

**GUROBI**  
OPTIMIZATION

**The Fastest Solver in the World**

Get a free evaluation license.  
Contact us via:

**Web**

[Gurobi.com](http://Gurobi.com)

**Email**

[info@gurobi.com](mailto:info@gurobi.com)

**Phone**

1 (713) 871-9341

# The Gurobi Optimizer

## The State-of-the-Art Mathematical Programming Solver

At Gurobi, optimization is all we do. Our solvers get 100% of our development effort. That is a large part of the reason why, on average, we have doubled MIP performance with each major release since we started.



The Gurobi Optimizer has been used to produce measurable improvements in a wide range of high-value business functions, including production, distribution, purchasing, finance, capital investment and human resources. Proven to be both robust and scalable, it also includes a range of intuitive interfaces that make it easy for new users to get up and running quickly.

Beyond its core performance, the Gurobi Optimizer is offered with flexible licensing and outstanding, responsive support from optimization experts. See why more than 1600 companies in 40+ industries use Gurobi to help turn data into smarter decisions.

## Features and Benefits

- **The Best Performing Solvers Available** – Benchmarks consistently show that Gurobi finds both feasible and proven optimal solutions faster than competing solvers.
- **Solves All Major Problem Types**
  - ✓ Linear programming (LP)
  - ✓ Mixed-integer linear programming (MILP)
  - ✓ Mixed-integer quadratic programming (MIQP)
  - ✓ Quadratic programming (QP)
  - ✓ Quadratically-constrained programming (QCP)
  - ✓ Mixed-integer quadratically-constrained programming (MIQCP)
- **Responsive Support** – We provide our customers direct access to PhD-level optimization experts with years of experience working with commercial models.
- **Flexible Deployment** – Gurobi enables you to deploy your model where and how you want it.
- **Support for a Full Range of Interfaces** – All of our object-and-matrix-oriented interfaces are implemented as lightweight, modern APIs.
  - ✓ OO interfaces for C++, Java, .NET and Python
  - ✓ Matrix-oriented interfaces for C, MATLAB® and R
  - ✓ Links to standard modeling languages, including AIMMS, AMPL, GAMS and MPL
  - ✓ Links to Excel through Frontline Solvers
- **Quickly Develop Models and Turn them into Full-Featured Applications** – The Gurobi distribution includes our own interactive interface built on our Python object-oriented API. The interface can be used as a development environment to build complex models, and then transition these models to full applications.

Gurobi's Python API includes higher-level modeling constructs that make it easier to build optimization models. Python users can choose to use the Anaconda Python distribution with pre-built libraries to support application development, Spyder for graphical development, and Jupyter for notebook-style development.



Together, Gurobi's Python API and distributions like Anaconda give you the ease of a modeling language with the power of a programming language.

- **Switching to Gurobi** – You'll have access to step-by-step migration instructions (as well as our support) for common scenarios. Our intuitive interfaces and support for MPS and LP file formats help you get up and running as quickly as possible.
- **Getting the Best Performance** – The Gurobi Optimizer provides a wide variety of parameters that allow you to control the operation of the optimization engines. The easy-to-use Gurobi tuning tool will help you find the right setting to improve model performance. In addition, we provide free tuning services to speed the search for robust parameter settings.
- **Most Advanced Algorithms** – The Gurobi Optimizer provides advanced implementations of the latest algorithms, including:
  - ✓ LP algorithms -- simplex, parallel barrier with crossover, concurrent and sifting
  - ✓ QP algorithms -- simplex and parallel barrier QCP algorithms -- parallel barrier (SOCP)
  - ✓ MIP algorithms -- deterministic parallel, non-traditional search, heuristics, solution improvement, cutting planes, and symmetry breaking
- **Flexible Licensing** – Our licenses may be used for both development and deployment. Gurobi offers a wide range of licensing options to fit your needs.

Visit [www.gurobi.com/optimizer](http://www.gurobi.com/optimizer) to learn more.

## Try Gurobi for Free

See why so many companies believe that Gurobi is a better choice than CPLEX® and XPRESS®, and in a completely different class than free solvers.

To request an evaluation of Gurobi, visit [www.gurobi.com/eval](http://www.gurobi.com/eval)

## Free Academic Licenses

Gurobi supports the teaching and use of optimization within academic institutions. We offer free, full-featured copies of Gurobi for use in class, and for research.

Visit [www.gurobi.com/academic](http://www.gurobi.com/academic) to learn more.

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# Gurobi Compute Server

## A Better Way to Deploy Optimization Applications

Create high-performance, fault-tolerant optimization applications that make more efficient use of your computing resources and your optimization software licenses.

Gurobi Compute Server is designed to greatly simplify the task of building and deploying modern optimization applications. It allows you to seamlessly offload your optimization computations onto a set of one or more dedicated optimization servers grouped in a cluster. Users and applications can share the optimization servers thanks to advanced queuing and load balancing capabilities. Users and administrators can monitor and manage the optimization servers and jobs.

## Key Features and Benefits

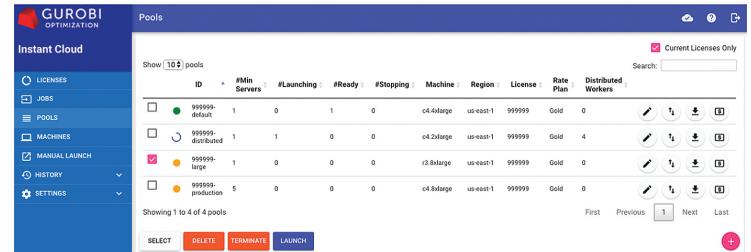
- **Seamlessly Integrate Client-Server Capabilities** – The Gurobi Optimizer library allows you to use existing interfaces to write a single program that can either run locally or, with the flick of a switch, can offload optimization computations to one or more Gurobi Compute Servers.
- **Powerful Queuing Capabilities** – Make the most of your computing resources with built-in queuing and load balancing capabilities.
- **Fault-tolerant Capabilities** – If a server goes offline, the remaining servers will continue to operate unimpeded.
- **Secure and Efficient Communication** – Compute Server uses HTTP or HTTPS for improved security, ease of deployment, and robustness. It also performs on-the-fly data compression to reduce the volume of transmitted data.
- **Clustering and Management Tools** – Clustering allows nodes to be added to and removed from clusters dynamically. Command line tools allow users to monitor the servers and the jobs. Administrators can list the licenses, abort jobs and manage the servers. The supported REST API allows you to programmatically monitor and manage your cluster.
- **Useful in a Wide Range of Scenarios** – Gurobi Compute Server has proven to be useful in a number of situations:
  - ✓ **High Reliability Requirements**
  - ✓ **Demand Spikes**
  - ✓ **Integrate Optimization with Multi-tier Architectures**
- **Support for Multiple Client Platforms** – Clients can run on any Gurobi-supported operating system, including Windows, Linux, and Mac. Furthermore, clients don't need to run the same operating system as the Compute Server.
- **No Client Licenses Required** – Gurobi Compute Server can support an unlimited number of clients, and no client licenses are required. Simply point your client application at a Compute Server and you are ready to go.

Visit [www.gurobi.com/compute-server](http://www.gurobi.com/compute-server) to learn more.

# Gurobi Instant Cloud

## Powerful Optimization on Fast Machines

The Gurobi Instant Cloud is a simple and cost-effective way to get up and running with powerful Gurobi optimization software running on cloud systems. It allows you to launch one or more computers, pre-loaded with Gurobi software and dedicated to you, to handle whatever your optimization needs are. Simply choose the subscription plan and deployment option that best meets your needs, and then pay only for what you use.



ID	#Min Servers	#Launching	#Ready	#Stopping	Machine	Region	License	Rate Plan	Distributed Workers
999999-default	1	0	1	0	c4.4large	us-east-1	999999	Gold	0
999999-distributed	1	1	0	0	c4.2large	us-east-1	999999	Gold	4
999999-large	1	0	0	0	i3.8large	us-east-1	999999	Gold	0
999999-production	5	0	0	0	c4.8large	us-east-1	999999	Gold	0

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.

## Key Features

- **Ease of Use** – We handle all of the behind-the-scenes details. Simply install Gurobi software on a local machine, download your license from the Cloud Manager ([cloud.gurobi.com](http://cloud.gurobi.com)), and the Gurobi Instant Cloud connects your computer to the cloud.
- **Maximum Power** – Choose the number and power of machines you want, and even create multiple machine pools. Computers are available across the globe, with up to 244 GB of memory. Scale up or down your machine pools depending on your needs.
- **Flexibility** – Once you have purchased a subscription plan, you pay only for the number and type of machines you use. You can even upgrade your plan to a higher usage level at any time. There are no restrictions on model sizes, users or client machines.
- **Available Anytime** – Your dedicated cloud servers are provisioned automatically in a matter of minutes, pre-configured with the latest Gurobi software and a license.
- **Intuitive Web Interface** – Use the Cloud Manager to list active machines and jobs, display detailed job information within the job dashboard, or access the history.
- **Room to Grow** – With a simple REST API, your application can control its cloud servers.
- **Streamlined Billing** – With the Gurobi Instant Cloud you receive one bill covering both license and machine costs.

## Common Use Cases

- **Solve Challenging Models** – Leverage the power of multiple computers to solve a single model without having to set up a network of machines. Systems with up to 244 GB of memory are available.
- **Handle Spikes in Demand** – Scale resources for peak demand without having to maintain them on an ongoing basis.
- **Handle Intermittent Optimization Needs** – Whether for infrequent solves or performance tuning, only pay for machines and licenses when you need them.
- **Track and Minimize Expenses on New Projects** – Try Gurobi for a new project. Usage reports show you detailed billing records.

Visit [www.gurobi.com/gurobi-cloud](http://www.gurobi.com/gurobi-cloud) to learn more.

## Try Gurobi Cloud

Contact [sales@gurobi.com](mailto:sales@gurobi.com) to request free trial hours, and see how quickly and easily a model can be solved on the cloud.

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# Gurobi Licenses

Gurobi offers perpetual, subscription and cloud licenses to meet your specific business requirements. Choose a license that's right for your needs.

## Perpetual and Subscription

License Type	Overview
<b>Named User</b>	Single machine license for a single named person, unlimited simultaneous uses.
<b>Unlimited Use, Unlimited User</b>	Single machine license for unlimited simultaneous users and uses.
<b>Compute Server</b>	Allows an unlimited number of client machines to submit jobs to a server.

## Cloud

License Type	Overview
<b>Bronze</b>	Situations where the user wants to solve one model at a time and doesn't need the features or flexibility of Compute Server. Allows at most one simultaneous use.
<b>Silver</b>	More active development and deployment situations where the hourly charge is more of a factor. Includes a Compute Server license.
<b>Gold</b>	Heavy usage situations where the features of Compute Server and getting the lowest hourly charge are important.

### Other types of licensing agreements

- ALA's (Application License Agreements) and ELA's (Enterprise License Agreements)
- OEM/ISV licensing agreements for customers who wish to embed and distribute Gurobi inside other applications

We are happy to discuss any special licensing needs or situations.

### Maintenance and Support

Maintenance and support provides phone and email support, as well as upgrades to any new versions released during the period of the contract. It is available for all perpetual licenses, and is included for subscription and cloud licenses.

**Please contact your sales representative or email [sales@gurobi.com](mailto:sales@gurobi.com) to discuss your unique needs.**

# National Football League | Season Scheduling

## Introduction

Over the past few decades optimization has made huge strides; what were once unsolvable problems are now solved in only seconds. Of course, the response to this advancement has been to tackle ever larger and harder problems.

The US's National Football League is a perfect example of this. Four people have 10 weeks to schedule 256 games over the course of a 17-week season. To some, that may seem like a lot of planning time available for seemingly few decisions. However, when you work it out, the number of possible schedules is well into the trillions. Imagine the number one followed by 19 zeros.

A data scientist would take years to determine a good schedule out of that huge number of possibilities. Making the problem particularly hard is the addition of numerous "additional" constraints including not scheduling teams from shared markets, such as the NY Jets and Giants, to play on the same day/time, ensuring no team has more than three road games in a row, and increasing the importance of late-season games by scheduling as many divisional match-ups as possible in the final weeks.

## From Boards to Computers

Until the last decade, a wooden six-foot square board was used to map out who would play whom, when and where. Hung on a wall the board consisted of a grid with 17 rows representing each week of the season and 32 columns representing each team. The original goal was simply to find a feasible schedule and accomplishing that often consumed up to 90 percent of the available planning time. The remainder was spent tweaking that feasible schedule to improve either a specific team or network's schedule.

With the switch to computers and the increasing power of optimization, a dramatic shift happened. The focus migrated from schedule creation (which by itself is far more complicated than it was only two-three years ago) toward schedule analysis. Before, the question facing the planning team was simply, "Can we just get it done?" Now, it is about finding the best possible schedule.

## As Much Art as Science

This shift is important since building a great schedule can be as much art as science. For example, one goal of the scheduling process is to get the best match-ups in the TV time slots that have the widest possible audience. This is very challenging to do since it requires a subjective evaluation of the match-up while also ensuring the resulting schedule doesn't violate any constraints such as the maximum number of away games in a row for a given team. In addition, these subjective evaluations can change dramatically during the course of the scheduling process due to a variety of factors, including free agency.

The art aspect is central to the scheduling process. The planners can now evaluate any given schedule, identify what they want to change, and then see how that affects the overall schedule. If the resultant schedule is better, then it is the new leader; if not, it is dropped. Even as recently as just eight years ago planners might only have been able to look at five total schedules; using Gurobi for the 2014 regular season schedule, they examined more than one thousand feasible schedules.

## From Linear to Parallel Optimization

The complexity of the NFL scheduling problem has grown exponentially over the past few years. A big part of the strategy for combatting this massive increase in difficulty was to obtain significantly more computer hardware. The NFL initially started with a single 24-core box, but recently moved to a room full of 16-core, 40-core, and larger servers.

As is often the case with new technologies, you typically won't reap the full benefits by applying existing strategies. Optimal Planning Solutions collaborated with the development team from Gurobi to rethink their approach to exploiting parallelism. This has enabled the NFL to employ a new approach, for the first time in 2014.

A key advantage of the parallelization approach is that a single problem is broken down into a finite number of smaller sub-problems, which are deployed to a pool of solving resources, all of which can share information, creating a much more coordinated search effort.

This approach has allowed the NFL to:

- do a substantially better job of sampling the whole solution space, as opposed to exploring only a small neighborhood of a few known solutions; and
- provide greater flexibility for future hardware configurations, including options to migrate away from multi-core solving boxes to smaller, less-expensive hardware configurations or even cloud-based technology.

## Looking Forward

In 2014, the NFL scheduling problem was solved across a network of more than 750 cores. In future years, as more difficult scheduling requirements continue to be added, this number will surely increase and possibly move to a cloud environment. Increasing problem complexity combined with optimization tools enhancements, will make strong partnerships between experienced end-users such as the NFL and consulting firms such as Optimal Planning and focused solver developers like Gurobi even more important.



“Switching to, and working with, the team from Gurobi has been a great experience. Their solver has met our high expectations, and the support they provide has been fantastic.”

— Michael North, Sr. Director, NFL

# Try Gurobi for Free!

We are happy to provide a free license of Gurobi for commercial and academic users. To request one, visit [www.gurobi.com/eval](http://www.gurobi.com/eval).

When you register for a commercial evaluation license, you'll also get:

- ✓ Access to Gurobi's world-class support
- ✓ Access to free benchmarking and tuning services
- ✓ Two free hours of 1:1 consulting



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