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Product Pairing Selection for Promotion using Partitioning Method

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ABSTRACT

Slow-moving product is harmful to the business. The slow-moving products take up space and tie up the company's capital and leave the company with fewer funds to invest in its business. Several factors can cause this issue. There are several methods ranging from statistics to heuristic methods for a company to identify slow-moving inventory but all of them rely on data. In this paper, a partitioning technique from the graph network is proposed to partition the inventories or products into a few clusters. It can help the company to identify what group does the product belongs to and at the same time suggest to the company which product can be paired up or bundled up together to clear up aging and slow-moving products. The partition technique is proposed, and the algorithm is coded using the Visual C++ programming language. The simulation results show that the proposed method can partition the task graph onto smaller subgraphs. The subgraphs called cluster consists of the nodes or products with similar purchase volume (the strong connection between the two nodes). Implementing the partitioning technique could help the companies or managers select the appropriate product to be paired together when doing the promotion.

1. Introduction

Slow-moving inventory is a common problem for most shops, and it's something that needs to be addressed. Slow-moving inventory is described as stocks or products that have been sitting in a storage room or warehouse for an extended length of time (and have not moved). While the

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definition of slow-moving differs depending on the product or industry, most companies already consider stocks that have not shipped within 90 days to be slow-moving.

This problem can be caused by several causes. It could be due to inaccurate sales predictions, a market slump, intense competition promotions, or just the procurement team's desire to reduce per-unit costs by ordering greater volume. The combo for the discounted item is not related sometimes. Therefore, this is a good opportunity to study selecting the correct pairing products when promoting to minimize the slow-moving products from shelves. The slow-moving product maybe can sell fast. Therefore, the method used must be effectively and efficiently solving the problem.

There are various approaches for a corporation to identify slow-moving inventory, ranging from statistics to heuristic methods, but they all rely on data. To benefit from any of these strategies, they need accurate, timely, and complete data, as well as the appropriate analysis tools. There are also numerous successful techniques to convert slow-moving goods into cash to keep the organization moving forward.

Whitin and Youngs [1] were the first to explore the problem of slow-moving pieces. Since World War II, operations research methodologies have been used to inventory management issues constantly [2]. Work on smooth and continuous demand control of various stockholding systems has evolved since 1915, but it is not suitable for slow-moving commodities. The fundamental challenge with slow-moving products, according to Williams [3] is a lack of historical data. Large quantities of slow-moving things are common in industries that produce a variety of products. These items should have a fluctuating demand pattern and an unknown lead time. Slow-moving products are difficult to estimate when they will need to be reordered, resulting in higher carrying costs. To avoid this issue, the company needs to know the inventory manufacturing amount and retention term [4]. Managing slow-moving or obsolete commodities is a major issue for the manufacturing, distribution, and retail industries due to an overstock situation. Otherwise, every object should be liquidated before it reaches its salvage value, or it will become obsolete [5].

Balaji and Kumar [6] presented numerous researchers' perspectives on slow-moving inventories. Slow-moving objects make up a big percentage of firm items. The decision to liquidate a portion of an on-hand stock of slow-moving items is unpredictably difficult. Managing slow-moving or obsolete commodities is a major issue for various sectors due to an overstock situation. The many tactics involved in slow-moving inventory are explored, including ideal level, forecasting, and obsolescence.

Despite the methods introduced by the previous researchers, there are none of them attempt to solve the problem using graph network analysis. Motivated from the issue, thus in this paper, a partitioning technique from the graph network is proposed to partition the inventories or products into a few clusters to find an alternative way to solve the slow-moving product issue. It can help the company to identify what group does the product belongs to and at the same time suggest to the company which product can be paired up or bundled up together to clear up aging and slow-moving products. This is one of the contributions of this study. The graph network, G is said to have a set of nodes, $V= \{v_1, v_2, v3, \ldots, v_n\}$ and edges, $E= = \{e_1, e_2, e3, \ldots, e_m\}$, where n and m are natural numbers. The nodes are representing the products while the edges are representing the connection between products purchased. The two nodes are connected by an edge if there is a strong connection between both nodes. The connection is created when there is a high volume of several purchases between the products.

2. The Slow-Moving Products

Slow-moving things make up a huge percentage of firm items. The decision to liquidate a portion of an on-hand stock of slow-moving items is unpredictably difficult. Managing slow-moving products

is a major issue for various businesses due to an overstock scenario. Many kinds of literature cover numerous tactics regarding slow-moving products, such as optimal level, forecasting, and obsolescence. Balaji and Kumar [6] divided the slow-moving products into three categories for analysis: optimal inventory levels, forecasting, and different difficulties. Each problem is dealt with in the most effective way possible.

Few studies have been done to minimize the slow-moving products. The attention on the optimal stocking level of slow-moving inventory using the mathematical model, analytical model, and graphical decision model. In slow-moving inventory forecasting, two models had been implemented called the traditional model and the computerized model. The dynamic programming model and heuristic method have been introduced to solve the slow-moving products subject to obsolescence [7].

For commodities with extremely low demand, Whitin and Youngs [1] created an inventory control policy. In such an instance, the carrying charge is more than the predicted profit, thus they employed an exact order system with a Poisson distribution for the demanding unit. For the slow-moving item, a formula was constructed to determine whether the item should be stored at all. Croston [8] proposed a set of formulas for maximizing standard forecasting and minimizing incorrect replenishment levels. An iterative technique is proposed to achieve the accurate optimal integer values of both s and Q utilizing a Poisson distribution for demand in a continuous review (s, Q). A multinomial probability function and a Dirichlet prior distribution were assumed in this scenario. The best decision was made in a timely and effective manner. Babai *et al.,* [9] devised a method for determining the optimal order level for a single echelon single item inventory with stochastic demand and lead time that follows the compound Poisson process. The concept is based on cost-oriented inventory systems that backorder unfilled orders. For slow-moving components, the model converges quite quickly.

Heyvaert and Hurt [10] proposed a solution for a specific expensive slow-moving part with a short lead time about its lifetime. Initially, a closer optimal technique was proposed based on the infinite lifetime assumption, but an explicit formula is unable to provide. Kalpakam and Sapna [11] investigated the ordering policy for high-cost, slow-moving products with sporadic demand and potential replenishment delays. The optimal time delay for demand distribution with increasing and decreasing renewal densities that minimize the projected cost rate is investigated. Lindsey and Pavur [12] investigated the challenges of forecasting future demand for a collection of products with no demand. They presented and evaluated prediction intervals for slow-moving item demand rates in the future. Under various assumptions, the prediction intervals are reliable.

When it comes to slow-moving items, there are four crucial marketing management factors to which organizations and managers should pay attention. It's known as the 4 Ps. The four Ps of marketing is the most important aspects of selling a product or service. They are a good or service's product, pricing, location, and promotion. The 4 Ps, often known as the marketing mix, are influenced by both internal and external elements in the broader corporate environment, and they interact heavily.

According to literature, more researchers have focused on determining the best inventory level for slow-moving products in various industries, followed by forecasting and obsolescence. Managing slow-moving products is a major issue in the industry due to an overstock scenario. Many scholars have attempted their research work on appropriate stocking levels of slow-moving products compared to other problems to avoid this climate [13].

3. Products Pairing Strategy

Bundling slow-moving products with fast-moving ones are one of the most effective techniques to reduce slow-moving products. Customers will be more interested in purchasing product bundles than those sold separately since they are more appealing to them [14]. Product pairing or matching is a method that may be used by almost any firm. It is a good approach for selling complimentary and available products when you offer pair items and sell them as a bundle, telling clients that they are getting more for their money. Match less popular products with more popular ones to clear up overstock inventory. Because it makes the consumer's life easier, product matching works so well. When combining items, it's best not to overwhelm shoppers with too many options; just enough to make the proposal convenient and enticing. When done correctly, it appears to be useful advice rather than a forced upsell. People love it when businesses make recommendations, according to studies. This product pairing, for example, has demonstrated that bundling or pairing works to increase sales from Amazon sellers to Netflix.

The benefits go far beyond simply saving time while shopping. The basic benefits of bundling include improving the customer experience to produce a happier customer, providing a tailored shopping experience, limiting choices to reduce or eliminate decision exhaustion, increasing customer confidence by increasing product value, increasing product understanding by the consumer, increasing product insights through automatic customer feedback, and increasing average order value. When a client sees a product pairing, it does more than just save them time or help them match similar things. It appeals to them on a psychological level to raise the value of the main object and its companion. Most individuals understand the value of getting two items for less than the cost of one. They value both products more when you bundle them and deliver additional value. According to a survey of marketers, 85% believe that most factors that influence consumer purchasing decisions are subconscious. Simply put, buyers are more likely to buy a bundle if it looks nice and saves them from having to add individual items to their cart. Combo packing products can be done in a variety of ways, and it is a strategy that can benefit almost any firm.

4. Graph Network

A network graph is a graph that uses simple links to show relationships between items (nodes). It is a significant area of current mathematics that has many applications not just in other branches of mathematics, but also in scientific disciplines such as engineering, computer science, management sciences, operational research, and the life sciences. It is derived from graph theory. In general, a graph is a collection of vertices (also known as nodes) and links (sometimes known as edges), along with a rule for how the nodes and edges are connected. Modelling with graphs is a great way to go. A graph can be scanned for all information and the abstract definition from the graph can be recorded uniquely. As a result, the real-world applications can be reduced to graphs.

People can rapidly visualize clusters and interactions between nodes using network graphs. A graph's structure is made up of nodes (also called vertices) and edges. Edges represent a relationship or channels of communication between nodes, whereas nodes represent points or items in the graph data. Every edge has a weight and a direction (one-way, bidirectional, or non-directed) that represents the relationship's strength. Nodes can be people, such as consumers or employees, or places, such as retail stores or airports, or they can represent objects like assets, grids, bank accounts, URLs, and so on in real-world scenarios. Likes and dislikes, emails, money, phone calls, and much more can all be represented by edges. Properties are auxiliary information or attributes that describe a node.

The graph network saves a lot of time since it takes less time to organize data and requires fewer efforts to merge more data sources or points. It is also easier to work with as a result of this. It also provides for data analysis modelling, storage, and retrieval. Graphs are also more visually appealing and understandable than most other data analytics tools and methods. It can also uncover indirect relationships and coherently express huge and complex data.

5. The Partitioning Technique

The partitioning technique improves the performance, manageability, and availability of many applications while also lowering the total cost of ownership for huge quantities of data storage. Partitioning may be used to practically any program since it is completely transparent, which eliminates the need for potentially costly and time-consuming application changes. According to Moller [15], partitioning analysis is used to identify groups of directly competing product variants, known as attribute vectors. Marketing strategy, on the other hand, aims to identify groups of consumers who share similar purchasing or usage habits or responses to marketing activities. The partitioning method discussed here is based on different data than perceptual geographic data. In partitioning analysis, product qualities are represented as nominally scaled variables. As a result, approaches that rely on the correlation between metric variables, such as factor analysis, are inapplicable. The amount to which two items compete in a marketplace can be quantified most realistically by analysing actual consumer buy behaviour in a succession of purchasing situations, according to a key premise of partitioning analysis. If a customer is spotted purchasing a group of products to meet a specific need, those commodities are discovered to be replacements and hence effectively competing with anyone. In this paper, the clique partitioning technique is implemented to obtain the cluster or group of products. In graph theory, a clique partition into cliques of a given undirected graph is a partition of the vertices of the graph into cliques, subsets of vertices within which every two vertices are adjacent. A minimum clique cover is a clique cover that uses as few cliques as possible. The minimum k for which a clique cover exists is called the clique cover number of the given graph.

6. Marketing Mix Theory

Although it is impossible to deny the need to adapt the marketing mix to the changes in society and the market caused by the diffusion of digital technologies, particularly the Internet, a smaller but theoretically consistent body of literature asserts that the 4 Ps' model is perfectly capable of adapting and remaining the dominant paradigm in these new contexts. According to Haneveld and Teunter [16], the "internal orientation" criticism of the 4 Ps is based on a misunderstanding of the relationship between the marketing mix and the marketing concept. The 4 Ps paradigm is perfectly consistent with the marketing concept, which states that "marketing activities should be based on the identification of customer needs and wants," as well as the selection of explicit information to be gathered from customers to fulfil their needs, through segmentation, product differentiation, and positioning.

According to Yudelson [17], the new communicative capabilities provided by digital technologies are radically changing marketing in several sectors, but the marketing mix approach is adaptable to the new needs: product, with the introduction of co-design with customers; price, with higher levels of transparency; place, with the creation of new ways to reach customers; and promotion, with the introduction of new interactive capabilities. Product. Today, the product should be redefined as "all the benefits that the user enjoys over time from the transaction"; this definition applies to the digital

context [18]. From the supply side, product policies can profit greatly from the Internet's ability to engage consumers in long-term relationships that lead to the development of new items. The Internet's interactive and connecting potential gives rise to a new commercial concept: the "virtual product". The virtual product is viewed as the union of tangible and intangible characteristics that are adapted and customized in response to the variety and variability of individuals' preferences by customizing the product with the active participation of consumers.

7. The Relationship Between the Graph Network with The Product Pairing Selection

By integrating the graph network knowledge with the selection of pairing products, the products can be referred to as the nodes while the edges which connected the two nodes are defined as the strong purchase volume between the products. It is shown in Figure 1. The nodes and edges are the task graph which will be partitioned into a few subgraphs (clusters) according to the similarity of the purchase volume. In other words, the products will be divided into different clusters [19]. The products will be located on their cluster. Each of the clusters consists of products with similar purchase volumes. It can be the fast-selling products in one cluster, an average selling product in another cluster, and the slow-moving products lying in one cluster. Instead of the statistical and stochastic methods used by other researchers, in this study, the graph network is proposed to identify the group of products. Then, the companies or managers will be proposed to set the selling price of the products [20].

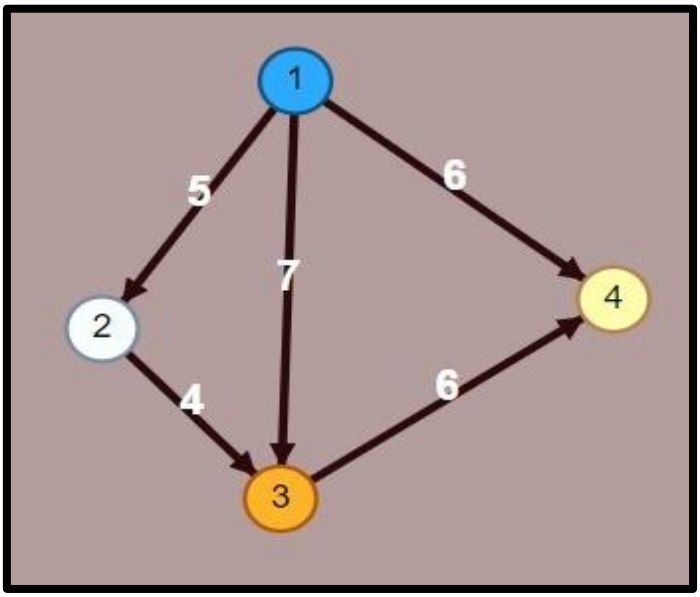

Fig. 1. The nodes, edges, and their relationship

8. The Research Design

The methodology of this research can be divided into three phases. The first phase involves the problem definition and the development of 50 nodes randomly generated by the computer with edges connected to the nodes. In the second phase, the partitioning technique is applied to divide the strongly connected graph into five clusters. The proposed algorithm, along with 50 nodes, was coded and tested in the C++ programming language with Intel Core i7-3632 QM CPU @ 2.20GHz and 4GB RAM environment. The results are tabulated and analysed. Recommendation of the product pairing is discussed. The solution is analysed and then being implemented. Recommendations for

selecting the product pairing are discussed. The general steps of the research design are shown in Figure 2.

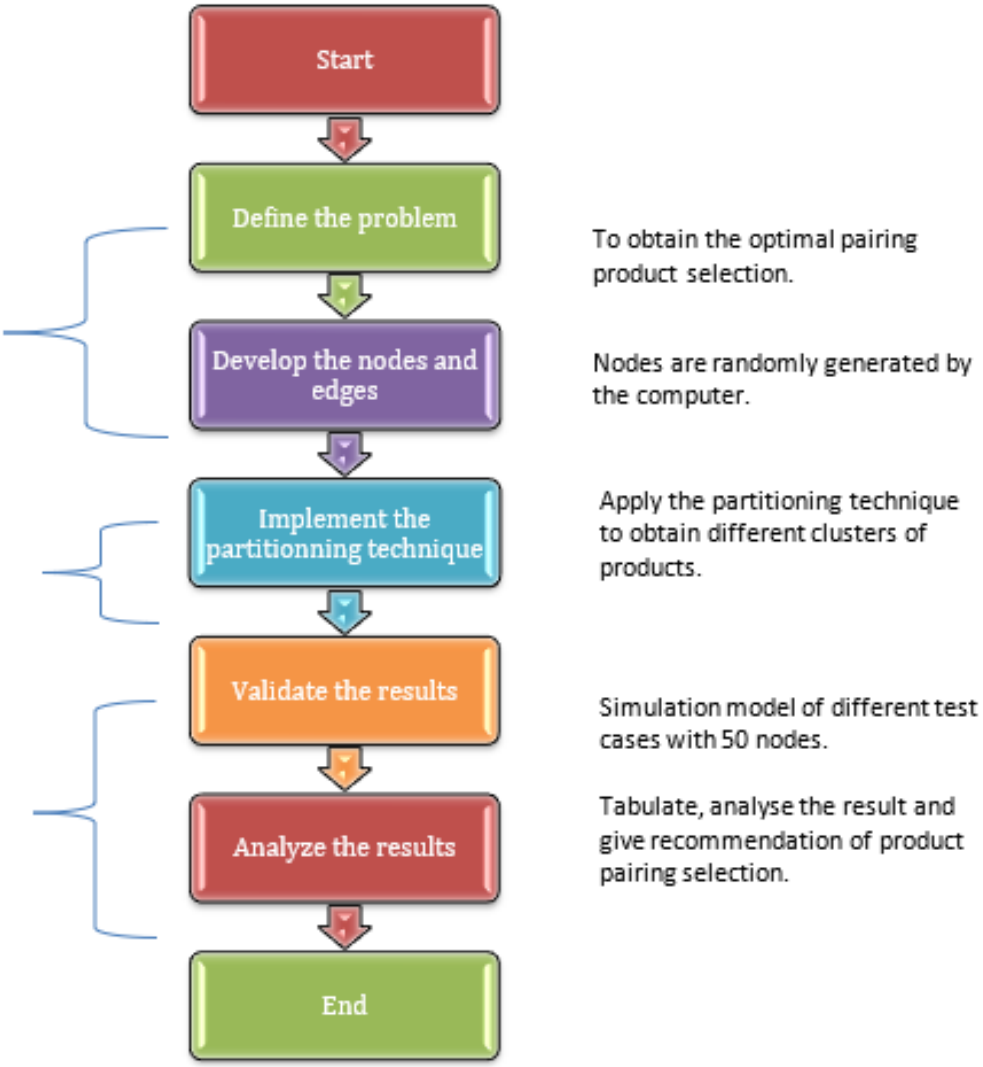

Fig. 2. The general flow chart of research methodology

9. Numerical Experiment

The development of partitioning algorithm and specifically partitioned the task graph of products onto three clusters starts with a small number of nodes, i.e., 10 nodes. The interface of the simulation model is shown in Figure 3.

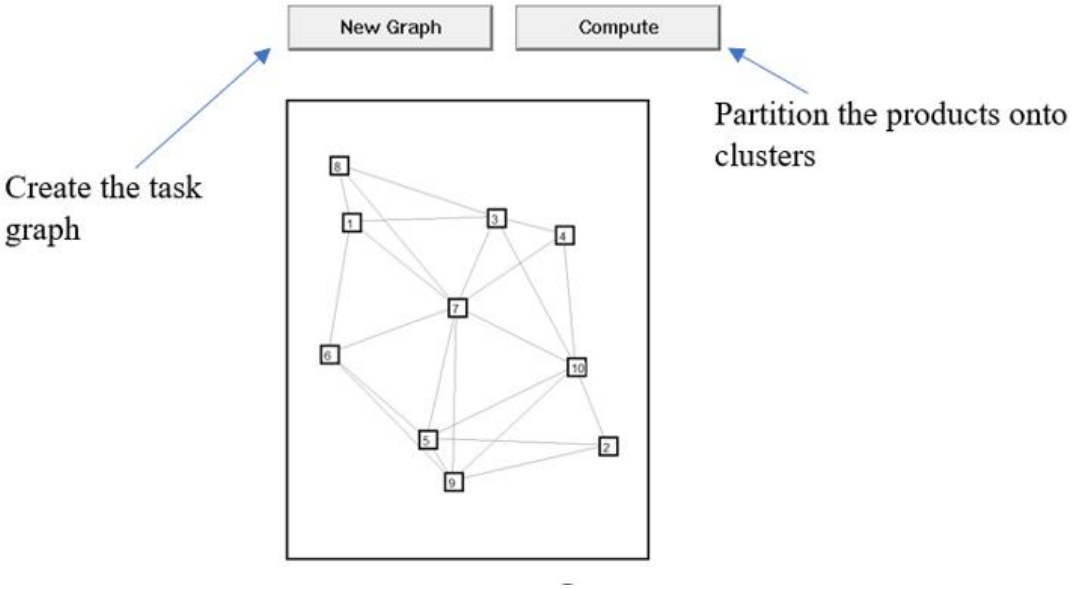

Fig. 3. The interface of the simulation model with 10 nodes

The interface of the simulation model consists of two main buttons which are the New Graph button and Compute button. These buttons create the task graph with 10 products and partition the products into three clusters. When the user clicks the Compute button, the simulation model will show the following information as shown in Figure 4.

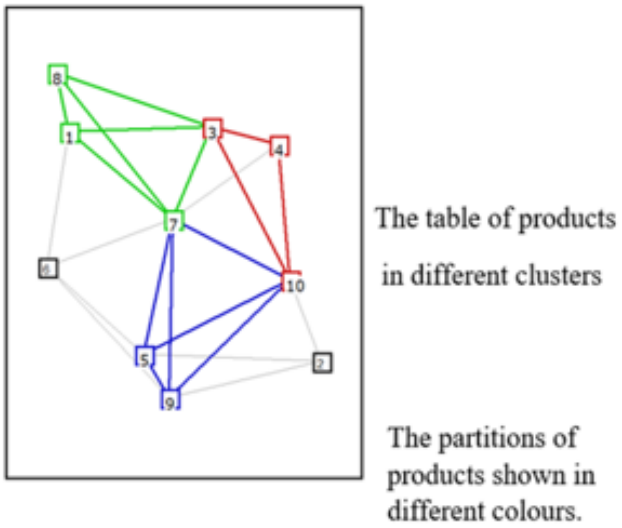

Fig. 4. The simulation results of 10 nodes randomly generated by the computer

From the above simulation model and result, the algorithm is then tested to a different case with 50 nodes. Figure 5 below shows the simulation of 50 nodes.

Figure 5 shows the 50 nodes (products) are partitioned into five different clusters. It is visualized with different colours and then tabulated according to their cluster. From the marketing perspective, it can be called the product having the same number of purchasing volume.

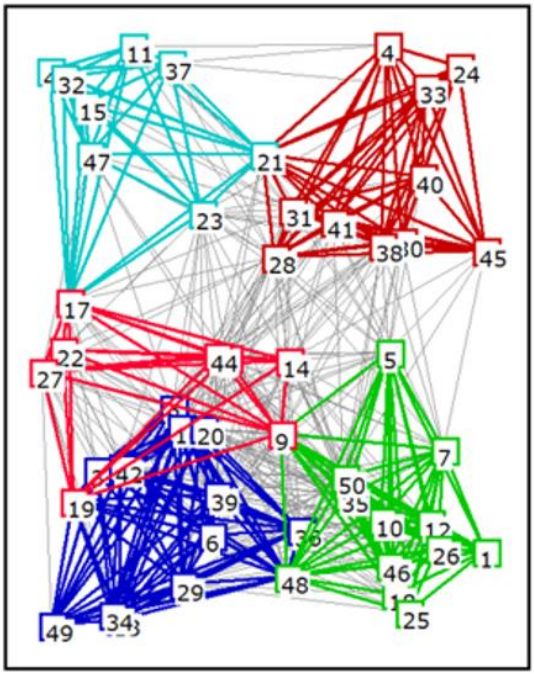

Fig. 5. The simulation of 50 nodes

10. Results and Discussion

Figure 5 shows 50 nodes being partitioned into 5 clusters. Let us denotes Product 49, 3, 6, 8, 13, 16, 19, 20, 29, 34, 36,39, 42 and 48 as Cluster 1. Then, Product 1, 5, 7, 9, 10, 12, 18, 25, 26, 35, 46, 48 and 45 belongs to Cluster 2. Products 24, 4, 21, 28, 30, 31, 33, 38, 40, 41 and 45 exist in Cluster 3. Cluster 4 consists of Product 43, 11, 15, 17, 21, 23, 32, 37 and 47. Products 19, 2, 9, 14, 17, 22, 27, and 44 are grouped in Cluster 5. All products with the same cluster are coloured with a specific colour and tabulated in the table next to the task graph. In this case, let us define Cluster 1 as the fast-selling product while Cluster 5 is the slow-moving product that exists in a company. According to the suggestion and recommendation of selecting the pairing products and setting up the price for each of the products as shown in Figure 6 and Figure 7, the same idea can be implemented on the simulation results if 50 nodes according to the objective set by the company. If the company aims to minimize the slow-moving products i.e., products from Cluster 5, therefore it is recommended to select a product from the fast-selling group in Cluster 1 as the core product while any product in Cluster 5 is the hooked product. Both products can be sold at the retail price or one sell at a retail price, while the other one is at markdown price. Product at Cluster 5 is not only can be paired with products in Cluster 1. It can also be paired with Cluster 2,3 or 4. The option of selecting both products from the same cluster i.e., Cluster 5 also can be done. But the company needs to struggle in doing the promotion. Of course, the cost in implementing the promotion like advertising involves high cost. Therefore, the manager can use another alternative by selecting the products from a different cluster. The suggestion of selecting the pairing products is shown in Table 1.

Table 1
The selection of pairing products from Cluster 1 and Cluster 5

Core product	Hook product
49	19
3	2
6	9
8	14
13	17
16	22
19	27
20	44
29	
34	
36	
42	
48	

Good decision-making is very important. The 4 Ps are used by companies to identify some key factors for their business, including what consumers want from them, how their product or service meets or fails to meet those needs, how their product or service is perceived in the world, how they stand out from their competitors, and how they interact with their customers. As has been mentioned before, the 4 Ps are the product, price, place, and promotion of goods or services and are often referred to as the marketing mix. Here, for the company to set up the promotional items with good promotion strategies, the selection of the right products is important. From this study, the suggestion and recommendation of product selection that gives the benefit to the companies are shown in Figure 6.

Based on Figure 6, the recommendation of product selection can be from the same cluster. It means that all products within Cluster 1, Cluster 2, and Cluster 3 can be selected. The manager can decide to choose one product as a core product while the other one as a pairing product. Let us take an example from Cluster 3. Cluster 3 consists of Product 7, 2, and 4. Thus, the manager can select any one of these as a core and a pair product, say Product 7 and Product 4 respectively. Here, the manager can easily decide to set the price of each type of product. It can be Product 7 sell at a retail price, while Product 4 will be sold at a markdown price. Otherwise, to make the slow-moving product clear efficiently and effectively in a short period, the manager can sell both products at a markdown price.

This is not the only option that the manager has. Apart from the above suggestion, this study also can recommend the manager to decide by considering the different clusters of products. This is shown in Figure 7.

As can be seen from Figure 7, the products can be divided into two categories i.e., core product and hook product. Products in these two categories are selected from different clusters. It is recommended that the core product can be sold at a retail price and the same goes for the hook product. This is only can be done by sticking to the principles that all marketing strategies are done in a proper plan. When choosing the products from the different clusters, the manager could also set the price of the core product being sold at a retail price while the hook product at the markdown price. Since in this study, the products are already being partitioned into different clusters, therefore it is easier for the managers to decide on selecting the product while doing the promotion. Other than that, it helps the companies to clear up their slow-moving products on shelves and stores.

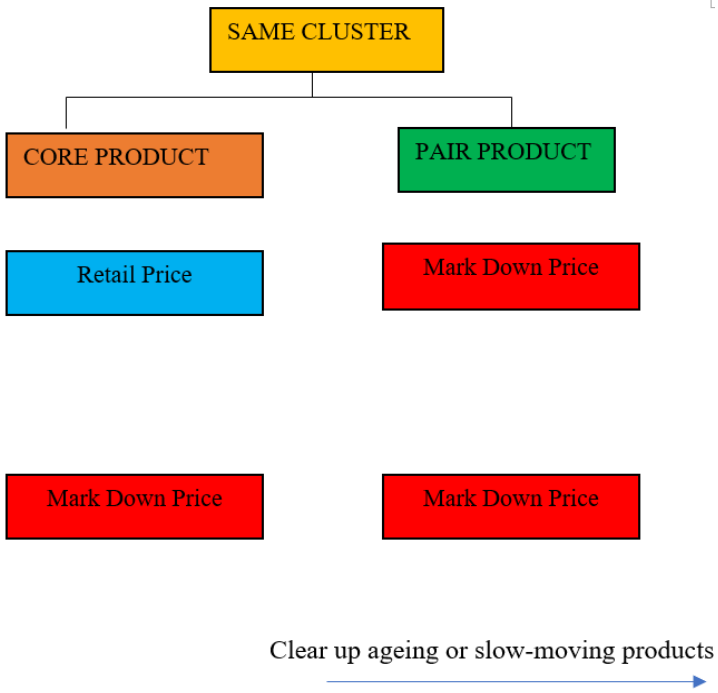

Fig. 6. The recommendation of product selection within the same cluster

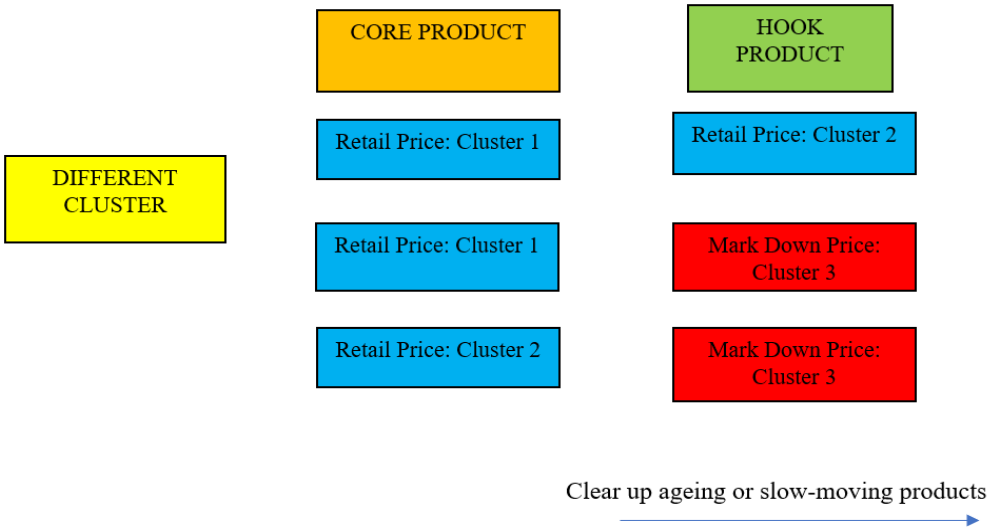

Fig. 7. The recommendation of product selection within different clusters

11. Conclusions

In this respect, the first objective was to study the relationship between the product pairing selection with the graph networks. The nodes and the edges are well defined in the task graph. The integration of management, marketing, and mathematics bits of knowledge are blended to introduce an alternative technique in obtaining the solution. The clique partition is implemented to find the similarity of the connection in terms of purchase volume so that all nodes can be partitioned into the appropriate cluster. The proposed method and algorithm are tested to 10 nodes and then extended to larger nodes, i.e., 50 nodes. The simulation results manage to divide the products into clusters. The proposed method with validation through simulation models is subjected to the proposed task

graphs. This work remains open, and there are several issues where further work is required. Future studies need to improve the proposed methods by exploring the hybrid learning and optimization methods due to their efficiency in handling real-world problems. The results obtained from this study provide a fundamental output of product selection after being partitioned. In the future, the actual dataset can be used. The data must be collected for a few months to study the consumers' behaviour in purchasing. Then, the information is transformed into customer transaction data. Market basket analysis and neural networks are among the useful methods to be applied. R programming and Python are other useful programming packages to be used in line with the current needs and trends.

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