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Market Guide for Optimization Solutions

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This guide explains the market of optimization solutions, which is made up of a broad spectrum of tools, from packaged applications for business users to optimization modeling platforms and the optimization solvers that drive them.

Key Findings

- Optimization is a prescriptive analytics approach used to solve complex decision problems that involve conflicting objectives and constraints, making the best use of limited resources.
- There are three segments of optimization solutions — domain-specific optimization applications, optimization modeling platforms for skilled users to define a problem, and the optimization solvers that work together with these platforms to find the "best" solution.
- Awareness of optimization in corporate BI and analytics teams has been limited, but with increased awareness of the benefits, usage is growing rapidly, especially in embedded applications.

Recommendations

Business analytics leaders:

- First, identify the decisions to improve in your organization and determine if optimization is the right approach.
- Use this guide to understand the optimization landscape of solution types and providers.

Analytics teams new to optimization:

- Begin with packaged optimization applications aimed at business users, if they exist for your problem, or work with skilled service providers.

Analytically mature teams:

- Evaluate optimization modeling platforms or configurable optimization applications to maximize the reach and benefits that optimization can deliver.

Strategic Planning Assumption

By 2018, optimization will no longer be a niche discipline; it will become a best practice for leading organizations to address a wide range of complex business decisions.

Market Definition

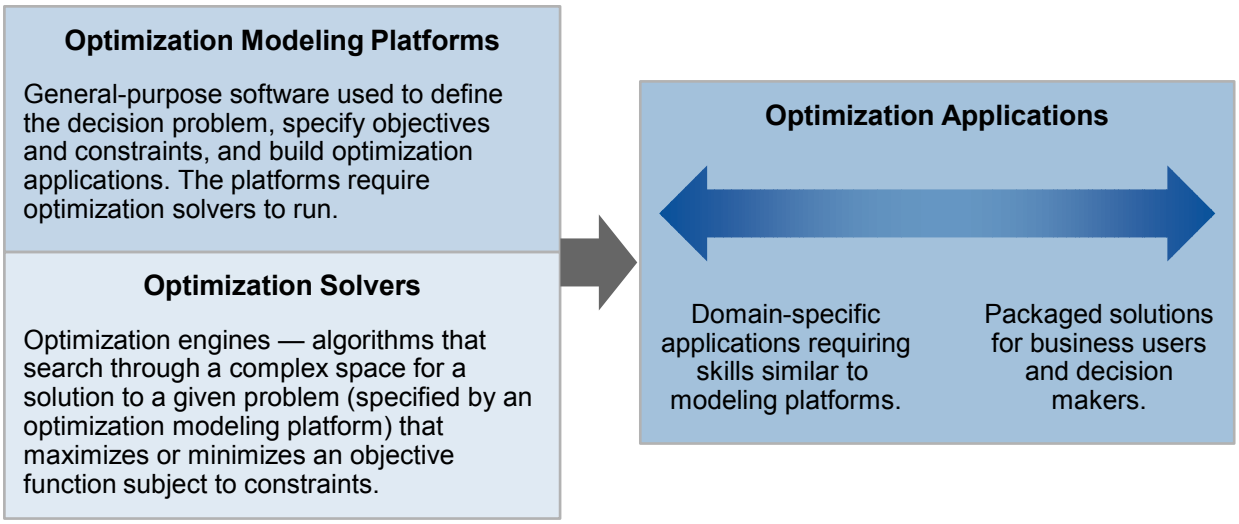
Optimization is a type of prescriptive analytics (see "How to Get Started With Prescriptive Analytics") that finds a "best" solution from a set of "feasible" solutions, using a mathematical algorithm that maximizes or minimizes a specified objective function subject to constraints. Common approaches to solve this problem include linear programming, integer programming, stochastic programming and constraint programming (see Appendix). It comes from the field of operations research and management science.

Optimization is best applied to situations that involve many alternatives, constraints or trade-offs. Use cases range from "operational" (transport route planning, loan approvals or marketing offers) to "tactical" (allocating budget or other limited resources, setting pricing/policy, or matching supply to demand) or "strategic" (deciding which company to acquire or where to expand). When organizations embrace optimization in their decision making, they can see significant improvements in profitability, efficiency or cost. Even a 1% or 2% reduction in cost can lead to millions of dollars in savings in some types of problems. Common business applications where optimization is applied today include supply chain, logistics and scheduling (such as airlines or transport routing), marketing offer optimization, and pricing optimization.

There are three main tiers of optimization solutions, each of which serves a different purpose and requires different skill sets (see Figure 1).

- **Optimization Solvers —** A numerical algorithm that searches through a complex space of alternatives for the "best" one for a given problem.
- **Optimization Modeling Platforms —** Application design and authoring environments that allow skilled users (typically operations research analysts or quantitative types) to specify an optimization problem, design and run scenarios (using the solvers), and create a wide range of optimization applications.
- **Optimization Applications —** Solutions aimed at domain experts or business users for a particular type of problem or industry. Hundreds of these exist, and they range from completely packaged solutions for business users to loosely packaged applications requiring configuration by skilled users.

Figure 1. Three Main Types of Optimization Solutions



Source: Gartner (May 2015)

Organizations can either buy packaged optimization applications focused on a specific decision or build one using an optimization modeling platform (with associated solvers), using either internal teams or external consultants.

Market Direction

The theory of optimization was developed in the decade following World War II to analyze and improve military operations and logistics. While many optimization use cases have existed for years in logistics, supply chain and manufacturing, we are now beginning to see broader business uses, such as customer best next offer, pricing optimization and call center agent assignment. New use cases are continuing to emerge, such as healthcare providers applying optimization to hospital operations to meet patient care goals while minimizing costs.

Several factors have led to renewed interest in and usage of optimization solutions. Overall awareness of the value of analytics and data-driven decision making means that more organizations are moving up the analytics maturity ladder and building analytics capabilities beyond descriptive analytics to predictive and prescriptive analytics. At the same time, the availability of data sources and the increased compute power means we can solve ever-more-complex types of problems more quickly, such as those in the optimization space.

While the focus of this technology has been solving for the "best answer," maximizing or minimizing an objective function that met specified business objectives and constraints, additional — and deeper — insights often come from the ability to explore alternative scenarios to understand trade-offs between objectives and constraints. This drives adoption, as well as the applicability to broader problems.

Going forward, optimization will move beyond its core community of operations research and management science professionals and become increasingly embedded in business applications. Analytics teams — as well as vendors — will add prescriptive analytics capabilities, including optimization, to their portfolio. Other trends reflected in these platforms' future include:

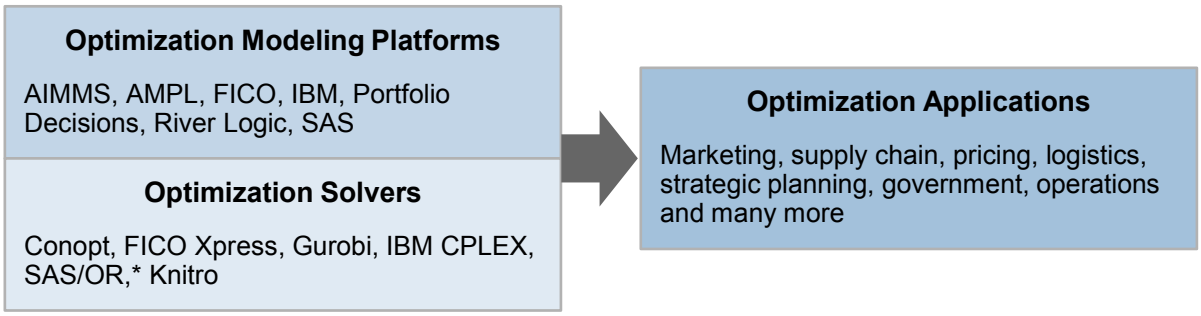
- **Rise of Self-Service Optimization:** Many vendors are beginning to enhance their self-service optimization capabilities by incorporating a "drag-and-drop" interface and "point-and-click" deployment capabilities for configuring optimization models into complex decision management solutions.
- **User Collaboration:** Vendors are increasingly beginning to offer user collaboration features, such as multiuser optimization, Microsoft Office integration and risk simulation via a shared database.
- **Support for Open-Source Analytic Libraries:** Several vendors are either offering or planning to offer support for open-source analytic libraries, such as R and Python, to enhance their optimization modeling support.
- **Web-Based Development Workbench:** Moving from a desktop development workbench to a Web-based development environment allows the use of many supported devices for both model and app development.
- **Integration With Business Intelligence (BI), Analytics and Other Transaction Systems:** Vendors are looking to support and enhance their optimization solutions' data integration capabilities with BI and analytics tools and other transaction systems, such as ERP, CRM and supply chain management (SCM).
- **Application Programming Interfaces (APIs) and Solvers:** Release of APIs for popular programming languages and expansion of support for open-source and third-party solvers is also on the rise in this upcoming and evolving market.

Even though the optimization solutions market is rapidly gaining momentum in the advanced analytics space, it is still in the emerging phase of maturity with a market penetration of less than 10% of the possible target audience (see "Hype Cycle for Advanced Analytics and Data Science, 2014").

Market Analysis

As we introduced above, the three segments of the optimization market include optimization solvers, modeling platforms and applications. Figure 2 shows some of the vendors that offer these solutions and the areas where they are commonly applied. There are multiple vendors that offer both solvers and modeling platforms, such as FICO, IBM and SAS. However, there are also vendors that focus on creating the modeling platforms (such as Advanced Integrated Multidimensional Modeling Software [AIMMS], Portfolio Decisions and River Logic) working primarily with third-party solvers, and there are vendors whose focus is building better, faster solvers (such as Gurobi and Knitro).

Figure 2. Representative Vendors for Optimization Solution Categories



*Available only as bundled with vendor's platform

Source: Gartner (May 2015)

Optimization applications, similar to Gartner's broader definition of analytic applications, are any industry- or domain-specific optimization capabilities that help casual users build or adopt optimization solutions. This packaging may be accomplished through issue-specific templates, wizards, user interfaces (UIs), data models or other configuration for a use case or category of use cases.

Being domain-specific in this market still implies a wide range of solutions and skills requirements. At one end of the spectrum, these are completely built and packaged solutions for business users and decision makers with no optimization expertise. In fact, the underlying models may be completely invisible to the user, who cannot see or change the model, but only its outputs. Top use case categories where optimization applications exist include:

- Marketing — Who to target, what offer to make and through what channel; marketing mix optimization
- Customer management — Best next offer, cross-selling/upselling and retention decisions
- Pricing and revenue management — Understanding price elasticity to price goods and services, such as airline seats, hotel rooms or groceries; retail promotion and markdowns
- Supply chain — Demand planning and inventory optimization, supply chain network optimization, and cost-to-serve optimization
- Logistics — Routing and scheduling of transportation, from trucking to airlines
- Strategic planning — Capital budget allocation, portfolio investment decisions and R&D investment decisions
- Government — Military logistics, anti-terrorism and emergency response
- Other operations — Call center routing; oil drilling; hospital operations; water and electrical utilities; where to place stores, ATMs and warehouses; and many other industry-specific scenarios

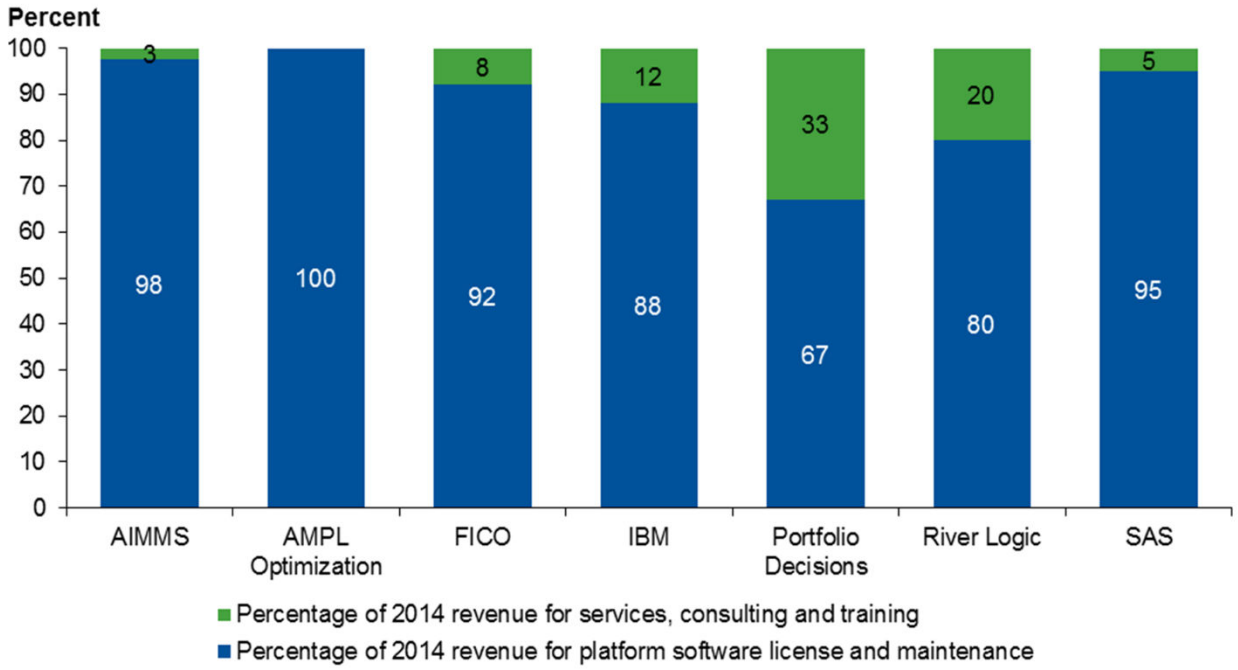
These solutions may be built by internal staff, external consultants or vendors. While there are too many providers of optimization applications to mention them all, many examples exist on the Hype Cycles for analytic applications (see "Hype Cycle for Customer Analytic Applications, 2014" and "Hype Cycle for Back-Office Analytic Applications, 2014").

Some of these optimization applications allow more control and access to models, yet they are still domain-specific. Examples include supply chain optimization applications, such as LLamasoft; asset management applications like SEAMS; and pricing optimization applications like Earnix, Nomis Solutions and Pros. More quantitative skills, sometimes even optimization skills, may be required to use these configurable applications to create a more packaged application for use by a business user.

The focus of this research — and the focus of the majority of vendors described in this document — is optimization modeling platforms, which are the general-purpose software tools that organizations use to build optimization applications for many use cases. These optimization platforms are used together with optimization solvers to build optimization applications. A discussion of the vendors that provide platforms and solvers is found in the following sections.

The optimization platform market is estimated by Gartner at more than $100 million in 2014 and growing at more than 10% in 2015. (The optimization application market is many times greater and has not been estimated.) The majority of vendors in this space generate a significant percentage of their revenue from software licenses and maintenance (see Figure 3), and very few have begun to offer their platforms in the cloud (see Figure 4).

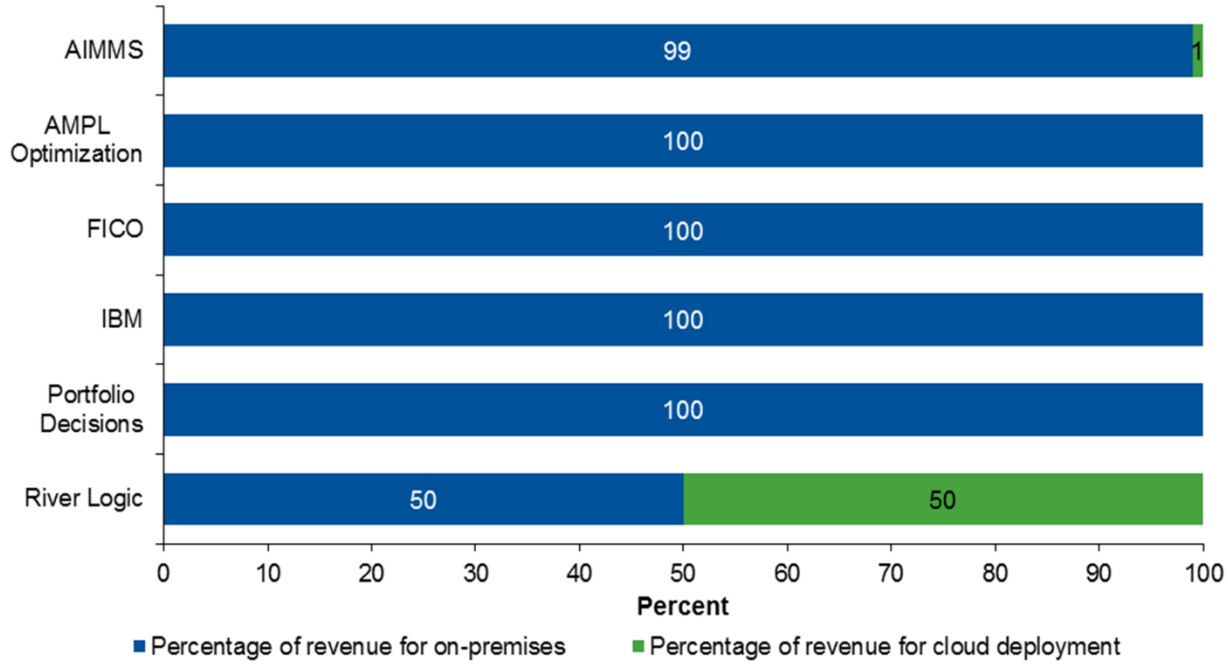
Figure 3. Optimization Platform License Revenue vs. Service Revenue



n = 7
Survey question: What percentage of your organization's revenue in 2014 (for your optimization platform) came from services, consulting and training versus software licensing and maintenance?

Source: Gartner (May 2015)

Figure 4. Optimization Platform Deployment Models



n = 6
Survey question: What percentage of your organization's revenue came from on-premises versus cloud deployment of your optimization platform in 2014?

Source: Gartner (May 2015)

Despite very few cloud deployments today, most platform vendors are moving to cloud. The rise of cloud deployments and cloud-based solutions provides the ability to create, configure and deploy optimization-based applications quickly and easily.

Representative Vendors

The vendors listed in this Market Guide do not imply an exhaustive list. This section is intended to provide more understanding of the market and its offerings.

The vendors and products listed here are representative because they have achieved some level of visibility and traction in this market. Vendors are widely diverse in their capabilities, although all support the general template described earlier in this report.

Vendors have been listed in alphabetical order rather than ranked in priority.

For each optimization platform detailed in the tables below:

- The Employees on Product row lists the full-time equivalents dedicated exclusively to the optimization platform of the company as reported by the vendors.

- The Geographic Presence and Top Industries are listed in decreasing order of revenue reported by the vendor from those geographies or industries for their optimization platforms as reported by the vendors.
- The Number of Deployments/Sales of Optimization Modeling Platform row indicates the approximate number of sales/deployments of the optimization platform of the vendor in the financial year 2014 as reported by the vendors.

Optimization Platforms

AIMMS

www.aimms.com

AIMMS was founded as Paragon Decision Technology in 1989 and rebranded as AIMMS in 2013. It is headquartered in Haarlem, the Netherlands with regional offices in the U.S., Singapore and China.

AIMMS provides an end-to-end optimization suite to model and develop optimization apps, as well as an enterprise app store (on a cloud technology platform) to roll out and deploy those optimization apps. Its optimization platform enables global companies to capture and quantify the business value of optimization and to empower business users to apply optimization models and share best practices through browser-compatible apps.

The differentiator of AIMMS is that its platform is built to easily create and publish optimization applications. It offers a browser-based platform for instant publishing, deployment and collaboration on optimization-based and non-optimization-based applications and proofs of concept throughout the enterprise combined with development tools to create optimization solutions in line with the business problems.

It provides its users with a fully integrated model and application development environment, with productivity tools including model trees, a page manager, a point-and-click UI, a math program inspector, and intuitive modeling constructs for time, units of measure, and advanced and broad optimization support. It offers an open Web UI visualization standard, supporting many solvers through an open solver interface and a generated math program library for custom algorithms and heuristics.

Table 1. AIMMS Overview

Attributes	Details
Product Name	AIMMS (for modeling and development of AIMMS optimization applications) and AIMMS Pro (Web-based deployment platform to roll out AIMMS applications)
Employees on Product	40
Geographic Presence	North America, EMEA, Latin America, Asia/Pacific
Top Industries	Manufacturing and natural resources (including consumer packaged goods and food and beverage), utilities, retail, government, public sector, services
Most Common User Roles/Job Titles	Optimization/analytics practitioners Data scientists Planners Business analysts Strategic consultants
Most Common Use Cases	Long-, medium- and short-term planning considering demand, production, and sourcing Supply chain network design Operational process optimization (for example, oil, gas and chemicals)
Notable Customers	Shell, Nike, Air Liquide
Number of Deployments/Sales of Optimization Modeling Platform	2014 overall installed base: For commercial users — 3,500 installed licenses for more than 5,000 users For academic users — more than 15,000 users 2014 business sales: 225 AIMMS licenses sold for 420 users
Licensing Model	Perpetual licensing along with an additional maintenance fee. Additional support for subscription-based licensing on a situational basis.
Average Deal Size	$100,000 to $150,000 in licenses for the AIMMS Pro platform
Data Sources	Common databases (through ODBC connectivity) Text files Spreadsheets (through ODBC or specialized Excel functions) ERP data exchanges Custom data exchange (through AIMMS SDK files or by calling functions from customer dynamic-link library files).
Solvers Included as a Part of the Standard License	CBC (open source), Ipopt (open source), AOA MINLP solver (from AIMMS)
MINLP = mixed-integer nonlinear programming; ODBC = Open Database Connectivity	

Source: Gartner (May 2015)

AMPL Optimization

www.ampl.com

AMPL Optimization is a privately held organization founded in 2002 and headquartered in Albuquerque, New Mexico, U.S.

AMPL Optimization develops and markets a general-purpose modeling language and platform dedicated to building, maintaining and deploying complex, customer-designed decision models. Originating from the work of Robert Fourer, David M. Gay and Brian Kernighan at Bell Laboratories, the company has expanded its support of optimization to encompass diverse problem types and solvers, as well as varied interfaces for development and deployment of enterprise solutions.

It provides its users with streamlined development models and applications and gives them the flexibility to switch to more than 30 popular solvers through its open-source solver interface. Its optimization platform is based on a modeling and scripting language (AMPL) with batch, command line, and windowing interfaces, and it can connect to any ODBC data source to support optimization across all the information sources and assets of the organization.

Table 2. AMPL Optimization Overview

Attributes	Details
Product Name	AMPL
Employees on Product	5
Geographic Presence	North America, EMEA, Latin America, Asia/Pacific
Top Industries	Manufacturing and natural resources, utilities, transportation, education, government, public sector
Most Common User Roles/Job Titles	Analytics Operations research Corporate research
Most Common Use Cases	Energy Transportation Production/supply chain
Notable Customers	Not available
Number of Deployments/Sales of Optimization Modeling Platform	300
Licensing Model	Perpetual licensing model with an annual maintenance fee. It also supports single-user, floating and per-socket server options.
Average Deal Size	$20,000 in licenses
Data Sources	AMPL can connect to any ODBC data source, as well as formatted and unformatted text data.
Solvers Included as a Part of the Standard License	None — AMPL distributes solvers developed by other companies, and supports open-source and other third-party solvers.

Source: Gartner (May 2015)

FICO

www.fico.com

FICO was founded in 1956 and is headquartered in San Jose, California, U.S. It provides analytic products and services to help businesses improve the precision, consistency and agility of their complex, high-volume decisions.

FICO Xpress Optimization Suite is a platform for building optimization solutions that drive business process improvements. In January 2008, FICO acquired Dash Optimization — the makers of Xpress-MP, which was a decision modeling and optimization software product.

FICO Xpress Optimization Suite provides its users with a user-friendly graphical user interface (GUI) to create, deploy and utilize business optimization solutions based on scalable algorithms, a modeling environment, and rapid application and reporting capabilities for on-premises and cloud installations. The Xpress Optimization Suite is structured on three layers of integrated and interactive tools: modeling and development tools, optimization solver engines, and business insight model deployment and presentation services. It has several hundred customers across multiple industries and is backed by its own professional services team for training and implementation services. The optimization platform is an integrated component of the FICO Decision Management Suite and is optionally available on the FICO Analytic Cloud.

Table 3. FICO Overview

Attributes	Details
Product Name	FICO Xpress Optimization Suite
Employees on Product	About 30
Geographic Presence	North America, Latin America, Asia/Pacific, EMEA
Top Industries	Banking and securities, utilities (energy — most notable), transportation, others (telecom and travel), manufacturing and natural resources
Most Common User Roles/Job Titles	OR analysts Business analysts Pricing analysts
Most Common Use Cases	Customer strategy optimization (pricing, collections, credit) Marketing optimization (customer, offer, channel) Energy (distribution, unit commitment) Transportation (vehicle routing, network design)
Notable Customers	Southwest, Sprint, Poyry
Number of Deployments/Sales of Optimization Modeling Platform	Not available
Licensing Model	Perpetual or term-based licensing model
Average Deal Size	Not available
Data Sources	Files, databases, Web services or any ODBC-enabled data source. Specific Oracle driver and other drivers for Excel, CSV, XML and JSON, as well as its own DAT format. Users can implement custom drivers and use the free form reading and writing capabilities of Xpress Mosel (FICO's modeling language)
Solvers Included as a Part of the Standard License	The platform always contains the standard FICO Xpress solvers and modeling tools.
OR = operations research	

Source: Gartner (May 2015)

IBM

www.ibm.com

IBM was founded in 1911 and is headquartered in Armonk, New York, U.S. It is a globally integrated technology and consulting company with operations in more than 175 countries.

IBM completed the acquisition of Ilog in January 2009 and with it gained access to its optimization portfolio. The optimization portfolio now includes IBM Decision Optimization Center and IBM CPLEX Optimization Studio analytical decision support tools for building and deploying optimization models and optimization-based enterprise applications. CPLEX Optimization Studio consists of the CPLEX Optimizer for mathematical programming, the IBM CPLEX CP Optimizer for constraint programming, the Optimization Programming Language (OPL), and an integrated development environment (IDE). The Ilog optimization team is now a part of IBM's broader business analytics portfolio of services, which also encompasses BI and predictive and prescriptive analytics solutions.

With the CPLEX Studio IDE, users can create and modify project files, as well as model and data files, using the integrated editing capabilities. Model creation is done directly through OPL or APIs for Python, Matlab, C/C++, Java or .NET. Users can create and modify settings and files to apply language options, mathematical programming parameters and constraint programming parameters, and execute a project.

It allows users to connect to simple text files and spreadsheets to sophisticated enterprise database systems followed by visualization and relaxation of OPL results to attain feasible mathematical programming (MP) models. Models can be solved on a remote server with results available in the IDE.

In addition, IBM Decision Optimization Center provides a complete UI for business decision makers to access the functionality they need for operational planning and scheduling. Existing user interfaces can also integrate with most of the IBM Decision Optimization Center functionality using documented Java APIs.

Table 4. IBM Overview

Attributes	Details
Product Name	IBM CPLEX Optimization Studio IBM Decision Optimization Center IBM Decision Optimization on Cloud (beta)
Employees on Product	Not available
Geographic Presence	North America, EMEA, Asia/Pacific, Latin America
Top Industries	Manufacturing and natural resources, banking and securities, transportation, retail, utilities
Most Common User Roles/Job Titles	OR professionals Business analysts Data scientists Optimization modelers IT solution integrators
Most Common Use Cases	Planning applications Scheduling applications Finance-related applications
Notable Customers	Embraer, Airbus, Red Electrica
Number of Deployments/Sales of Optimization Modeling Platform	Not available
Licensing Model	Development users: authorized and simultaneous user license support. On-premises deployment: perpetual license and monthly rental with CPU/PVU capacity and client device license for small desktop and device embedding. Cloud offering: flexible, pay-as-you-go, committed hours or reserved capacity plans without requiring license or installation.
Average Deal Size	Not available
Data Sources	Out-of-the-box connectors to common databases and spreadsheets, as well as custom data sources (for example, text/comma-separated values files) Connectors for IBM SPSS Modeler
Solvers Included as a Part of the Standard License	The CPLEX Optimizers (math programming and constraint programming solvers)
PVU = Processor Value Unit	

Source: Gartner (May 2015)

Portfolio Decisions

www.portfoliodecisions.com

Portfolio Decisions was founded in 1998 and is headquartered in Houston, Texas, U.S.

It is a software and consulting company providing advanced analytics to executives for strategic decisions, such as allocation of capital, funding a portfolio of projects, acquisitions and divestitures.

Its optimization platform — Perspectives — provides an optimization and risk simulation environment that enables its users to bring together planning data, assumptions, business goals and constraints to address decisions involving risk or uncertainty. Perspectives uses an Excel-based UI enhanced with custom menus that call the workflow and analytic code, enabling its users to quickly create a time series model customized for each company combining financial, operational and strategic planning.

The use of an Excel interface allows analysts to quickly structure the input variable requirements and results of the analysis (data and charts) in a user-specific "packaged" format. Excel worksheets within an analysis model can then be customized to provide the specific input and output as required for a particular industry or unique application of the optimization routine. The application allows users to leverage linear optimization and Monte Carlo simulation (see Note 1) without a detailed understanding of these techniques, enabling self-service optimization within the organization by business users.

Table 5. Portfolio Decisions Overview

Attributes	Details
Product Name	Perspectives
Employees on Product	9
Geographic Presence	North America, EMEA, Asia/Pacific, Latin America
Top Industries	Energy
Most Common User Roles/Job Titles	Recipients of the analysis are C-level executives or VPs Hands-on users are usually planning or financial analysts
Most Common Use Cases	Strategy development Capital allocation Acquisitions and divestitures
Notable Customers	Not available
Number of Deployments/Sales of Optimization Modeling Platform	34 licenses at 14 companies
Licensing Model	Leased licensing model (based on number of named users)
Average Deal Size	$180,000 annually for a three-year lease
Data Sources	Capability to capture data from most commercial applications and databases since its UI is in Excel and data can be exported to Excel.
Solvers Included as a Part of the Standard License	What'sBest! — Excel add-in for linear, nonlinear, and integer modeling and optimization (from Lindo Systems)

Source: Gartner (May 2015)

River Logic

www.riverlogic.com

River Logic was founded in 2000 and is headquartered in Dallas, Texas, U.S.

River Logic provides Enterprise Optimizer (EO), a knowledge-based (fifth-generation language) optimization platform. EO is a drag-and-drop visual modeling package created from River Logic's own proprietary development environment called Constraint Oriented Reasoning (COR). Variables and constraints are defined in natural language — therefore, no coding or equation definition/management is required. EO's embedded error and data checking, reporting and visualization/debugging capabilities enable users to quickly identify errors, resolve infeasibilities and analyze model results. Dashboards are integrated and can also be developed through the built-in drag-and-drop features. EO models are built entirely within the UI, but they can be managed externally by the

API and EO Server jobs and internally using the built-in Microsoft Visual Basic for Applications (VBA) environment.

River Logic also provides Integrated Business Planning (IBP) platform components that enable enterprise deployments of prescriptive analytics via SaaS or on-premises. IBP components include model libraries, UIs, workflows and adapters and address multiple industries.

River Logic's go-to-market strategy is through its global consulting partners, resellers and independent software vendors (which repackage River Logic's optimization platform via OEM), as well as direct.

Table 6. River Logic Overview

Attributes	Details
Product Name	Enterprise Optimizer (EO) Integrated Business Planning (IBP) platform
Employees on Product	20
Geographic Presence	North America, EMEA, Asia/Pacific, Latin America
Top Industries	Manufacturing and natural resources, healthcare providers, transportation, utilities, services
Most Common User Roles/Job Titles	Sales and operations planning managers Business analysts Consultants Analytics centers of excellence
Most Common Use Cases	Integrated business planning Strategy planning Scheduling policy
Notable Customers	BHP Billiton, PwC, DST Health
Number of Deployments/Sales of Optimization Modeling Platform	More than 40
Licensing Model	Perpetual or subscription-based licensing models for Enterprise Optimizer (EO), which is licensed by seat. Integrated Business Planning (IBP) platform (which includes EO) supports a SaaS subscription model (based on revenue, the number of users and the number of models).
Average Deal Size	EO — $75,000 per year; IBP — $250,000 per year
Data Sources	Common databases (SQL Server, Oracle, PostgreSQL, MySQL and Access), file systems, email clients, CICS, FTP, IMS, JDBC, SAP, Oracle and other packaged applications via included adapters. Microsoft Excel It has included packages to connect with messaging systems such as JMS, MSMQ, and also to with other compatible system via SOAP and REST-based Web service calls.
Solvers Included as a Part of the Standard License	River Logic provides Mixed Integer Optimizer (MIO) and CPLEX solvers- depending on SKUs.

Source: Gartner (May 2015)

SAS

www.sas.com

SAS was founded in 1976 and is headquartered in Cary, North Carolina, U.S. and has customers in 140 countries.

SAS/OR is part of an end-to-end advanced analytics platform and includes mathematical optimization, discrete event simulation, and project and resource scheduling as a complete commercial off-the-shelf (COTS) solution. It allows its users to call other SAS procedures, SAS functions and SAS macros directly from within its OPTMODEL modeling language (in the OPTMODEL family of procedures). OPTMODEL provides capabilities including direct invocation of linear, nonlinear, quadratic, network, constraint programming, and mixed-integer solvers and support for the rapid prototyping of customized optimization algorithms, including named problems and subproblems.

OPTMODEL also supports full algebraic expression of decision variables, bounds, constraints, and objectives, and supports the ability to build and use named models. It can maintain full separation between the logical structure of a model and the data that is used in the model for a given instance. It supports the use of column generation and row generation methods that iteratively redefine the problem during the solution process. It also provides a decomposition algorithm (Dantzig-Wolfe method) for linear and mixed-integer optimization that requires only the identification of blocks in the constraint matrix (manual or automatic) and automates the interplay between solution of the master problem and parallel solution of subproblems.

Table 7. SAS Overview

Attributes	Details
Product Name	SAS/OR
Employees on Product	Currently four full-time equivalents are dedicated for the OPTMODEL (modeling language) of the SAS/OR platform. However, many other developers and testers contribute in SAS software that can be used by OPTMODEL.
Geographic Presence	North America, EMEA, Asia/Pacific
Top Industries	Banking and securities, government/public sector, insurance, services, communications and media, other (life sciences)
Most Common User Roles/Job Titles	Decision sciences managers/analysts Business analysts Pricing specialists Data scientists Supply chain specialists
Most Common Use Cases	Pricing and revenue management Human and capital resource allocation Advertising optimization
Notable Customers	Not available
Number of Deployments/Sales of Optimization Modeling Platform	2,879 sites worldwide (actual number of users is considerably higher)
Licensing Model	Annual licensing model, which is priced according to CPU count and/or number of users and typically licensed with other SAS products
Average Deal Size	Cannot be determined since SAS/OR is always sold in conjunction with other SAS software
Data Sources	SAS/OR can connect to all major database and file formats. SAS/ACCESS engines can communicate with data in its native format.
Solvers Included as a Part of the Standard License	The SAS/OR license includes a host of SAS solvers including LP, network solvers, MILP, NLP, QP and CLP out of the box in the form of COTS.

Source: Gartner (May 2015)

See Table 8 for further details on the optimization platform features available from the vendors covered in this analysis.

Please note that some vendors, including General Algebraic Modeling System (GAMS), Lindo Systems, MathWorks and Tomlab, did not respond or could not be contacted in time for this research. The following vendors also have optimization modeling platforms that allow skilled users

to define all the components of an optimization problem, from data to objective function and constraints.

In Table 9, we list them in alphabetic order and list information regarding them, which has been prepared leveraging publicly available information and our own knowledge of the market through client inquiries and vendor briefings.

Table 8. Vendors' Product Features for Optimization Platforms

	AIMMS	AMPL Optimization	FICO	IBM	Portfolio Decisions	River Logic	SAS
Solvers Supported	CPLEX, Gurobi, XA, CBC, Conopt, AOA, Knitro, Ipopt, Baron, Minos, Snopt, CP Optimizer, Path	Over 30 solvers supported; usage data not available	FICO's own solvers for LP, MIP, NLP, QP, QCQP Knitro from Ziena as alternative method for NLP Kalis from Artelys for CP	Math programming engine: includes simplex and interior-point algorithms. Constraint programming engine: includes algorithms such as GA, local search and edge finder.	What'sBest! solver from Lindo for LP, NLP, QCP, second-order cone, stochastic, and integer optimization	Solvers for Mixed Integer Optimizer (MIO) and CPLEX	Solvers for MILP, LP, NLP, network, QP, local search and CLP
API Support (Yes/No): Explanation	Yes: Through the AIMMS SDK. Provides a Java, C++ or C# interface for integration of optimization model with custom applications.	Yes: APIs released for C++, Java and Matlab	Yes: APIs for solvers, modeling and application framework ranging from Web services over Java, to .NET to plain C interfaces	Yes: the modeling layer (OPL) can be embedded through C++, Java, .NET and Python API. The Decision Optimization Center has Java API and a Groovy extension.	No	Yes: Full automation API accessible with C#, VBA and other programming languages and support for SOAP and REST Web services	Yes: Support for multiple APIs for running SAS code, including Web services API
Ability to Deliver Optimization Platform as OEM (Yes/No)	Yes	Yes	Yes	Yes	No	Yes	No
Ability to Create Packaged Optimization Applications (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes
Does the Platform Have: Own Solvers/Solvers Procured From	Obtained mostly from other companies. The company has created	Distributes solvers developed by other companies and	FICO mainly uses its own solvers. However, for interior-point nonlinear	IBM mostly uses its own solvers, but also supports other open-source	Solvers are procured from other companies.	River Logic has its own solvers and also procures solvers	Uses solvers developed by SAS.

	AIMMS	AMPL Optimization	FICO	IBM	Portfolio Decisions	River Logic	SAS
Other Companies (Third Party)/ Using Open-Source Solvers	AOA, a special MINLP solver, which is fully customizable by the user.	supports open-source solvers.	problems, it uses Knitro from Ziena, and for CP it uses Kalis from Artelys.	or third-party solvers through APIs.		from other companies. However, they do not support open-source solvers at the moment.	
Open Solver Interface Support (Yes/No): Explanation	Yes: Through an open solver interface: AIMMS OSI	Yes: Through an open solver interface	No generic open solver interface is provided. However, the platform can be extended using APIs.	No generic open solver interface is provided. However, the platform can be extended using APIs.	No	No	No
Optimization Platform Composition — UI/ Modelling Language/Both	Both	Both	Both	Both	UI	UI	Modeling Language
CP = constraint programming; OSI = Open Systems Interconnection							

Source: Gartner (May 2015)

Table 9. Information on Some Other Optimization Modeling Platforms

Vendor	Optimization Platform	Headquarters	Region	Product Description
GAMS	GAMS	Frechen, Germany	EMEA	GAMS is a modeling system for mathematical programming and optimization. It consists of a language compiler and a set of integrated high-performance solvers. GAMS is tailored for complex, large-scale modeling applications and allows building large maintainable models that can be adapted quickly to new situations. GAMS is used for handling complex problems that may require many revisions to establish an accurate model. The system models problems in a compact way and can also allow the user to change the formulation and switch to different solvers or different problem types seamlessly.
Lindo Systems	Lingo	Chicago, Illinois, U.S.	North America	Lingo provides an integrated package that includes a modeling language for expressing optimization models, a featured environment for building and editing problems, and a set of built-in solvers. Lingo is designed to make building and solving linear, nonlinear (convex and nonconvex/global), quadratic, quadratically constrained, second-order cone, stochastic, and integer optimization models faster and more efficient.
MathWorks	Optimization Toolbox	Natick, Massachusetts, U.S.	North America	Optimization Toolbox is an optimization software package developed by MathWorks. It is an add-on product to Matlab, and provides a library of solvers that can be used from within the Matlab environment. Optimization Toolbox provides functions for finding parameters that minimize or maximize objectives while satisfying constraints. The toolbox includes solvers for linear programming, mixed-integer linear programming, quadratic programming, nonlinear optimization, and nonlinear least squares. Users can use these solvers to find optimal solutions to continuous and discrete problems, perform trade-off analyses, and incorporate optimization methods into algorithms and applications.
Tomlab	Tomlab Optimization Environment	Seattle, Washington, U.S.	North America	The Tomlab Optimization Environment is an end-to-end optimization and modeling package for solving applied optimization problems in Matlab. Tomlab provides a wide range of features, tools and services for the user's solution process, such as a modeling class (tomSym) for source transformation, many algorithms for linear, discrete, global and nonlinear optimization, call compatibility with MathWorks' Optimization Toolbox, and a large number of fully integrated FORTRAN and C solvers.

Source: Gartner (May 2015)

Optimization Solvers

While there are several vendors in the optimization modeling platform market that also make solvers, the solver market is a separate segment. Many optimization platforms can call any number of solvers — including open-source ones. The following is a representative list of commercially available solvers. Open-source solvers include Computational Infrastructure for Operations Research (COIN-OR) branch and cut (Cbc), GLPK, Ipopt and PATH (see Table 17).

For all solvers listed below:

- The "Employees on Product" row lists the full-time equivalents dedicated exclusively to the optimization solver of the company as reported by the vendors.
- The "Percentage of Solver Revenue From OEM Relationships" and "Percentage of Customers That Are OEM Customers" rows are indicative for the financial year 2014 as reported by the vendors.

Arki Consulting & Development (Conopt)

www.conopt.com

Conopt is a solver for large-scale nonlinear programming (NLP) developed and maintained by Arki Consulting & Development, a company founded in 1986 and headquartered in Bagsvaerd, Denmark.

Conopt is a feasible path solver based on the generalized reduced gradient (GRG) method with many newer extensions. Conopt also has a multimethod architecture combined with built-in logic for dynamic selection of the most appropriate method. Conopt has been designed for large and sparse models. Models with over 10,000 constraints are routinely being solved and specialized models with up to 1 million constraints have also been solved with it.

Table 10. Conopt Overview

Attributes	Details
Vendor Name	Developed and maintained by Arki Consulting & Development
Employees on Product	1
Licensing Model	Perpetual license with maintenance option
Most Common Use Cases	Not available
Notable Customers	Not available
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	Yes
Optimization Platforms to Which This Solver Can Be Delivered via OEM	Available with GAMS, Lindo, AIMMS, AMPL, Mosek and other recognized platforms
Percentage of Solver Revenue From OEM relationships	100%
Percentage of Customers That Are OEM Customers	100%
Does the Solver Run in a Parallel/Multithreaded Environment? (Yes/No)	No

Source: Gartner (May 2015)

FICO (Xpress)

www.fico.com

The FICO Xpress-Optimizer is a commercial optimization solver for LP, MILP, QP, QCQP, second-order cone programming (SOCP) and their mixed-integer counterparts. It is developed and maintained by FICO, which was founded in 1956 and is headquartered in San Jose, California, U.S. Xpress includes a range of linear algorithms and a general-purpose nonlinear solver through successive linear programming (SLP), and optionally incorporates Knitro. Xpress includes its modeling language Xpress-Mosel and was originally developed by Dash Optimization, which was acquired by FICO in 2008.

Table 11. Xpress Overview

Attributes	Details
Vendor Name	FICO
Employees on Product	About 10
Licensing Model	Perpetual or term licenses. Combination of per seat (for the UI) with per CPU or user for the optimization capacity.
Most Common Use Cases	Customer strategy optimization (pricing, collections and credit) Marketing optimization (customer, offer and channel) Energy (distribution and unit commitment)
Notable Customers	American Airlines, Honeywell, Oracle
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	Yes
Optimization Platforms to Which This Solver Can Be Delivered via OEM	Part of large solutions, like Oracle Transport Management
Percentage of Solver Revenue From OEM Relationships	45%
Percentage of Customers That Are OEM Customers	25%
Does the Solver Run in a Parallel/Multithreaded Environment? (Yes/No)	Yes: Xpress leverages the available cores for dual simplex, interior-point solvers and search (MIP).

Source: Gartner (May 2015)

Gurobi Optimization (Gurobi Optimizer)

www.gurobi.com

The Gurobi Optimizer is a commercial optimization solver for LP, QP, QCP, MILP, MIQP, and MIQCP. It has been developed by Gurobi Optimization, which was founded in 2008 and is headquartered in Houston, Texas, U.S.

It supports many programming and modeling languages including:

- Object-oriented interfaces for C++, Java, .NET and Python
- Matrix-oriented interfaces for C, Matlab and R
- Links to standard modeling languages: AIMMS, AMPL, GAMS and MPL
- Links to Excel through Premium Solver Platform and Risk Solver Platform

Table 12. Gurobi Overview

Attributes	Details
Vendor Name	Gurobi Optimization
Employees on Product	17
Licensing Model	Perpetual, lease and cloud license options along with OEM/ independent software vendor, application license agreements (ALA) and enterprise license agreements (ELA)
Most Common Use Cases	Supply chain, finance and energy planning, production, and distribution
Notable Customers	The NFL Federal Express NYISO
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	Yes
Optimization Platforms to Which This Solver Can Be Delivered via OEM	Gurobi is available for use with AIMMS, AMPL, GAMS, Matlab and Frontline Solvers
Percentage of Solver Revenue From OEM Relationships	Not available
Percentage of Customers That Are OEM Customers	Not available
Does the Solver Run in a Parallel/Multithreaded Environment? (Yes/No)	Yes: Gurobi has parallel processing and distributed optimization (concurrent and parallel MIP) capabilities in its solver.

Source: Gartner (May 2015)

IBM (CPLEX Optimizers)

www.ibm.com

The CPLEX Optimizers from IBM are high-performance solvers for linear programming (LP), mixed-integer programming (MIP), all types of quadratic programming (QP/QCP/MIQP/MIQCP), and constraint programming problem types. The math programming solver and constraint programming solvers include various algorithms such as simplex, barrier (interior point), branch and cut, network/ embedded network, local search, genetic algorithm (GA), edge finder and distributed parallel MIP algorithms.

IBM CPLEX Optimization Studio includes IBM CPLEX Optimizers for math programming, constraint programming and constraint-based scheduling. All IBM optimization algorithms and solvers can work in-memory to be modified and share solution/data, especially in problem decomposition. It is

noteworthy that IBM, through its IBM Academic Initiative, provides free CPLEX licensing to more than 1,000 universities worldwide in support of research and teaching.

Table 13. IBM CPLEX Overview

Attributes	Details
Vendor Name	IBM
Employees on Product	Not available
Licensing Model	For development users: authorized and simultaneous user licenses. For on-premises deployment: perpetual license and monthly rental with CPU/PVU capacity and client device license for small desktop and device embedding. For its cloud offering: flexible pay-as-you-go plan, committed hours, or reserved capacity plans, without requiring license or installation.
Most Common Use Cases	Production planning and scheduling applications Inventory management Logistics
Notable Customers	Indeval Continental Tire Swiss Federal Railways
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	Yes
Optimization Platforms to Which This Solver Can Be Delivered via OEM	Key partners to which IBM OEMs its solver include: GAMS, Paragon (AIMMS), AMPL, Maximal and Tomlab
Percentage of Solver Revenue From OEM Relationships	Not available
Percentage of Customers That Are OEM Customers	Not available
Does the Solver Run in a Parallel/ Multithreaded Environment? (Yes/No)	Yes: both math and constraint programming solvers' defaults are the shared-memory parallel solving. The math programming solver has distributed parallel MIP algorithm. Remote Object for constructing custom distributed parallel algorithm is also available.

Source: Gartner (May 2015)

SAS (SAS/OR)

www.sas.com

SAS/OR solver comes embedded within its optimization platform and cannot be procured or repackaged separately by other vendors or users. It supports the SAS/OR platform with MILP, LP, NLP, network, QP, local search and constraint logic programming (CLP) optimization problem types.

Its local search optimization capability allows users to solve a wide range of problems and gives them the option of performing either single-objective or multiobjective optimization within its platform. User-defined functions are supported for customization.

It is noteworthy that SAS provides its clients with the ability to integrate SAS/OR with other SAS capabilities, including data, descriptive and predictive analytics, along with BI and query/reporting to construct an end-to-end solution for business analytics.

Table 14. SAS/OR Overview

Attributes	Details
Vendor Name	SAS
Employees on Product	25
Licensing Model	SAS currently supports an annual licensing model, priced according to CPU count and/or number of users, and is typically licensed with other SAS products.
Most Common Use Cases	Pricing and revenue management Human and capital resource allocation Advertising optimization
Notable Customers	Not available
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	No
Optimization Platforms to Which This Solver Can Be Delivered via OEM	Not applicable since this solver is sold only as part of the larger optimization platform (SAS/OR)
Percentage of Solver Revenue From OEM Relationships	Not applicable since this solver is sold only as part of the larger optimization platform (SAS/OR)
Percentage of Customers That Are OEM Customers	Not applicable since this solver is sold only as part of the larger optimization platform (SAS/OR)
Does the Solver Run in a Parallel/ Multithreaded Environment? (Yes/No)	Yes: Its concurrent solve capability, Branch and cut algorithm, decomposition algorithm, and linear algebra for the interior-point solver are all parallelized.

Source: Gartner (May 2015)

Ziena Optimization (Knitro)

www.ziena.com/knitro.htm

http://artelys.com/en/optimization-tools/knitro

Knitro is developed by Ziena Optimization, which was founded in 2001 and is headquartered in Evanston, Illinois, U.S. It is distributed worldwide by Artelys, which is headquartered at Paris, France.

It is a robust solver for NLP problems. Leveraging its four algorithms, it can solve complex problems, including problems with complementarity constraints, equality and inequality constraints (both convex and nonconvex), and bound constraints. Special handling is also provided for linear programming (LP), quadratic programming (QP), systems of nonlinear equations, and nonlinear least squares problems. Knitro 6.0 and higher can also be used to solve mixed-integer nonlinear programming (MINLP) problems.

Table 15. Knitro Overview

Attributes	Details
Vendor Name	Developed by Ziena Optimization and distributed by Artelys
Employees on Product	3
Licensing Model	Perpetual license: per user or per CPU (if there are multiple users)
Most Common Use Cases	Economics/statistics Energy/process optimization Optimal control
Notable Customers	Not available
Is the Solver Available to Other Optimization Platforms via OEM? (Yes/No)	Yes
Optimization Platforms to Which This Solver Can Be Delivered via OEM	FICO Xpress Optimization Suite, AMPL, Matlab, MPL, AIMMS, GAMS, FrontLine
Percentage of Solver Revenue From OEM Relationships	Not available
Percentage of Customers That Are OEM customers	Not available
Does the Solver Run in a Parallel/Multithreaded Environment? (Yes/No)	Yes: Knitro offers capabilities to exploit parallel computations on shared-memory multiprocessor machines. These features include: parallel finite-difference gradients, parallel multistart, parallel algorithms, parallel basic linear algebra subroutine and parallel sparse linear system solves.

Source: Gartner (May 2015)

Table 16. Supported Math Program Types by Solvers

Optimization Solvers	Linear Programming (LP)	Mixed Integer Programming (MIP)		Quadratic Programming (QP)	Mixed-Integer Quadratic Programming (MIQP)	Quadratically Constrained Quadratic Problem (QCP)	Mixed-Integer Quadratically Constrained Programming (MIQCP)	Nonlinear Programming (NLP)	Mixed-Integer Nonlinear Programming (MINLP)	Global Optimization (GO)	Constrained Programming (CP)	Others
Conopt	X			X		x		X				
Gurobi Optimizer	X	X		X	X	X	X					Piecewise linear optimizer for approximating nonlinear functions
IBM CPLEX Optimizers	X	X		X	X	X	X			X	X	▪ Network and embedded network ▪ Robust optimization and stochastic programming ▪ Populate algorithm to generate alternative MIP solutions

Optimization Solvers	Linear Programming (LP)	Mixed Integer Programming (MIP)		Quadratic Programming (QP)	Mixed-Integer Quadratic Programming (MIQP)	Quadratically Constrained Quadratic Problem (QCP)	Mixed-Integer Quadratically Constrained Programming (MIQCP)	Nonlinear Programming (NLP)	Mixed-Integer Nonlinear Programming (MINLP)	Global Optimization (GO)	Constrained Programming (CP)	Others
Knitro	X	X		X	X	X	X	X	X	X		▪ Mathematical programs with complementary constraints (MPCC/MPEC) ▪ Derivative-free optimization (DFO) problems
SAS/OR	X	X		X		X		X		X	X	▪ Network ▪ Local Search
Xpress	X	X		X	X	X	X	X	X		X	Second-order conic programming

Optimization Solvers	Linear Programming (LP)	Mixed Integer Programming (MIP)		Quadratic Programming (QP)	Mixed-Integer Quadratic Programming (MIQP)	Quadratically Constrained Quadratic Problem (QCP)	Mixed-Integer Quadratically Constrained Programming (MIQCP)	Nonlinear Programming (NLP)	Mixed-Integer Nonlinear Programming (MINLP)	Global Optimization (GO)	Constrained Programming (CP)	Others
X = Math program type is supported by the solver. For the definitions and explanations of each math problem type, refer to the Appendix.												

Source: Gartner (May 2015)

Please note: Frontline Systems also offers a family of solvers that work with Excel. We did not have sufficient information to include them in this research.

Open-Source Solvers

Table 17. Common Open-Source Solvers

Solver	Developer	About	Type of Programming	Adapters to standard modeling platforms
COIN-OR branch and cut (Cbc)	COIN-OR	COIN-OR branch and cut (Cbc) is a commonly used open-source mixed-integer programming solver written in C++. It can be used as a callable library or using a stand-alone executable.	MILP, MIQP	AIMMS, AMPL, GAMS, PuLP, MPL
GLPK	Free Software Foundation (GNU Project)	The GLPK (GNU Linear Programming Kit) package is intended for solving large-scale linear programming (LP), mixed-integer programming (MIP), and other related problems. It is a set of routines written in ANSI C and organized in the form of a callable library. GLPK supports the GNU MathProg modeling language, which is a subset of the AMPL language.	LP	AMPL
Ipopt	COIN-OR	A part of the COIN-OR project, Interior Point Optimizer (Ipopt) is a software package for large-scale nonlinear optimization. It is designed to find (local) solutions of mathematical optimization problems	QP, QCP, NLP	AIMMS, AMPL, GAMS, Matlab
PATH	University of Wisconsin	The PATH solver is a Newton-based solver for solving mixed complementarity programming (MCP) problems. The PATH solver is extensively used by economists for solving general equilibrium problems.	Mixed-complementarity programming (MCP)	AMPL

Source: Gartner (May 2015)

Market Recommendations

Business analytics leaders considering optimization solutions should first identify the decisions to improve in your organization and determine if optimization is the right approach. This includes, but is not limited to, the ability to frame the decision as an optimization problem and determine if there is sufficient data to support optimization. If needed, seek advice from those with optimization expertise. Then, use this guide to determine the solution type for your needs and skills.

Analytics teams new to optimization should begin with packaged optimization applications aimed at business users, if they exist for your problem, or work with skilled service providers. Analytically mature teams, with the appropriate skills, can evaluate optimization modeling platforms or configurable optimization applications to maximize the reach and benefits that optimization can deliver to different problems across your organization.

Appendix

Table 18. Math Programming Types and Their Definitions

Programming Type	Definition
CP	Constraint programming (CP) is the process of solving a system of constraints of various types over a set of unknown discrete variables possibly along with an objective function to be maximized or minimized. Part of the attraction of CP is that it enables the capturing of many structures observed in reality in a very natural manner. It may use, for example, "AllDifferent" and "Sequence" constraints, element-valued variables and the Resource and Activity concepts.
GO	Global optimization (GO) is a branch of applied mathematics and numerical analysis that deals with the global optimization of a function or a set of functions according to some criteria. Typically, a set of bound and more general constraints is also present, and the decision variables are optimized considering also the constraints. Global optimization is distinguished from regular optimization by its focus on finding the maximum or minimum over all input values, as opposed to finding local minima or maxima.
LP	Linear programming (LP) is a mathematical technique used in solving a variety of problems related with management, from scheduling, media selection and financial planning to capital budgeting, transportation and many others, with the special characteristic that linear programming expects always to maximize or minimize some quantity. Linear programming helps to make the best possible use of available productive resources. Linear programming problems involve the linear optimization of a linear objective function, subject to linear equality and inequality constraints. In addition, all variables in a linear programming model are continuous.
MINLP	Mixed-integer nonlinear programming (MINLP) problems contain nonlinear expressions and integer variables. MINLP problems are in general more difficult to solve than mixed-integer programming problems and nonlinear programming problems.
MIP	Mixed-integer programming (MIP) problems involve the optimization of a linear objective function, subject to linear equality and inequality constraints. Some or all of the variables are required to be integers. Mixed-integer programming problems are in general more complex to solve than linear programming problems.
MIQCP	A mixed-integer quadratically constrained program (MIQCP) is a special case of the MINLP in which all the nonlinearities are required to be quadratic.
NLP	Nonlinear programming (NLP) is the process of solving a system of equalities and inequalities, collectively termed constraints, over a set of unknown real variables, along with an objective function to be maximized or minimized, where some of the constraints or the objective function are nonlinear.
Piecewise Linearization Methods	NLP problems are often solved using a piecewise-linear approach, where nonlinear functions are approximated using a set of linear pieces. The resulting model will have more variables and constraints than the original, but it can be solved by an LP or MIP solver.
QCP	A quadratically constrained program (QCP) is a special case of the nonlinear programming in which all the nonlinearities are required to be quadratic. Solving a model using the QCP model type allows LP solvers to be used to solve quadratic models as well as linear ones. Some NLP solvers may also take advantage of the special (quadratic) form when solving QCP models.
QP	Quadratic programming (QP) involves minimizing or maximizing an objective function subject to bounds, linear equality, and inequality constraints. Example problems include portfolio optimization

Programming Type	Definition
	in finance, power generation optimization for electrical utilities, and design optimization in engineering.
Stochastic Programming	Some mathematical programming types, including linear programming, mixed-integer programming and nonlinear programming, have a common assumption that all the input data used in the formulation of the mathematical program is known with certainty. This is known as decision making under certainty, and the corresponding models are called deterministic models. Models that account for uncertainty in the input data with a set of scenarios are called stochastic models. The theory and techniques used to solve stochastic models is commonly referred to as stochastic programming and stochastic optimization.

Source: Gartner (May 2015)

Acronym Key and Glossary Terms

AIMMS	Advanced Integrated Multidimensional Modeling Software
API	application programming interface
CICS	customer information control system
CPU	central processing unit
FTP	File Transfer Protocol
GA	genetic algorithm
IMS	information management system
JDBC	Java Database Connectivity
JMS	Java Message Service
MILP	mixed-integer linear programming
MIQP	mixed-integer quadratic programming
MSMQ	Microsoft Message Queuing
OEM	original equipment manufacturer
OSI	Open Systems Interconnection
PVU	Processor Value Unit
REST	Representational State Transfer
SDK	software development kit
SOAP	Simple Object Access Protocol

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

"How to Get Started With Prescriptive Analytics"

"An Eight-Question Decision Framework for Buying, Building and Outsourcing Data Science Solutions"

"Extend Your Portfolio of Analytics Capabilities"

"Critical Capabilities for Advanced Analytics Platforms"

"Combine Simulation and Optimization for More Effective Supply Chain Modeling"

"Market Guide for Unified Price, Promotion and Markdown Optimization Applications"

"Hype Cycle for Advanced Analytics and Data Science, 2014"

"Hype Cycle for Customer Analytic Applications, 2014"

"Hype Cycle for Back-Office Analytic Applications, 2014"

Evidence

In 2Q15, Gartner conducted a survey on optimization platforms and solvers. Out of 15 vendors invited to participate, there were 10 submissions based on the attributes of a representative vendor. The respondents were AIMMS, AMPL Optimization, Arki Consulting & Development, Artelys, Gurobi Optimization, FICO, IBM, Portfolio Decisions, River Logic, and SAS.

The information we received through the survey was augmented (where appropriate) by publicly available information and our interactions with Gartner clients. Due to the fluid nature of this market, no references were requested or references contacted for this research, so the information that was not publicly available could not be independently verified for accuracy. Due to the timing of the survey, the results submitted are considered to apply to the end of April in the calendar year 2015.

Vendors received a copy of the information for factual review prior to publication.

Note 1 Monte Carlo Simulation

Monte Carlo simulation is a computerized mathematical technique that allows users to account for risk in quantitative analysis and decision making. It is often used in physical and mathematical problems and is most useful when other mathematical methods are difficult or impossible to use. Monte Carlo simulation furnishes the decision maker with a range of possible outcomes and the probabilities that they will occur for any choice of action.

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