# THE ALGORITHMIC SOLUTION FOR SEARCH MARKETING OPTIMIZATION

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EfficientFrontier™

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# Introduction

## The Complexity of Search Engine Marketing

Since GoTo launched the first paid search advertising platform in 1998, search marketing has grown into a $9 billion per year industry. The ability of paid search marketing to drive results for advertisers is unparalleled, and its measurability ensures its continued growth as more advertisers adopt the medium. As search marketing has evolved, it has become increasingly complex, driving advertisers to seek out more advanced technologies to increase return.

Some of the initial challenges of the search marketer include choosing keywords, grouping them into portfolios and campaigns, writing ads, and choosing the search engines on which to show them. Further challenges involve navigating the search engine marketplaces across such factors as match type, minimum bid, quality score, competitive activity, geography, time of day, week or season, and landing page quality, all of which can significantly impact click-through rates (CTR) and cost per click (CPC). To add to the challenges presented by the basics of running a campaign along with managing the complexities of the marketplace, the advertiser must also then manage campaigns to what may be multiple business metrics, within the constraints of budget, and account for factors like seasonality and external promotions.

Figure 1: The Complexity of Search Engine Marketing


Such complexities, when viewed by the average marketer, can seem daunting. Indeed they are, particularly when increasingly large amounts of money are being spent and a business' success is dependent upon driving traffic through search.

To mathematicians skilled in building algorithms, these complexities present an exciting opportunity to build a system that will manage through all of these variables and optimize the allocation of dollars to drive the highest return on investment (ROI) for the advertiser for a given level of spending.

# Why are algorithms important?

Let us first define *'algorithm.'* At its most basic level, an algorithm is a procedure for solving a mathematical problem, using a precise series of steps. The word derives from the name of Mohammed ibn-Musa al-Khwarizmi, a mathematician, geographer, and astronomer who was part of the royal court in Baghdad in the 9th century and is considered to be the father of algebra.,

In general, solving problems with algorithms requires performing a substantial number of rote calculations, which is highly labor intensive for humans. Originally, the word *'computer'* meant "one who computes." In the 19th and early 20th centuries, roomfuls of people were employed as computers; they helped perform calculations that influenced astronomical discoveries and helped plan war strategies, among other tasks. Not until the advances in machine computing in the mid 20th century did algorithmic science evolve significantly since the time of al-Khwarizmi.

## Computing and algorithms

The ability of computers to perform numerous calculations on vast amounts of data allowed the science of algorithms to advance rapidly in the latter part of the 20th century, and helped bring about major advances in the sciences, economics and industry. Today, everything from shipping logistics, credit card transaction processing, retail store shelving patterns, and call center queue routing is determined by algorithms.

An article in *The Economist* from September 13, 2007 stated:

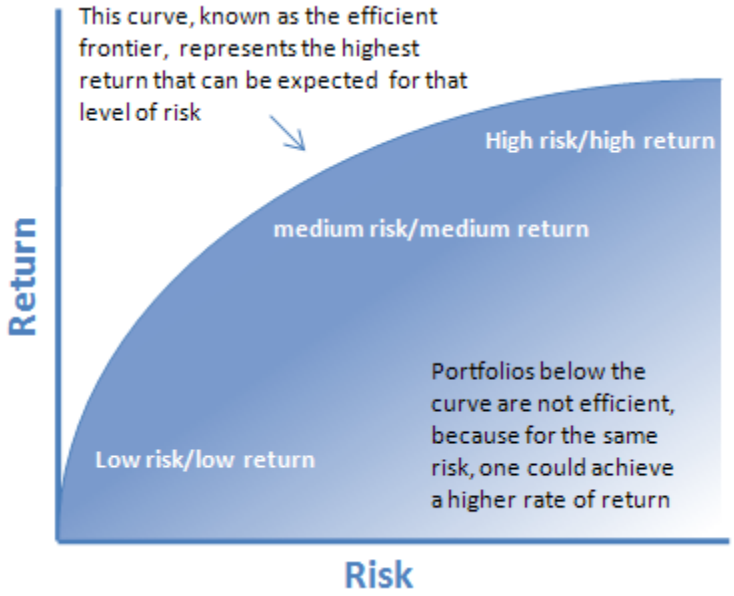
> Their [algorithms'] pervasiveness reflects the application of novel computing power to the age-old complexities of business. "No human being can work fast enough to process all the data available at a certain scale," says Mike Lynch, boss of Autonomy, a computing firm that uses algorithms to make sense of unstructured data. Algorithms can. As the amount of data on everything from shopping habits to media consumption increases and as customers choose more personalisation, algorithms will only become more important.

## Economics and Modern Portfolio Theory

One type of algorithmic analysis that became possible to perform on a large scale through computing is modern portfolio theory, which was introduced in 1952 by Dr. Harry Markowitz in a *Journal of Finance* article entitled "Portfolio Selection*."* A few years later, in 1956, Markowitz published an essay that showed how to calculate the optimal portfolio using a quadratic programming algorithm, and his later works further expanded on the topic.

Modern portfolio theory assumes that investors are risk averse, and will take on increased risk only if compensated by higher expected returns. Thus, a rational investor will not invest in a portfolio if a second portfolio exists with better expected returns for that given level of risk. By holding a diversified portfolio of assets, an investor can reduce their exposure to risk. The investor can see which portfolio will achieve the highest level of return for a specified level of risk by plotting every possible asset combination in the risk-return space as shown in Figure 2. The line along the upper edge of this region is known as the efficient frontier, which represents portfolios for which the highest level of return can be achieved for a given level of risk.

Figure 2: Modern Portfolio Theory and the Efficient Frontier




The concept of modern portfolio theory should be familiar to those who have had to choose between various retirement fund portfolios based upon their risk profile. Markowitz's theory is widely used by institutional investors and is a standard topic in college economics courses. In 1990, Markowitz was awarded the Nobel Prize in Economics along with Merton Miller and William Sharpe for their pioneering work in the theory of financial economics.

While modern portfolio theory and its algorithms revolutionized how investments are allocated, algorithmic portfolio trading has become increasingly popular on Wall Street as computing power has increased. Many mutual funds, pension funds and hedge funds now conduct their trading algorithmically. According to the consulting firm Aite Group, a third of all US and EU stock trades in 2006 were driven by algorithmic trading programs. Aite Group predicts that figure will reach 50 percent by 2010.

## Search engines and the PageRank algorithm

In 1996, the PageRank algorithm, created by Larry Page and Sergey Brin, revolutionized searching on the World Wide Web and led to the creation of Google. Google now accounts for more than 60 percent of searches on the Internet, according to some estimates.

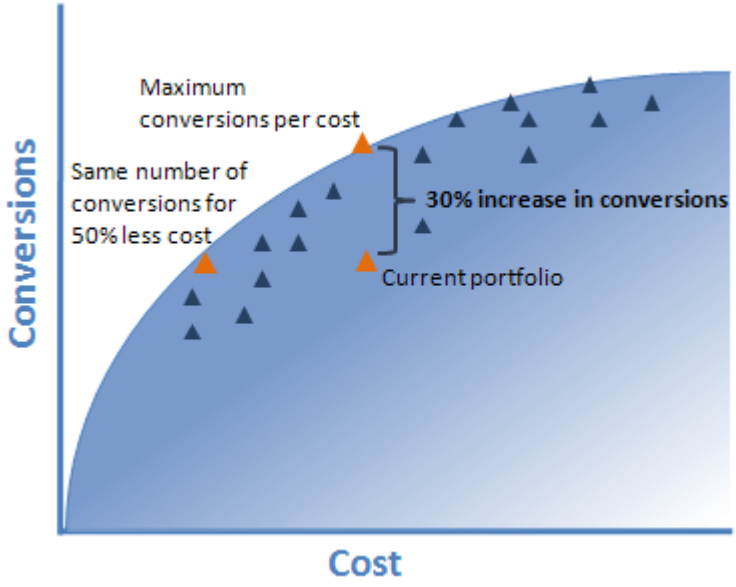
Google's success at using algorithms to deliver relevant results to users led to the development of an auction-based system that allows advertisers to bid for placement on search engine result pages (SERPs) based upon the search keyword. Advertisers pay only when their ad is actually clicked upon. Google's interest in providing relevancy for its users, combined with its business need to maximize revenue per page, led it to develop another algorithm that ranks search advertisements based upon the ad's click through rate, maximum bid, and the quality of the advertiser's landing pages (quality score), among other factors. The other major search engines have developed similar models for displaying advertisements.

# Why do search marketers need algorithms?

The net effect of the algorithm-based system for displaying ads in a biddable marketplace is that the advertiser can never be exactly sure where an ad will appear for a given bid, and how much that click will actually cost, or what the conversion rate might be. This opaque system presents a huge challenge to the advertiser that wishes to maximize return on search advertising investment. Even with positive returns, the advertiser does not know how much better returns could be by making adjustments to the campaign, and what adjustments should be made.

If we think of an advertiser's group of keywords like a portfolio of stocks, we can see how modern portfolio theory could be applied to the search advertising marketplace. By replacing "risk" shown in Figure 2 above with cost, or total search spend, and "expected return" with conversions, and plotting the possible portfolio options as shown in Figure 3 below, we can find the efficient frontier for a portfolio of keywords – the maximum return that can be expected for a given level of spend.

Figure 3: Portfolio Theory Applied to Search Engine Marketing



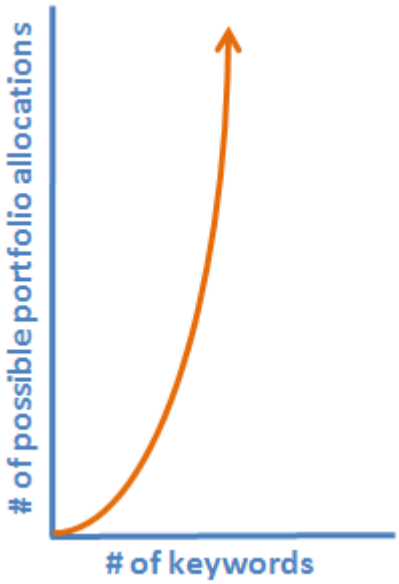

The triangles on the chart represent possible portfolio allocations. It may not be known that there is a better allocation of the portfolio of keywords that will yield 30 percent more conversions than the "current portfolio" shown. It may also not be known that there is a portfolio that will yield the same number of conversions for 50% less cost than the current portfolio. Thus the modeling techniques of portfolio theory give the advertiser greater visibility into potential campaign performance.

## The set of all possible solutions

The term '*search space'* refers to the set of all possible solutions for a given problem. In search engine advertising, the search space can be thought of as the set of all possible keyword bids. The size of the search space, and consequently the difficulty of navigating it, increases exponentially with the number of elements.

Consider a campaign consisting of two keywords that can be bid to 10 different positions. If there is one bid combination that will maximize revenue for a given budget, 100 trials would be needed to find the optimal solution for those two keywords. Increase the portfolio to 10 keywords, and that number increases to 10 billion combinations.

Figure 4: The search space of keyword bids




As more keywords are added to the portfolio, the problem of navigating the search space becomes far too complex to be solved by humans using Excel spreadsheets and applying rules to keywords. In addition, the keyword landscape is continually in flux due to seasonality, shifts in the marketplace, and competitive activity. The task of our algorithms is to navigate the search space and find the point within it that will maximize conversions or revenue.

# The algorithmic solution for search marketing optimization

Given the vast size of the search space and the many variables in search marketing campaigns (such as CTR, CPC, match type, ad copy, week or season, geography, and the advertiser's specific conversion goals), other methods of search engine bid management will most certainly not yield the return that a mathematically optimized campaign can. There are three steps to Efficient Frontier's method for achieving the optimal bidding scenario for a given portfolio of keywords.

## Click modeling

The click model predicts the click volume, the bid required to win each available position, and the actual CPC. Data on keywords' clicks, impressions, cost, and average position are downloaded daily from the search engines in order to create this model. Because not every position has been seen in the historical data, the results of unobserved positions are estimated by applying mathematical models which use traditional data-fitting methods from statistics and take into account specific insights into the paid search marketplace such as:

- Premium placements at the top of the SERP usually receive a higher CTR than ads on the right-hand side.
- Bidding an ad into the top positions can qualify it for broader distribution across a search engine's syndication partners, resulting in additional impressions and clicks.

## Revenue modeling

The revenue model predicts the conversion rate and is based on both click data and conversion data. The click data already gathered for the click model is reused and is supplemented by daily conversion data for each keyword. The conversion metrics are specific to each advertiser's goals, and usually include revenue, signups, or leads. This data is gathered from a tracking pixel, advertiser feed, or third-party tracking system.

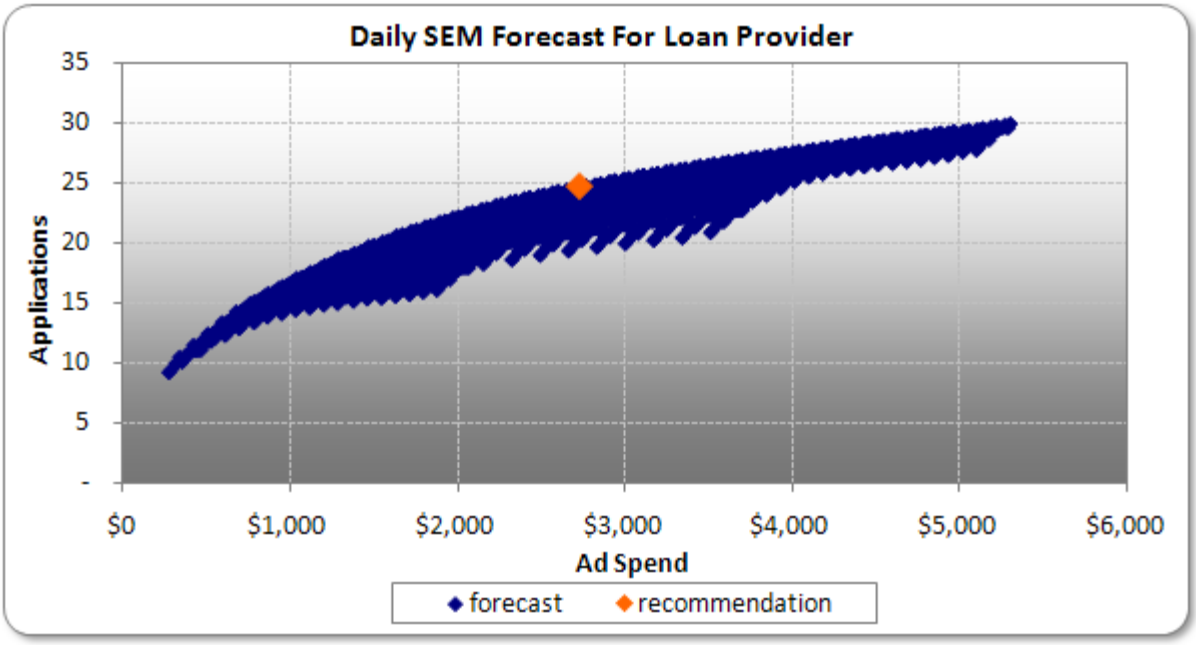
## Optimization and bid execution

Once the click and revenue models are built, the optimization system determines the optimal bidding strategy for a portfolio based upon the stated business goals, which might be to

- Maximize revenues within a fixed budget
- Maximize revenues to a given CPA (cost per acquisition) or profit margin
- Maximize net profits
- Minimize cost to a fixed revenue target

This bidding strategy finds the point on the efficient frontier of the advertiser's keyword portfolio options, as shown on the image below of an actual client bid model. Bids are then executed through the search engines' API (application programming interface).

Figure 5: Actual bid forecast model




The forecast above shows that the difference between the optimal portfolio and the lowest performing portfolio is 5 completed applications at the recommended ad spend of $2,750 per day. With this forecast, the advertiser can be certain that optimal performance for a campaign has been achieved, which will result in a 20% lower CPA than the sub-optimal portfolio. Remaining resources can now be used to further improve campaign performance through keyword generation, campaign restructuring, and landing page and ad copy testing.

# Conclusion

The highly complex search marketing industry presents challenges to the marketer that demand sophisticated solutions. The search engine marketplace can adopt solutions similar to those that revolutionized financial markets. Just as the algorithmic approach of modern portfolio theory revolutionized financial investing, PageRank and the search engines' subsequent algorithms revolutionized the searcher experience and search engine marketplaces. Thus, applying portfolio algorithms to keyword marketplaces, as pioneered by Efficient Frontier, is the only logical effective approach that can fully navigate the search space to ensure maximum return.

# About Efficient Frontier

Efficient Frontier is the market and technology leader in search marketing solutions for global advertisers. The company provides the most powerful, most effective search engine marketing algorithms available to ensure that clients with large-scale, complex search marketing campaigns are able to achieve the highest possible return-on-investment. The largest advertisers in the most competitive markets use Efficient Frontier to achieve unprecedented levels of search marketing efficiencies, scalability, and risk reduction. The company is headquartered in Mountain View, CA with offices in New York, the United Kingdom, France, and India. For more information, please visit www.efrontier.com.