



The National Football League is the steward of the game of football – they work tirelessly to bring football to millions of fans across the globe. The NFL is a professional American football league that consists of 32 teams and the highest professional level of American football in the world.

Industry: Sports

Location: Americas

Use Cases: Customer Management, Location Planning, Workforce (Allocation/Scheduling)

Website: nfl.com

Results

- Increased its decision-making capacity by 2000%
- Quickly identify the best possible match-ups, in the time slots with the widest audience
- Schedules that drive revenue while delighting audiences



Tackling One of the World's Most Complex Scheduling Problems

The NFL quickly identifies the best possible game schedules—driving revenue while delighting audiences.

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 U.S.'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 New York 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 a few 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.

" Switching to, and working with, the team from Gurobi has been a great experience.

Michael North
Sr. Director, NFL

“ [The Gurobi solver] has met our high expectations, and the support they provided has been fantastic.”

Michael North
Sr. Director, NFL



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 a decade ago, planners might only have been able to look at five feasible schedules. Since adopting Gurobi in 2013, this number has increased dramatically, and now planners are able to generate and compare over 10,000 feasible schedules despite adding more and more constraints to the process every year.

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 move from a linear to a parallel approach to optimization.

The NFL initially started with a single 24-core box, but a few years ago has moved to utilizing a room-full of 16-core 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, starting back 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 neighbourhood of a few known solutions
- 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 2017, the NFL scheduling problem was solved across a network of more than 960 cores. In future years, as more difficult scheduling requirements continue to be added, this number will surely increase. The NFL has moved to

a cloud environment, as it grants them a tremendous amount of computing power while minimizing the need for capital investment. 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.

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