Birchbox: Subscription Box Service Optimization

Case Study

Discover how e-commerce company Birchbox uses mathematical optimization to drive greater efficiency and revenue growth.

Mathematical Optimization Powers a New Operating Universe at Birchbox

As subscription e-commerce continues to expand, Birchbox – the trailblazing subscription box service – has stood out with a strong value proposition that engages underserved, overlooked, "casual" beauty and grooming consumers, and meaningfully increases their spend in the category. Birchbox – which launched in 2010 – delivers five to six samples a month, tailored to each subscriber's needs and preferences.

A subscription box service's operational success is powered mainly by its "black box" – the custom soft-ware solution that groups subscribers into clusters and then creates configurations of available products to send to each group of subscribers. The solution must be formulated to deliver product groupings and box creations deemed "ideal" by the company's proprietary criteria. Additionally, the solution must accommodate meaningful business changes and scale as the service grows.

The Challenge of Scale

By 2015, Birchbox had over a million subscribers and more than 800 brand partners. The company relied on a mixed-integer programming (MIP) model solved with the Gurobi Optimizer to group products and assign subscribers according to proprietary objectives and constraints tied to subscriber profiles, history, and activity, and product and vendor attributes. This model worked adequately for several years, but as Birchbox's customer base grew further and offerings expanded, solutions to this model were difficult to obtain in a reasonable amount of time – and this limited business flexibility. Operations executives were forced to pain-stakingly manage and monitor the model because it too often could not find adequate solutions and, when it could, the average run time of 30-50 hours jeopardized production deadlines.

When Birchbox introduced exciting improvements to its box experience in early 2019, its leaders sought to increase the flexibility of how products were assigned to a box (for example, adding a sixth sample while not compromising the integrity of the assortment). However, testing determined that the model could not adequately handle the additional mathematical complexity.

Model Review and Reformulation

Birchbox leaders retained Princeton Consultants' Optimization Practice to improve the performance of the existing mathematical optimization model. Princeton Consultants' team of Operations Research practitioners interviewed business and technical personnel from Birchbox about the existing model's functionality, and reviewed documentation of the existing formulation. Analysis of the existing model uncovered the causes of the poor performance.

In reformulating the model to meet Birchbox's needs, the team leveraged its deep understanding of the Gurobi Optimizer – the mathematical optimization solver utilized by Birchbox – and advanced linear programming and MIP techniques. The team created the Reciprocating Integer Programming (RIP) technique to address this challenge.

About Princeton Consultants

Princeton Consultants blends advanced analytics, data science, and management consulting to help industry leaders and fast-growing innovators transform performance. Founded in 1981, Princeton Consultants has a long track record in developing and successfully implementing breakthrough solutions. Additionally, Princeton Consultants reviews and improves optimi-zation and predictive analytics models through their quality assurance service.

Princeton Consultants is a Gurobi Premier Partner.

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Better Solutions, 99% Faster

The reformulated model generates better results that reduce the required number of box configurations to meet the subscriber needs. Birchbox executives can create a larger number of clusters in their machine learning approach, resulting in greater customization per subscriber.

The new model's average run time is 10 minutes – which represents an improvement of more than 99%. David Bendes – Birchbox's Vice President of Global Business Technology, whose team ran, monitored, and adjusted the original model – described this acceleration as "life altering."

The transformed performance allows the Birchbox team to tweak inputs and re-run the model – and therefore evaluate different parameters, levels of subscriber aggregation, definitions of a "good" box, and even optimize on box value. Previously, such experimentation was impossible. Furthermore, it is quickly determined if a given set of products can meet the needs of all subscribers (e.g. is it feasible to assign every subscriber a box?) – and this is a key for operations.

Using Princeton Consultants' innovative RIP technique, Birchbox executives are transforming their technology, operations, and service as they further solidify their position as a leading subscription box service.

The Benefits of Gurobi

The RIP technique employed in the Birchbox solution requires a reliable, robust integer programming solver to solve different integer programs that are coordinated to find a solution to the business problem. The Gurobi Optimizer's performance allowed the concept of RIP to become a reality.

Due to the speed of the Gurobi Optimizer, the flexibility of the Gurobi Python API, and Gurobi features that allowed the performance to be tuned for different problems, combined with the innovative RIP technique, the Birchbox team now reliably solves problems of increasing complexity in minutes instead of days.

> " *The increase in speed and flexibility from the new model impacts every piece of our business across multiple teams. Now we can strategically invest that time in everything from building more personal customer experiences to decreasing our production costs. With this new model, Birchbox has truly entered a new operating universe.*

> David Bendes, Vice President of Global Business Technology at Birchbox