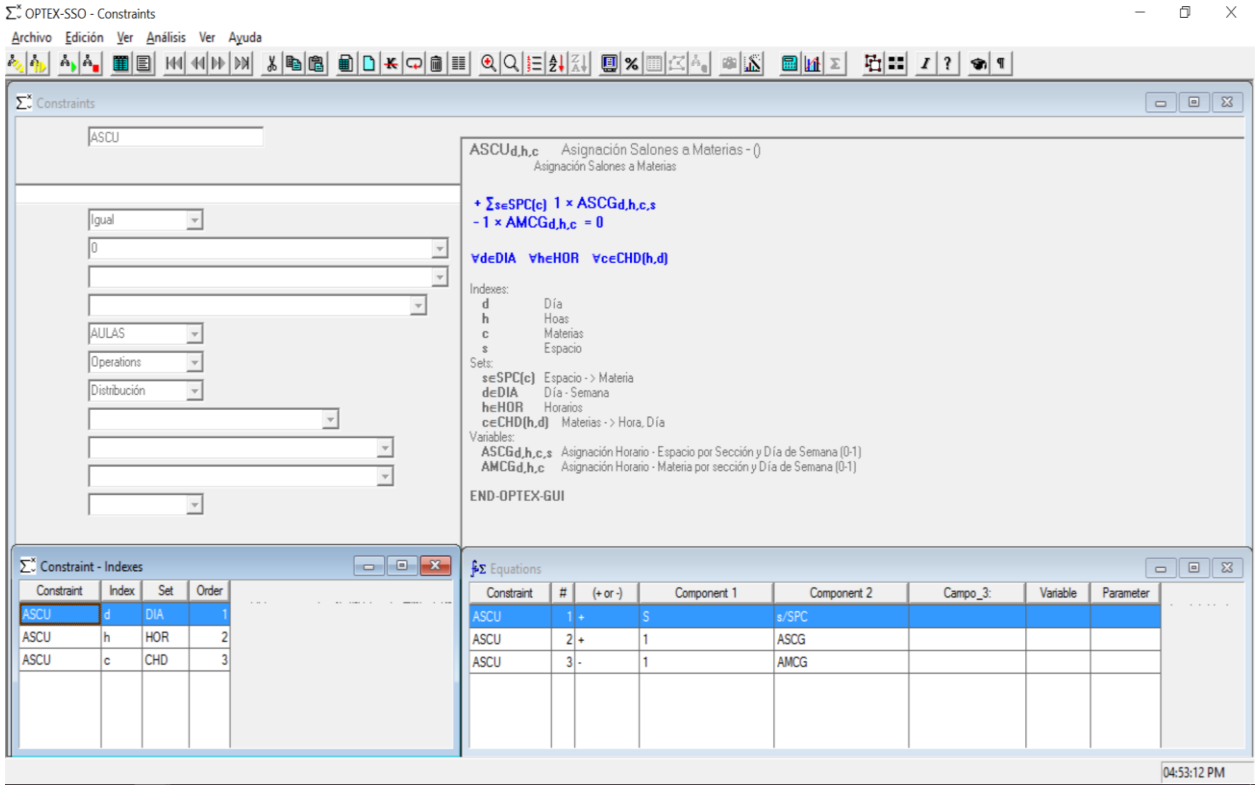


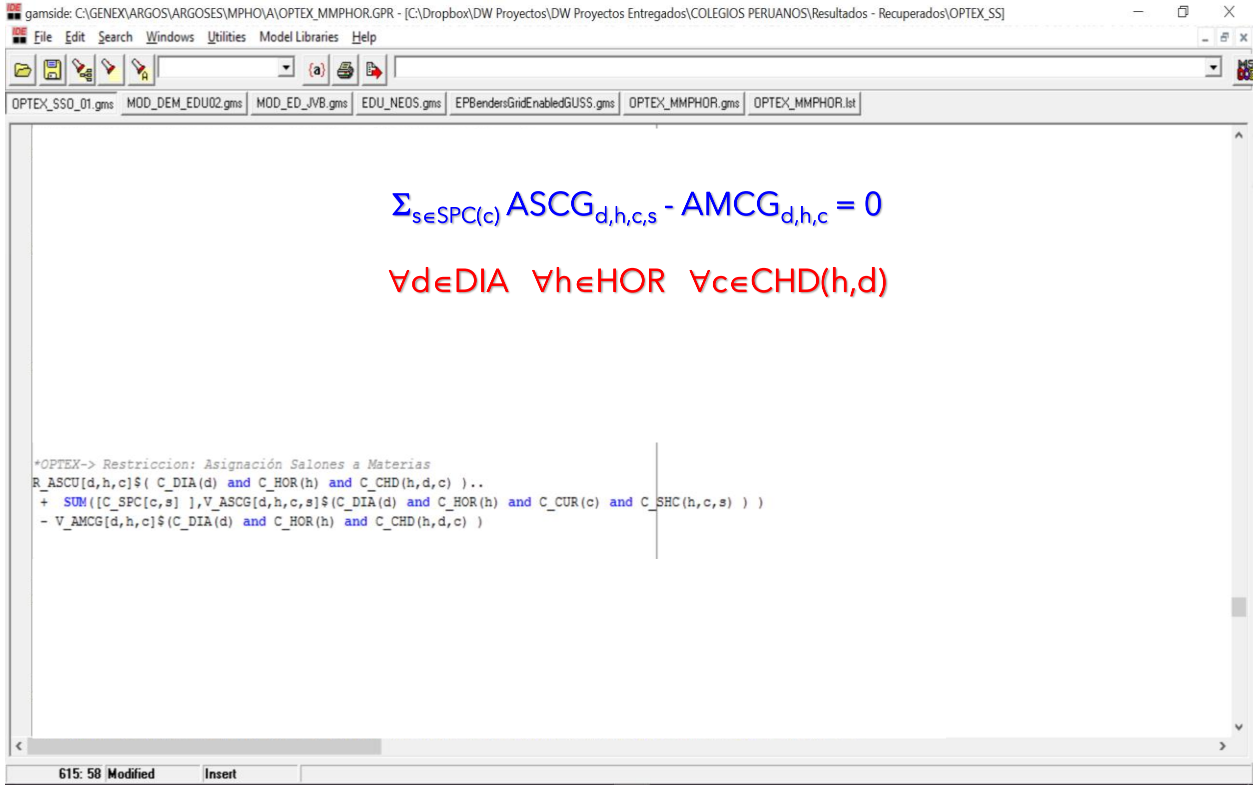


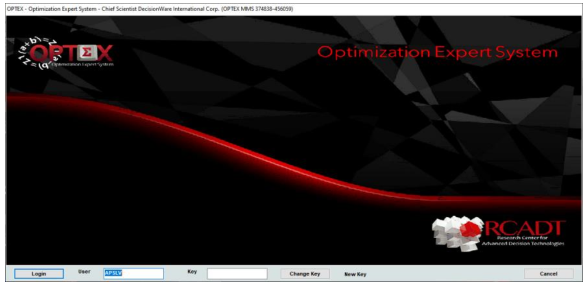


GAMS

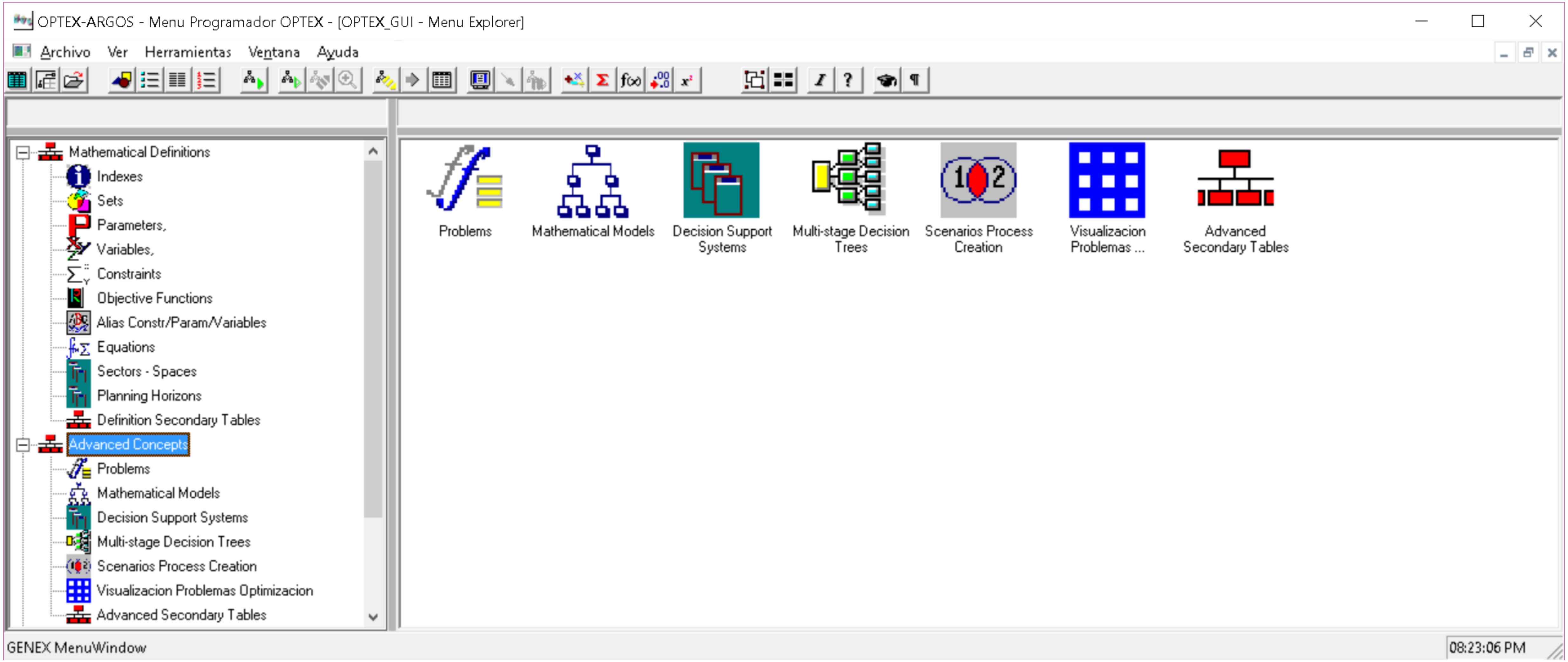
Structured Mathematical Modeling – Automatic MS-WORD Report Generation







GAMS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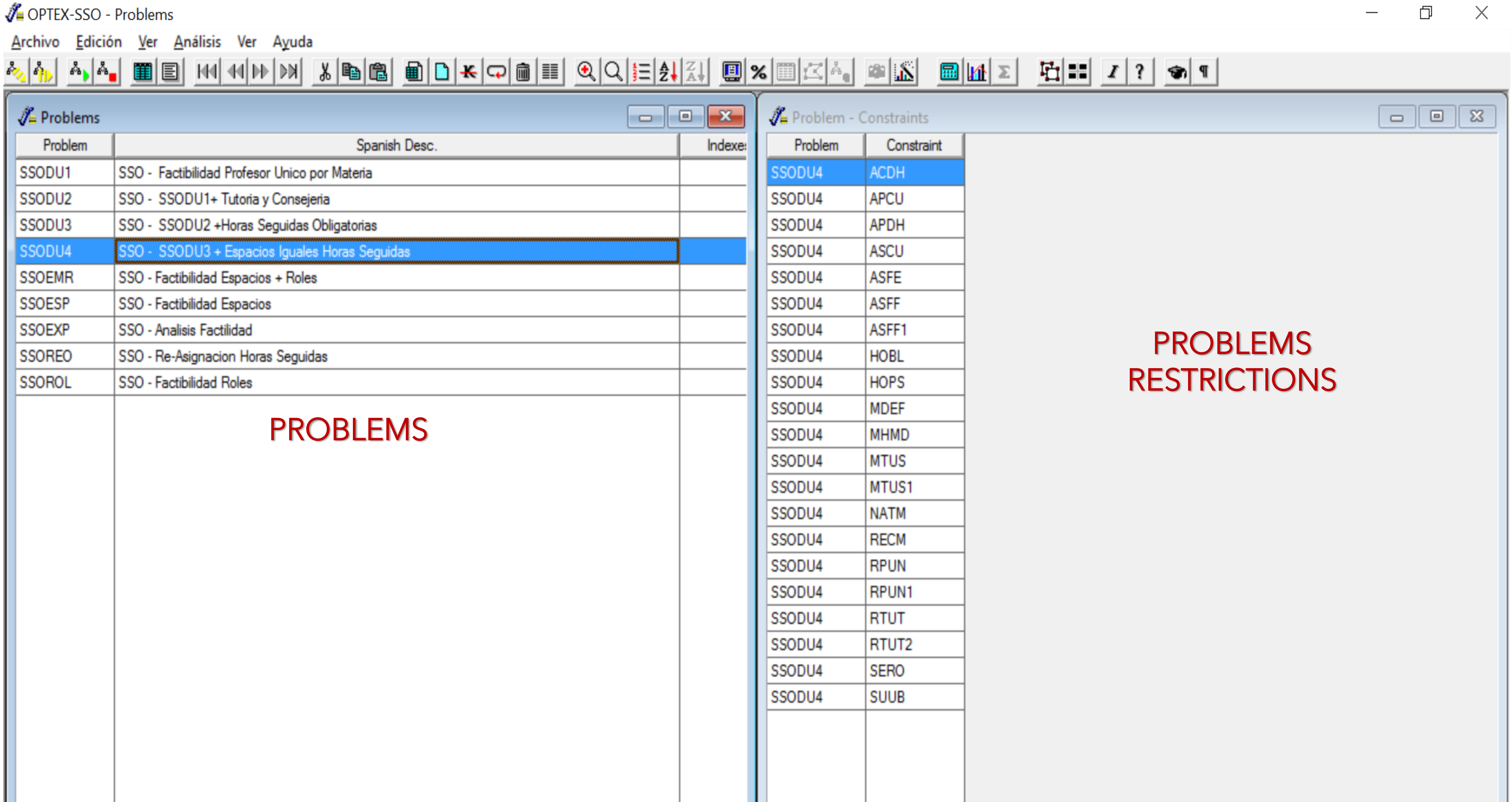
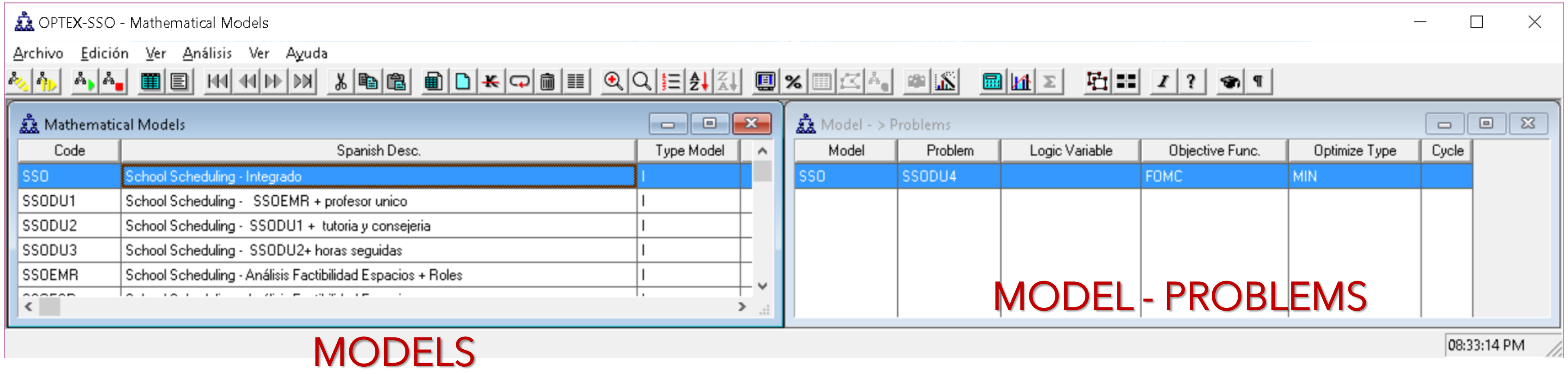
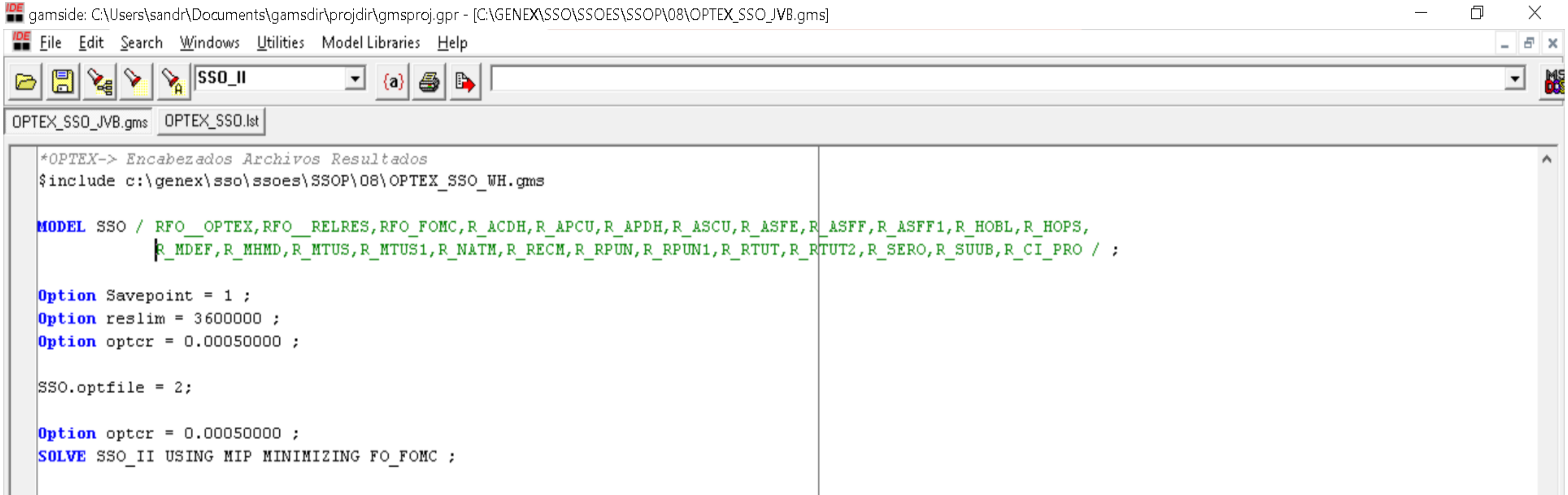
Archivo Ver Herramientas Ventana Ayuda
Mathematical Definitions
Indexes
Sets
Parameters,
Variables,
Constraints
Objective Functions
Alias Constr/Param/Variables
Equations
Sectors - Spaces
Planning Horizons
Definition Secondary Tables
Advanced Concepts
Problems
Mathematical Models
Decision Support Systems
Multi-stage Decision Trees
Scenarios Process Creation
Visualizacion Problemas Optimizacion
Advanced Secondary Tables
Problems
Mathematical Models
Decision Support Systems
Multi-stage Decision Trees
Scenarios Process Creation
Visualizacion Problemas ...
Advanced Secondary Tables
GENEX MenuWindow
08:23:06 PM


OPTEX-SSO - Problems
Archivo Edición Ver Análisis Ver Ayuda
Problems
Problem
Spanish Desc.
Indexe
SSODU1
SSO - Factibilidad Profesor Unico por Materia
SSODU2
SSO - SSODU1+ Tutoria y Consejeria
SSODU3
SSO - SSODU2 +Horas Seguidas Obligatorias
SSODU4
SSO - SSODU3 + Espacios Iguales Horas Seguidas
SSOEMR
SSO - Factibilidad Espacios + Roles
SSOESP
SSO - Factibilidad Espacios
SSOEXP
SSO - Analisis Factilidad
SSOREO
SSO - Re-Asignacion Horas Seguidas
SSOROL
SSO - Factibilidad Roles
PROBLEMS
Problem - Constraints
Problem
Constraint
SSODU4 ACDH
SSODU4 APCU
SSODU4 APDH
SSODU4 ASCU
SSODU4 ASFE
SSODU4 ASFF
SSODU4 ASFF1
SSODU4 HOBL
SSODU4 HOPS
SSODU4 MDEF
SSODU4 MHMD
SSODU4 MTUS
SSODU4 MTUS1
SSODU4 NATM
SSODU4 RECM
SSODU4 RPUN
SSODU4 RPUN1
SSODU4 RTUT
SSODU4 RTUT2
SSODU4 SERO
SSODU4 SUUB
PROBLEMS RESTRICTIONS

Structured Mathematical Modeling – Models





Mathematical Models Documentation

OPTEX generates RTF documents (Rich Text Format), 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.

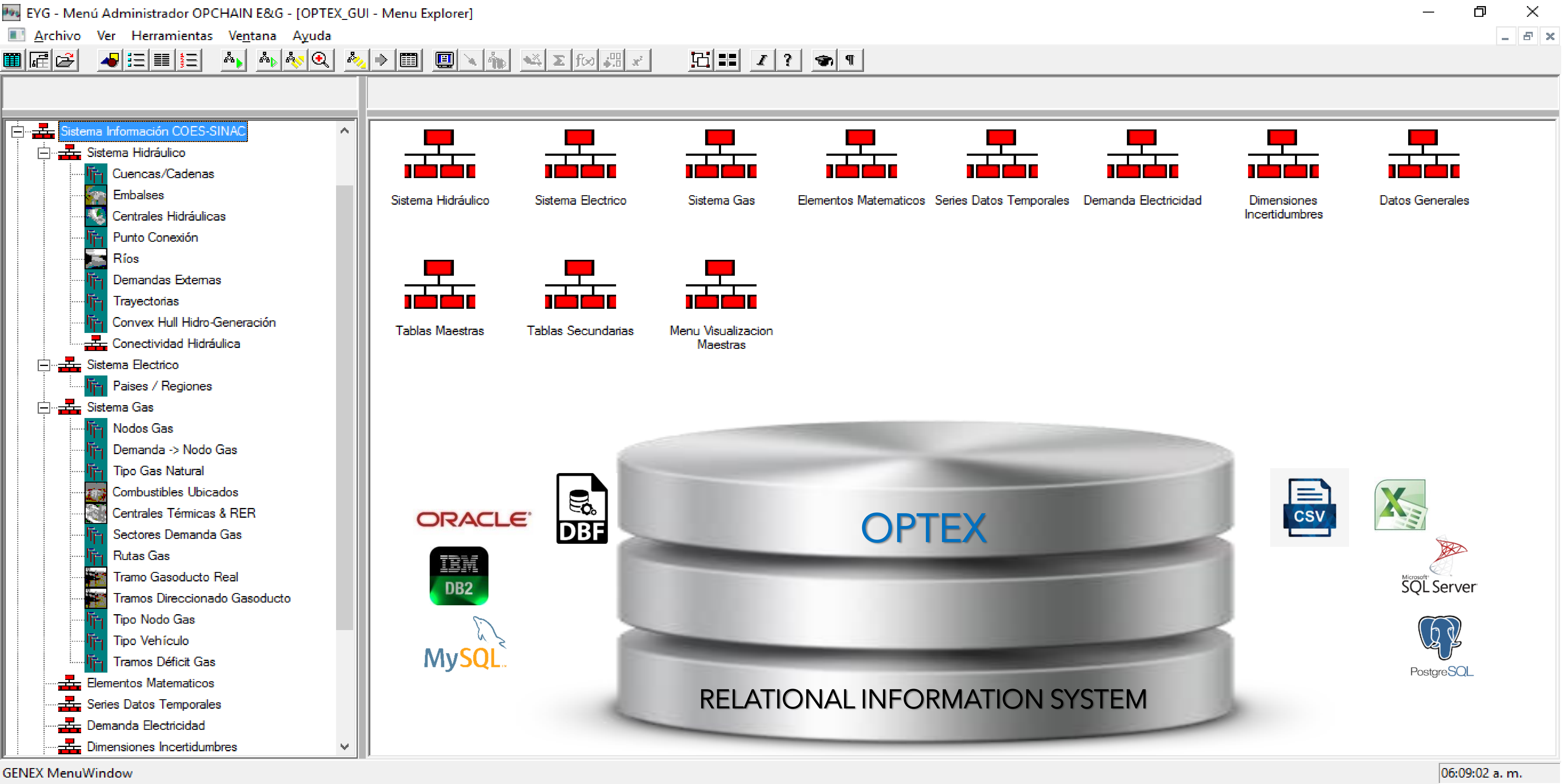
Reports include the description of the data model and the link between the fields of each table and the sets and the parameters of the models that are read as input data.

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 $\Sigma_{p\in PT(j)} \Sigma_{v\in PVJ(p\ j)} ICE_{t,j,p,v,hh} + \Sigma_{v\in JV(j)} EVJ_{t,j,v,hh} \leq ACE_j$ $\forall t \quad \forall j\in PUN \quad \forall hh\in\_DIM\_hh(*)$ Índices: t Período j Centro Distribución hh Escenario Demanda p Producto v Envase Conjuntos: $p\in PT(j)$ Productos Cerveceros x Centro de Distribución j $v\in PVJ(p,j)$ Envases x Producto x Centro de Distribución j $v\in JV(j)$ Envases x Centro de Distribución j $j\in PUN$ Centros de Distribución (j) $hh\in\_DIM\_hh(*)$ 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: $p\in LP(l)$ Productos x Línea de Envase $v\in LTV(l,p)$ Envases x Línea de Envase x Producto $l\in LN$ Línea de Envase $hh\in\_DIM\_hh(*)$ 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)	

OPTEX
User Information Systems

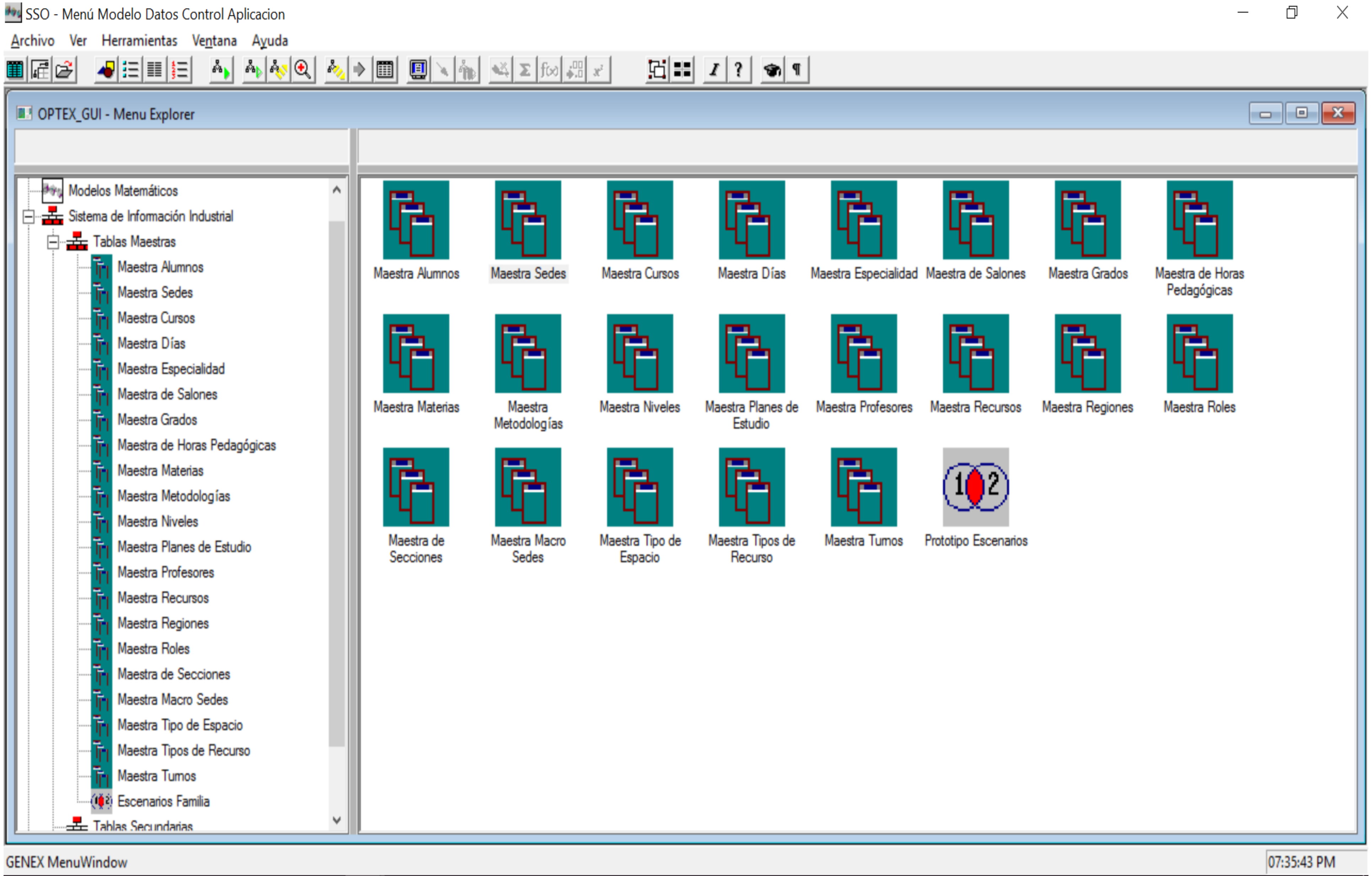
OPTEX – User Information System



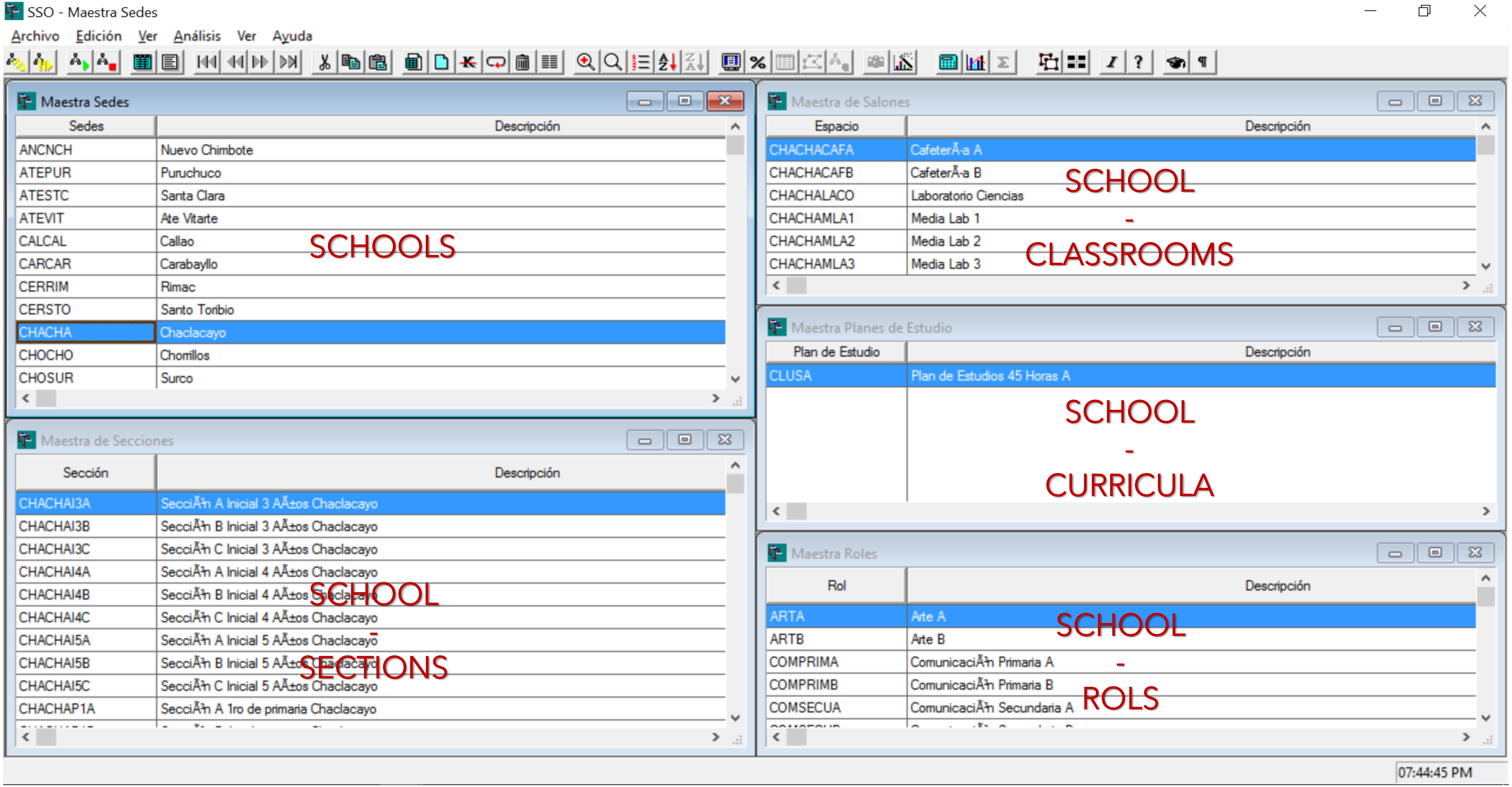
OPTEX – User Information System

Optimization Information System – Case: SPI-UNIVERSIDAD

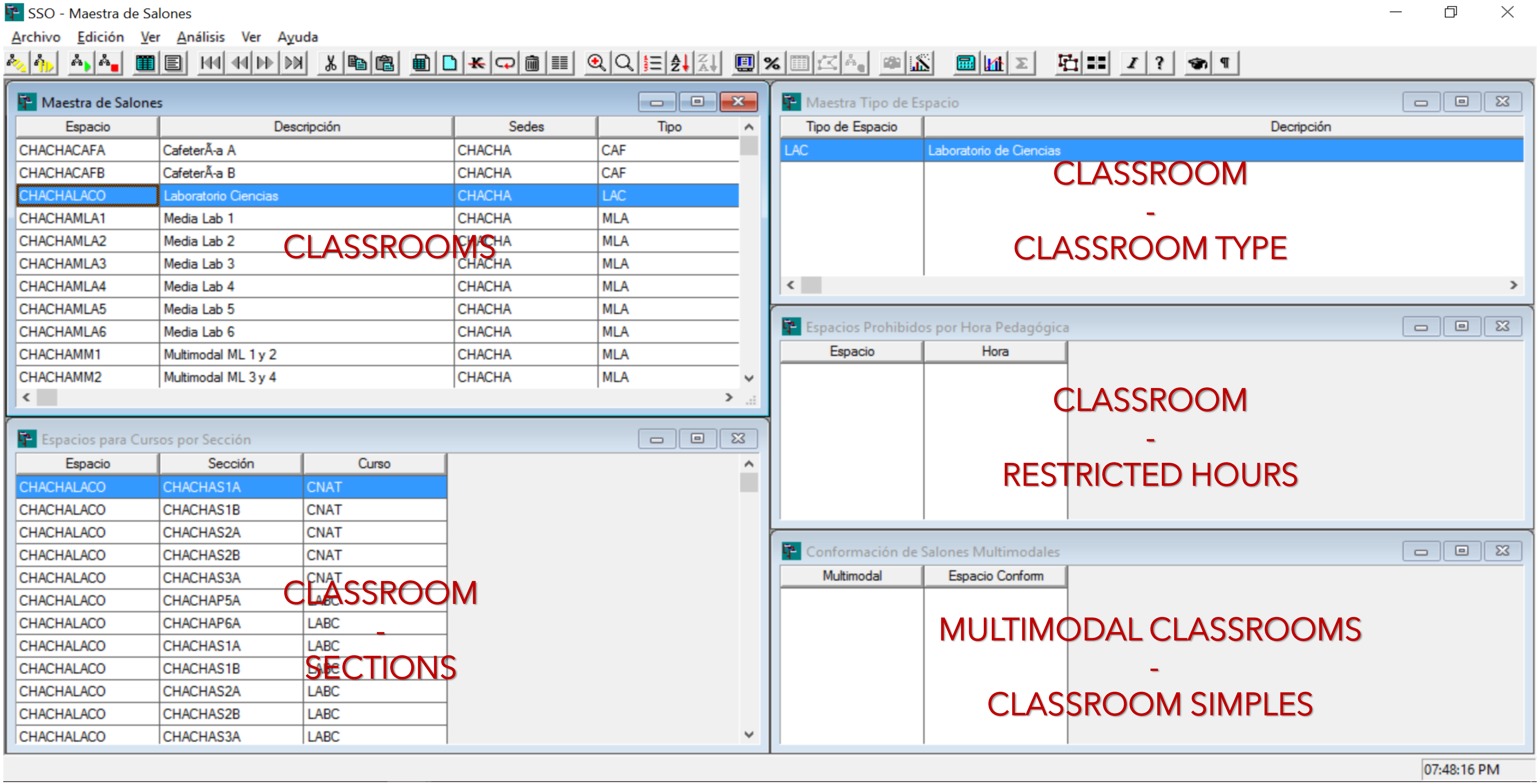
Optimization Information System – OPTEX Visual Interface



Optimization Information System – OPTEX Visual Interface



Optimization Information System – OPTEX Visual Interface

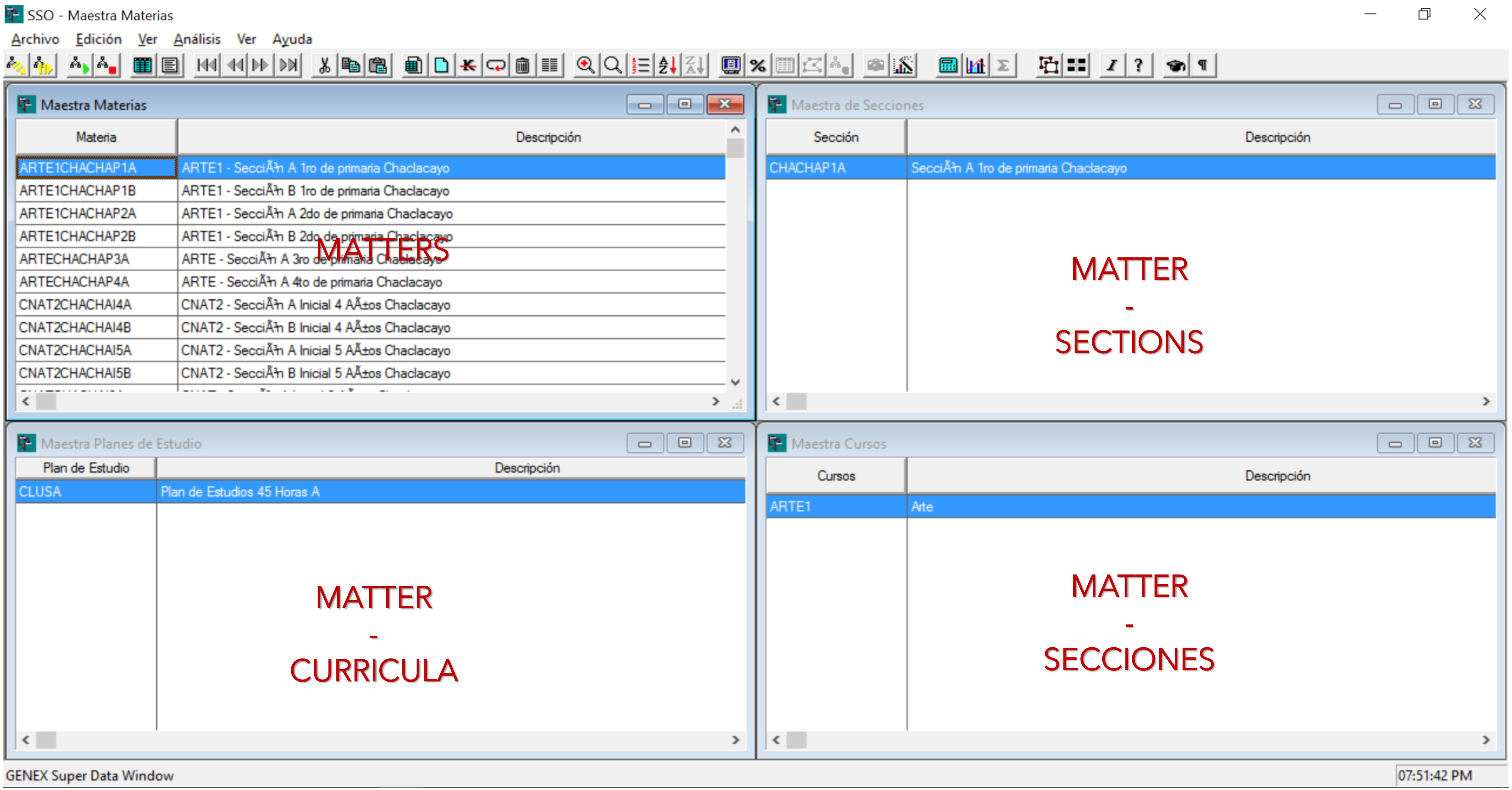


Espacio	Descripción	Sedes	Tipo
CHACHACAFA	CafeterÃ-a A	CHACHA	CAF
CHACHACAFB	CafeterÃ-a B	CHACHA	CAF
CHACHALACO	Laboratorio Ciencias	CHACHA	LAC
CHACHAMLA1	Media Lab 1	CHACHA	MLA
CHACHAMLA2	Media Lab 2	CHACHA	MLA
CHACHAMLA3	Media Lab 3	CHACHA	MLA
CHACHAMLA4	Media Lab 4	CHACHA	MLA
CHACHAMLA5	Media Lab 5	CHACHA	MLA
CHACHAMLA6	Media Lab 6	CHACHA	MLA
CHACHAMM1	Multimodal ML 1 y 2	CHACHA	MLA
CHACHAMM2	Multimodal ML 3 y 4	CHACHA	MLA

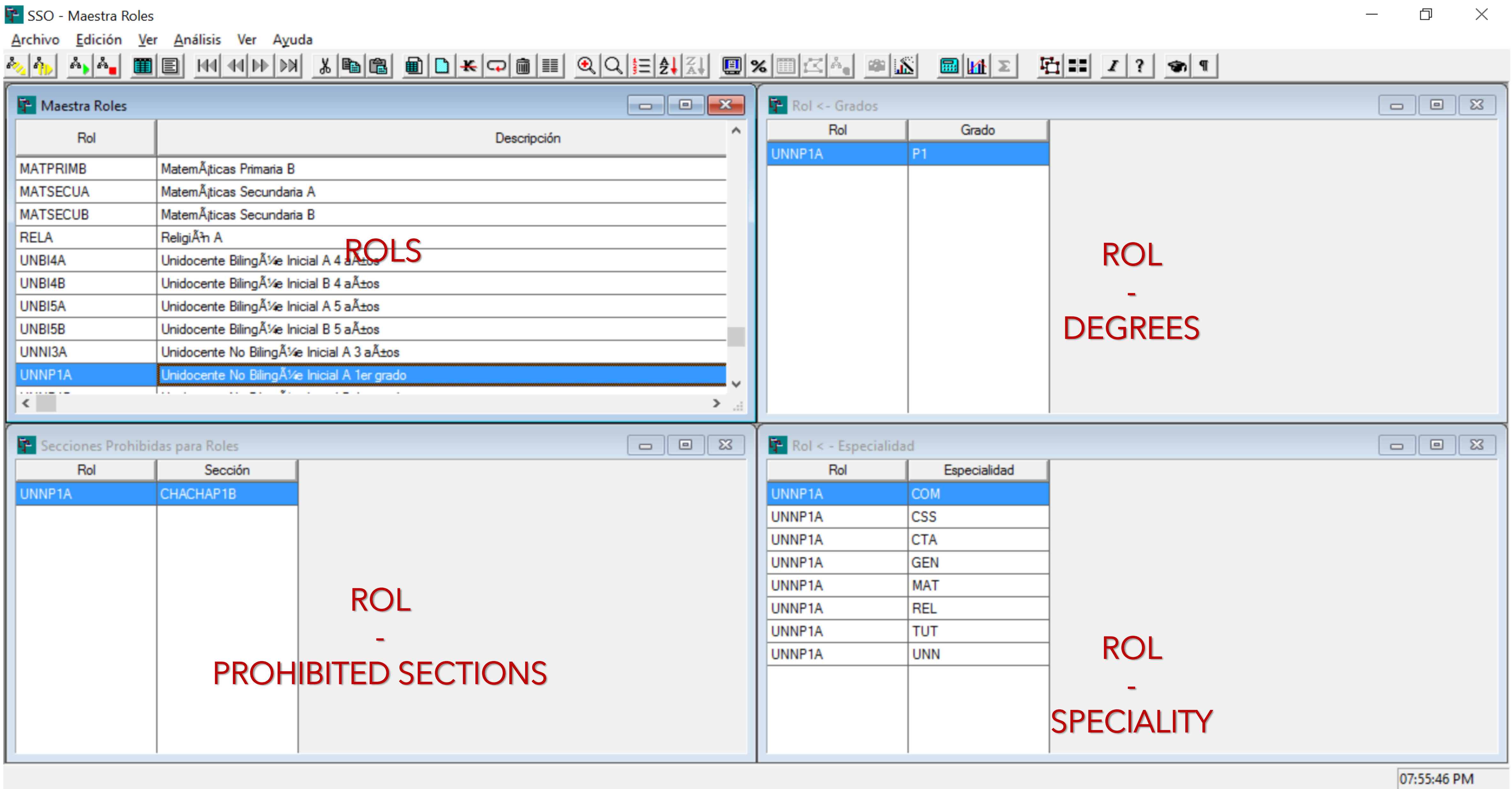
Tipo de Espacio	Decripción
LAC	Laboratorio de Ciencias

Espacio	Sección	Curso
CHACHALACO	CHACHAS1A	CNAT
CHACHALACO	CHACHAS1B	CNAT
CHACHALACO	CHACHAS2A	CNAT
CHACHALACO	CHACHAS2B	CNAT
CHACHALACO	CHACHAS3A	CNAT
CHACHALACO	CHACHAP5A	LABC
CHACHALACO	CHACHAP6A	LABC
CHACHALACO	CHACHAS1A	LABC
CHACHALACO	CHACHAS1B	LABC
CHACHALACO	CHACHAS2A	LABC
CHACHALACO	CHACHAS2B	LABC
CHACHALACO	CHACHAS3A	LABC

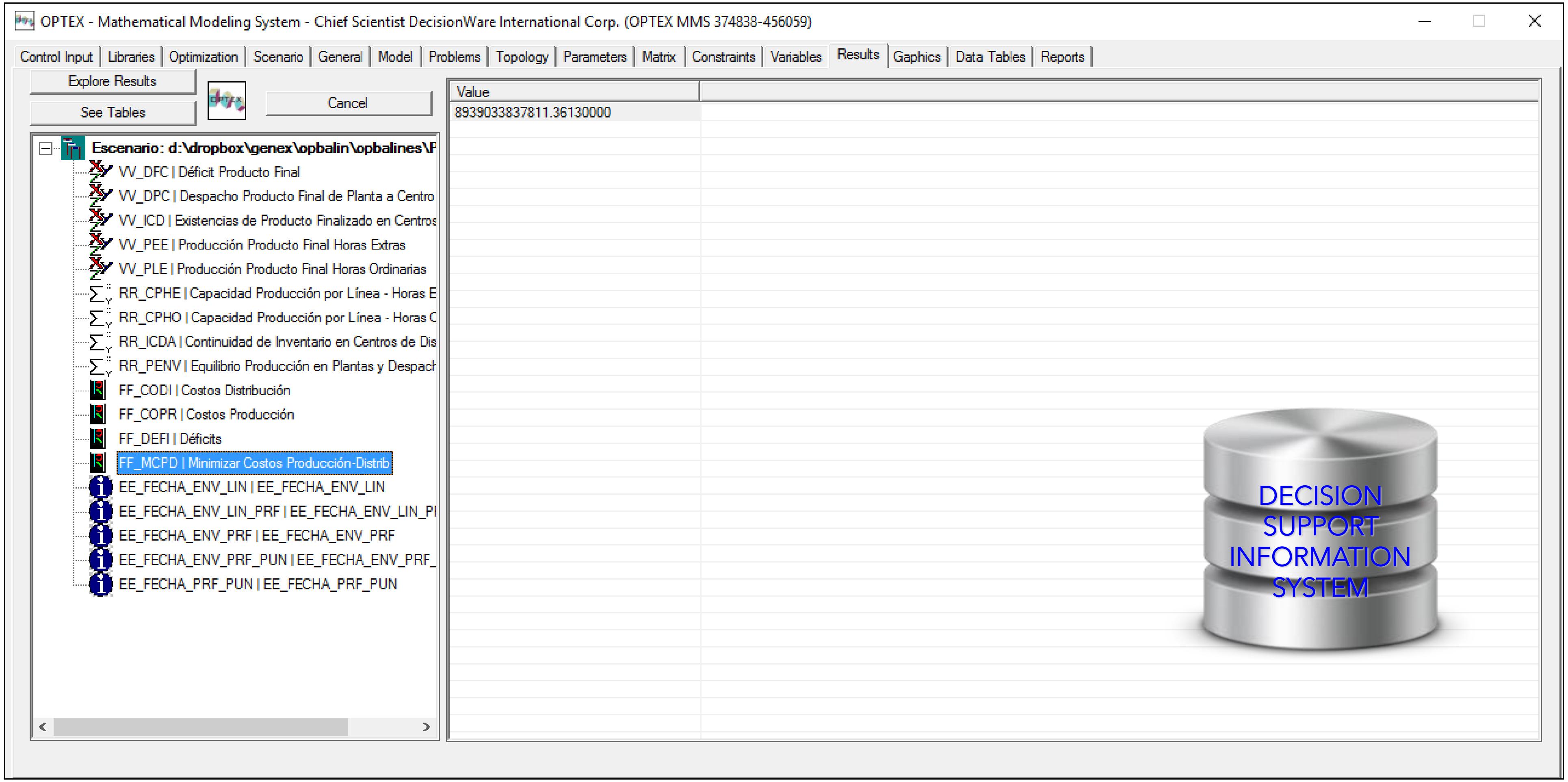
Optimization Information System – OPTEX Visual Interface



Optimization Information System – OPTEX Visual Interface



Optimization Information System – OPTEX Visual Interface - Results



Optimization Information System – OPTEX Visual Interface - Results

OPTEX-OPBALIN - Optimization Data Explorer: d:\dropbox\genex\opbalin\opbalines\PTA1B\A\

Archivo Ver Herramientas Ventana Ayuda

Resultados Escenario: d:\dropbox\genex\opbalin\opbalines\PTA1B\A

- VV_DFC | Déficit Producto Final
- VV_DPC | Despacho Producto Final de Planta a Centro de Distribución
- VV_ICD | Existencias de Producto Finalizado en Centros de Distribución
- VV_PEE | Producción Producto Final Horas Extras
- VV_PLE | Producción Producto Final Horas Ordinarias
- RR_CPHE | Capacidad Producción por Línea - Horas Extras
- RR_CPHO | Capacidad Producción por Línea - Horas Ordinarias
- RR_ICDA | Continuidad de Inventario en Centros de Distribución
- RR_PENV | Equilibrio Producción en Plantas y Despacho
- CC_ENP | Centros de Distribución j x Planta Empacadora
- CC_ENV | Plantas Empacadoras del Sistema Industrial
- CC_EPF | Planta Envasadora - Producto Final
- CC_EVL | Plantas Envasadora - Línea de Envase
- CC_LIE | Líneas de Envasado x Planta
- CC_LPF | Línea de Envasado - Producto Final
- CC_PCA | Producto Final - Centro Distribución
- CC_PEV | Producto Final - Planta Envasadora
- CC_PPJ | Producto Final - Planta Envasadora - Centro Distribución
- CC_PRL | Producto Final - Líneas de Envasado
- CC_PUN | Centros de Distribución (j)
- PP_BOCF | Botellas por Caja Física
- PP_BOCU | Botellas por Caja Unitaria
- PP_CUPE | Costo Unitario Producción Producto Final Hora Extra
- PP_CUPF | Costo Unitario Producción Producto Final
- PP_DMJN | Demanda Producto Final - Centro Distribución (negativo)
- PP_DMJS | Demanda Producto Final - Centro Distribución
- PP_FCPF | Factor Conversión Pallet a Caja Física
- PP_FCUF | Factor Conversión Caja Física a Caja Unitaria
- PP_FLPC | Flete Planta Envasadora -> Centro de Distribución
- PP_FPCF | Flete Planta Envasadora -> Centro de Distribución (Caja Fisica)

Período (a)	Envasadora	Centro Distribución	Producto Final	Value
01/01/2014	1000	7010	252348	0.00000000
01/01/2014	1000	7010	252434	0.00000000
01/01/2014	1000	7010	252525	0.00000000
01/01/2014	1000	7010	252530	0.00000000
01/01/2014	1000	7010	252531	0.00000000
01/01/2014	1000	7010	252532	0.00000000
01/01/2014	1000	7010	252533	0.00000000
01/01/2014	1000	7010	252542	0.00000000
01/01/2014	1000	7010	252629	0.00000000
01/01/2014	1000	3100	250030	3042.66000000
01/01/2014	1000	3100	250031	0.00000000
01/01/2014	1000	3100	250032	203.34000000
01/01/2014	1000	3100	250070	0.00000000
01/01/2014	1000	3100	250204	0.00000000
01/01/2014	1000	3100	250418	0.00000000
01/01/2014	1000	3100	250421	0.00000000
01/01/2014	1000	3100	250422	0.00000000
01/01/2014	1000	3100	250423	0.00000000
01/01/2014	1000	3100	250443	0.00000000
01/01/2014	1000	3100	250445	0.00000000
01/01/2014	1000	3100	250669	0.00000000
01/01/2014	1000	3100	250670	0.00000000
01/01/2014	1000	3100	250689	0.00000000
01/01/2014	1000	3100	250692	0.00000000
01/01/2014	1000	3100	250736	197268.48353020
01/01/2014	1000	3100	250746	0.00000000
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01/01/2014	1000	3100	251528	0.00000000
01/01/2014	1000	3100	251554	0.00000000
01/01/2014	1000	3100	251570	0.00000000
01/01/2014	1000	3100	251604	51691.00000000
01/01/2014	1000	3100	251620	0.00000000
01/01/2014	1000	3100	251637	0.00000000
01/01/2014	1000	3100	251641	0.00000000
01/01/2014	1000	3100	251642	27137.99000000
01/01/2014	1000	3100	252323	0.00000000
01/01/2014	1000	3100	252348	65221.17000000
01/01/2014	1000	3100	252433	47305.50000000

GENEX MenuWindow 04:09:25 p. m.

VARIABLES PRIMALES

Optimization Information System – OPTEX Visual Interface - Results

OPTEX-OPBALIN - Optimization Data Explorer: d:\dropbox\genex\opbalin\opbalines\PTA1B\A\

Archivo Ver Herramientas Ventana Ayuda

Resultados Escenario: d:\dropbox\genex\opbalin\opbalines\PTA1B\A

- VV_DFC | Déficit Producto Final
- VV_DPC | Despacho Producto Final de Planta a Centro de Distribución
- VV_ICD | Existencias de Producto Finalizado en Centros de Distribución
- VV_PEE | Producción Producto Final Horas Extras
- VV_PLE | Producción Producto Final Horas Ordinarias
- RR_CPHE | Capacidad Producción por Línea - Horas Extras
- RR_CPHO | Capacidad Producción por Línea - Horas Ordinarias
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- RR_PENV | Equilibrio Producción en Plantas y Despacho
- CC_ENP | Centros de Distribución j x Planta Empacadora
- CC_ENV | Plantas Empacadoras del Sistema Industrial
- CC_EPF | Planta Envasadora - Producto Final
- CC_EVL | Plantas Envasadora - Línea de Envase
- CC_LIE | Líneas de Envasado x Planta
- CC_LPF | Línea de Envasado - Producto Final
- CC_PCA | Producto Final - Centro Distribución
- CC_PEV | Producto Final - Planta Envasadora
- CC_PPJ | Producto Final - Planta Envasadora - Centro Distribución
- CC_PRL | Producto Final - Líneas de Envasado
- CC_PUN | Centros de Distribución (j)
- PP_BOCF | Botellas por Caja Física
- PP_BOCU | Botellas por Caja Unitaria
- PP_CUPE | Costo Unitario Producción Producto Final Hora Extra
- PP_CUPF | Costo Unitario Producción Producto Final
- PP_DMJN | Demanda Producto Final - Centro Distribución (negativo)
- PP_DMJS | Demanda Producto Final - Centro Distribución
- PP_FCPF | Factor Conversión Pallet a Caja Física
- PP_FCUF | Factor Conversión Caja Física a Caja Unitaria
- PP_FLPC | Flete Planta Envasadora -> Centro de Distribución
- PP_FPCF | Flete Planta Envasadora -> Centro de Distribución (Caja Fisica)

Período (a)	Envasadora	Producto Final	Dual Variable	Slack
01/02/2014	7000	252554	100.00000000	0.00000000
01/02/2014	7000	252555	7.08040000	0.00000000
01/02/2014	7000	252565	4.62450000	0.00000000
01/02/2014	7000	252566	4.37520000	0.00000000
01/02/2014	7000	252567	4.59440000	0.00000000
01/02/2014	7000	252568	4.76800000	0.00000000
01/02/2014	7000	254697	0.00000000	0.00000000
01/02/2014	7000	254698	0.00000000	0.00000000
01/02/2014	7000	254699	3.99510000	0.00000000
01/02/2014	7000	254700	100.00000000	0.00000000
01/02/2014	7000	254703	4.09430000	0.00000000
01/02/2014	7000	254705	3.76230000	0.00000000
01/02/2014	7010	250039	7.14020000	0.00000000
01/02/2014	7010	250070	4.95320000	0.00000000
01/02/2014	7010	250422	6.60830000	0.00000000
01/02/2014	7010	250443	6.90170000	0.00000000
01/02/2014	7010	250445	6.74510000	0.00000000
01/02/2014	7010	250498	4.83080000	0.00000000
01/02/2014	7010	250774	5.29280000	0.00000000
01/02/2014	7010	251405	100.00000000	0.00000000
01/02/2014	7010	251641	1.45240000	0.00000000
01/02/2014	7010	252322	2.50120000	0.00000000
01/02/2014	7010	252323	3.36180000	0.00000000
01/02/2014	7010	252434	4.75100000	0.00000000
01/02/2014	7010	252542	6.56820000	0.00000000
01/02/2014	7010	252553	6.51730000	0.00000000
01/02/2014	7010	252554	6.78320000	0.00000000
01/02/2014	7010	252555	6.78320000	0.00000000
01/02/2014	7010	254700	6.57490000	0.00000000
01/02/2014	7010	254703	4.09430000	0.00000000
01/02/2014	7010	254705	4.09430000	0.00000000
01/03/2014	1000	250029	6.55050000	0.00000000
01/03/2014	1000	250030	5.80280914	0.00000000
01/03/2014	1000	250031	4.45155181	0.00000000
01/03/2014	1000	250032	5.00866154	0.00000000
01/03/2014	1000	250033	5.07460316	0.00000000
01/03/2014	1000	250070	4.55333948	0.00000000
01/03/2014	1000	250204	4.86518788	0.00000000
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01/03/2014	1000	250422	6.79550000	0.00000000
01/03/2014	1000	250423	4.78328788	0.00000000

GENEX MenuWindow 04:10:40 p. m.

VARIABLES DUALES

RESTRICCIONES

Optimization Expert System

OPTEX
Visualization Technologies

OPTEX Optimization Expert System

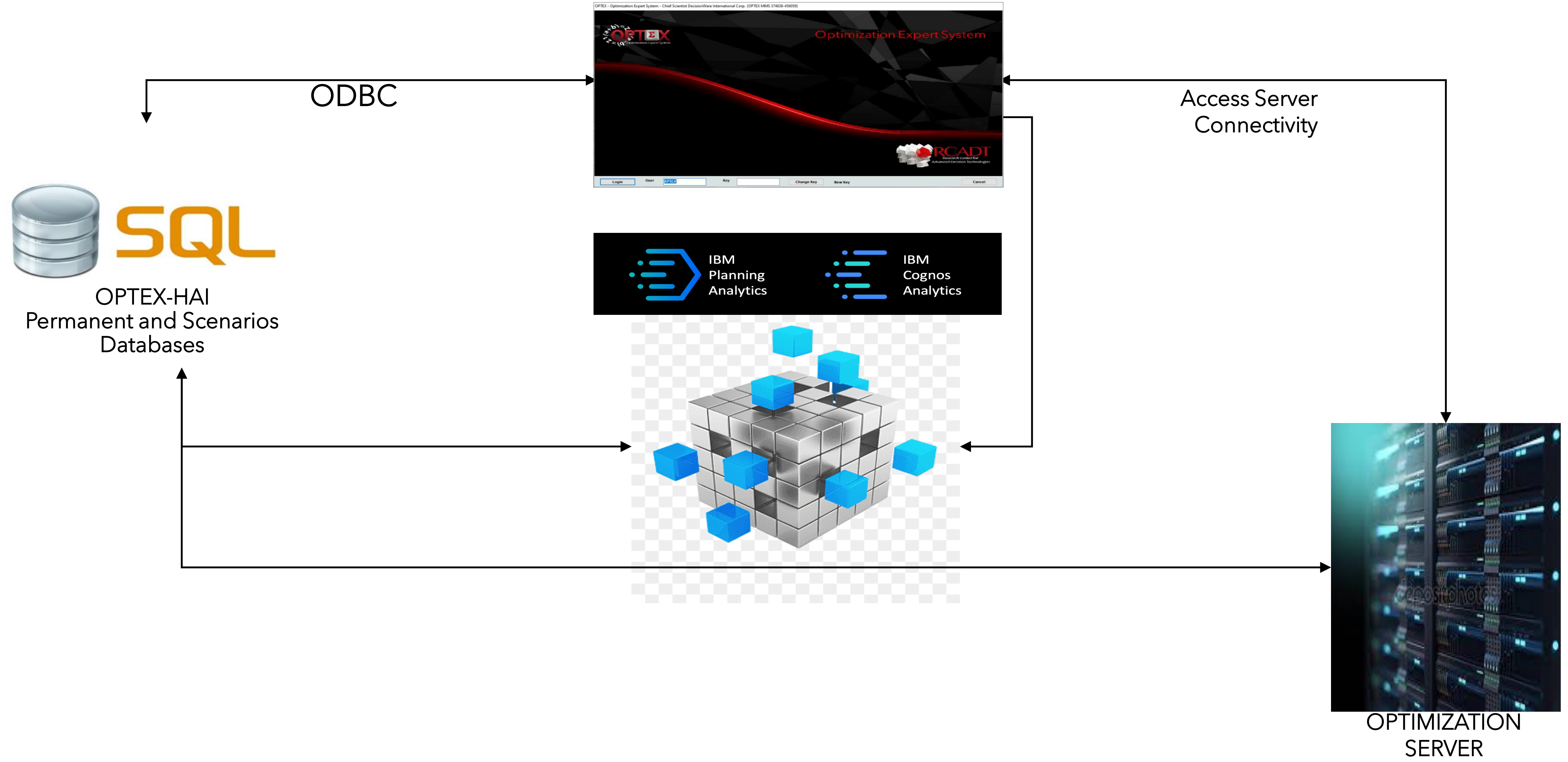
LINKING OPTEX – TM1
IBM PLANNING ANALYTICS
IBM COGNOS ANALYTICS

IBM Planning Analytics

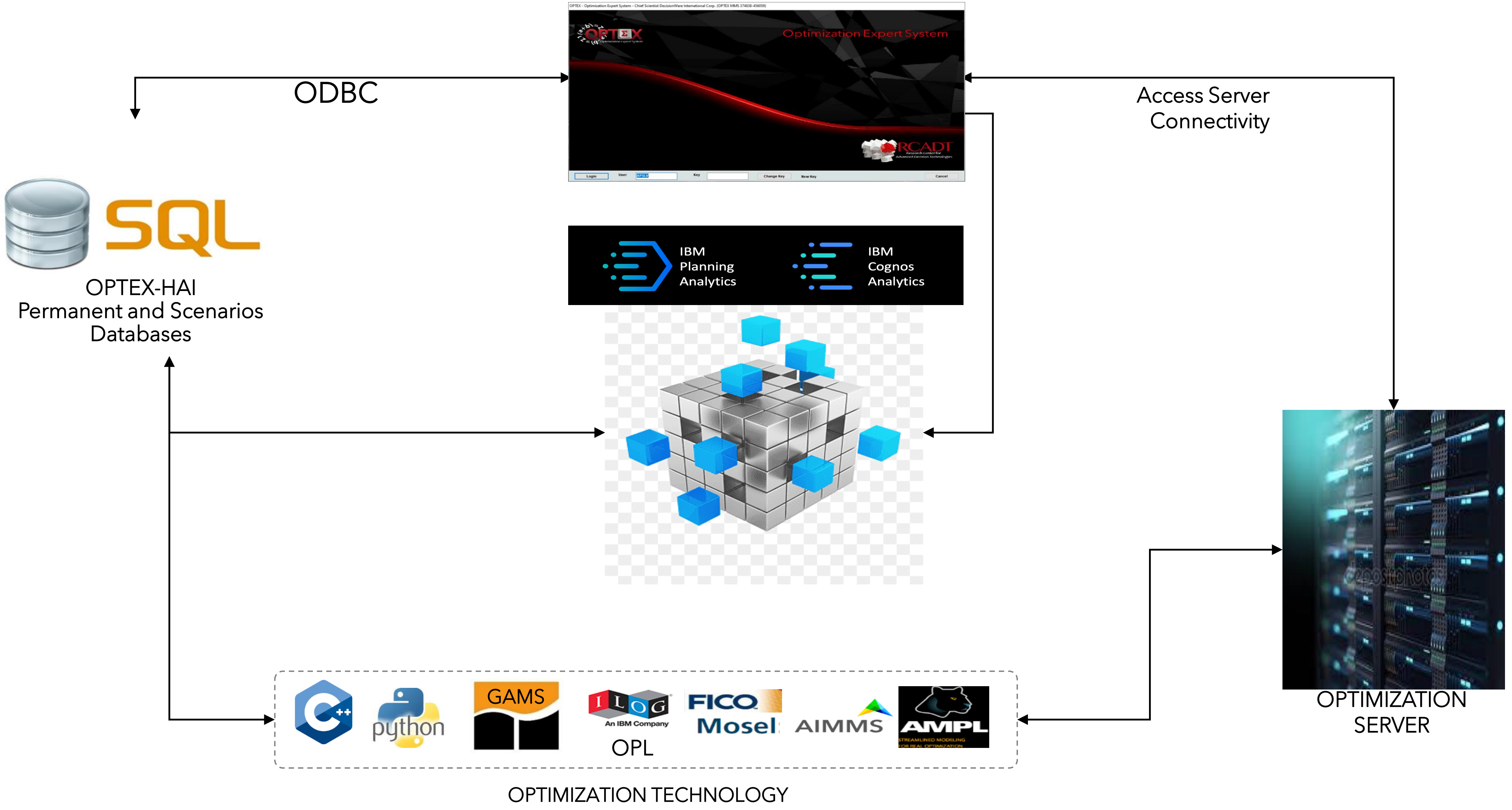
IBM Cognos Analytics

IBM Business Partner

OPTEX-HAI - IBM CPLEX – TM1 – COGNOS – PLANNING ANALYTICS



OPTEX-HAI - IBM CPLEX-OPL – TM1 – COGNOS – PLANNING ANALYTICS



OPTΣX

MODELO DE OPTIMIZACIÓN TACTICA Y FINANCIERA DE LA CADENA DE SUMINISTROS GLOBAL PARA LA INDUSTRIA CERVECERA

Producción

Envasado

Distribución

Transferencias

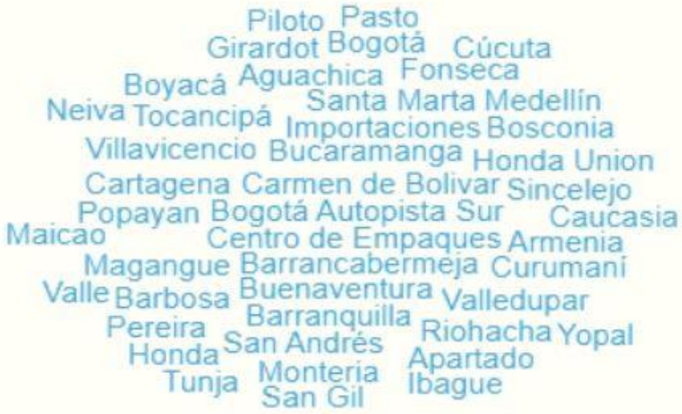
Estados Financieros

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Escenario: SOPALM-SOPALM-1 | Período: 2014 | Centro Distribución: Total Centro Distribución

Centros de Distribución

- Recepción de Importaciones
- Recepsión de CEDIS
- Horas Recepción
- Reempacado de Producto
- Producción de Combos
- Horas Producción
- **Despacho a CEDIS**
- Despacho Productos a Zonas
- Despacho Combos a Zonas
- Volumen de Despacho
- Horas Despacho
- Inventario Final



Despacho de Productos Finales

	Cartagena	Santa Marta	Bogotá	Bucaram
Poker R 330cc X 30	0	0	0	
Pony Malta Pet 200ccX30	0	0	5,451	
Pony Malta BSplit Pet 200X30	0	0	0	
Pony Malta Fresa Pet 200X30	0	0	0	
Pilsen R 330cc X 30	0	0	0	
Pony Mlta Pet 1.5L X 6	0	0	5,353	
Aguila Lig R 330cc X 30	52,168	49,689	0	

Despacho de Combos

	Barranquilla	Cartagena	Santa Marta	Valledu
Pilsen Lta 330cc X 12 Agr	19	19	19	
Club Col Lta 330cc X 6 Agr	205	205	205	
Pilsen Tw 330cc X 6 Agr	343	343	343	
Aguila Lta 330cc X 18 Agr	127	127	127	
Cola&Pola Pet 1.5LX2 Agr	227	227	227	
Aguila Lig Lta 330ccX4 Agr	177	177	177	
Aguila Lig Lta 330ccX10 Agr	31	31	31	

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Escenario SOPALM-SOPALM-1

Período 2014

Zona Consumo Total Zona Consumo

Centros de Distribución

- Recepción de Importaciones
- Recepsión de CEDIS
- Horas Recepción
- Reempacado de Producto
- Producción de Combos
- Horas Producción
- Despacho a CEDIS
- **Despacho Productos a Zonas**
- Despacho Combos a Zonas
- Volumen de Despacho
- Horas Despacho
- Inventario Final

Despacho de Productos Finales

Poker R 330cc X 30	241,151
Pony Malta Pet 200ccX30	34,301
Pony Malta BSplit Pet 200X30	24
Pony Malta Fresa Pet 200X30	24
Pilsen R 330cc X 30	161,016
Pony Mlta Pet 1.5L X 6	45,270
Aguila Lig R 330cc X 30	397,975
Aguila RN 330cc X 30	167,860

Despacho de Productos Sustitutos

Deficit de Productos Finales

Poker Lta 330ccX 24	49,850
Poker R 330cc X 30	465,229
Poker Lta 330cc X 6	56,825
Pony Malta Pet 200ccX30	30,244
Pony Malta BSplit Pet 200...	87
Pony Malta Fresa Pet 200...	87
Pilsen R 330cc X 30	33,041
Pony Mlta Pet 1.5L X 6	40,573
Aguila Lig R 330cc X 30	140,224
Aguila RN 330cc X 30	83,993
Aguila RN 225cc X 38	25,191
Pony Malta R 330cc X 30	21,303
Maltizz Kiwi Pet 400ccX12	2,560
Maltizz Kiwi Pet 225ccX15	1,640
Maltizz Mcuya Pet 400cc...	2,560
Maltizz Mcuya Pet 225cc...	1,640
Aguila Lig R 750cc X 16	15,187
Poker R 750cc X 16	110,578

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Centros de Distribución

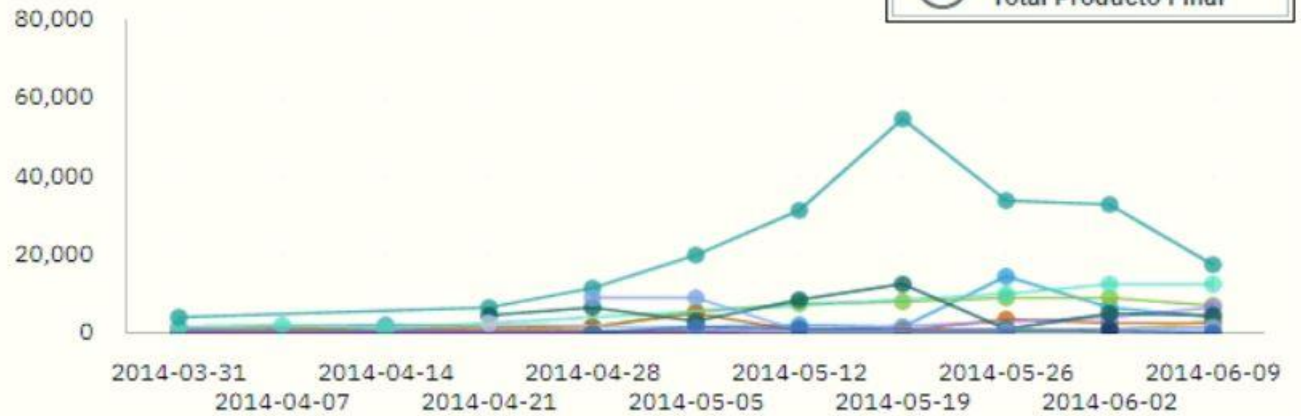
- Recepción de Importaciones
- Recepsión de CEDIS
- Horas Recepción
- Reempacado de Producto
- Producción de Combos
- Horas Producción
- Despacho a CEDIS
- Despacho Productos a Zonas
- Despacho Combos a Zonas
- Volumen de Despacho
- Horas Despacho
- **Inventario Final**

Escenario: SOPALM-SOPALM-1

Período: 2014

Centro Distribución: Total Centro Distribución

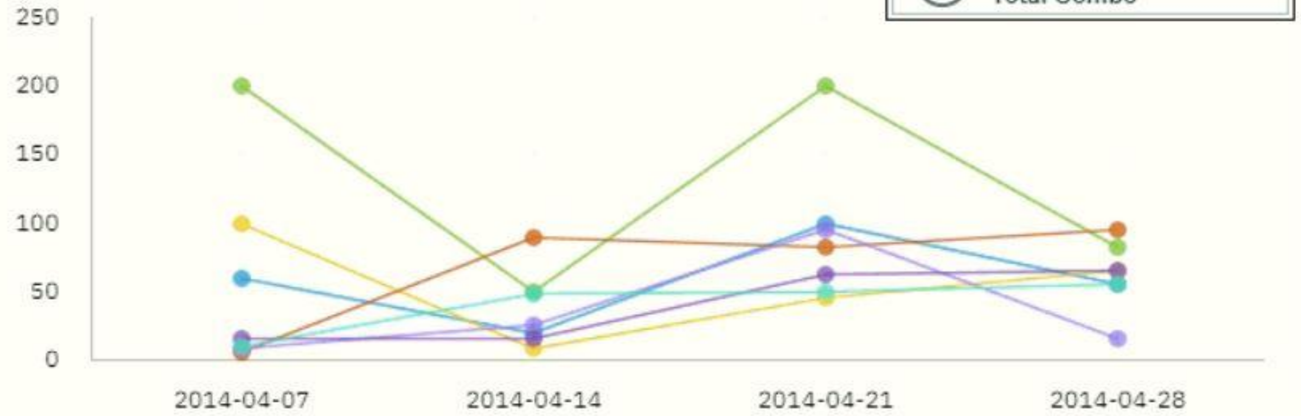
Producto Final: Total Producto Final



Déficit de Política de Inventarios de Productos Finales

Costeña R 350cc X 30	92,715
Costeñita R 175cc X 38	28,345
Pilsen Night Lta 269ccX24	437
Miller Lite Lta 330ccX24	2,910
Maltizz Pet 400ccX12	647
Maltizz Pet 225ccX15	670
Total Producto Final	2,472,365

Combo: Total Combo



Déficit de Política de Inventarios de Combos

Pony Mlta Pet 1.5LX2 Agr	4,268
Pony Malta Pet 200 X6 Agr	35,214
Pony Malta MIX Pet 200cc...	1,178
Pony Malta PET 1.5x2+ P...	163
Pony Malta PET 1.5x2+ P...	163
Maltizz MIX Pet 225ccX15	4,083
Total Combo	45,071

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Centros de Distribución

- Recepción de Importaciones
- Recepsión de CEDIS
- Horas Recepción
- **Reempacado de Producto**
- Producción de Combos
- Horas Producción
- Despacho a CEDIS
- Despacho Productos a Zonas
- Despacho Combos a Zonas
- Volumen de Despacho
- Horas Despacho
- Inventario Final

Escenario
SOPALM-SOPALM-1

Período
2014

Centro Distribución
Total Centro Distribución

Producto Final (Alias)
Total Producto Final (Alia:

Producto Reempacado

	Producto Reempacado
Aguila Lta 330cc X 24 Evt	112
Aguila Lta 330cc X 24 PAS	101
Total Producto Final (Alias)	213

Producto a Reempacar

	Producto a Reempacar
Aguila Lta 330cc X 6 Evt	447
Aguila Lta 330cc X 6 PAS	403
Total Producto Final	850

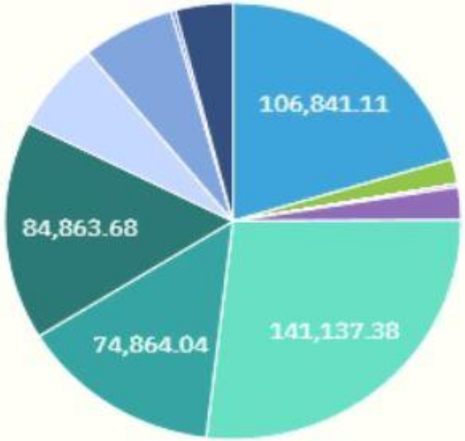
Producción | Envasado | Distribución | Transferencias | Estados Financieros

Centros de Distribución

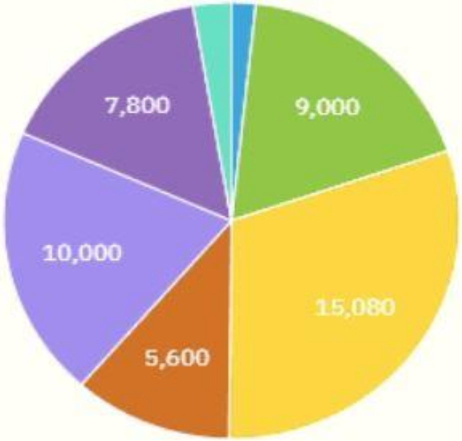
- Recepción de Importaciones
- Recepsión de CEDIS
- Horas Recepción
- Reempacado de Producto
- Producción de Combos
- Horas Producción
- Despacho a CEDIS
- Despacho Productos a Zonas
- Despacho Combos a Zonas
- Volumen de Despacho
- Horas Despacho
- Inventario Final

Escenario SOPALM-SOPALM-1 | Período 2014 | Ctro Distribución (Alias) Total Ctro Distribución (A

Productos Finales



Combos



Aguila Lig R 330cc X 30	141,137
Aguila RN 330cc X 30	74,864
Aguila RN 225cc X 38	84,864
Pony Malta R 330cc X 30	34,782
Aguila Lig R 750cc X 16	34,619
Costeña R 350cc X 30	1,555
Costeñita R 175cc X 38	21,283
Total Producto Final	523,550

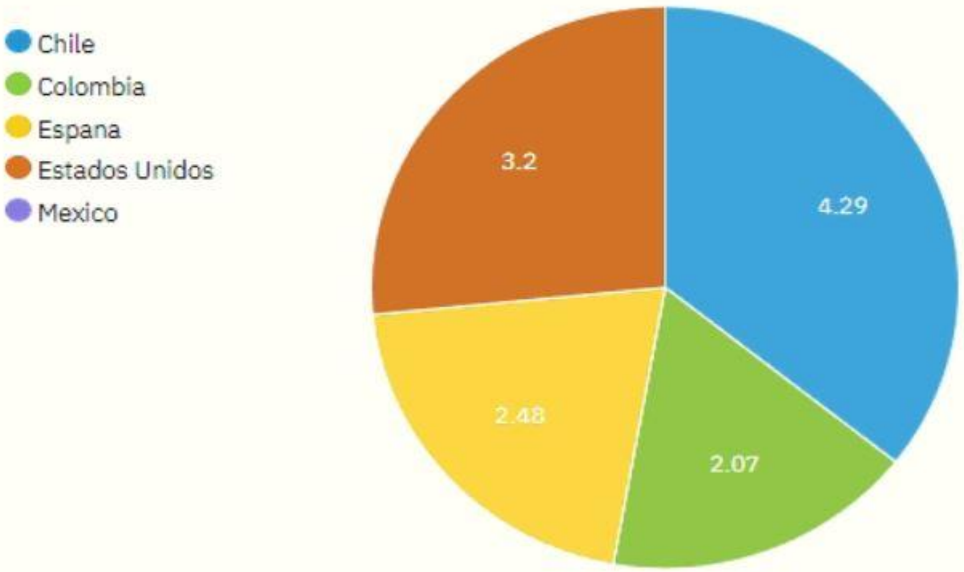
Pilsen Lta 330cc X 12 Agr	850
Club Col Lta 330cc X 6 Agr	9,000
Pilsen Tw 330cc X 6 Agr	15,080
Aguila Lta 330cc X 18 Agr	5,600
Cola&Pola Pet 1.5LX2 Agr	10,000
Aguila Lig Lta 330ccX4 Agr	7,800
Aguila Lig Lta 330ccX10 Agr	1,350
Total Combo	49,680

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Escenario	Período	País	MET_VAR_FECHA_PAI
SOPALM-SOPALM-1	2014	Total País	Costos de Horas Operaci

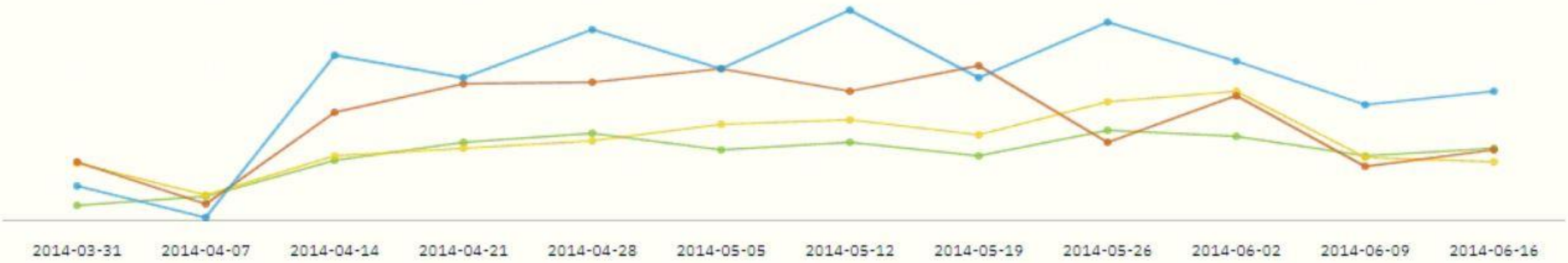
Estados Financieros

- Reporte de P&L
- Análisis Vertical
- Análisis de P&L
- **Análisis de Costos**



Costos

Costos de Horas Operación	$12
Costos de Inventario	$0
Costos de Producción	$6,825
Costos de Sustitución	$0
Costos de Transporte	$66
Costos de ventas	$6,904
Costo de Importación	$126
Costos Fijos	$0



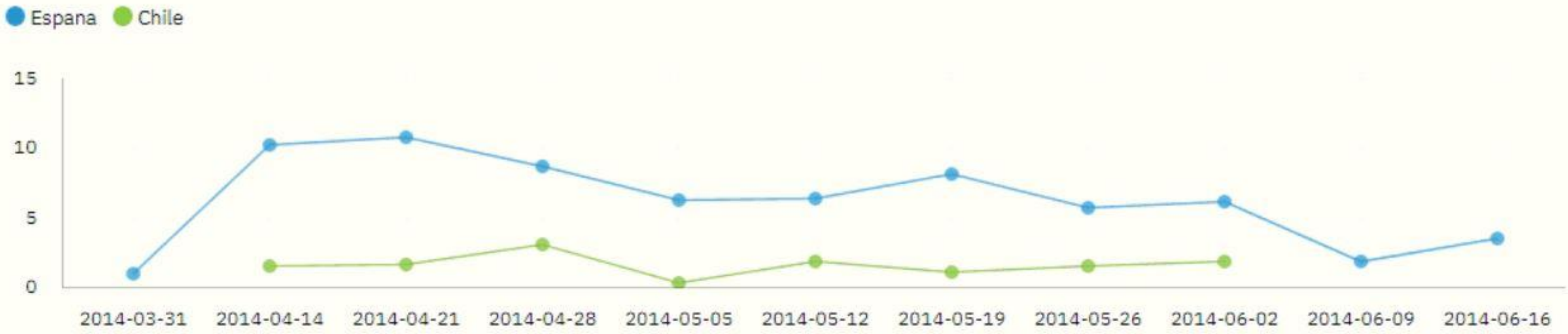
Producción Envasado Distribución Transferencias Estados Financieros

Escenario SOPALM-SOPALM-1 | Período 2014 | País Total País

Transferencias de Producto Final

- Exportaciones
- **Valor Exportaciones**
- Valor Importaciones
- Costo Importaciones

	Valor Exportación
Costeñita R 175cc X 38	$2
Costeña R 350cc X 30	$2
Pony Malta R 330cc X 30	$5
Aguila RN 330cc X 30	$7
Aguila Lig R 330cc X 30	$7
Aguila Lig R 750cc X 16	$12
Pony Malta Pet 200ccX30	$13
Pony Mlta Pet 1.5L X 6	$13



OPTΣX

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Transferencias de Producto Final

Exportaciones

Valor Exportaciones

Valor Importaciones

Costo Importaciones

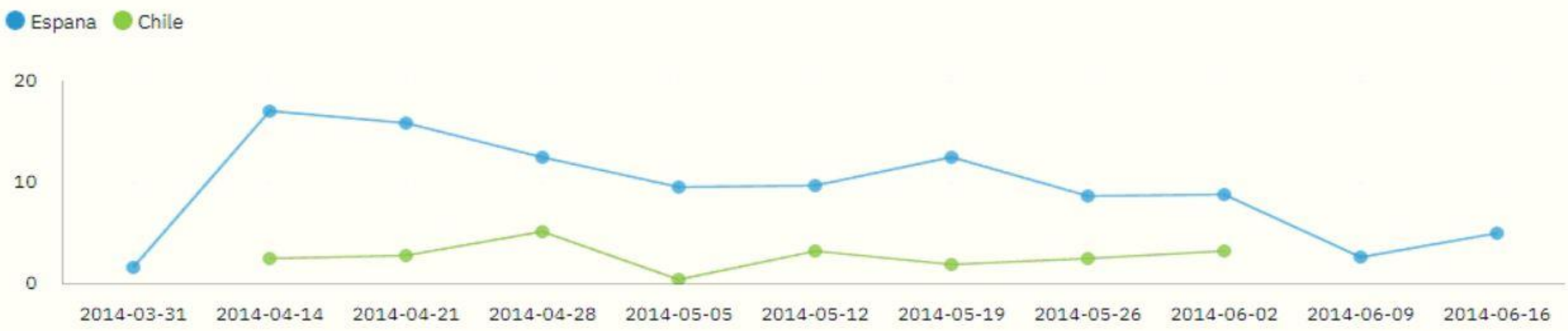
Escenario: SOPALM-SOPALM-1

Período: 2014

País: Total País

Espana

	Costo de Importac...
Costeñita R 175cc X 38	$3
Costeña R 350cc X 30	$3
Pony Malta R 330cc X 30	$9
Aguila RN 330cc X 30	$11
Aguila Lig R 330cc X 30	$12
Pony Malta Pet 200ccX30	$18
Pony Mlta Pet 1.5L X 6	$18
Aguila Lig R 750cc X 16	$19



Producción Envasado Distribución Transferencias Estados Financieros

Estados Financieros

Reporte de P&L

Análisis Vertical

Análisis de P&L

Análisis de Costos

Escenario
SOPALM-SOPALM-1

Período
2014

	Espana	Chile	Colombia	Mexico	Estados Unid...	Total País
Ingresos por Ventas	$3,496	$4,173	$2,321	$108	$3,892	$13,989
Valor Exportación	$69	$13	$0	$0	$0	$82
Costos de Horas Operación	$2	$4	$2	$0	$3	$12
Costos de Inventario	$0	$0	$0	$0	$0	$0
Costos de Producción	$1,981	$1,886	$1,029	$0	$1,929	$6,825
Costos de Sustitución	$0	$0	$0	$0	$0	$0
Costos de Transporte	$33	$14	$11	$0	$8	$66
Costos de ventas	$2,016	$1,905	$1,042	$0	$1,941	$6,904
Costo de Importación	$104	$22	$0	$0	$0	$126
Ganancia Bruta Corporativa	$1,445	$2,259	$1,279	$108	$1,952	$7,042
Costos Fijos	$0	$0	$0	$0	$0	$0
Ganancia Operacional por País	$61	$657	($260)	($2,215)	$699	($1,057)
Impuesto Sobre la Renta por País	$105	$258	$25	$0	$372	$760
Ganancia Neta por País	$0	$0	$0	$0	$0	$0

OPTEX

Producción | Envasado | Distribución | Transferencias | Estados Financieros

Estados Financieros

Reporte de P&L

Análisis Vertical

Análisis de P&L

Análisis de Costos

Escenario SOPALM-SOPALM-1

Período 2014

País Espana

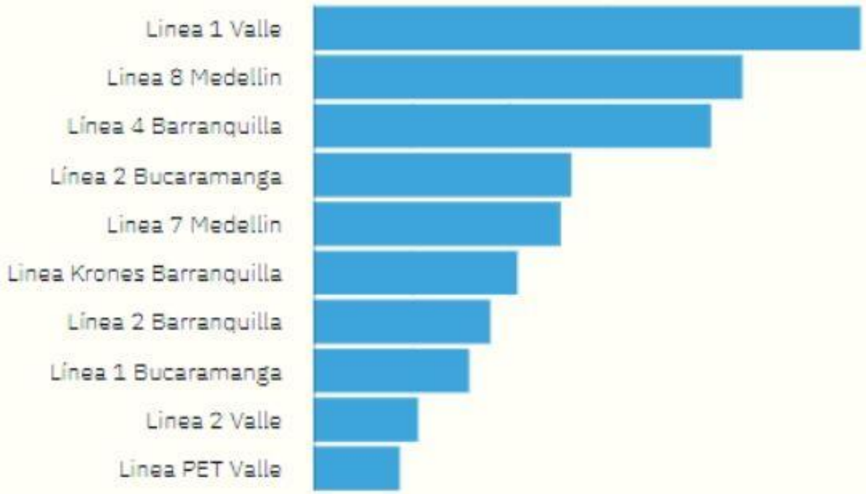
	Espana	% de Ing.	% de T.Emp.	Total Empresa
Ingresos por Ventas	$3,495.60	98.07%	24.99%	$13,989.24
Valor Exportación	$68.88	1.93%	84.09%	$81.92
Ingresos Totales	$3,564.48	100.00%	25.33%	$14,071.16
Costos de Horas Operación	$2.48	0.00%	20.63%	$12.04
Costos de Inventario	$0.00	0.07%	14.62%	$0.01
Costos de Producción	$1,980.78	55.57%	29.02%	$6,825.30
Costos de Sustitución	$0.00	0.00%	.00%	$0.00
Costos de Transporte	$32.78	0.92%	49.41%	$66.35
Costos de ventas	$2,016.05	56.56%	29.20%	$6,903.70
Costo de Importación	$103.84	2.91%	82.67%	$125.61
Ganancia Bruta Corporativa	$1,444.59	40.53%	20.51%	$7,041.84
Costos Fijos	$0.00	0.00%	.00%	$0.00
Ganancia Operacional por País	$61.43	1.72%	-5.81%	($1,057.08)
Impuesto Sobre la Renta por País	$104.89	2.94%	13.80%	$760.09
Ganancia Neta por País	$0.00	0.00%	.00%	$0.00

Producción | Envasado | Distribución | Transferencias | Estados Financieros

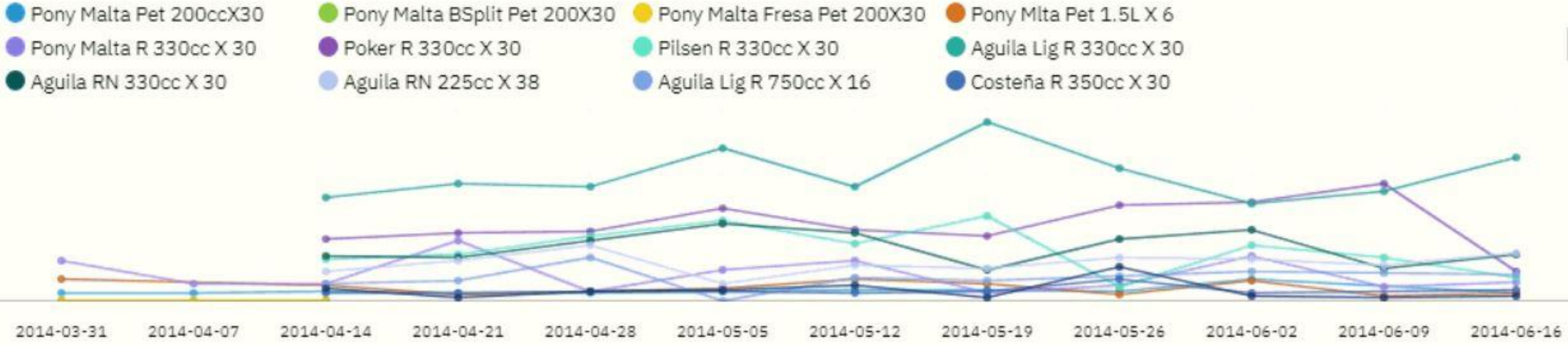
Escenario: SOPALM-SOPALM-1
Período: 2014
Línea Envasadora: Total Línea Envasadora
Producto Final: Total Producto Final

Plantas Envasadoras

- Recepción de Cerveza
- **Envasado de Cerveza**
- Horas Envasado



	Volumen de Envasado de Cerveza en Líneas Envasado... (hl/t)
Pony Malta BSplit Pet 200X30	24
Pony Malta Fresa Pet 200X30	24
Costeña R 350cc X 30	28,681
Costeñita R 175cc X 38	31,487
Pony Malta Pet 200ccX30	34,301
Pony Mlta Pet 1.5L X 6	45,270
Aguila Lig R 750cc X 16	73,282



OPTΣX

Producción | Envasado | Distribución | Transferencias | Estados Financieros

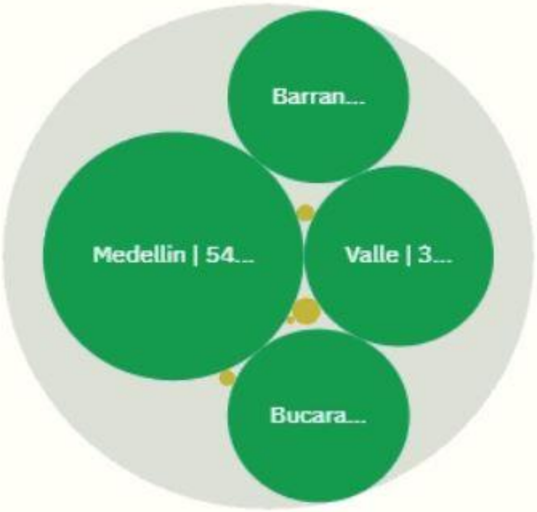
Plantas Procesadoras

- Producción de Mostos
- Despacho de Mostos
- Recepción de Mostos
- Viajes distribución
- Producción de Cervezas
- Inventario Final de Mostos
- **Horas Producción**

Escenario
SOPALM-SOPALM-1

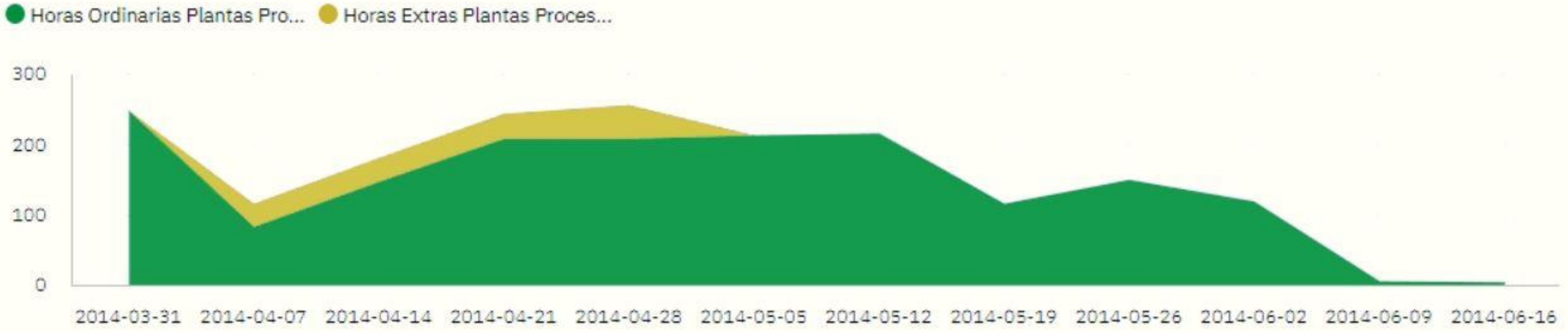
Período
2014

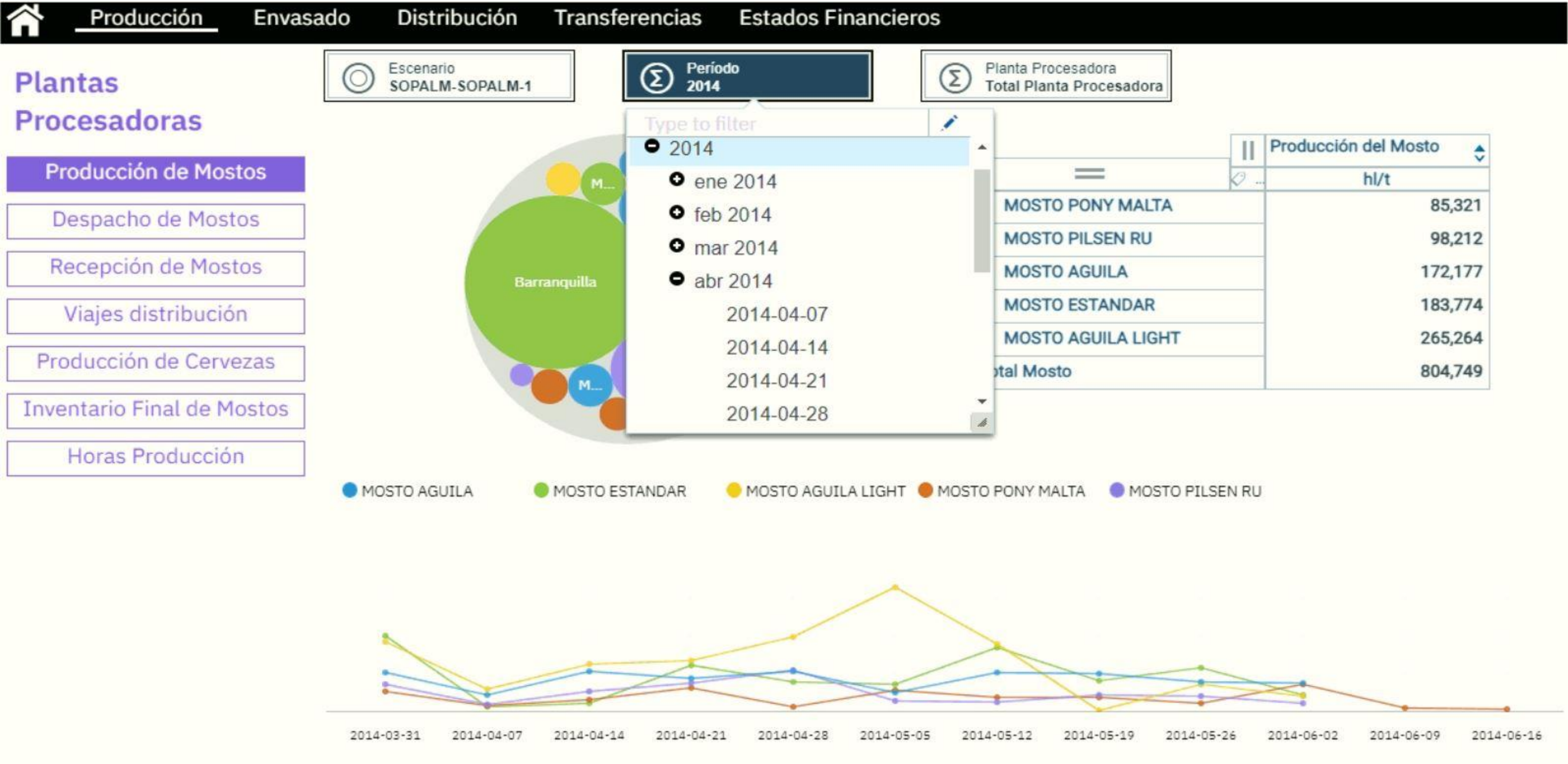
Planta Procesadora
Total Planta Procesadora



Horas Trabajadas en Planta Procesadora

	Horas Ordinarias Plantas Procesadoras	Horas Extras Plantas Procesadoras	Horas Totales Plantas Pro...
Valle	399	18	417
Bucaramanga	383	35	418
Barranquilla	382	38	420
Medellin	549	60	609
Total Planta Proces...	1,713	151	1,864





Producción
Envasado
Distribución
Transferencias
Estados Financieros
Plantas Procesadoras
Producción de Mostos
Despacho de Mostos
Recepción de Mostos
Viajes distribución
Producción de Cervezas
Inventario Final de Mostos
Horas Producción
Escenario SOPALM-SOPALM-1
Período 2014
Planta Procesadora Total Planta Procesadora
Type to filter
2014
ene 2014
feb 2014
mar 2014
abr 2014
2014-04-07
2014-04-14
2014-04-21
2014-04-28
Barranquilla
M...
Producción del Mosto
hl/t
MOSTO PONY MALTA 85,321
MOSTO PILSEN RU 98,212
MOSTO AGUILA 172,177
MOSTO ESTANDAR 183,774
MOSTO AGUILA LIGHT 265,264
otal Mosto 804,749
MOSTO AGUILA
MOSTO ESTANDAR
MOSTO AGUILA LIGHT
MOSTO PONY MALTA
MOSTO PILSEN RU
2014-03-31
2014-04-07
2014-04-14
2014-04-21
2014-04-28
2014-05-05
2014-05-12
2014-05-19
2014-05-26
2014-06-02
2014-06-09
2014-06-16

Producción | Envasado | Distribución | Transferencias | Estados Financieros

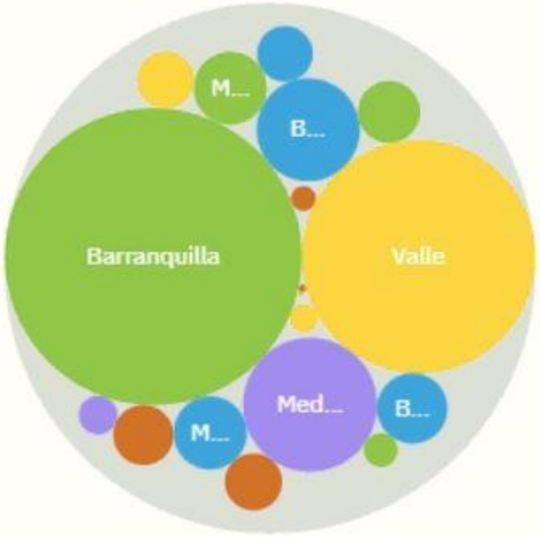
Plantas Procesadoras

- **Producción de Mostos**
- Despacho de Mostos
- Recepción de Mostos
- Viajes distribución
- Producción de Cervezas
- Inventario Final de Mostos
- Horas Producción

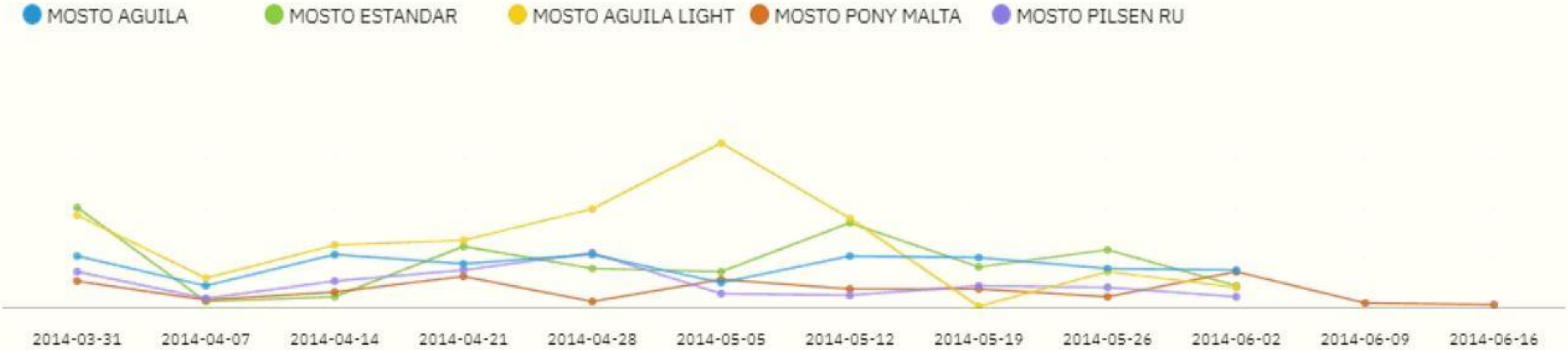
Escenario: SOPALM-SOPALM-1

Período: 2014

Planta Procesadora: Total Planta Procesadora



	Producción del Mosto
	hl/t
MOSTO PONY MALTA	85,321
MOSTO PILSEN RU	98,212
MOSTO AGUILA	172,177
MOSTO ESTANDAR	183,774
MOSTO AGUILA LIGHT	265,264
Total Mosto	804,749



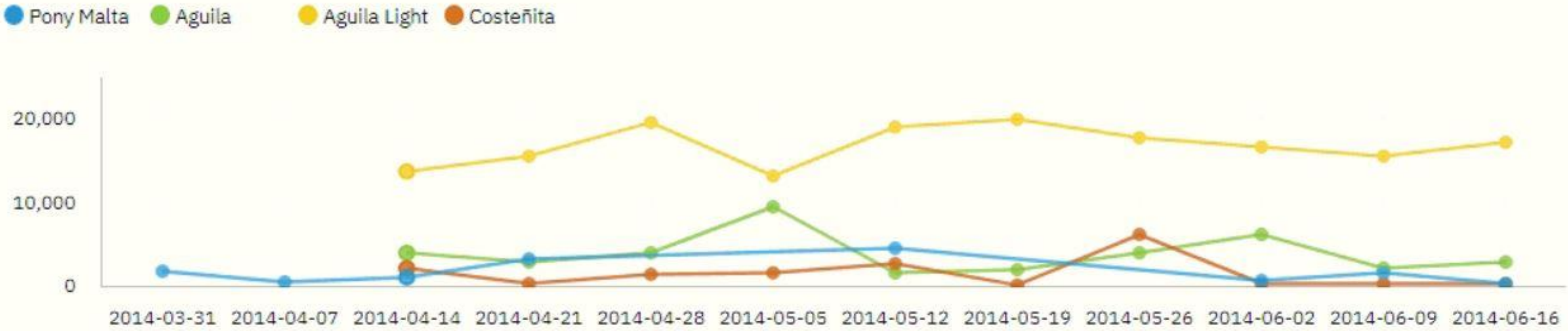
Producción Envasado Distribución Transferencias Estados Financieros

Plantas Procesadoras

- Producción de Mostos
- Despacho de Mostos
- Recepción de Mostos
- Viajes distribución
- **Producción de Cervezas**
- Inventario Final de Mostos
- Horas Producción

Escenario: SOPALM-SOPALM-1 | Período: 2014 | Planta Procesadora: Barranquilla

	Producción de Producto Marca hl/t
Pony Malta	14,098
Costeñita	15,814
Aguila	40,097
Aguila Light	168,963
Total Producto Marca	238,971



OPTEX Optimization Expert System

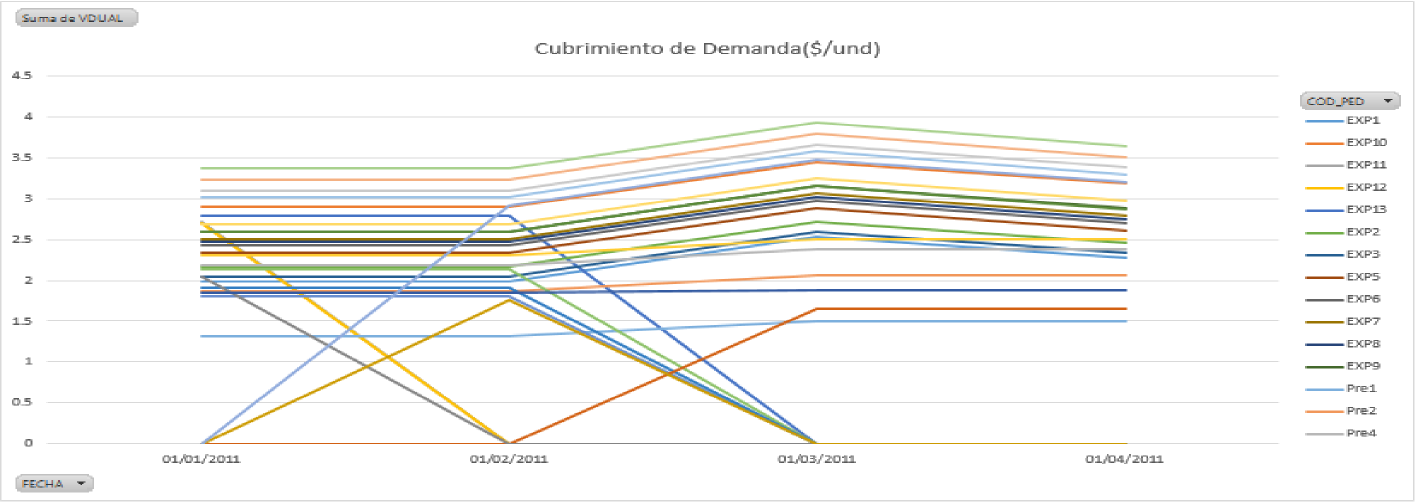
LINKING OPTEX – EXCEL

Microsoft®
Excel

OPTEX-EXCEL-MMS

Cubrimiento de Demanda($/und)

SISTEMA	FAMILIA	ESCENARIO	FECHA
VONG - Acopio Frutas - Vong - Regbanpac	PTEMP	A	10/07/2015



GRF_RR_SPEW | TD_RR_SPEW | DATA_RR_SPEW | GRF_RR_OMRC | TD_RR_OMRC | DATA_RR_OMF ...

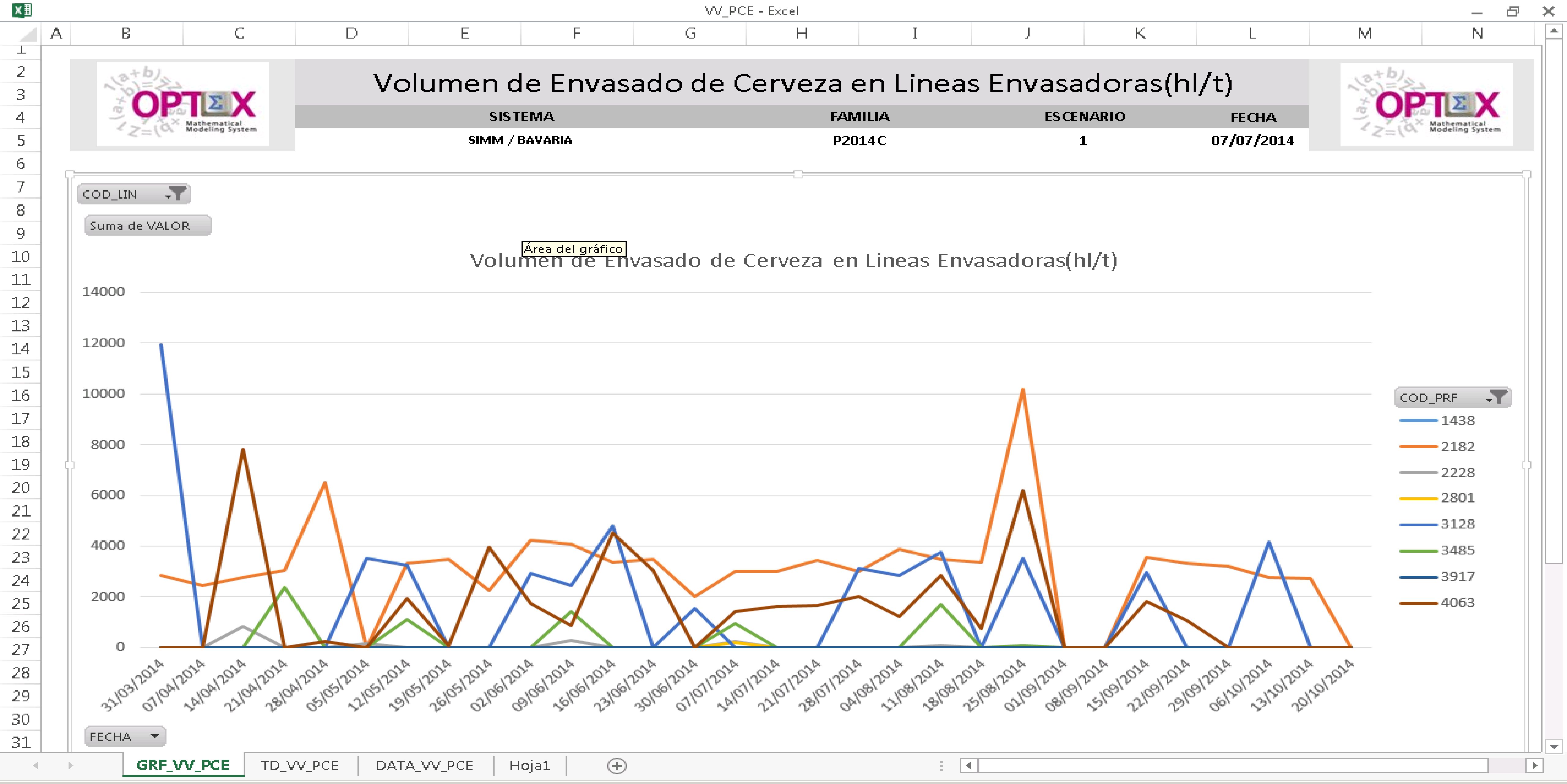
Suma de VDUAL	Etiquetas de columna									
Etiquetas de fila	EXP1	EXP10	EXP11	EXP12	EXP13	EXP2	EXP3	EXP5	EXP6	EXP7
01/01/2011	1.99	2.9	2.72	2.7	2.79	2.17	2.05	2.33	2.42	2.51
01/02/2011	1.99	2.9	0	0	2.79	2.17	2.05	2.33	2.42	2.51
01/03/2011	2.54	3.45	0	0	0	2.72	2.6	2.88	2.97	3.06
01/04/2011	2.27	3.18	0	0	0	2.45	2.33	2.61	2.7	2.79
Total general	8.79	12.43	2.72	2.7	5.58	9.51	9.03	10.15	10.51	10.87

FECHA	COD_PED	COD_PRF	HOLGURA	VDUAL
01/01/2011	EXP1	EXPRE	302044	1.99
01/01/2011	EXP10	EXPRE	33480	2.9
01/01/2011	EXP11	EXPRE	64800	2.72
01/01/2011	EXP12	EXPRE	716816	2.7
01/01/2011	EXP13	EXPRE	194292	2.79
01/01/2011	EXP2	EXPRE	70200	2.17
01/01/2011	EXP3	EXPRE	59400	2.05
01/01/2011	EXP5	EXPRE	2052	2.33
01/01/2011	EXP6	EXPRE	59824	2.42
01/01/2011	EXP7	EXPRE	4320	2.51
01/01/2011	EXP8	EXPRE	14040	2.47
01/01/2011	EXP9	EXPRE	2200	2.6
01/01/2011	Pre1	PREM	4800	1.31
01/01/2011	Pre2	PREM	43200	1.87
01/01/2011	Pre4	PREM	64800	2.19
01/01/2011	Pre5	PREM	9720	2.31
01/01/2011	Pre6	PREM	178003	1.81
01/01/2011	Pre7	PREM	10359	2.13
01/01/2011	Pre8	PREM	416858	1.91
01/01/2011	Pre9	PREM	0	0
01/01/2011	Res1	RESCA	19267	2.047
01/01/2011	Res2	RESCA	0	0
01/01/2011	Res3	RESCA	10279	1.847
01/01/2011	SP1	SPRE	75600	2.59

GRF_RR_SPEW | TD_RR_SPEW | DATA_RR_SPEW

ALL THE RESULTS IN ONE EXCEL BOOK - AUTOMATICALLY.

OPTEX-EXCEL-MMS



OPTEX Optimization Expert System

LINKING OPTEX
BUSINESS INTELLIGENCE TECHNOLOGIES

OPTEX Optimization Expert System

LINKING OPTEX
GEOGRAPHIC INFORMATION SYSTEMS

Optimization Expert System

"the computer-based mathematical modeling is the greatest invention of all times"

Herbert Simon
Alfred Nobel Memorial Prize in Economic Sciences (1978)
"for his pioneering research into the decision-making process within economic organizations"

Research Center for Advanced Decision Technologies