Notes on "Optimization"

1. Introduction

"Optimization" is a term bandied about quite frequently in business conversations. Broadly speaking, the term is only used in one of two ways to describe a business process:

1.1. as a statement that the process produces results that literally cannot be improved upon, or
1.2. as pure marketing hype in the biggest scam on the American public since one hour martinizing

Further attempts at humor aside, these notes will attempt to provide a simple classification scheme to describe the ways algorithms improve business performance more accurately.

2. Classifying Improvement

Our sense is that business processes very rarely optimize anything. Instead, the general rule is that business processes only improve business activities to varying degrees. The CDS classification scheme places every business process into one of three categories:

2.1. A Dumb Improvement Process (DIP): Simple Improvement
2.2. A Smart Improvement Process (SIP): Near Optimization
2.3. A True Optimization Process (TOP): Actual Optimization

A Dumb Improvement Process (DIP) is one which improves a business objective in a straight forward manner but stops searching for further improvement immediately upon hitting its first constraint. DIPs make no effort to determine if a constraint can be sidestepped so that further improvement can take place.

A Smart Improvement Process (SIP) differs from and improves upon a Dumb Improvement Process (DIP) because it will repeatedly attempt to look for alternative solutions that either:

2.4. better use resources under any constraints initially encountered by a DIP, or
2.5. seek solutions that find constraints less restrictive to its objective than that initially found by a DIP

Lastly, a True Optimization Process (TOP) is a process with a theoretical certainty of achieving a business process objective that cannot be improved upon by any other solution.

3. Illustrative Examples

Suppose the business objective is profit and the problem facing some business process is to maximize the revenue of Inserts included in a mail piece with 12 grams of Surplus Weight. The weights and revenues of each Insert are given by the table below:

Insert ID	Weight (Grams)	Revenue	Revenue/Gram
1	3.80	$0.0380	$0.0100
2	3.80	$0.0380	$0.0100
3	3.80	$0.0380	$0.0100
4	3.00	$0.0291	$0.0097
5	3.00	$0.0291	$0.0097
6	3.00	$0.0291	$0.0097
7	3.00	$0.0291	$0.0097

Vendors in the mail industry might claim that they are "optimizing" the revenue of Inserts in a mail piece by implementing a strategy of either:

3.1. Choosing the highest revenue inserts that will fit under the 12 gram weight constraint, or
3.2. Choosing the highest revenue per gram (most efficient) inserts that will fit under the 12 gram weight constraint

However, under both of these strategies Inserts 1,2, and 3 will be chosen. This will result in a total revenue of $0.1140 and total weight used of 11.4 grams. So both strategies hit the weight constraint of 12 grams and stop immediately. For this reason, we classify these strategies as Dumb Improvement Processes (DIPs). The selection of the four Inserts with both the lowest revenue per Insert and lowest efficiency per Insert in terms of revenue per gram would yield a total revenue of $0.1164 which is greater than $0.1140 and does not violate the 12 gram constraint. The point in this case is simply that neither strategy, in general, can be correctly termed "optimization" since we have shown that a superior result exists in both cases.

A True Optimization Procedure (TOP) would be a relatively small but exhaustive search over all possible combinations of each Insert being included or not. The general rule on how many combinations would need to be examined is:

3.3. $NrOfCombinations = 2^{NrOfInserts}$

So In the case of 7 Insert possibilities

3.4. $NrOfCombinations = 2^{7} = 128$

Each combination would be checked for:

3.5. Total Revenue, and
3.6. Total Weight not exceeding 12 grams

The combination with the highest revenue that did not violate the weight constraint would be a truly "optimized" solution. This TOP also qualifies as a Smart Improvement Procedure (SIP) because it repeatedly searches for alternative solutions after it finds a first possible solution that cannot be improved because of the weight constraint.

For a small number of Inserts the exhaustive search through all combinations can be done relatively quickly. However, suppose one had 200 possible Inserts. The NrOfCombinations would be 2^{200}. This is a very large number: something on the order of 1 followed by 60 zeroes. Even with relatively fast computers of today, doing an exhaustive search on one recipient mail piece, much less millions of recipient mail pieces, is simply not feasible. However, it may very well be that the DIP of following a path of highest revenue or highest efficiency Inserts would lead to unacceptably low level of revenue generation.

At that point, some Smart Improvement Procedure (SIP) should come into play. SIPs are often a hybrid search procedure. As a though experiment, if examination of 128 combinations allows for acceptable speed in determining which Inserts get into any given recipients mail piece then a possible SIP might be the following:

3.7. Determine the 7 (out of 200) most efficient (revenue per gram) Inserts
3.8. Subject these highly efficient "pre-qualified" Inserts to the exhaustive combinatorial analysis TOP above

This SIP is very likely to improve upon the results of either DIP described above. Nonetheless, at some point in the future we will run some test simulations to compare revenue per recipient under three scenarios:

3.9. DIP
3.10. SIP
3.11. TOP

While there are sophisticated mathematical algorithms that can drastically cut down the number of combinations actually examined for a truly "optimized" solution for this 200 Insert case, there are larger problems that may not yield easily to these algorithms. Many problems that may have a theoretical specification that is solvable by a TOP may be too large to be solved by that TOP within a reasonable time frame. In these cases, the SIP approach can be a very effective combination of common sense and True Optimization Procedures (TOP) that will yield near optimal results.

4. Some Notes on True Optimization Procedures

There is a field of mathematics called Operations Research (OR). OR has a wide variety of techniques and algorithms that are True Optimization Procedures (TOP). However, we find that operations managers often are completely unaware that these algorithms exist. TOP can directly provide true optimization to business processes and/or contribute greatly to process improvement as integral parts of hybrid SIPs.

We will focus on just one of these known OR algorithms, Linear Programming (LP), and present a high level, robust sample of seemingly different problems upon which LP behave as a TOP.

4.1. The Transportation Problem

Consider a trucking company that has warehouses at various points around the country. Each of these warehouses has a supply of goods and each of these warehouses has a demand for the goods. Some of the warehouses are capable of acting as transshipment points to subject to limits on the amount of goods that can pass through. Further, assume that the cost of shipping a unit of goods from one warehouse to another is known but not all pairs of warehouses are possible legs in shipping routes. What transportation plan satisfies the demands for goods at all warehouses at minimum shipping costs?

4.2. The Seating Problem

A diplomatic function has a guest list of 84 guests: 50 males and 30 females. There is a "compatibility value" associated with each guest sitting at the same table with every other guest. Some guest pairs cannot be seated at the same table. Some guest pairs must sit at the same table. There are two types of tables: those that seat 4 guests and those that seat 6 guests. The room will only hold 18 tables. Lastly, each table must have at least one female. What seating arrangement maximizes the total "compatibility values" of the final seating assignments while adhering to the seating mix and number of table constraints.

4.3. The Product Mix Problem

A plant can manufacture 6 different products. Each product requires processing on each of 4 machines. Management knows the minutes each machine needs for processing of a unit of each product. Given maintenance issues, the amount of time each machine is available in a week varies (for example, 30 to 40 hours per week). Products 1,2, and 3 can be sold at a constant prices per unit regardless of how many units are produced. Products, 3,4, and 5 can be sold at initial prices subject to a quotas: if production of any of these products exceeds generally different quotas then prices are dropped by some given amounts. Lastly, Product 5 must meet a minimum production level. What combination of manufactured products will maximize weekly profits while adhering to the numerous constraints stated above?

4.4. The On the Job Training Problem

A manufacturer has a contract to produce 2000 units of product. The contract calls for a varying but exact amount of deliveries of the product over a 10 month span. Therefore, the manufacturer has a choice of producing a unit of the product in the period it is due or producing in a prior period and storing it with a given storage charge per period. It also has the option of delivering a product late but will face a penalty for each period it is late. The manufacturer has on hand an initial number of workers. These workers can be used in one of two ways: either to produce some units of product at a know rate for delivery or to train some given numbers of new workers to produce the (requiring some number of periods). The manufacturer has four options with a worker: use for training, use for production, allow the worker to remain idle, or fire the worker. Each of those options incurs a cost. What weekly scheduling plan for workers as producers, trainers, idlers, or releases delivers the 2000 required units at minimum cost?

4.5. The Mass Mailer - Third Party Marketer Problem

A mass mailer must send a mail piece to each one of its many customers. The required contents of the mail piece weigh significantly less than the weight allowed by the postal rates. The mass mailer has a choice of a relatively large number (say 150) of Third Party Marketer (3PM) Inserts that can be included in mail pieces that will generate some revenue without increasing postage costs. However, technology limits the number of Inserts (say 11) that can be considered for inclusion in the mail piece for any subset of customers and customers can only receive a maximum of 4 Inserts in any mailing. There is a fixed cost incurred for changing the set of 11 Inserts that can serve any subset of customers. The set of Inserts have different weights and customer specific revenues. Certain pairs of Inserts cannot appear in the same mail piece. What sequence of 11 Insert combinations will maximize the mass mailer profit from Third Party Marketer Inserts without incurring additional postage?

We note that every one of the above problems (and countless many more) can be solved by the exact same algorithm if one simply fills out a number of matrices and vectors with relevant problem data. LP is but one of many OR algorithms that can be brought to bear on business problems both large and small.

5. Some Further Comments on Management Decision Making and "Optimization"

A large portion of academic training in economics focuses on the behavior of the firm and its theoretical objective to maximize profits. In the late 1960s an economist named Herbert Simon undertook a study to determine if firms were actually engaging in profit maximization. The salient conclusion of his study essentially was that "Humans have not the wits to maximize profits". He further concluded that management only engaged in "satisficing" behavior. Satisficing was roughly defined as "searching through a set of available alternatives until an acceptability threshold is met". Suffice it to say that we often have a hard time distinguishing this behavior from unimaginative managerial stagnation.

Our response to Simon is that "Humans only need the wits to use software that has the wits to maximize profits". Simon's observations were likely quite valid in the pre-computerization era. Applying rigorous, acute economic analysis to complex business processes was and is beyond the capabilities of any human mind. However, robust SIP and TOP algorithms are readily available as well as extremely cost effective computing power needed to implement them. We hold that management ought to be actively bringing sophisticated SIP and TOP to bear on every business process it can. This is not taking place.