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Optimization of store performance for personalized pricing using evolutionary computation

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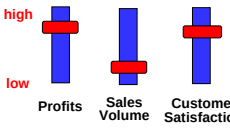
Introduction

- Grocery stores use loyalty card programs to drive sales, maximize profits and customer satisfaction. 70% of all US households participate in a loyalty card program for grocery shopping.
- However these discounts are same for everyone (*i.e., not targeted*).
- A more determined approach such as *personalized pricing* could optimize the store performance on *sales*, *profits* and *customer satisfaction.*
- Our aim is to compare the potential performance of personalized pricing over mass marketing.

Problem:
How can we optimize the store performance?

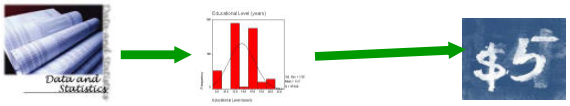
Relative importance of the following three goals determine the overall store strategy:



Objective: Given a store strategy, obtain *individual* discounts to *optimize* the profits, sales volume and customer satisfaction.

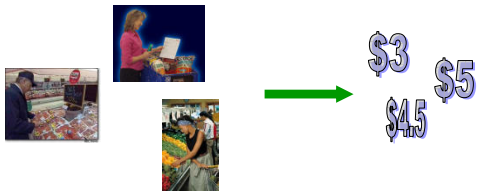
Current Approach in the market

Use several data sources to cluster consumers into several groups and provide the same price to everyone

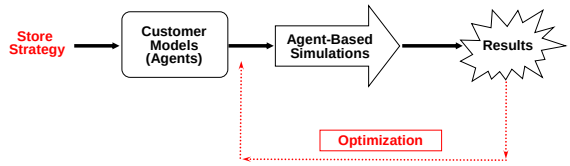


Our approach

Say "No" to clustering. Create a model for each individual and provide individual pricing



Our Approach: Agent-based Simulation



Our approach consists of the following:

- Modeling each customer's shopping behavior from transaction data
- Creating agents using these models
- Performing agent-based simulations and optimizing the store performance for a given store strategy

Problem Modeling

Store Model:

- Number of products
- Quantity of items
- Sales price
- Product replenishment rate
- Replenishment Threshold
- Replenishment size
- Daily stock keeping cost

Customer Model:

- Shopping frequency
- Price sensitivity
- Buying probability for each product
- Quantity bought from each product
- Substitutes and complements

Problem Formulation

Two objectives

1- What is the optimal set of products for each customer?
2- What should be the discount values on these products?

$$Maximize\ f(x, y, z) = w_1 * x + w_2 * y + w_3 * z$$

Where;
x=profits
y=sales volume
z=customer satisfaction

Problem Formulation

We can formulate the problem for each customer using agent-based modeling:

i=1,2,...,n

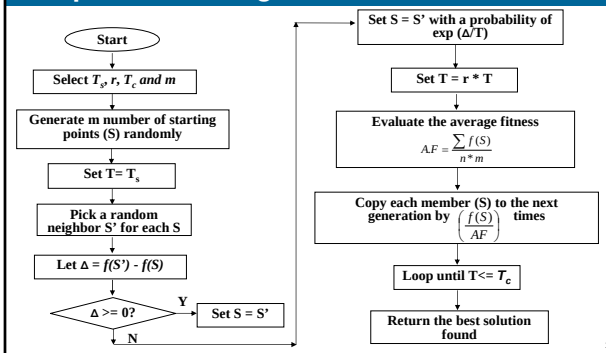
$$Maximize\ f_i(x, y, z) = w1*x_i + w2*y_i + w3*z_i$$

Product set $P_i = \{P_1, P_2, \ldots, P_k\}$

Discount set $D_i = \{D_1, D_2, \ldots, D_k\}$

Where;
n=total number of customers
k=number of coupons
P=product set for each customer
D=discount set for each customer

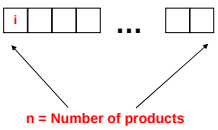
Optimization Algorithm



Representation

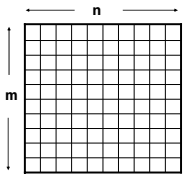
N-bit, integer representation was used

For each customer:



n = Number of products

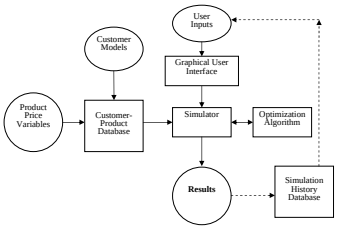
i = {0,1,2,...,12} % of discount



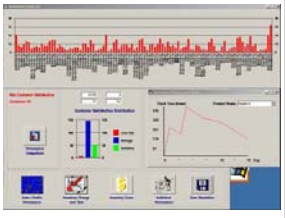
Size of search space= i^{m*n}

(200 customers, 100 products, 13 elements = 13^{20000})

Developed System



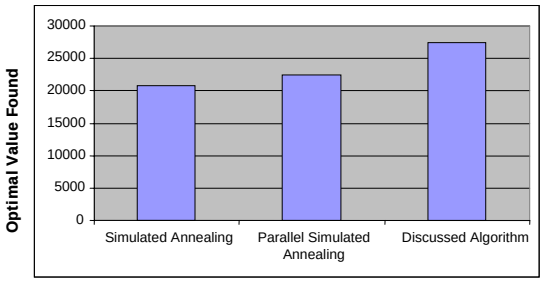
System Architecture



Graphical User Interface

Results – Comparison of algorithms

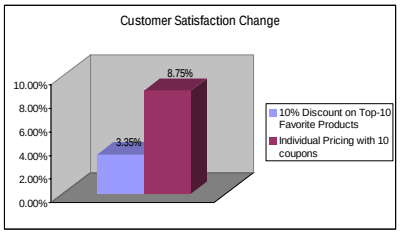
Maximize **f(x, y, z) = *0.75*x+0.25*z***



Case Studies – Grocery Store

STORE PERFORMANCE SIMULATIONS FOR 15 DAYS

(The objective is to maximize the customer satisfaction by spending $1150 on discounts)



Case Studies – Grocery Store

STORE PERFORMANCE SIMULATIONS FOR 15 DAYS

(The objective is to minimize the promotion spending to achieve the same satisfaction level)

Discussions and Conclusion

- A system was developed to simulate the performance of personalized pricing in grocery stores.
- Case studies showed that personalized pricing significantly outperforms the traditional couponing approach.
- Individual pricing can help store managers optimize their store performance.