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OPTIMIZATION

The Fastest Solver in the World

Choosing a Math Programming Solver

A Step-by-Step Guide

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Introduction

This guide provides all the information you need to choose the best math programming solver for your business requirements. This guide is divided into three parts.

- **Part One: Criteria for Choosing a Math Programming Solver**

  A breakdown of the factors to consider when choosing a solver, whether you're starting an optimization project or already involved in one

- **Part Two: The Right Time to Switch**

  Common scenarios from our customers that indicate it's time to switch to a more robust solver like Gurobi

- **Part Three: The Next Steps**

  How to successfully switch to Gurobi from your current solution

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Solutions

When facing an optimization problem, you need to choose the solver that addresses your business needs.

Types of solutions available include the following:

- Commercial solvers
- Open-source solvers
- Modeling examples or frameworks

When determining which solver is the best fit for your business application, it is important to establish the decision evaluation criteria.

Having switched thousands of customers to Gurobi, we know precisely which factors influence their decision to change: budget and licensing, performance, scalability, professional support, overall ease of use, deployment, and active development.

Another important point to consider is the potential complexity of switching solvers down the road. If you start an optimization project today and a year from now you realize your chosen solver is no longer a good fit, how much work will be required to switch to a more robust solver?

The table below shows the advantages of available commercial and free tools and points out the superior tool for each criterion.

Criterion	Advantage
Budget and Licensing	Free tools
Performance and Scalability	Commercial tools
Professional Support	Commercial tools
Active Development	Commercial tools and some free tools
Deployment	Commercial tools
Ease of Use	Commercial solvers and modeling frameworks
Complexity of Switching	Modeling frameworks

Table 1: Decision criteria and advantages of programming tools.

Criteria

Budget and Licensing

Free tools often don't have licensing fees, while a leading solver like Gurobi requires a license purchase. If your budget is limited or not immediately available, there are a few ways to get started with Gurobi for free. We offer a 30-day trial license for commercial users and provide free full-feature licenses for academic users and researchers. Details are available on www.gurobi.com or by contacting sales@gurobi.com.

Performance and Scalability

Performance is an important criterion when choosing a math programming solver. At Gurobi, we are extremely proud of our solver's performance and industry-leading speed. We achieve and maintain this standard by focusing on research and development and testing our solver against customer models. Many customers are happy to submit their models to us as part of a support request, allowing us to continually improve our product's performance.

At Gurobi, we do our own internal bench-marking against the previously noted model test set.

Our internal test set consequently includes thousands of models. The commercial solver algorithms, capable of handling large, real-world problems, are fine-tuned and exploit parallelization. To further increase solver speed, our APIs and other interfaces are lightweight and capable of swiftly handling large amounts of data.

Free tools, on the other hand, experience significant issues when faced with real-world problems. While typically fast and easy to use on smaller problems, they often struggle to solve a large problem and require a significant amount of model setup time.

As for scalability, we offer the Gurobi Cloud solution, which is a fully managed Gurobi Solver on Microsoft Azure and Amazon Web Services. The Gurobi Cloud allows you to launch one or more computers preloaded with Gurobi software and dedicated to handling your optimization needs. There are several subscription plans and deployment options allowing users to pay for what is used.

The Gurobi Instant Cloud communication is secured with HTTPS encryption. Most Gurobi Cloud plans provide Gurobi Compute Server capabilities, which include queuing and load balancing for an unlimited number of client jobs. These plans also offer distributed optimization capabilities.

The Gurobi Compute Server allows you to build your model on a client and then hand it over to a compute server (a more powerful virtual machine) and run your model on that machine instead of on your client. This helps you create high-performance, fault-tolerant optimization applications that make more efficient use of your computing resources and optimization software licenses.

You can learn more by visiting this Compute Server page and this Instant Cloud page.

Part One: Criteria for Choosing a Math Programming Solver

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Professional Support

Support should be a major point of consideration when choosing a solver. Free tools often have very motivated developers working on improvements, but they offer limited support. Commercial tools, on the other hand, typically have dedicated experts available to help. At Gurobi, we have a team of PhD-level optimization experts and we guarantee fast response times. An additional benefit of working with the Gurobi support team is the two hours of free consulting we provide to our customers. During this session, we evaluate your model and help you make improvements to ultimately gain even better performance. This might include model reformulation assistance, parameter tuning, and more.

Active Development

As one would expect, commercial solvers emphasize active development with version to version improvements, including adding new features and product capabilities, to significantly boost performance. Gurobi's developers are some of the best in the industry, and they devote their days to making the product better and faster with each release. Our development team keep their fingers on the pulse of the optimization community and stay aware of the features and improvements most requested by our current and prospective customers. Many of the features implemented throughout the years originated from ideas and requests from customers who needed them.

Table 2 shows Gurobi's improvements over time – that is, how many of our test set models we were able to solve with each consecutive version. As of 2019, our test set consists of 3,781 mixed-integer programming (MIP) models. You can see that with version 1.1, we were unable to solve 1,045 of our models, while currently we are unable to solve just 104 with version 9.0.

To make a meaningful comparison, all runs are done on the same machine over time: the one we originally used for Gurobi version 1.1. This shows that our developers have continued to make Gurobi faster, more reliable, more robust, and able to progressively solve complex real-world problems.

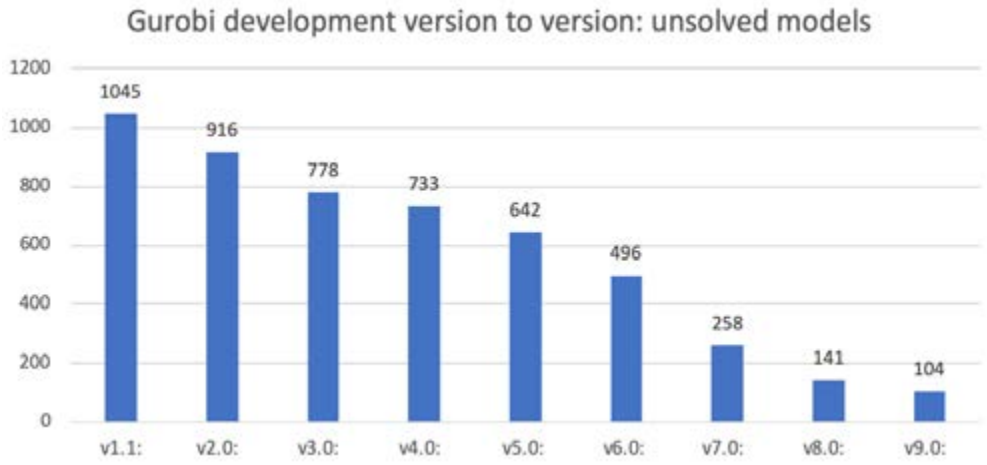

Table 2: Number of unsolved models from the Gurobi library.

Part One: Criteria for Choosing a Math Programming Solver

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Deployment

If your company integrates a solver into a software program and then deploys it to end customers, you need the deployment to go as smoothly as possible. Commercial solvers are capable of providing a stable product that supports this. In contrast, free solvers are limited in their ability to support various operating systems. With a free solver, you do have access to the source code and are able to compile it on a different system, but if an issue occurs, you are on your own with no additional support for a specific platform. As for the modeling frameworks, even though there are commercial frameworks available, you have an additional piece of software that also needs to be deployed. In addition to this, regardless of whether the modeling framework is free or commercial, you will need to consider another license, which creates an additional layer between your data and the actual MIP solver.

Some of the modeling frameworks are file-based, which means that they write out the model to a file and then pass that file to a solver. This sometimes makes things complicated. Commercial solvers support a lot of operating systems, providing you with flexibility when it comes to new situations. If a new or updated operating system comes on the market, commercial solver providers do their best to support it in the next version.

Ease of Use

In an ideal scenario, users want to build up an optimization problem and model it in the easiest possible way, using their programming language of choice. Learning a new syntax makes it cumbersome and difficult for teams to work on the problem together. What helps in such situations are APIs that make the tool easy to use. Free solvers are often limited in the APIs they provide and typically include only C and C++, which creates another barrier for those who prefer Python or other modeling languages.

At Gurobi, we provide APIs for C, C++, .NET, Java, MATLAB, R, and Python.

Modeling frameworks often require that the user models use the syntax specific to the tool. Commercial solvers typically provide APIs to support all popular programming languages. At Gurobi, we provide APIs for C, C++, .NET, Java, MATLAB, R, and Python. Most of our users, including our internal development team, have a preference for the Python API. We continually add more extensions to Python to make it as easy as possible to use, even for those not familiar with programming languages.

Part One: Criteria for Choosing a Math Programming Solver

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Complexity of Switching

Let's say you start an optimization project in which you solve planning optimization problems weekly. Everything is running smoothly until someone on your team says, "Let's not just plan for the week. Let's plan for the whole month – or the whole year!" This is the point where many free tools reach their capability limits. As the models get bigger, the results are sometimes not robust and, in some instances, cannot be solved at all. This is a major reason for switching to a better solver.

If you're currently using a modeling framework, switching solvers is as easy as changing one line of code where the actual solver is called. In some instances, certain modeling languages are limited to specific solvers, which might make the migration process more complex.

> **At Gurobi, we have a team of PhD-level optimization experts and we guarantee fast response times.**

Using modeling frameworks also comes with limitations around features and performance capabilities.

If you're using a commercial solver, switching will require some work since each solver has its own APIs and its own method and calls. You also might have to rewrite some of the code to use a different solver.

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Switching to Gurobi

There are a few common scenarios that indicate it's time to switch solvers. We have heard our customers say:

- ***"Our model is getting larger and it takes too long to solve with our free solver."***

  This is similar to the previously described situation of the optimization project where you start considering a more distant horizon for planning. Or, similarly, you want to look at a situation in more detail and your model is getting larger. This is the point in time when it makes sense – and may be essential – to try a commercial solver like Gurobi.

- ***"The results we're getting are neither robust nor reliable."***

  We have heard this type of comment many times, mostly from those using free solvers. The free tools will often crash or not solve the models at all, as they are unable to handle real-world problems.

- ***"Our model is getting more complex, and our current solver [a competing commercial solver] is running into performance issues."***

  Models often become more complex over time and outgrow the solver that is being used, resulting in infeasible solutions and unsolved models.

Submitting an MPS file to Gurobi Support is a great starting point for gaining efficiencies for your model.

If any of these three scenarios reflects your situation, we recommend you contact sales@gurobi.com to request a free 30-day evaluation license, allowing you to compare Gurobi to your current solution.

As part of this trial, you are welcome to work with our support team and send in your model to see how Gurobi performs on your problem once the team has applied tuning and other performance-enhancing adjustments. As we are the performance leader in speed and numerical robustness, there's a good chance Gurobi will work better on your models, too.

If you are interested in working with our support team and submitting an MPS file for review and tuning, please visit this link to learn more about exporting MPS files from other solvers. You can also submit a case at support.gurobi.com.

Exporting an MPS file is easy. Once you have an active license and have installed Gurobi on your machine, you will call Gurobi from a command line.

For Example: gurobi_cl TimeLimit=3600 MIPGap=0.01 myModel.mps

You can also set a time limit and MIP gap.

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Free 30 Day Trial

If you're interested in trying out Gurobi Optimizer, our Switching to Gurobi page is the place to start. There you will find code examples for various applications and different APIs, as well as full product documentation. You'll also find steps on how to switch from specific solutions, including:

- Switching from open-source linear and mixed-integer programming software and solvers
- Switching within a modeling language
- Switching from IBM CPLEX
- Switching from OPL
- Switching from FICO Xpress

For a no-cost trial, we recommend that you request a free 30-day evaluation license and try Gurobi on your models.This evaluation license comes with two free consulting hours provided by our internal PhD-level support team, who will be happy to discuss your current architecture, the software you're using, how to improve parameter tuning, and more. If you need technical assistance beyond this, we can recommend consulting partners to help you with additional questions.

Request your evaluation license or contact us at info@gurobi.com.

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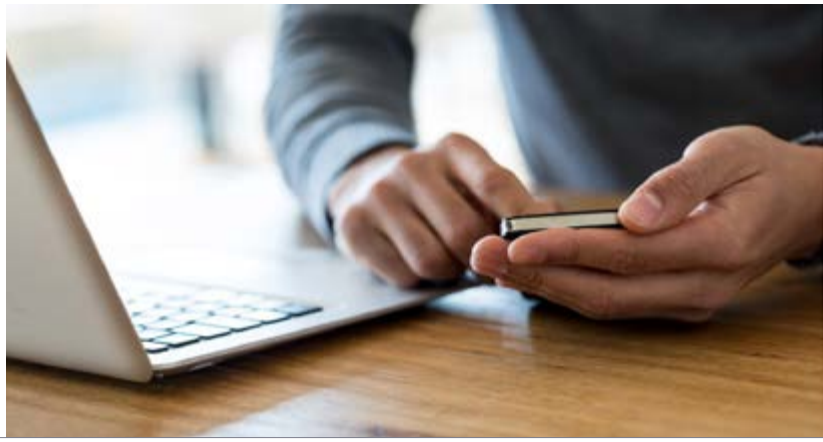
If you work in higher education, you can get up and running in minutes with free Gurobi licenses. We offer a variety of licenses to support the teaching and use of optimization at academic institutions. You can learn more on https://www.gurobi.com/academic.

Conclusion

A commercial solver is a good choice if solve speed is important to you and you cannot afford to wait for hours or weeks to get results on your optimization problems. If you are looking to significantly reduce solve time, get robust results, and not have the solver crash, a commercial solver is an ideal solution for your business.



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