Optimization for Dummies

Learn:
- What optimization is
- How to make optimization work for your organization
- Ways to be competitive with optimization

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Gurobi Optimization

Sanjay Saigal
Gurobi Optimization is dedicated to offering robust, high-performance optimization software based upon the latest technologies for linear, quadratic, and mixed-integer programming. Gurobi focuses on delivering top optimization performance and exceptional support to enable organizations to succeed with their optimization projects.

*Top performance — great interface options — straightforward licensing*

*Dedicated to Making You Successful with Optimization*
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These materials are the copyright of John Wiley & Sons, Inc. and any dissemination, distribution, or unauthorized use is strictly prohibited.
Welcome to Optimization For Dummies, Gurobi Special Edition! If you are considering an optimization-based solution for your business, you may have a lot of questions. What exactly is optimization? Is it different from other IT technology you use today, and if so, how? What kind of problems can optimization tackle? What sort of return on investment have other adopters seen? And if you do decide to optimize, how should you go about it? Are there unique challenges to implementing an optimization-based system? Should you do it in-house, or hire an outside provider? This book can help you answer these questions, and more.

About This Book

This book explains what optimization is and how it can help your business. We give lots of examples of successful companies that have used optimization to become even more successful. Today, optimization is used for everything from displaying and pricing store merchandise to deciding on which aircraft an airline should buy, and everything in between.

Foolish Assumptions

This book is directed towards a professional evaluating a business process improvement project that may involve optimization. It assumes that you are familiar with information technology (IT) practices and processes.

How This Book Is Organized

This book consists of four short chapters, each written to stand on its own. So feel free to start reading anywhere and skip around throughout the book!
Chapter 1: Understanding Optimization focuses on a basic grounding in optimization: what it is, how it works, and what the sometimes bewildering jargon of optimization really means.

Chapter 2: Optimization at Work is all about case studies — we name names and cite examples of real-world optimization success stories.

Chapter 3: Optimization: First Steps covers the basic issues to address as you start an optimization project: understanding the different types of optimization, enumerating the essential steps before you start your effort, and evaluating the pros and cons of building your own solution versus working with a vendor.

And in true For Dummies style, Chapter 4: Ten (Okay, Five) Reasons to Choose Gurobi presents five best reasons to choose Gurobi as your optimization provider.

Icons Used in This Book

For Dummies books use these icons to mark important points along the way.

When you see this icon, get ready to file away an important fact or a reminder for future reference.

Technical Stuff is just that: stuff that’s interesting but not necessarily vital for you to know.

Tips are important pointers to help you get things done or suggestions that will give you an edge in your decision-making process.

Where to Go from Here

Hey, it’s your book. Dive in anywhere or simply turn the page.
Chapter 1
Understanding Optimization

In This Chapter
▶ Taking a look at better business decisions
▶ Understanding the right time to apply optimization
▶ Realizing what optimization really is
▶ Doing it (optimizing) now!
▶ Getting up to speed on the jargon

You’ve probably heard the old saying that information is power. But that only holds true if insight can be extracted from information. How can a business turn data into profitable action? One answer you hear more often these days is . . . by using optimization.

Optimization is the generic label for an array of computational techniques that chew up vast quantities of data — store-level sales, machine uptimes, the price of tea in China, you name it — and in turn, spit out recommendations for common business processes — for example, price promotions, production planning, or material procurement.

Optimization is ubiquitous, embedded in software governing business processes ranging from airline reservations to lumber harvesting to online advertising. As with all information technology (IT), deploying optimization brings great benefits, but also a unique set of risks.

This chapter explains the nature of optimization, how it may help with your business challenges, and how to best harness its potential.
Making Better Business Decisions

The business environment today obviously poses unique and unprecedented opportunities and challenges. The unexpectedly rapid fall of global trade barriers and the increasing fluidity of information have created a cut-throat, competitive business environment. In reaction, new business platforms and tools have surfaced to deal with the challenges of this flood of data.

Twenty years ago, few “civilians” had heard of web marketing analytics, supply chains, or revenue management. But with the rise of Google and Wal-Mart and low fare airlines, these terms have become an essential part of the conversation. What do they have in common? All use data in large volumes to drive profitable decisions. And in many of them, optimization is the “secret sauce.”

Optimization is simply a mathematically sophisticated way to represent a business process in software. Built well, an optimization model uses relevant data and business rules to recommend decisions that generate the best possible result. The three key elements of an optimization model are

- **Objectives:** These are your business goals. Objectives can include goals such as maximizing profit, shrinking the quote-to-cash cycles, reducing shipment costs, or whatever else you want to minimize or maximize.

  *Note:* Objectives often conflict. For example, when you’re setting up a stock portfolio, maximizing your expected return will most likely produce a very risky portfolio. In such *multi-objective* situations, modelers find clever ways to balance different objectives. Most businesses optimize for one objective at a time.

- **Variables:** These are geek-speak for decisions in your control. Suppose you manage a refinery. Is the price of crude oil in your control? Um, no, no matter how much you might wish it were. How about how much West Texas Intermediate Crude you refine? Yes. In your production model, the amount of crude oil will be a variable. The forecast oil price? Simply data.
Chapter 1: Understanding Optimization

Variables are decisions you want to make in an optimization model.

✓ **Constraints:** Think of constraints as business rules or realities relevant to the optimization model. A factory only has so many workers on the swing shift. A portfolio manager is not allowed to invest more than a certain fraction in the tech sector. An arriving aircraft requires so many minutes for cleaning and refueling. All of these are constraints.

Put these three types of elements together and you get an optimization model. Program the optimization model into a computer and integrate it with a solver (a kind of number crunching machine) and a user interface, and you have yourself an optimization system. If fed good data, the system outputs best possible decisions.

“Best possible” has two parts: “best” and “possible.” “Best” means that no other decisions can yield a better objective. And “possible” means that the decision does not conflict with any of the business rules encoded in the constraints. We re-emphasize this important point later on in the chapter.

**Knowing When to Optimize**

Now that you know what optimization entails, consider how it fits into a typical business process flow. Specifically, look at what processes most benefit from optimization.

The first characteristic of an “optimizable” process is rich data. Optimization perfectly illustrates the adage “garbage in, garbage out.” The more accurately you measure what you’re doing, the greater your potential to improve.

As an example, delivery services such as FedEx and UPS minimize operation costs in large part through optimization. As part of their rich data collection, they track turn-by-turn locations of each vehicle, real-time traffic, operating costs, and continuously refreshed pick-up and drop-off information.

Another key factor for applying optimization is repeatability. While optimization has been applied with success to one-off decisions — the U.S. Federal Communications Commission’s 2008 auction of cellphone frequencies comes to mind — it
is more typically used to improve decisions that occur regularly, even frequently. For example, the National Broadcasting Company (NBC) uses optimization to sell “up front” television advertising every year, Marriott and Intercontinental use it to optimize their room inventory, and Hewlett Packard uses it to plan and run manufacturing. These are all repetitive processes where squeezing out even a 0.1 percent gain in efficiency can translate to millions of dollars.

Finally, optimization is most suited for complex, resource-constrained situations. Advertising seconds are a television network’s most precious commodity. The same holds true of rooms in a hotel for a hotel chain or expensive machine and staff time on a factory floor.

Further, in such situations, where the overall structure of the process may stay constant over time, ever-changing operating conditions — adding a Super Bowl to regular TV programming, a large convention booking to a hotel, or scheduled maintenance to a shop floor, to name three examples — can drastically change the economics from day to day, or even minute to minute. Optimization is the perfect technology for such complex and dynamic processes.

**Optimization Isn’t Just a Fancy Name for Automation**

While reading this chapter, you might be thinking, “This sounds good, but aren’t my IT systems already doing all this? Isn’t that what I should expect from my company’s Customer Relationship Management (CRM) or Enterprise Resource Planning (ERP) or Business Process Management (BPM) system?” No. Not really.

Most business IT systems — such as CRM and ERP — are essentially data repositories with a light sprinkling of rule-based automation. For example, the Salesforce Automation capability in your CRM may assign new leads to salespersons. That’s decision-making of a sort. But such assignment rules have to be defined up front, such as: “Calls from Canada are routed to Tracy.” The CRM can’t tell you which salesperson should be assigned the lead to maximize profitability; an optimization-based system can.
Chapter 1: Understanding Optimization

BPM systems are more sophisticated in terms of decision-making. But even they rely on pre-defined business rules that can only make as good a recommendation as the intuition behind them. In effect, the analyst has to pre-specify all possible situations that might occur. Recognizing this problem, leading BPM vendors have begun to market “analytic decision management” as a value-added feature. This is usually an optimization system bolted on to a rules framework.

**Optimize Now!**

At this point, you may be saying: “My business has been going just fine. Why do I need the headache of deploying a new technology in my IT toolkit now?” The answer is in two parts.

First, virtually no business today is sheltered from the flow of information, goods, and services across the global economy. That has created a situation in which competition can come at you from anywhere. Business as usual is simply not an option.

Disruptive technologies no longer occur sporadically. As companies become innovation-driven, they’re the norm. You can bet your competitors are trying to leverage every possible tool, including optimization, to gain an edge over you.

Second, understand that even though optimization may not be as widely known as some other analytics technologies (data mining, for example), its impact is ubiquitous: Every time you price a weekend flight, go to the ATM to withdraw money, or mail a return expecting it to get to the IRS on time, you rely on optimization. All airlines, most banks, and the United States Postal Service (USPS) have long used optimization to price seats, stock ATMs with cash, and sort and route mail. To be a world-class competitor implies using optimization. A manager ignoring optimization is leaving money on the table.

It is important to understand that optimization doesn’t simply add intelligence to existing business processes. It changes business practices.

As an example, consider scheduling power generators at an electric utility. The business issue seems fairly straightforward: schedule a power plant operation for the week to get the lowest cost while meeting anticipated demand and regulatory requirements.
Such optimized scheduling is impossible to do well without using optimization. But wait, there’s more! Once an optimal scheduling system is in place, a utility can also use it to track and control emissions. Planners can even simulate operations over longer periods — months or years — which lets them find ways to be “green” without losing sight of economic considerations.

In short, optimization isn’t simply about one-upping competitors. It’s also about helping businesses pivot from complexity to innovative practice.

In Chapter 2, we discuss how optimization can enable dramatic performance improvement.

Learning the Jargon

Now that you have a feel for optimization, this a good time to lay down its building blocks. We begin by revisiting three basic concepts:

- **Objectives**: The business goal or preference you want to maximize or minimize, such as profit or throughput.
- **Variables**: Decisions made in pursuit of the objective.
- **Constraints**: Rules that influence or limit your decisions.

Here are additional terms that are important to know.

*Optimization* is a mathematical discipline for finding best possible decisions where you have a multiplicity of rules, limitations, and preferences. Optimization is usually implemented in computer algorithms, that is to say, software.

A *model* is made up of variables, constraints, and an objective corresponding to a specific business problem. A model with its data completely available is called an *instance*.

Assign values to all variables in an instance, and you have a *solution*. If the solution satisfies all constraints, it is called *feasible*. If there’s no better solution, it’s called *optimal*.

The *solver* is the computational engine that reads in an instance and spits out the optimal feasible solution. Creating an optimization model is quite different from solving it. So modelers typically do not write their own solvers; instead, they rely on solvers from companies such as Gurobi.
Chapter 2
Optimization at Work

In This Chapter
▶ Using optimization to sell television advertising
▶ Scheduling a truck fleet with optimization
▶ Optimizing highly automated manufacturing
▶ Improving call center employee seat assignment

This chapter is all about exploring the power and reach of optimization in improving business efficiency. Optimization has been used to increase profitability and improve operations across the business spectrum for more than five decades. The following success stories are taken from a variety of business settings, industry sectors, and applications. Keep in mind, however, that these short descriptions represent only the tip of the iceberg.

Must-Sell TV: Pricing Ad Time

Today, optimization is an essential tool to manage on-line advertising at companies such as Google. However, some 15 years ago, before on-line advertising became the revenue juggernaut it now is, NBC pioneered the use of optimization to maximize television advertising revenues by creating a recommendation engine for pricing and scheduling advertising blocks.

NBC’s optimization model compared all available time-slots against the customer’s viewership requirements, generating multiple scheduling alternatives for each customer. Based on the demand for the shows — recall that it was the heyday of “must-see TV” with marquee shows like Friends and ER — the system also measured the price pressure for each alternate
schedule. The latter capability allowed sales staff to close deals using pricing tuned to maximize profitability.

NBC calculated that its optimization-based ad sales system increased revenues by at least $50 million annually. Just as important, it sped up the sales plan generation from hours to around 20 minutes. This dramatically improved NBC’s response times and deal-making flexibility, helping the network cement its market lead while continuing to charge a market leader’s premium.

**Dance of the 30-Ton Trucks: Scheduling Cement Delivery**

Yes, that really is how developers describe their system for scheduling and dispatching concrete trucks for Virginia Concrete, whose 125 computerized trucks deliver 400–600 loads of concrete every day. Delivering a highly perishable product over congested city streets, in a setting where 90 percent of all orders change before delivery, is a challenge that only optimization can meet.

The optimization-based system determines everything from which orders should be accepted to when drivers should report for duty. It assigns drivers, in real-time, to delivery loads, dispatches trucks to customers and back to plants, and schedules loading at each plant.

As per the most recent public reports, the software had provided significant benefits beyond the $750,000 estimated yearly savings. Its deployment improved employee retention and made scheduling more uniform and less dispatcher dependent. Most impressively, the company began promoting optimization-based dispatch as an industry best practice.

**Fast Fab: Automating Semicon Manufacturing**

First-tier microprocessor manufacturers such as Samsung and TSMC fabricate 300 mm silicon wafers for the mass market.
These highly advanced chip fabrication plants, or fabs, are fully automated, with up to 30,000 dispatch operations every day. Humans do not touch silicon at any stage.

Due to the need for speed, real-time dispatch within each manufacturing module, or tool, is governed by static dispatch rules. However, such a system cannot look across tools to detect backups and choke-points. It cannot adjust to changing business conditions. That calls for optimization-based scheduling.

The most advanced fabs in the world use optimization to run at peak efficiency. Publicly available IBM benchmarks show that optimization, running continuously through the day, improves throughput (the number of chips fabricated) in its 300 mm plant by 10 percent and cycle times (how long it takes a wafer to exit the factory) — a key performance indicator for fabs — by 25 percent! For a single plant, this translates to a return on investment (ROI) of up to $30 million per year.

**Visual Chairs: Seating Shift Workers**

A well-known e-commerce vendor has a call center to assist its millions of customers over the phone. Hundreds of customer service reps (CSRs) are grouped into teams. Team members work similar shifts, but not all report to work at the same time and not all leave simultaneously.

To promote learning and build morale, company policy mandates that team members should sit near each other. Due to growth in the number of customers, space at the call center is at a premium. CSR team seating used to be assigned through a painstaking manual process: A dedicated staff analyst spent hours every week poring over a large spreadsheet to create a seating chart for the upcoming roster.

Naturally, the manual process had its shortcomings. First and foremost, it was incredibly slow, requiring more than half a day’s time every week. Second, because the previous week’s chart was used as a basis for the following week, the assignment changed only incrementally from week to week. This
implicit preference for small changes caused unnecessary team splits. While it was accepted that manually created seating charts were not necessarily the best, there was no way to know how far away from optimality they were.

The new optimization solution, implemented using Gurobi, automatically seats teams to minimize splits while obeying numerous workplace rules and management preferences. The optimization-based tool automates and speeds up a previously laborious and error-prone manual process. What distinguishes this model from the other examples is that it’s not about economics; it’s about improving a set of fuzzy and often conflicting criteria.

Extensive validation has shown that not only are the new seat maps quicker to create, but they also are subjectively comparable with those produced by hand.

The most important potential benefit the new optimization-based process offers is this: Because good seating plans are now generated quickly, automatically, and without errors, managers can, for the first time, simulate the impact of a workplace scenario or policy change in advance, at no cost, simply by running the seat assignment system over multiple scenarios.

The benefits of an optimization-based IT project often extend well beyond their original scope. While such projects are usually launched to improve an existing process, optimization often makes it possible to improve the larger business function that encapsulates that process.
Enabling optimization-based improvements in your business requires more from you than just learning about the technology. Success depends on how well your requirements are defined, modeled mathematically, and implemented in software. What makes matters tricky is that an upstream decision can have a potentially dramatic impact on how well the software performs and how well the results address your business needs. In this chapter, we cover the most critical of these considerations. We begin with a little more (unavoidable) technical jargon.

**Twenty-One Flavors: Types of Optimization Models**

How a solver works depends on the properties of the variables, constraints, and objectives of the model it’s meant to solve. We begin with the most basic properties:

- **Linearity** is a simple concept: If a widget costs $100, two widgets cost $200. And if a dongle costs $150, two widgets and five dongles cost $200 + 5 * $150 = $950.

- **Integrality** means necessarily expressed in whole units, or integers. For instance, you can only produce 4 widgets or 5, but not 4.3. So the variable for widget production has to be defined to be integral. In contrast, an airplane may fly 18.25 hours in a day. It isn’t limited to 18 or 19 hours. Its daily utilization corresponds to a continuous variable.
Now, get ready for more technical information; but don’t worry, there’s no quiz at the end.

If all of a model’s variables, constraints, and objectives are linear, you’re solving *linear programs* (LP). Solving models that aren’t linear is the province of *nonlinear programming* (NLP). Linear optimization is usually quicker and more robust than nonlinear optimization.

A particular type of nonlinear objective or constraint often encountered in financial and pricing models is called *quadratic*. *Quadratic programming* (QP) is slower than LP, but it is usually faster than general programming, that is, non-QP, NLP. An LP model with variables constrained to be integral is called an *integer program* (IP). If it has a mix of integral and continuous variables, it is a *mixed integer program* (MIP). MIP models are common; pure IP models are much less common.

LP solvers usually contain one or both of two algorithms. The simplex method (1947) works well across the board. The interior point method (mid-1980s) usually works better for larger LPs.

The general-purpose method to solve MIPs — called *branch-and-bound* — uses LP algorithms, which is why the two model types are commonly combined and called LP/MIP.

Nonlinear programming (NLP) is quite another kettle of fish. Algorithms for handling nonlinearity differ from LP/MIP algorithms, both in mathematical theory and in computer implementation. Developing an NLP-based application requires a significantly different, arguably greater, effort at the model-solver interface. An LP solver that broadly performs well on LP benchmark libraries is likely to perform well on your model. The same cannot be said for NLP. Achieving respectable performance requires much more effort in selecting and customizing the right NLP solver to your NLP model.

The previously described properties of models and algorithms lead to the following general rules (true as of this writing):

- ✔ LPs with hundreds of thousands of variables are solvable in seconds. The largest LPs have hundreds of millions.
- ✔ MIPs solve slower than comparable continuous models, yet, MIPs with millions of variables are routinely solved.
Quadratic programs (QP) are harder to solve than LPs, but easier than general NLPs. Although QPs are nonlinear, LP/MIP solvers usually include a QP solver.

**Implementation Considerations**

As is likely clear by now, optimization is not a one-size-fits-all technology. Implementing it in your situation requires forethought and planning. In particular, you need to carefully consider the problem scope, your data needs and availability, and whom you select to develop your application:

- **Modeling:** Process improvement efforts often arise from insightful observations — for instance, “our hydro turbine utilization is too low.” But going from that to “Let’s reengineer our generation dispatch process using MIP technology” is hard for the non-expert. The state of the art is evolving, and the rules described previously are approximate. Just because a QP model may take a while to solve doesn’t mean that you should move heaven and earth to avoid using QP. That’s why using the best optimization experts you can identify, and afford, is critical. Optimization modeling is not standard IT.

- **Data:** Because optimization is driven entirely by numeric computation rather than by rule-based inferences, it is highly susceptible to data quality shortfalls. As you begin your optimization project, allocate resources to assess your data needs — and ensure that you set up the needed business processes to maintain data quality over time.

- **Implementer selection:** After you identify an opportunity and develop a preliminary model, you may wish to develop the application using internal resources. This can work, if you have in-house optimization experts. If you do decide to outsource application development, make sure that your service provider staffs your project team with optimization-savvy programmers.

In this regard, note that solver vendors take considerable pains to develop competence networks of optimization experts. Because their business is selling solvers, not labor hours, they can provide objective advice in all project phases. You should not hesitate to use them.
Build or Buy?

Organizations that employ optimization experts often create their own applications. For others — this includes most companies — the main options are hiring consultants to write a custom application or purchasing a software suite. Each option carries pros and cons.

If you hire someone to develop custom software, expect to receive a solution uniquely adapted to your needs. However, the developer will need to spend time learning about your world. Practical optimization modeling also has an experimental flavor, so your project risks will be higher than standard IT projects. Be sure to budget for revisions, cost overruns, and delays.

Customizing pre-existing software to meet your requirements is an attractive option. Not only can it be cheaper, but you can also expect to get software well tested by other users, to learn from the user community, to have the option of deploying the software in multiple applications, and even finally conforming to industry norms through “standard” software. In reality though, your mileage will vary, for the worse!

If you do go down this path, ensure that you understand the implications of adapting your business processes to the vendor’s process model. Differences may require a significant outlay of time and money, maybe enough to negate projected savings. Also consider the possibility that the vendor’s generic framework could cancel any competitive intelligence built into your existing processes. That may, in turn, negate the value opportunity that got you going in the first place.

Finally, in dealing with a vendor, ask yourself: What are you being sold? Some vendors have optimization as their sole line of business. Their business interest lies in getting users to maximize their use of optimization. Other vendors have a broader agenda. The solver is the thin end of their technology wedge. Their business interest lies in selling you a range of products or services. That’s positive if you are in the market for such offerings, and a distraction if not. Consider the vendor’s business drivers while negotiating your solver purchase, especially if you are engaging the same vendor for implementation services.
Chapter 4

Ten (Okay, Five) Reasons to Choose Gurobi

In This Chapter
▶ Looking at the reasons for going with Gurobi

In the For Dummies tradition, here are five top reasons to select Gurobi for your optimization needs.

Performance

Stunningly, over the past 15 years, solver performance has more than doubled every year. In other words, on average, every year the aggregate solution times across benchmark model libraries is half what it was the previous year. If you’re thinking, “Must be because of Moore’s Law,” which states that processor speed roughly doubles every two years, think again! Improvements in solver algorithms make up most of this speed-up, not improvements in computer hardware. Although the company itself is only three years old, Gurobi’s founders have led the performance race over these 15 years.

Since its first release in 2008, independent benchmarks have shown Gurobi to be the fastest LP/MIP solver available. As Gurobi’s engineers work on the next release and the next one after that, maintaining its pole position is among their top goals.

Nearly as important as solution time is numerical stability. An LP/MIP solver relies on finite-precision arithmetic. That makes software susceptible to numerical inaccuracy. As the solver
churns through its calculations, minor errors can build on each other, and sometimes spiral out of control. That is why even highly respected solvers can produce solutions that are simply incorrect. Or, when encountering numerical instability, they slow down. In the worst case, a solver may crash.

Unfortunately there are no public benchmarks for stability. However, stability is among Gurobi’s widely recognized strengths. That is a primary reason that, despite the short time it’s been publicly available, Gurobi has been extensively adopted by the most demanding users of optimization tools — researchers.

**Focus**

A key consideration when adopting a new technology is the nature of your vendor’s commitment to the market. Gurobi began as, and steadfastly remains, an optimization technology-focused company. Thus optimization modelers, application developers, and solutions consultants are its core customer base. That focus manifests itself in everything from its product design to its licensing policies. No surprise then, that despite its relatively recent vintage as a company, Gurobi has gained widespread acceptance. It is important to understand, before making your technology choice, that such tight focus is not a given.

Many vendors enter the solver business via a company merger or technology acquisition. Their business interests tend to lie beyond optimization, either in a platform play (such as BPM, business process management), in their industry focus (for example, supply chain management, finance, and so on), or in selling services. The actual solver counts for a fraction of their revenue and interest.

Others enter the market as developers of specialized computational software, such as modeling languages, numerical workbenches, or spreadsheet add-ins. Some also embed Gurobi as an optional capability. Their R&D focus is usually on their own software, not solvers. Consulting firms, often offering deep industry expertise, may also sell solvers. Many of them are also Gurobi partners. Their business focus is IT services, not solver technology.
Gurobi’s focus on its solver, and only on its solver, sets it apart from the competition.

**User Orientation**

Because many solver-enabled systems fulfill “always-on” business functions, they are often considered mission-critical, requiring very high availability guarantees. Solver-related issues cannot be allowed to bring the overlying business process to its knees. For this reason, Gurobi customers have a direct line to optimization experts without having to suffer through non-technical gatekeepers.

Gurobi has made its licensing information and pricing as simple as possible. Licensing is straightforward and flexible, with no hidden restrictions. There are zero additional costs for multi-core processors or parallel architectures. Licenses covered by maintenance may be transferred from one machine to another for no additional cost. You can find the details at [www.gurobi.com](http://www.gurobi.com).

**“Just Right” Features**

As the most recently designed large-scale industrial solver, Gurobi is ideally suited to today’s application development environment.

**Platforms**

The key consideration when selecting a solver is to ensure that, regardless of where you start, IT staff can migrate to another platform as future requirements dictate. Gurobi is available on all major 32- and 64-bit operating systems including AIX, Linux, MacOS, and Windows.

Developers can build optimization applications using Gurobi in leading languages, such as Java, .NET, Python, and C/C++. Gurobi can also be invoked through algebraic modeling languages such as AIMMS, AMPL, GAMS and MPL, computational frameworks such as Microsoft Solver Foundation, and...
scientific computing platforms such as Matlab. For spreadsheet pros, Gurobi is even available as an add-in for Microsoft Excel from Frontline Systems.

**Standards**

The common format for describing linear problems is called *MPS*. Gurobi supports the MPS format, which makes benchmarking against older solvers very simple. In addition, once developers decide to upgrade a software system to Gurobi, its application programming interfaces (APIs) are designed to make the process as simple as possible.

**Model types**

This is an admittedly technical issue, but one critical to IT developers. As mentioned earlier, the bedrock of optimization is a class of models and algorithms called linear programming (LP). However, most real-world applications result in mixed-integer programming (MIP) models. In finance and pricing applications, among others, quadratic programming (QP) models also arise. Gurobi can handle all of these most common model types, usually faster and more robustly than any competing product.

**Live Ecosystem**

Perhaps with the help of this book, you may find it easy to identify opportunities to optimize your business processes. But, unless you happen to have optimization modelers on your staff, you will probably require optimization experts to help implement your ideas. Gurobi has created a network of consulting companies that can help you to implement optimization software while Gurobi focuses on delivering the absolute best solver performance. You can see the list at www.gurobi.com/html/partners.html#consultants.
What you need to know about optimization!

If you are considering an optimization solution for your business, you likely have a lot of questions. What kind of problems can optimization solve? Do you really need to optimize your business processes? Will you get a good enough return on your investment to justify the expense? And if you do decide to optimize, how should you go about it? Do it yourself, or hire an outside provider? This book can help you find the right answers to all of these questions.

- **Understand optimization** — *what it is, how it works, and how to speak its language*
- **Get up to speed on best practices** — *learn from real-world optimization wins*
- **Identify opportunities in your organization** — *recognize where optimization works best*
- **Improve your procurement process** — *know the pros and cons of the build-versus-buy decision*
- **Support your IT team** — *know the major trade-offs of architectural choices*

**Open the book and find:**
- How optimization can help your business become more successful
- How to choose the best optimization software
- Cost/benefit considerations
- The risk factors involved

**Go to Dummies.com** for videos, step-by-step examples, how-to articles, or to shop!

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