



# Integrating AHP and data mining for product recommendation based on customer lifetime value

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## Abstract

Product recommendation is a business activity that is critical in attracting customers. Accordingly, improving the quality of a recommendation to fulfill customers' needs is important in fiercely competitive environments. Although various recommender systems have been proposed, few have addressed the lifetime value of a customer to a firm. Generally, customer lifetime value (CLV) is evaluated in terms of recency, frequency, monetary (RFM) variables. However, the relative importance among them varies with the characteristics of the product and industry. We developed a novel product recommendation methodology that combined group decision-making and data mining techniques. The analytic hierarchy process (AHP) was applied to determine the relative weights of RFM variables in evaluating customer lifetime value or loyalty. Clustering techniques were then employed to group customers according to the weighted RFM value. Finally, an association rule mining approach was implemented to provide product recommendations to each customer group. The experimental results demonstrated that the approach outperformed one with equally weighted RFM and a typical collaborative filtering (CF) method.

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## 1. Introduction

Intense competition is forcing companies to develop innovative marketing activities to capture customer needs and improve customer satisfaction and retention. The use of the Internet and the explosive growth of e-commerce have expanded marketing activities and made large volumes of customer data available for analysis. Businesses can benefit significantly from analyzing customer data to determine

their preferences and thus improve marketing decision support. Providing adequate support to meet customer needs can boost the success of on-line e-stores [18] and web site success depends on enhancing information and service quality to serve customers better [21].

Recently, IT has been utilized to help companies maintain competitive advantage [36]. Data mining techniques [9] are a widely used information technology for extracting marketing knowledge and further supporting marketing decisions [4,5,33]. The applications include market basket analysis, retail sales analysis, and market segmentation analysis. Lin et al. [19] applied data mining techniques to extract inter-organizational retailing knowledge from POS information

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in retail store chains. Moreover, Hui and Jha [14] employed it to provide customer service support. The knowledge can support marketing decisions and customer relationship management.

The buying patterns of individual customers and groups can be identified via analyzing customer data [38], but also allows a company to develop one-to-one marketing strategies that provide individual marketing decisions for each customer [24]. Recommender systems are technologies that assist businesses to implement such strategies. They have emerged in e-commerce applications to support product recommendation [31]. The systems use customer purchase history to determine preferences and identify products that a customer may wish to purchase. Schafer et al. presented a detailed taxonomy of recommender systems in e-commerce, and determined how they can provide personalization to establish customer loyalty. Generally, recommender systems increase the probability of cross-selling; establish customer loyalty; and fulfill customer needs by discovering products in which they may be interested.

Collaborative filtering (CF) has been successfully used in various applications. The CF method utilizes preference ratings given by various customers to determine recommendations to a target customer based on the opinions of other customers. The GroupLens system [26] applied the CF method to recommend Usenet news and movies. Video recommender [12] also used this approach to generate recommendations on movies. Examples of music recommender systems are Ringo [32] and MRS [8]. SiteSeer [27] provided recommendations based on the bookmarks of the user's virtual neighbors. Content-based filtering provides recommendations by matching customer profiles (e.g. interests) with content's features (e.g. product attributes). NewsWeeder [17] is an example of content-based recommender systems. Changchien and Lu [7] developed a procedure for mining association rules to support on-line product recommendations. Amazon.com [20] employed item-to-item collaborative filtering to provide recommendations of those products that are similar to the customer's purchased and rated products. However, few have considered customer lifetime value (CLV).

From the perspective of niche marketing, all customers are not equal (they have different lifetime value or purchase behaviors), even if they purchase identical

products or services; market segmentation is therefore necessary. Firms are increasingly recognizing the importance of the lifetime value of customers [3]. Several studies have considered the use of CLV. Generally, recency, frequency, and monetary (RFM) methods have been used to measure it [16,23]. The concept has been applied to cluster customers for niche marketing [11].

Our work proposes a novel product recommendation methodology that combines group decision-making and data mining. The analytic hierarchy process (AHP) [28] was applied to evaluate the importance (weight) of each RFM variable, according to a group of decision-makers. Clustering was then employed to group customers based on their weighted RFM value. Finally, association rule mining was used to provide product recommendations for each group of customers.

## 2. Background

### 2.1. Customer lifetime value analysis and RFM evaluation

Customer lifetime value (CLV) is typically used to identify profitable customers and to develop strategies to target customers [15]. Measuring RFM is an important method for assessing customer lifetime value. Bult and Wansbeek [6] defined the terms as: (1) R (Recency): period since the last purchase; a lower value corresponds to a higher probability of the customer's making a repeat purchase; (2) F (Frequency): number of purchases made within a certain period; higher frequency indicates greater loyalty; (3) M (Monetary): the money spent during a certain period; a higher value indicates that the company should focus more on that customer.

Numerous studies have discussed the evaluation of CLV. Goodman [10] suggested that the RFM method avoided focusing on less profitable customers, allowing resources to be diverted to more profitable customers. Hughes [13] proposed a method for RFM scoring that involved using RFM data concerning to sort individuals into five customer groups. Different marketing strategies could then be adopted for different customers. Stone [35] suggested that different weights should be assigned to RFM variables depend-

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