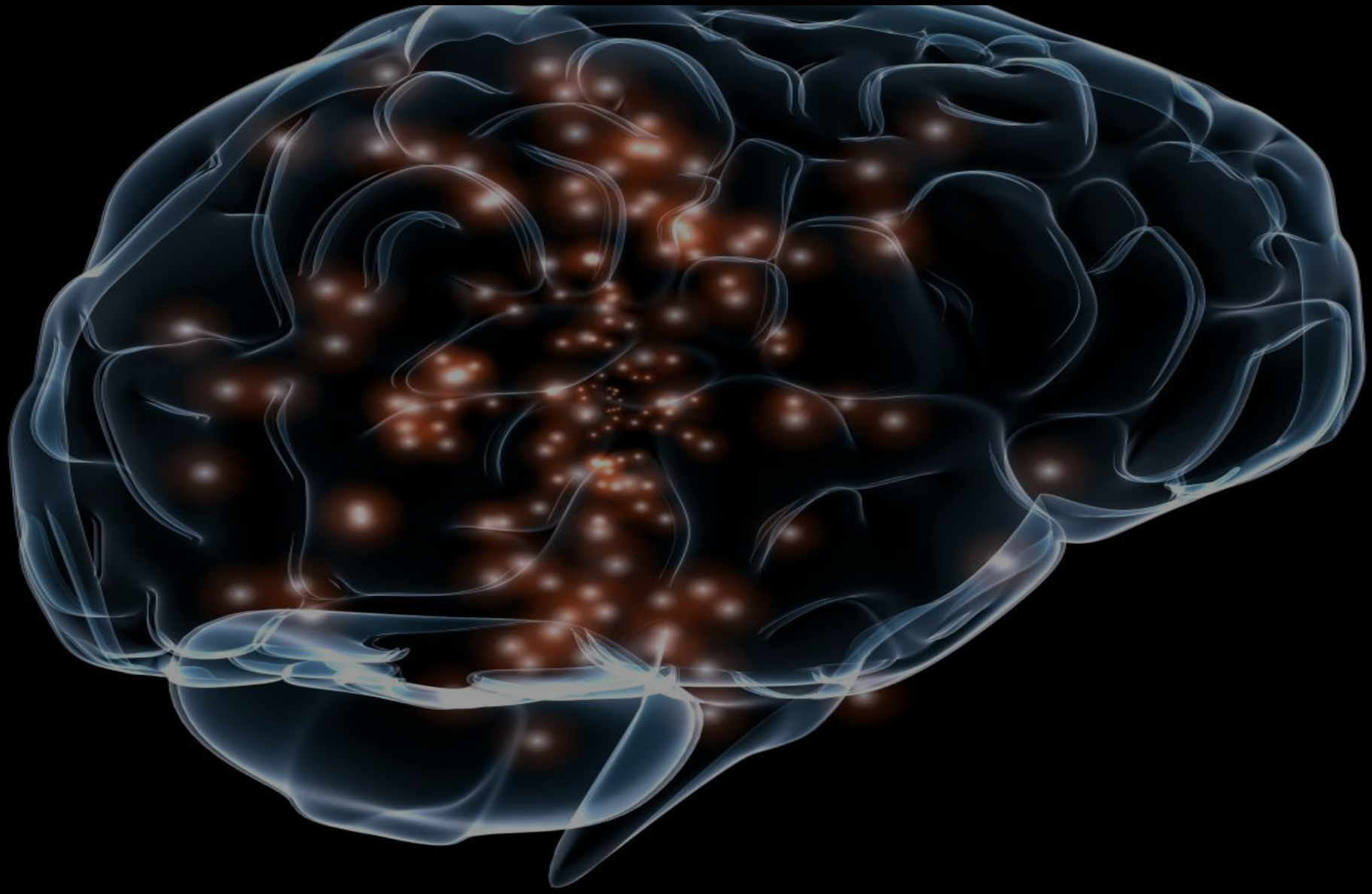
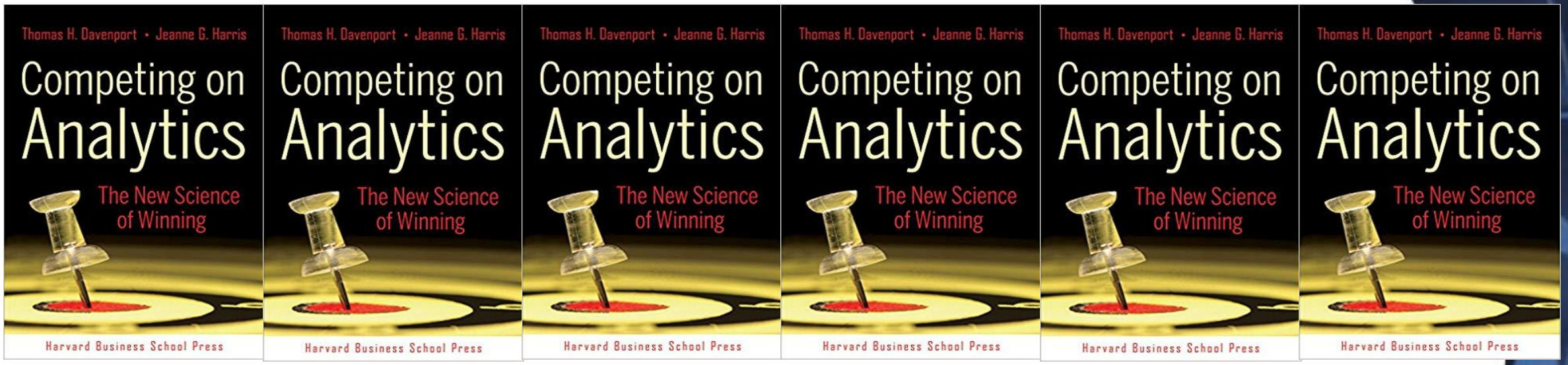
Artificial Intelligence and Mathematical Programming Integration



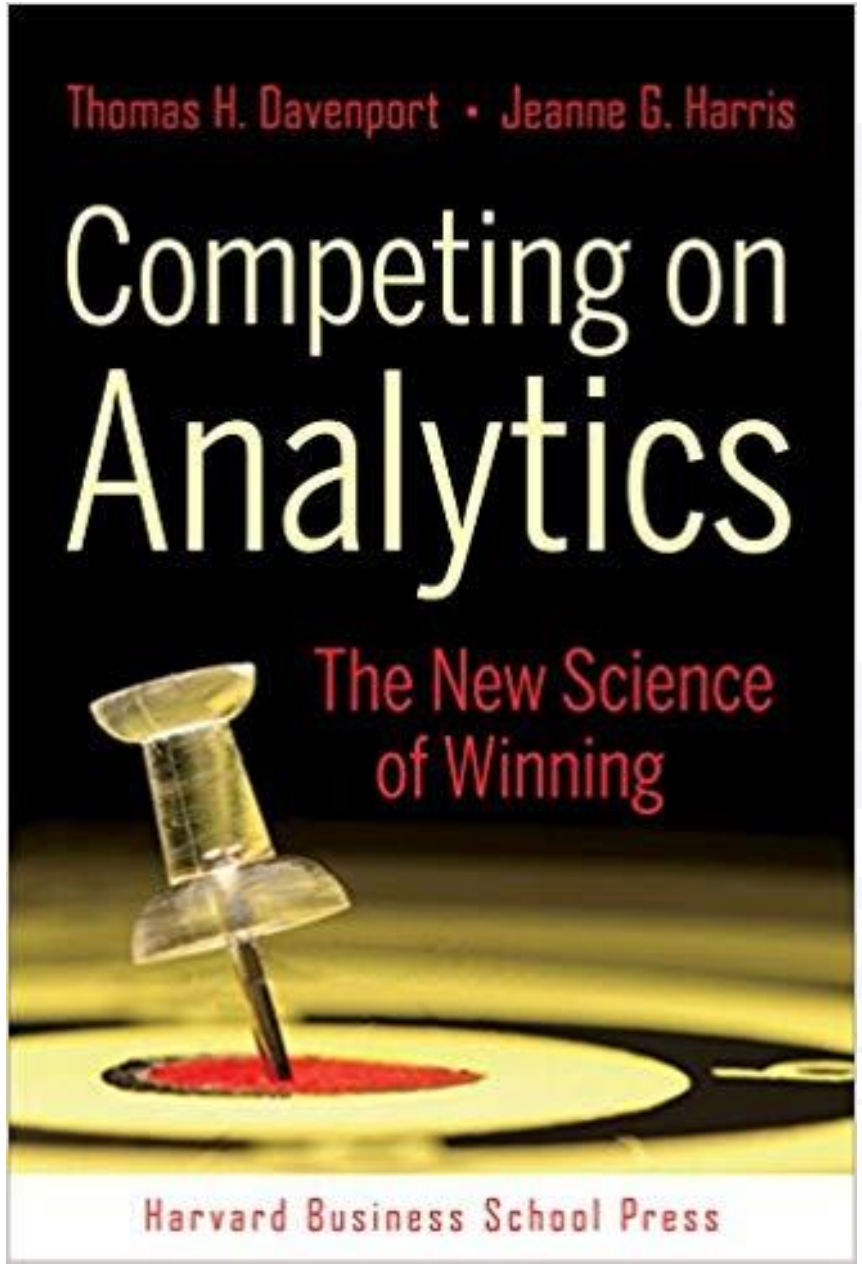
DECISIONWARE
MAKING YOUR WORLD SMARTER

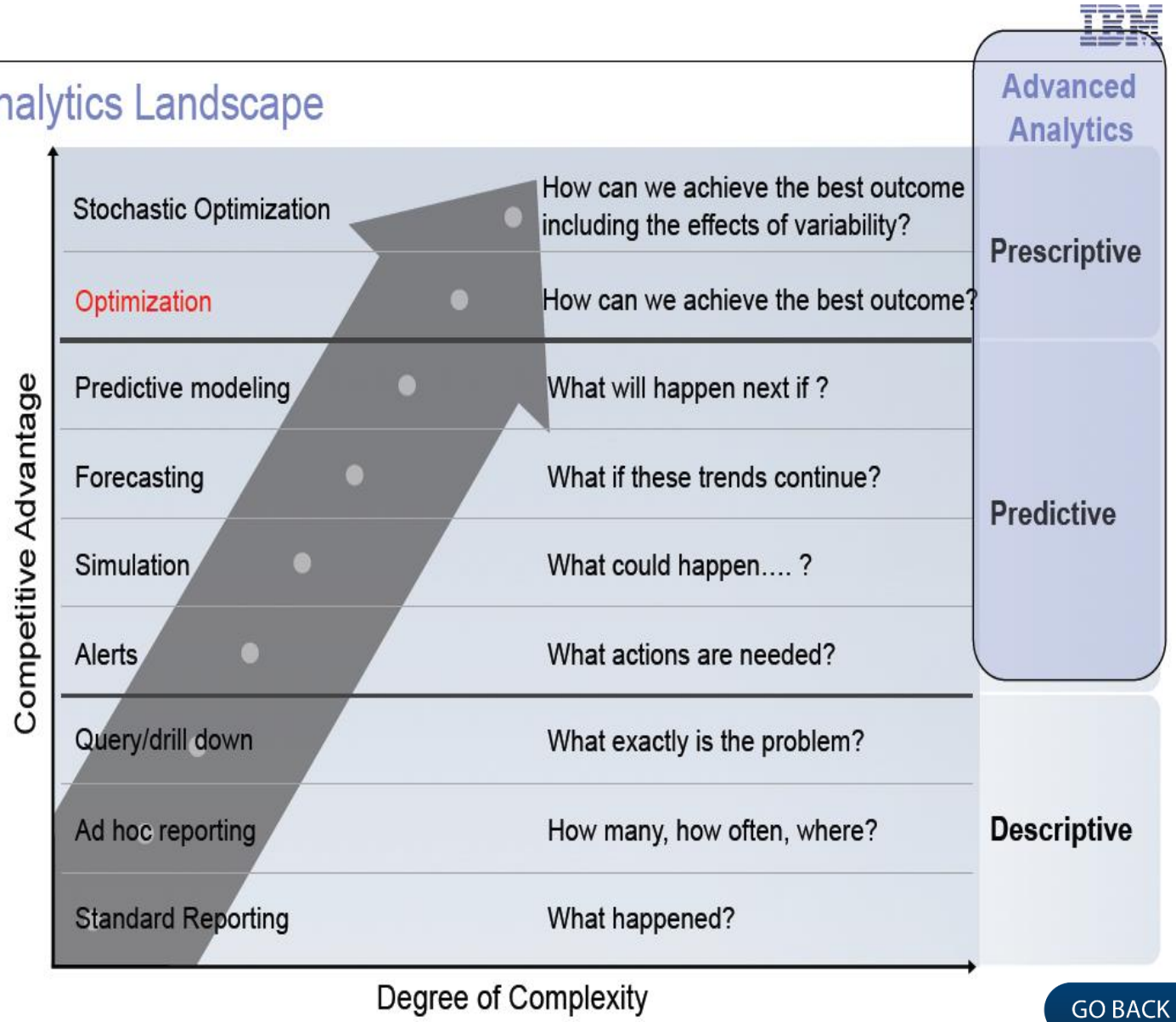
COMPETING ON ANALYTICS & BIG-DATA

THE NEW SCIENCE OF WINNING



COMPETING ON ANALYTICS





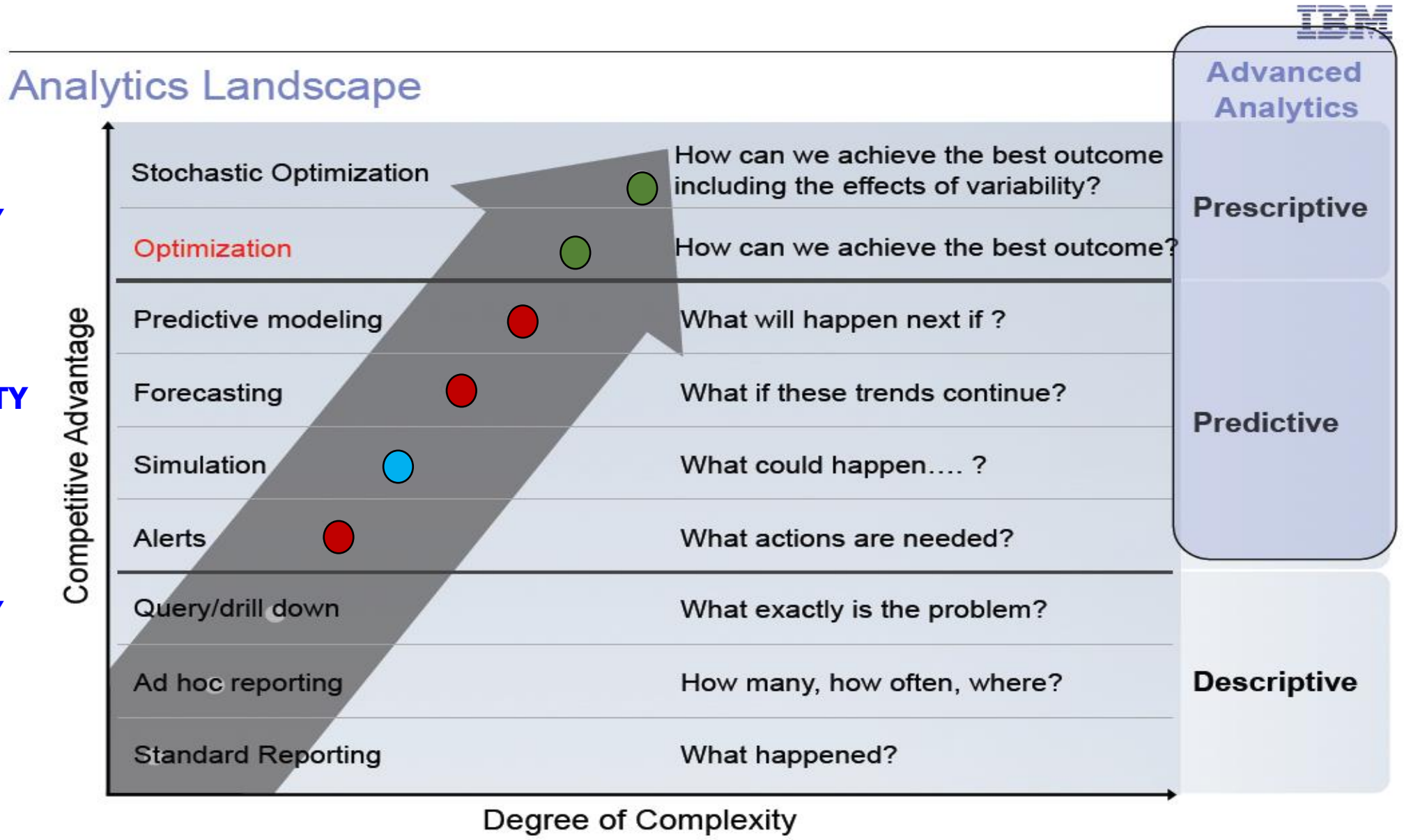
GO BACK

BUSINESS VALUE ADDED BY MATHEMATICAL METHODOLOGIES

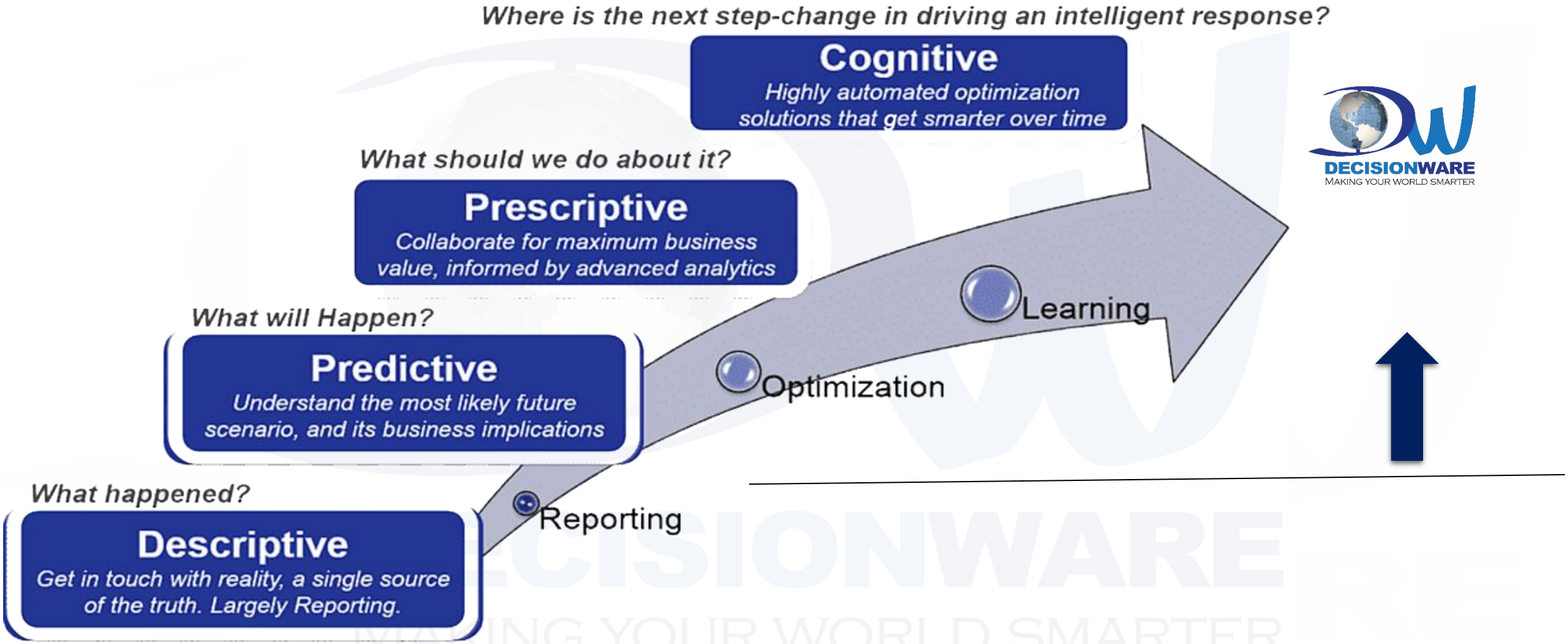
HIGH COMPLEXITY MATH MODELING

MEDIUM COMPLEXITY MATH MODELING

ZERO COMPLEXITY MATH MODELING

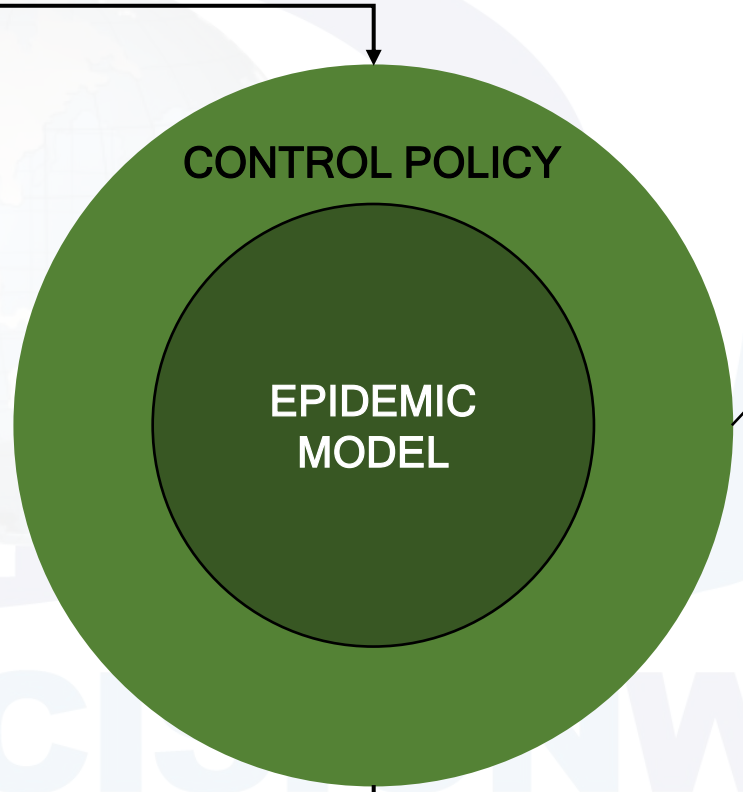


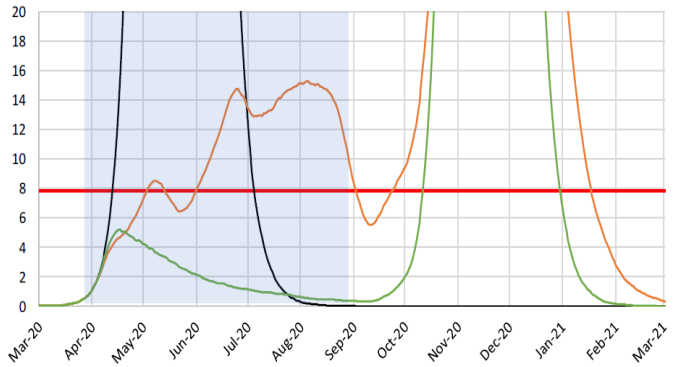
STATE OF THE ART OF ADVANCED ANALYTICS



SIMULATION MODELS – MEDIUM MATHEMATICAL COMPLEXITY

What if a New Decision?





SIMULATION MODEL

Impact of the Decision

OPTIMIZATION MODELS – HIGH MATHEMATICAL COMPLEXITY

DECISIONWARE
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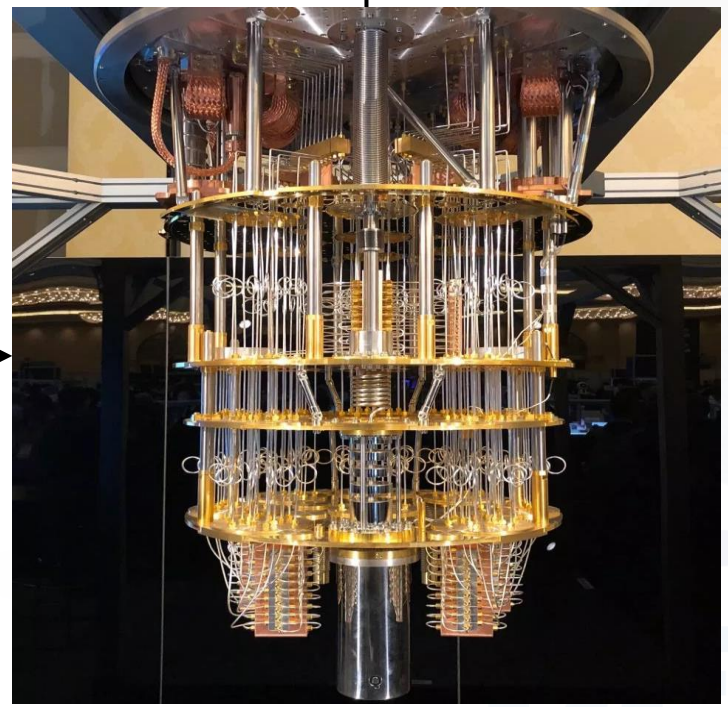
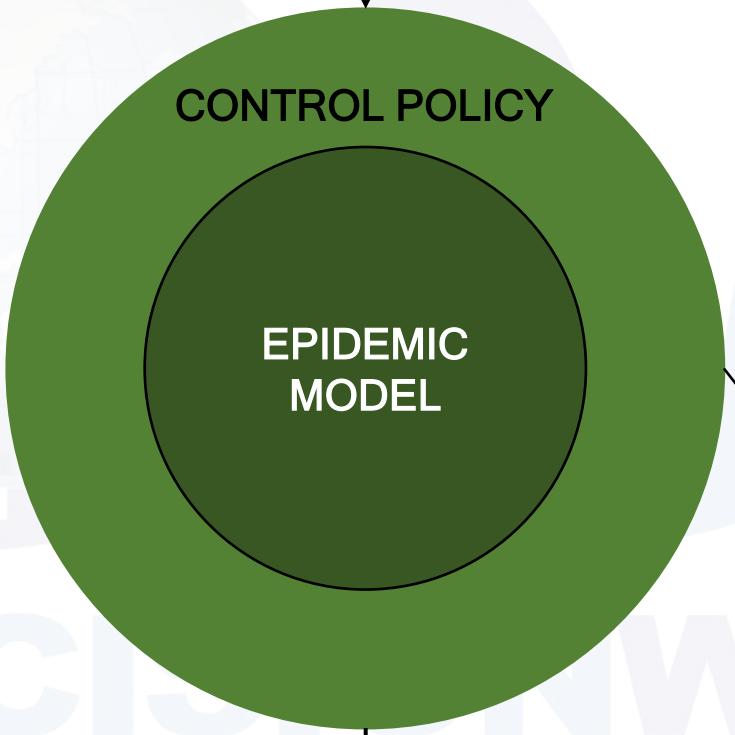
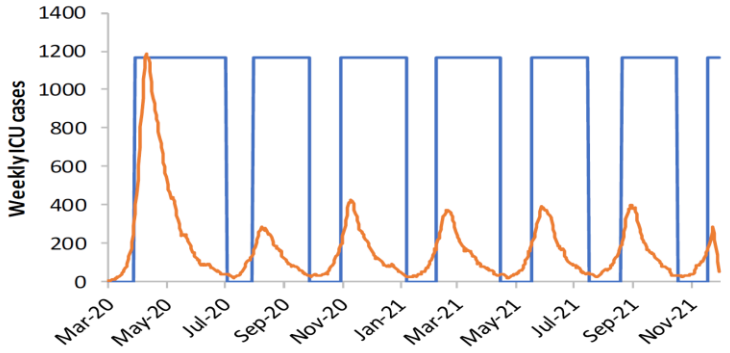
OPTIMIZATION
THE SCIENCE OF BETTER





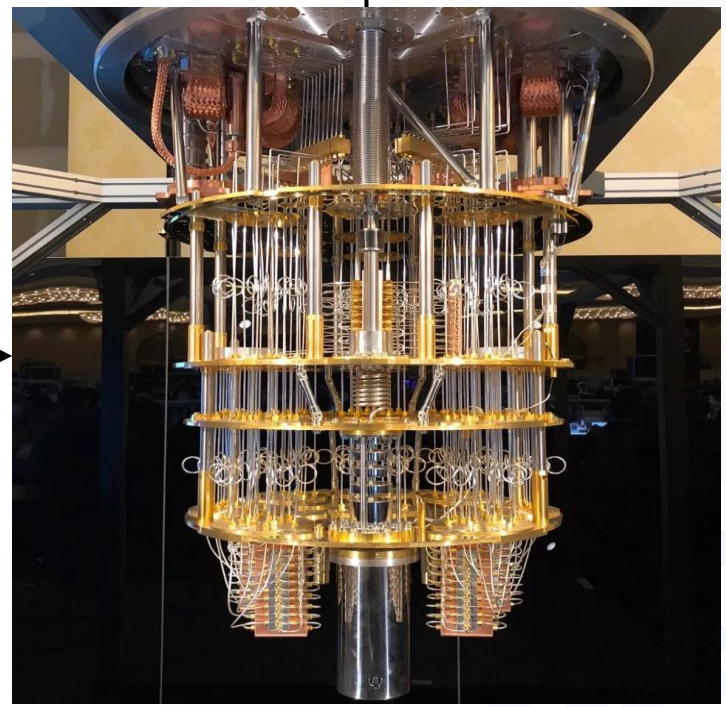
What is the best ?

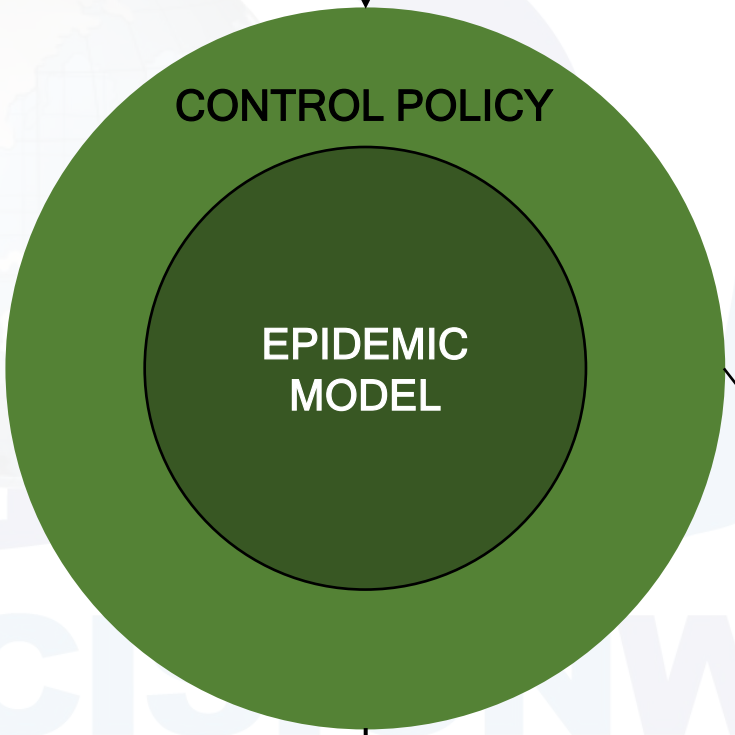
The Best Decision



OPTIMIZATION MODEL

OPTIMIZATION MODELS – HIGH MATHEMATICAL COMPLEXITY



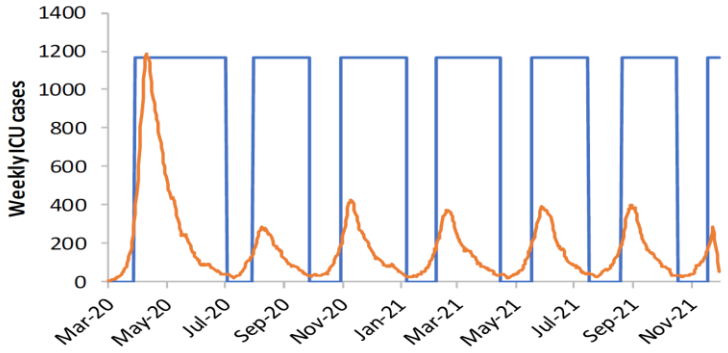


COMPLEXITY GROWS WITH:

SCALE
UNCERTAINTY
MATHEMATICS
DETAIL MODELING

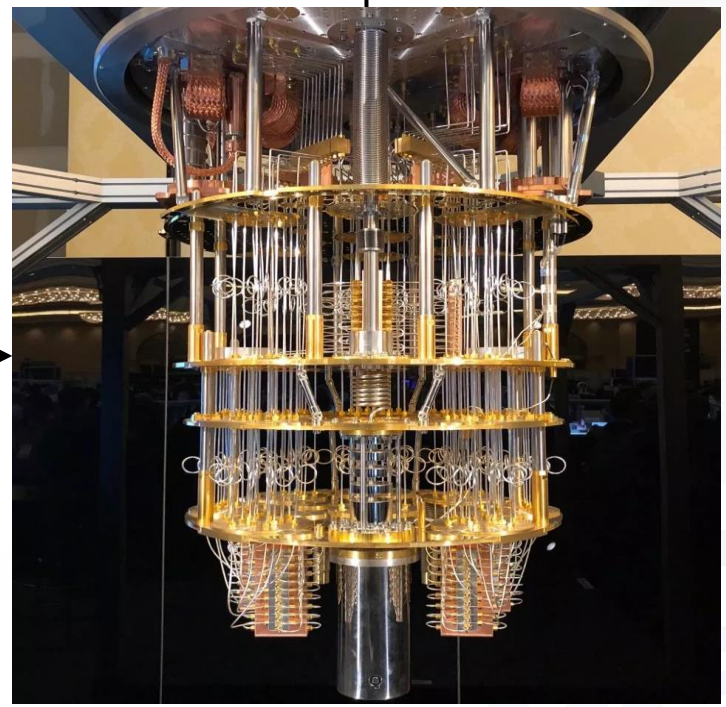
What is the best ?

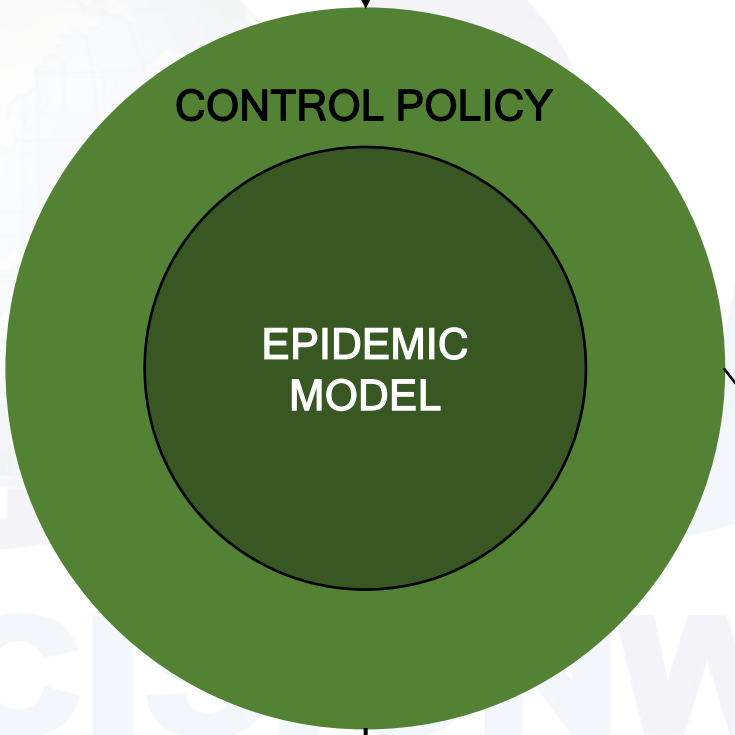
The Best Decision



OPTIMIZATION MODEL

OPTIMIZATION MODELS – HIGH MATHEMATICAL COMPLEXITY





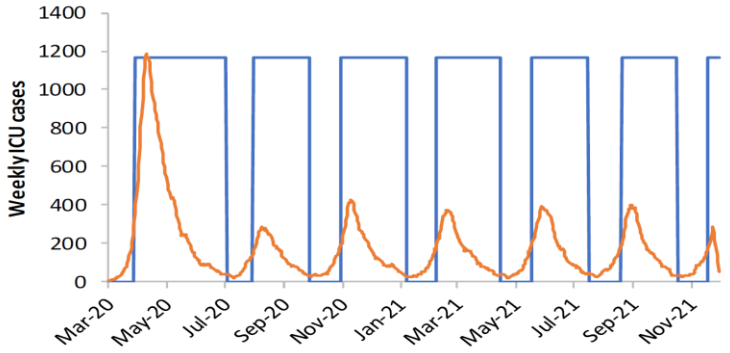
OPTIMIZATION
THE SCIENCE OF BETTER

IS
PRAGMATIC

QUANTITATIVE
NOT QUALITATIVE

What is the best ?

The Best Decision



OPTIMIZATION MODEL

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

A TRADITIONAL ORGANIZATION BELIEVE IN MENTAL MODELS & GOOD PRACTICES

1x

Organization and Professionals that only believe in mental models, based on the intuition and the "good practices", implemented in spreadsheets

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

A SMART ORGANIZATION BELIEVE IN
ADVANCED ANALYTICS

IBM Smarter Industries Symposium
Barcelona

Key finding 1
Analytics correlates to performance

Organizations that lead in analytics outperform those who are just beginning to adopt analytics

Top Performers are more likely to use an analytic approach over intuition*

Source: Analytics: The New Path to Value, a joint MIT Sloan Management Review and IBM Institute of Business Value study. Copyright © Massachusetts Institute of Technology 2010.
*within business processes

IBM

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

A SMART ORGANIZATION BELIEVE IN
ADVANCED ANALYTICS AND USE BIG-DATA

Organizations using big data and analytics are up to

more likely to report they are

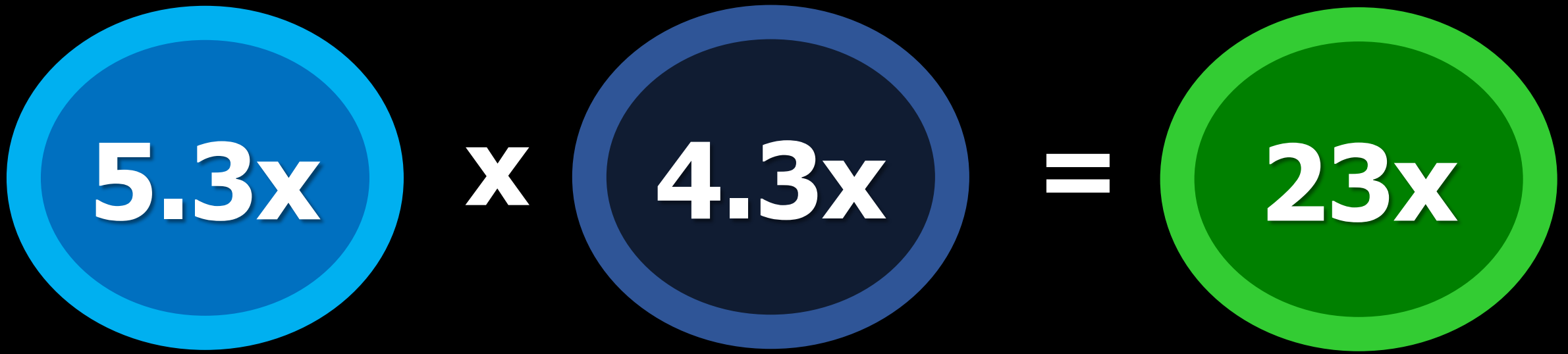
substantially outperforming their competitors

than those who do not use big data and analytics

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

PRODUCTIVITY OF DECISION TECHNOLOGIES



ANALYTICS

BIG-DATA

ANALYTICS
+
BIG-DATA

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

PRODUCTIVITY OF DECISION TECHNOLOGIES

PRODUCTIVITY ADDED BY ADVANCED ANALYTICS & OPTIMIZATION

DECISIONWARE
MAKING YOUR WORLD SMARTER

ORMS TODAY

December 8, 2020 in Intel wins Edelman

O.R. Inside Intel: Project Produces $25 billion in Benefits.

ORMS TODAY 25TH ANNIVERSARY

Tech giant receives coveted award from INFORMS for integrating product architecture design with supply chain planning.

By Peter Horner, Kara Tucker

https://pubsonline.informs.org/do/10.1287/orms.2020.06.06/full/

Beginning in 1991, "Intel inside" [1] became a wildly successful branding slogan and logo for the famed U.S. tech corporation best known for its semiconductors driving countless computers around the world. Now, after receiving the 2020 Franz Edelman Award for Achievement in Advanced Analytics, Operations Research and Management Science, it's an appropriate time to celebrate "O.R. inside Intel."

A panel of Edelman Award Committee members and judges named Intel Corporation the winner of the coveted honor for its use of operations research (O.R.) to maximize revenue and minimize cost thanks to a multiphase project that resulted in a whopping total benefit of $25.4 billion since 2009.

How do you achieve such impressive results? In the case of Intel's Edelman-winning O.R. team, you start with a massive, complex problem, which the team outlined as follows:

Due to its scale, the complexity of its products and manufacturing processes, and the capital-intensive nature of the semiconductor business, efficient product architecture design integrated with supply chain planning is critical to Intel's success. In response to an exponential increase in complexities, Intel has used advanced analytics to develop an innovative capability that spans product architecture design through supply chain planning with the dual goals of maximizing revenue and minimizing costs. (For technical details of the product feature design problem and the team's approach, see the accompanying sidebar story.)

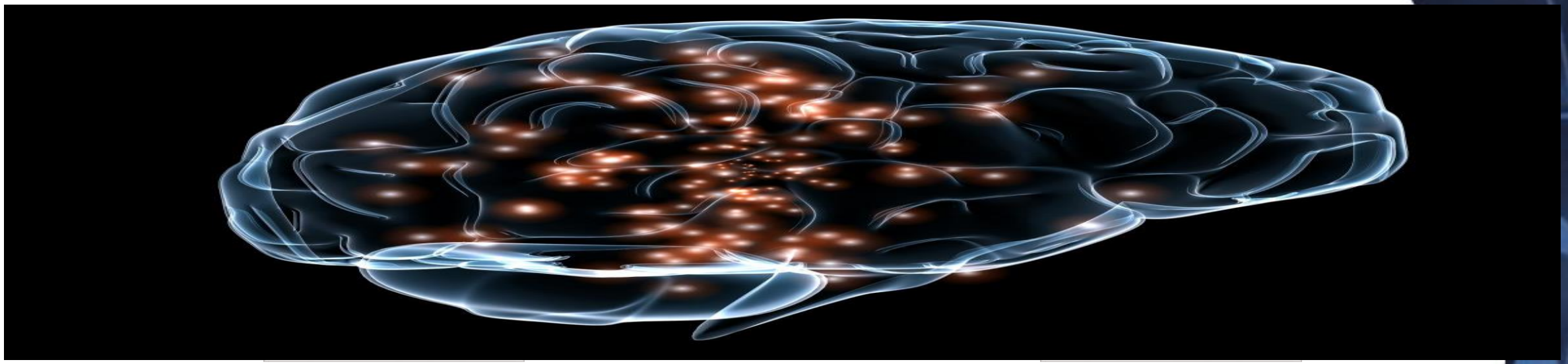
"The system has been vital to improving the process of corporate decision-making, and the results have been in the billions since the system began," says George Davis, CFO of Intel. "It is an innovative, cost-effective and sustainable strategy that uses operations research and data analytics to create efficiency across the corporation."

Karl Kempf, senior fellow and director of decision engineering at Intel, as well as a longtime member and Fellow of INFORMS, led Intel's Edelman presentation. In addition to the monetary benefits, Kempf noted that Intel has realized a number of organizational benefits. "One is the establishment of personnel on the front lines of product design and supply chain planning to make faster, better, more integrated decisions," he said. "Another gives senior management new insights and abilities to influence decisions impacting go-to-market strategies that they have never had before. Finally, our success has provided an existence proof of the power of applying advanced analytics to Intel business problems for other teams inside Intel, as well as teams across the advanced analytics community." (Shortly after the Edelman Award presentation, the co-authors interviewed Kempf via Zoom in preparation for this article. To listen to the interview, click here).

DECISIONWARE
MAKING YOUR WORLD SMARTER

STATE OF THE ART OF ADVANCED ANALYTICS

ARTIFICIAL HYPOTHALAMUS



HUMAN HYPOTHALAMUS

The hypothalamus is a portion of the brain that contains several small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland. It is not a separate system, but a collection of structures from the cerebrum, diencephalon, and midbrain. It supports many different functions, including emotion, behavior, motivation, long-term memory, and olfaction.

All vertebrate brains contain a hypothalamus it is responsible for the regulation of certain metabolic processes and other activities of the autonomic nervous system and controls body temperature, hunger, important aspects of parenting and attachment behaviors, thirst, fatigue, sleep, and circadian rhythms.

The hypothalamus is highly interconnected with other parts of the central nervous system, in particular the brainstem and its reticular formation. The hypothalamus receives many inputs from the brainstem, the most notable from the nucleus of the solitary tract, the locus coeruleus, and the ventrolateral medulla. It is the central regulator of several autonomous and endocrine visceral functions and acts as a relay point in the information that starts from the brain reaching the spinal cord. Each of the target systems influenced by the hypothalamus return feedback controls onto the hypothalamus completing a circuit and so establishing a homeostasis system. The role of the hypothalamus in regulation of homeostasis is essential for survival and reproduction of the species. The hypothalamus is one of those organs that we can't live without.

https://www.linkedin.com/pulse/artificial-intelligence-mathematical-programming-jesus-velasquez/

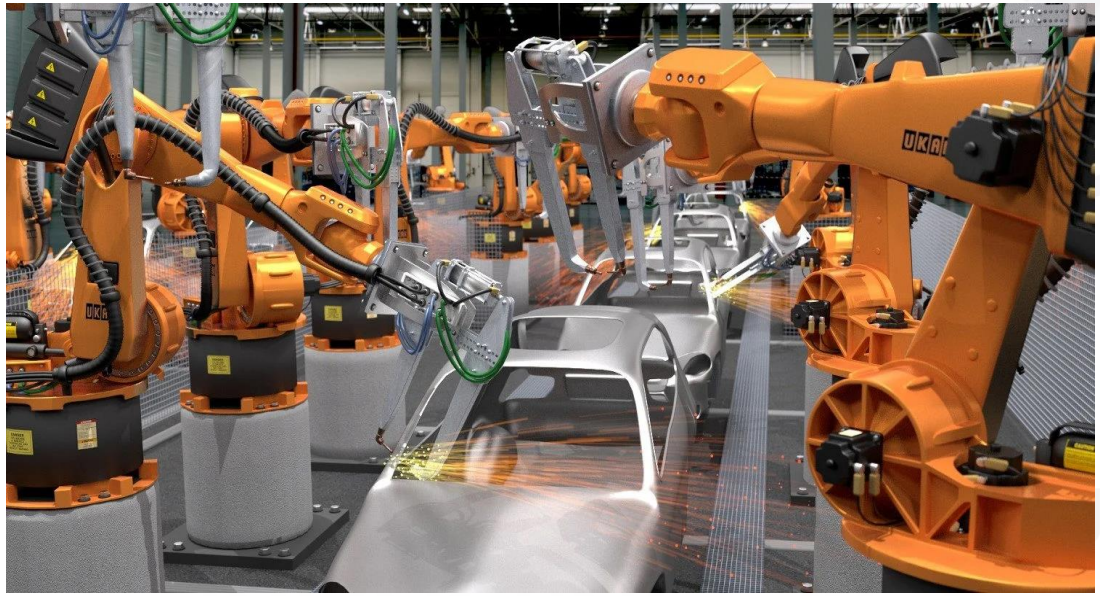
PROBLEM

STATE OF THE ART - 2020

Robots (algorithms) can autonomously and automatically perform targeted processes with preset coordination (limited intelligence) and little interaction between robots.

The robotization of real-time powerful processes (supply chain planning, operation of production plants, optimization of traffic systems, coordination of marketing campaigns, ...) is relatively little disseminated.

Today's computing power based on "ilimited" processor availability offers electronic computing capabilities at a completely different level than today.



INDUSTRY 4.0

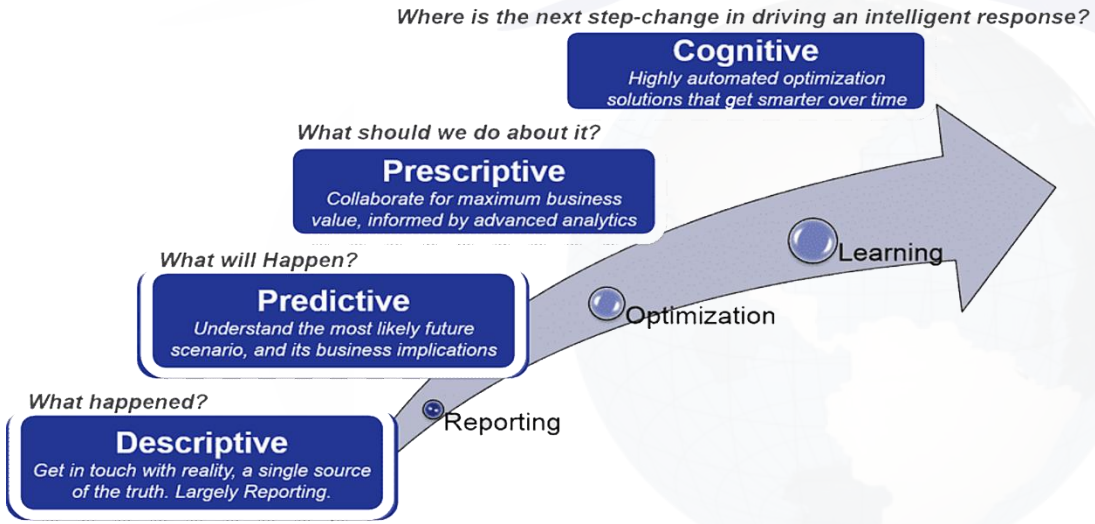
Robots capable of automatically performing large-coverage processes based on intelligent interconnection (mathematical conversation) between robots using information from "big data" (IoT-based) systems.

The current state of technology can be synthesized at the confluence of computer parallelism and complex mathematical modeling. Only companies that fully understand and manage the interrelationship between these pillars of socio-economic development will be able to participate fully in the knowledge generation required by INDUSTRY 4.0.

The companies cannot take advantage of the availability of hundreds of thousands of processors if their analytical tools only can organize high level mathematical calculations around the concept of a single processor.

STATE OF THE ART OF ADVANCED ANALYTICS

STATE OF THE ART OF ADVANCED ANALYTICS - 2020

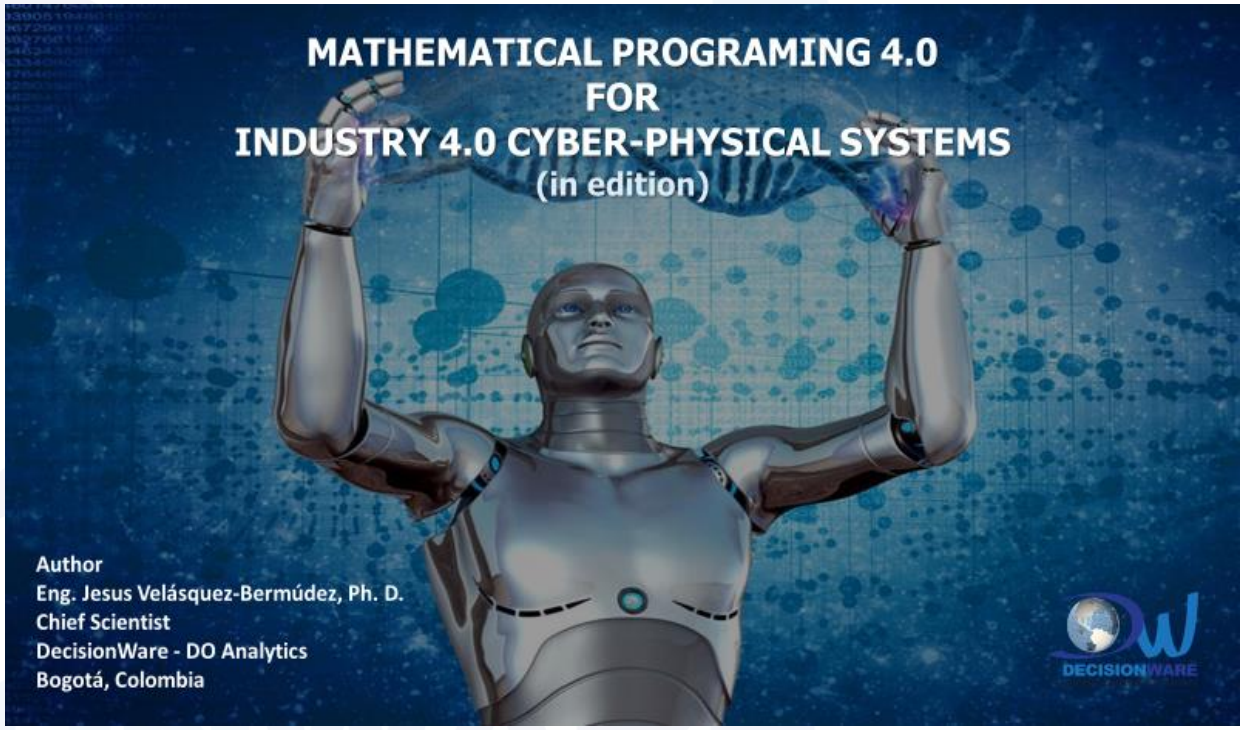


Advanced Analytics is a comprehensive set of analytical predictive techniques and methods, such as statistics, data mining, simulation, and analytical prescriptive methodologies (optimization), designed to help businesses discover trends and patterns, and accurately anticipate/predict the future to make the best decisions.

The next step of Advanced Analytics is Cognitive Analytics is built around cognitive learning using a rules-based engine to learn from the prescriptive methodologies and technologies.

It is the next step toward intelligent response, deploying highly automated optimization solutions that get smarter over time in real time environments.

THE FUTURE: MATHEMATICAL PROGRAMMING 4.0



MATHEMATICAL PROGRAMING 4.0 FOR INDUSTRY 4.0 CYBER-PHYSICAL SYSTEMS

MATHEMATICAL PROGRAMMING 4.0 is the formal support of an integrated Artificial Intelligence (AI) and Mathematical Programming (MP) approach to implement a new vision of high complexity mathematical modeling needed in INDUSTRY 4.0.

Its principles are:

1. A new level of AI based on the concept of artificial hypothalamus as the next step to the current level of artificial neural networks.

2. Formalization and standardization of a math language between cognitive robots based on the principles of large-scale optimization methodologies.

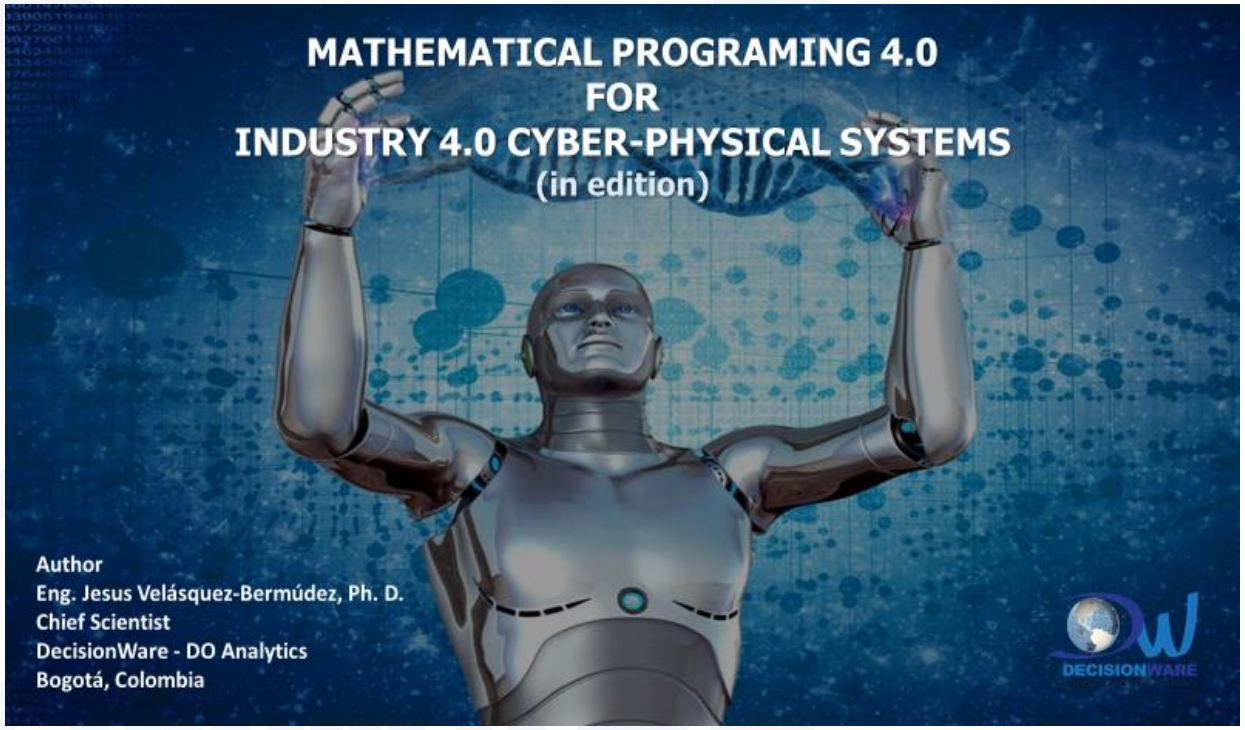
3. Socialization of the concept of Real-Time Distributed Optimization (RTDO) to solve mathematical problems by multiple parallel agents acting independently, but math coordinated, to solve a large-scale decision-making problem as a team.

4. Generalization of RTDO as the standard of Cognitive Analytics

5. Development and implementation of a Cognitive Robots (algorithm computer platforms) capable of automatically generating the software required to develop an artificial hypothalamus.

6. Design of a low-level user interface (based on modern app concepts) to make it easier for mathematical modelers to implement artificial hypothalamus.

7. Implementation of artificial hypothalamus reference to test theoretical concepts and their computer implementation (ATHENEA Project).



DECISIONWARE
MAKING YOUR WORLD SMARTER

INTEGRATED VISION OF OPTIMIZATION MODELS

Board of Directors

Business Management

STATE OF THE ART OF PRESCRIPTIVE ADVANCED ANALYTICS

1. Optimization problems (prescriptive analytics support) are developed from an integrated view of the system in which visibility of the interaction between the parties is lost.

2. The multiple models required by an organization are developed across multiple computing platforms and coordinated with each other through workflow-related processes. This approach produces suboptimal solutions that waste resources.

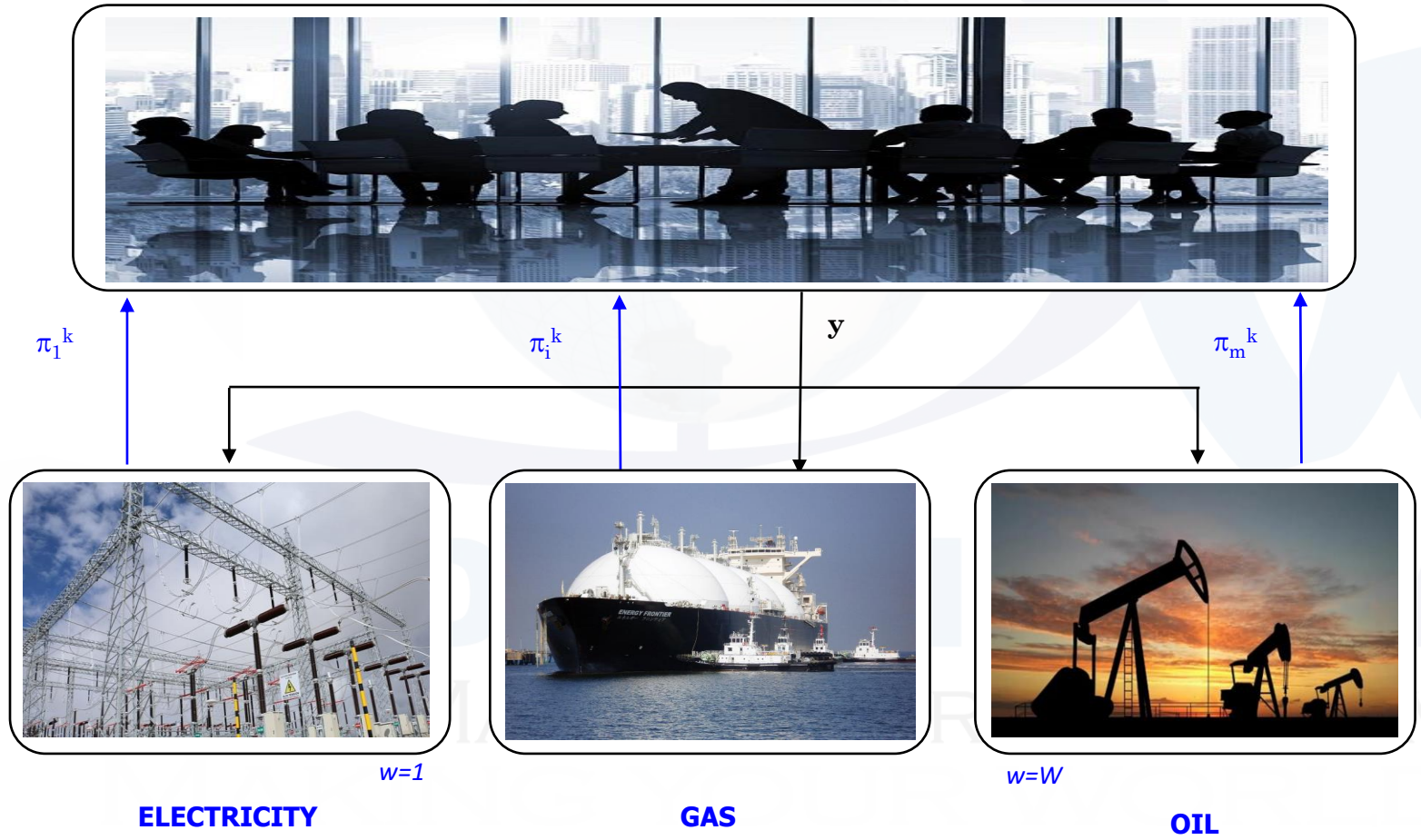
3. Due to the multiplicity of computer platforms and the non-existence of a standard protocol for the formulation of mathematical models, the integration of them, to produce an integrated mathematical model, is a very complicated task for mathematical modelers.

4. Mathematical models are designed to be solved periodically (off-line) and do not correspond to the real time current level of computer technology.

5. The organization's comprehensive problem solving remains on the formulation of algebraic equations and has not focus in the next logical step towards formulating the integration of mathematical models.

6. The exercise of prescriptive analytics is not supported in expert systems that capture the experience generated by the history of facing the optimization process.

LARGE-SCALE OPTIMIZATION VISION - PARALLEL OPTIMIZATION



MATHEMATICAL PROGRAMMING 4.0

The mathematical modeling based on algebraic equations, requires new ideas to meet the challenges of the future, which already is bringing fundamental changes in the way of doing things, this is reflected in Industry 4.0 revolution. It implies:

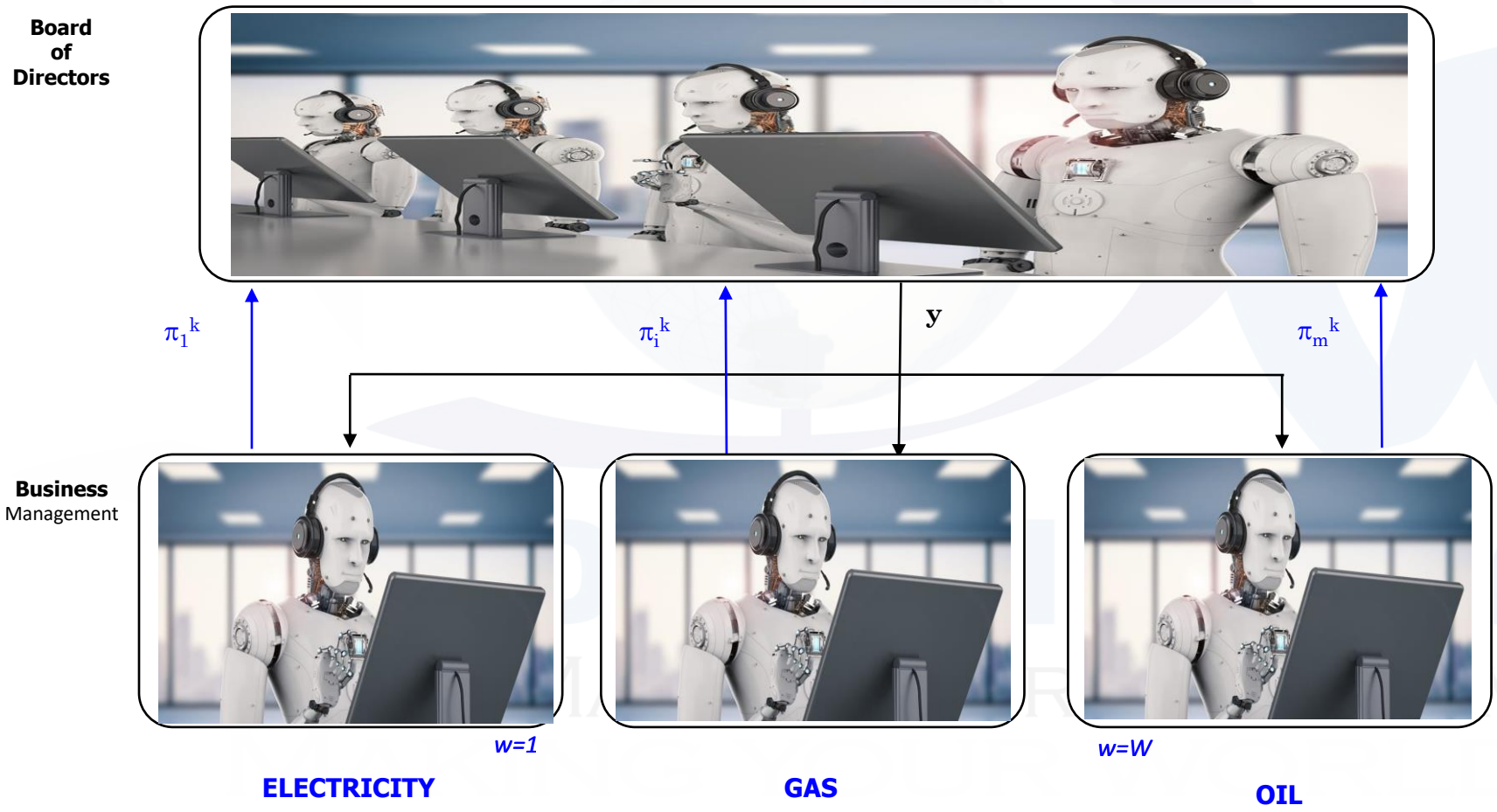
1. A new look of optimization according to the real-world technologies: i) IoT/IIoT), ii) smart metering and big data, and iii) cognitive robotization.

2. Structured Mathematical Modeling (SMM): standardization of math modeling that implies easy connection of multiple mathematical models so they can interact with each other.

3. Expert Optimization Systems that capitalized the knowledge about:
   i) The formulation of the models (optimization technologies must be able to reuse previous formulations to generate new models)
   ii) The results of the optimization models (optimization technologies must be able to reuse the historic results to facilitate and to accelerate complex problem-solving processes).
   iii) Automatic generation of lower-level mathematical structures that make easy the mathematical modeling including they in higher level mathematical models.

4. Availability of algorithms that solve basic optimization problems so that a complex mathematical problem can be solved based on the atomization of a large-scale model in "hundreds/thousands" of small-scale problems.

LARGE-SCALE OPTIMIZATION VISION - PARALLEL OPTIMIZATION



MATHEMATICAL PROGRAMMING 4.0

5. Socialization of large-scale optimization technologies as a basic knowledge not an expert knowledge; considering that they are necessaries to make effective use of modern computing technologies (multi core CPUs, multiples GPUs, tensor processors and quantic computing) all based on parallel and distributed processing.

6. Commercialization of large-scale methodologies that must be connected by parametrization, in a similar way that actually are used the basic solvers. It must imply higher level of high-level algebraic computer languages.

7. Includes the concept of Real Time Distributed Optimization (RTDO) in which multiple digital agents (robots) act simultaneously to cooperatively optimize, in real-time, a real-life problem based on agent-to-agent communication using IoT.

8. Cognitive robots that facilitate the implementation of:
   i) Complex algorithms that facilitate the implementation of Mathematical Programming 4.0;
   ii) Automatic interfaces with the information systems that store data related to mathematical models, and
   iii) Expert systems to support the design, developing, maintenance and use of complex mathematical models.

ARTIFICIAL NET OF MATH ALGORITHMS

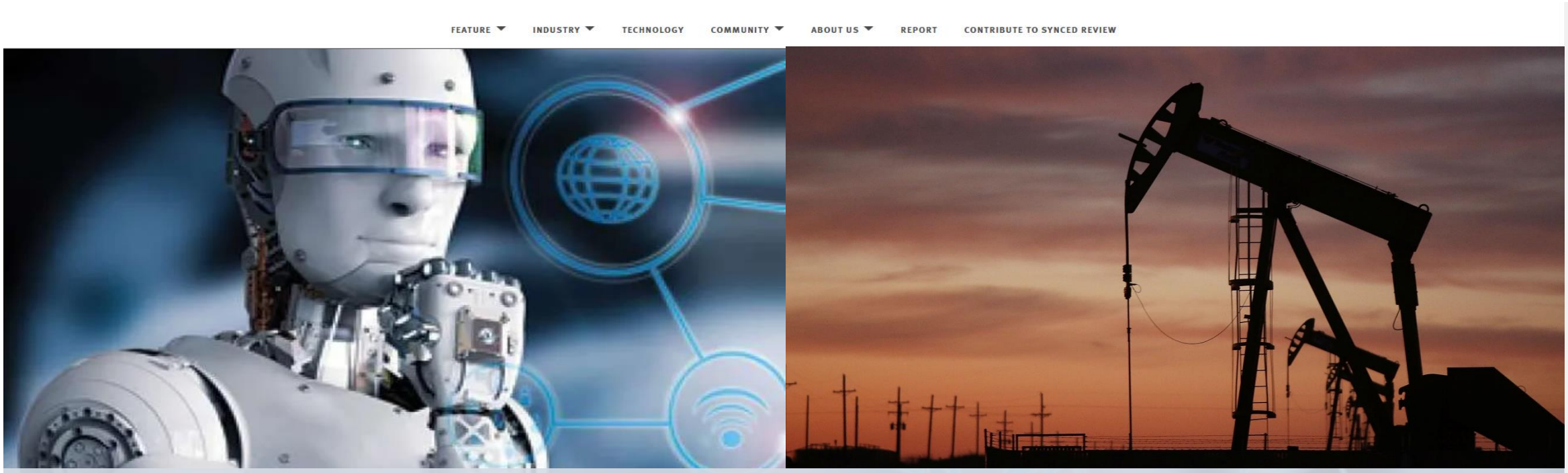
Like anything intelligent, private and public organizations to be smart require a hypothalamus to coordinate all the activities they carry out in such a way as to maintain the short/long-term balance and to ensure viability of the multifunctional structure involved in an organization.

Unlike the human being where the hypothalamus, and all the functions required to survive and evolve, is created by "life", in the business organization the humans (directives and executives) are responsible for creating the hypothalamus devices (vice-presidencies, departments) of productive and administrative functions.

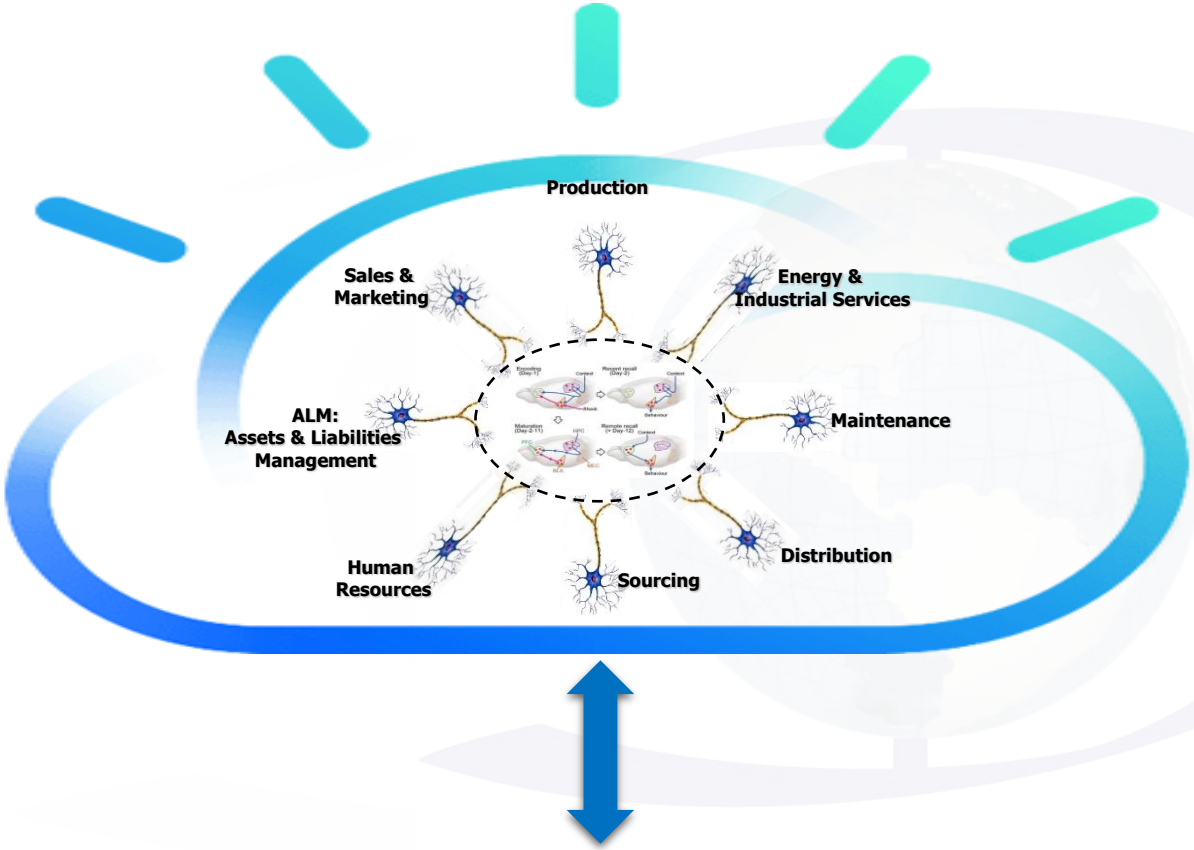
In the industrial environment, the hypothalamus of the enterprise must be based on the knowledge of the process of serving the final services/products of its end customers from the supply of raw materials and inputs that are required for this transformation. The construction of the hypothalamus, such 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.

The organizational hypothalamus ends up being the INDUSTRY 4.0 Decision Support System (DSS) of the organization that integrates through interconnected mathematical models, associated with the different business functions, all the knowledge that the organization had.

COGNITIVE ROBOTS + MATHEMATICAL PROGRAMMING 4.0



ATHENEA PROJECT
CLOUD INDUSTRIAL ENTERPRISE HYPOTHALAMUS



END USERS

The mathematical models individually are associated with different administrative divisions/functions that the organization must attend, for the General Industrial Hypothalamus the models are:

- Supply Chain
  - Resilient Supply Chain Design
  - Integrated Sales & Operations Planning (S&OP)
  - Optimal Inventory Policy Planning
  - Sourcing Optimization
  - Production Scheduling
  - Product Delivery Program Planning (ATP)
  - Product Distribution Scheduling
  - Predictive Maintenance Programming
  - Human Resources Planning & Scheduling

- Demand Chain
  - Demand Management & Forecasting
  - Marketing Mix Policy Optimization
  - Price Optimization (Revenue Management)
  - Suggested Order Optimization

There are other advanced mathematical models that may be integrated into the ATHENEA INDUSTRIAL HYPOTHALAMUS, but they are not considered in this initial stage.

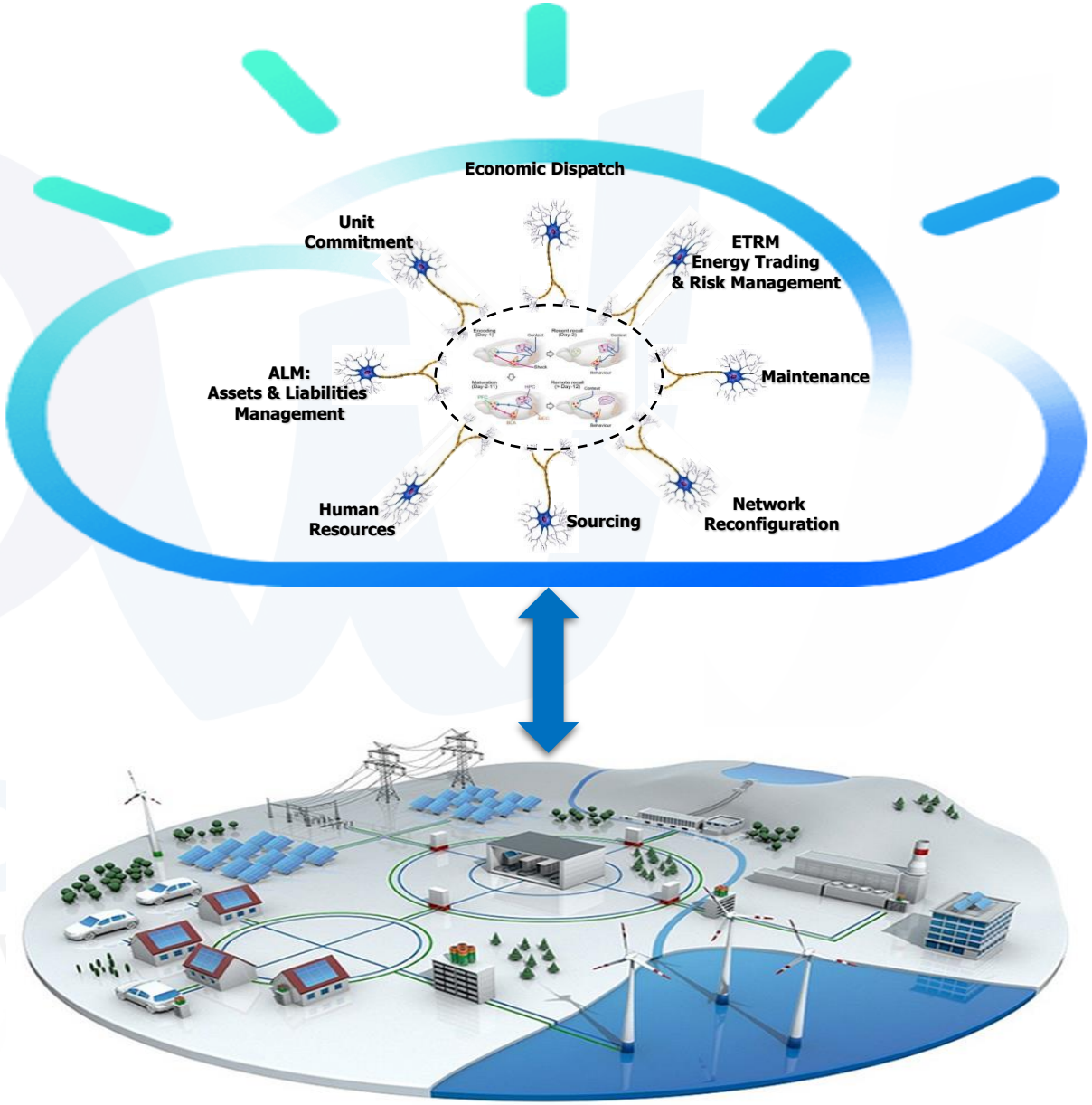
ATHENEA PROJECT
CLOUD ELECTRIC ENTERPRISE HYPOTHALAMUS

The mathematical models individually are associated with different administrative divisions/functions that the organization must attend, for the Electric Sector Hypothalamus the models are:

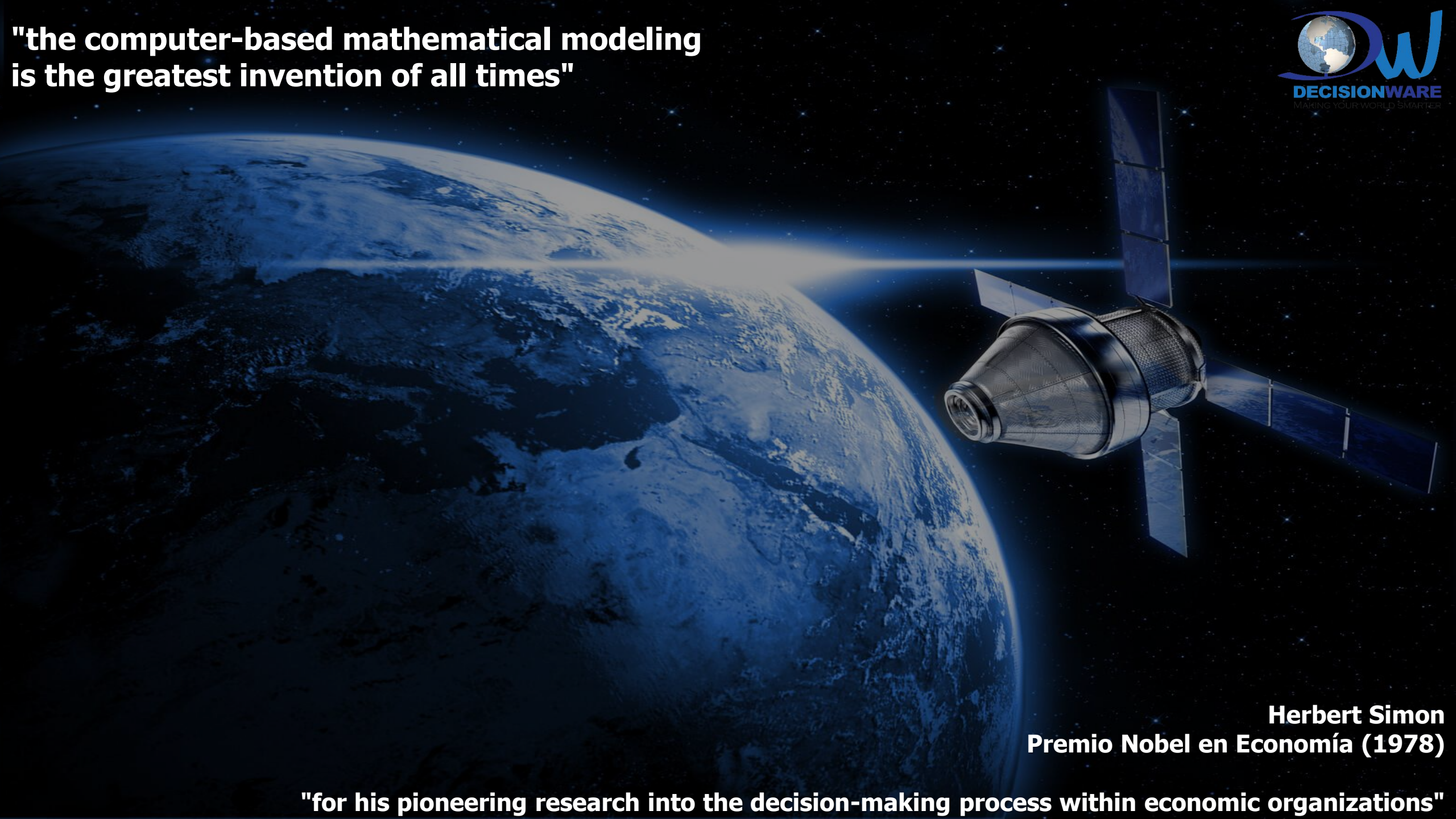
- Prescriptive Models
  - Optimal Economic Dispatch
  - Unit Commitment
  - Optimal Design of Smart Networks
  - Real-Time Reconfiguration of Smart Networks
  - ETRM: Energy Trading & Risk Management
  - ALM: Assets & Liabilities Management

- Predictive Models
  - Demand forecasting
  - Hydroclimatic forecasting

There are other advanced mathematical models that may be integrated into the ATHENEA ELECTRIC HYPOTHALAMUS, but they are not considered in this initial stage.



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



Herbert Simon
Premio Nobel en Economía (1978)

"for his pioneering research into the decision-making process within economic organizations"