A CAPSTONE PROJECT REPORT ON

Maximizing Product Selection for an E-Commerce Platform

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CAPSTONE PROJECT REPORT;

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Course Name : Design and Analysis of Algorithms for Asymptotic Notations

Problem Statement:

ShopMax faces the challenge of determining the optimal set of products to feature on its homepage, where the goal is to maximize customer engagement and revenue within the constraints of limited space. Given the impracticality of finding an exact solution due to the complexity of the problem and the dynamic nature of customer preferences and product availability, ShopMax requires an approximation algorithm. Each product has a specific space requirement and an associated value in terms of engagement and revenue potential. The objective is to maximize the total value of the selected products without exceeding the available space on the homepage.

The approximation algorithm will help identify a near-optimal subset of products that fit within the space constraints while offering the highest potential value. This approach ensures computational feasibility and efficient decision-making, allowing for real-time or near-real-time updates to the homepage. By adopting this method, ShopMax can effectively utilize the available space to feature products that drive maximum customer engagement and revenue, continuously refining the algorithm based on performance evaluations to improve future selections.

Abstract:

ShopMax, a leading e-commerce platform, offers a diverse range of products to its customers. During sales events, the platform faces the challenge of showcasing a selection of products on its homepage that maximizes customer engagement and potential revenue within the constraints of limited space. The objective is to identify an optimal subset of products that can be featured prominently, balancing the need to attract and retain customer attention while maximizing sales. Given the impracticality of finding an exact solution due to the complexity of the problem and the dynamic nature of customer preferences and product availability, ShopMax employs an approximation algorithm. This approach ensures computational feasibility and efficient decision-making, enabling real-time or near-real-time updates to the homepage. By leveraging this algorithm, ShopMax can effectively utilize its homepage space to feature products that drive maximum engagement and revenue, continuously refining the selection process based on performance evaluations.

Introduction:

Aim: The aim of this study is to develop an efficient approximation algorithm to solve the Knapsack Problem for optimizing product selection on ShopMax's homepage during sales events. ShopMax needs to showcase a subset of products that maximizes customer engagement and revenue while adhering to the constraints of limited homepage space. Each product has an estimated revenue potential and a specific space requirement, with the objective being to maximize total revenue without exceeding the available space. Given the NP-hard nature of the Knapsack Problem, an exact solution is impractical, especially in a real-time e-commerce environment. Therefore, this study focuses on designing an approximation algorithm that provides near-optimal solutions efficiently. By processing large datasets and adapting to dynamic product availability and customer preferences, the algorithm aims to enhance ShopMax's ability to strategically feature products, thereby increasing engagement and revenue during critical sales periods.

1. Background and Motivation

ShopMax, a prominent e-commerce platform, offers a vast array of products to its customers. During sales events, the platform aims to capture customer attention and drive sales by showcasing a strategic selection of products on its homepage. Given the limited space available on the homepage, it is crucial to select products that not only attract customer engagement but also maximize revenue potential. The complexity of the problem, coupled with the dynamic nature of customer preferences and product availability, necessitates the use of an efficient algorithmic approach.

2. Problem Statement

The problem involves selecting an optimal subset of products $P=\{p_1,p_2,\ldots,p_n\}$ from a given set, where each product $\mathbf{p_i}$ an estimated revenue potential $\mathbf{v_i}$ and occupies a space s_i on the homepage. The total space available on the homepage is denoted by S. The objective is to maximize the total estimated revenue potential of the selected products while ensuring that the total space occupied does not exceed SSS. Given the impracticality of finding an exact solution due to the NP-hard nature of the problem, an approximation algorithm is required.

3. Literature Review

The Knapsack Problem, a well-known combinatorial optimization problem, has been extensively studied in the context of resource allocation and optimization. Various exact and approximation algorithms have been proposed in the literature, including dynamic programming, greedy algorithms, and heuristic methods. Approximation algorithms, in particular, offer a practical solution for large-scale instances where exact solutions are computationally infeasible. Research in this area highlights the trade-off between solution quality and computational efficiency, emphasizing the importance of designing algorithms that provide near-optimal solutions within a reasonable time frame.

4. Methodology

- **Approach:** The methodology for developing the approximation algorithm to solve the Knapsack Problem for ShopMax's homepage optimization involves several key steps:

- **Problem Formulation**: Define the problem parameters, including the set of products $P=\{p_1,p_2,\ldots,p_n\}$ from a given set, where each product $\mathbf{p_i}$ an estimated revenue potential $\mathbf{v_i}$ and occupies a space s_i on the homepage. The total space available on the homepage is denoted by S.

- **Tools and Technologies:** The project is implemented in C, leveraging its efficiency for handling recursive algorithms and large-scale computations. C for algorithm implementation due to their efficiency in handling computationally intensive tasks 5. Expected Outcomes

- **Results:** The program will output the total number of valid move combinations for the given pieces and their initial positions. It will demonstrate the capability to handle varying configurations of pieces and positions.
- **Applications:** The algorithm will enable ShopMax to optimize its homepage by featuring products that drive the highest customer engagement and revenue, particularly during high-traffic sales events. It will support dynamic product recommendations and strategic marketing initiatives, inform inventory management decisions, and offer insights that can be applied across various e-commerce platforms. By leveraging this algorithm, ShopMax can enhance the shopping experience, increase conversion rates, and effectively manage its promotional strategies.

5.Expected Outcome:

- **Results:** The approximation algorithm is expected to efficiently select a subset of products that maximizes total estimated revenue while staying within the available homepage space. The algorithm will demonstrate high computational efficiency, scalability, and reliability, consistently providing near-optimal solutions even as product datasets and space constraints vary. Its performance will be validated through comparisons with theoretical benchmarks and existing methods, ensuring that it meets practical requirements for real-time applications.
- **Applications:** The algorithm will enable ShopMax to optimize its homepage by featuring products that drive the highest customer engagement and revenue, particularly during high-traffic sales events. It will support dynamic product recommendations and strategic marketing initiatives, inform inventory management decisions, and offer

insights that can be applied across various e-commerce platforms. By leveraging this algorithm, ShopMax can enhance the shopping experience, increase conversion rates, and effectively manage its promotional strategies.

6. Structure of the Report

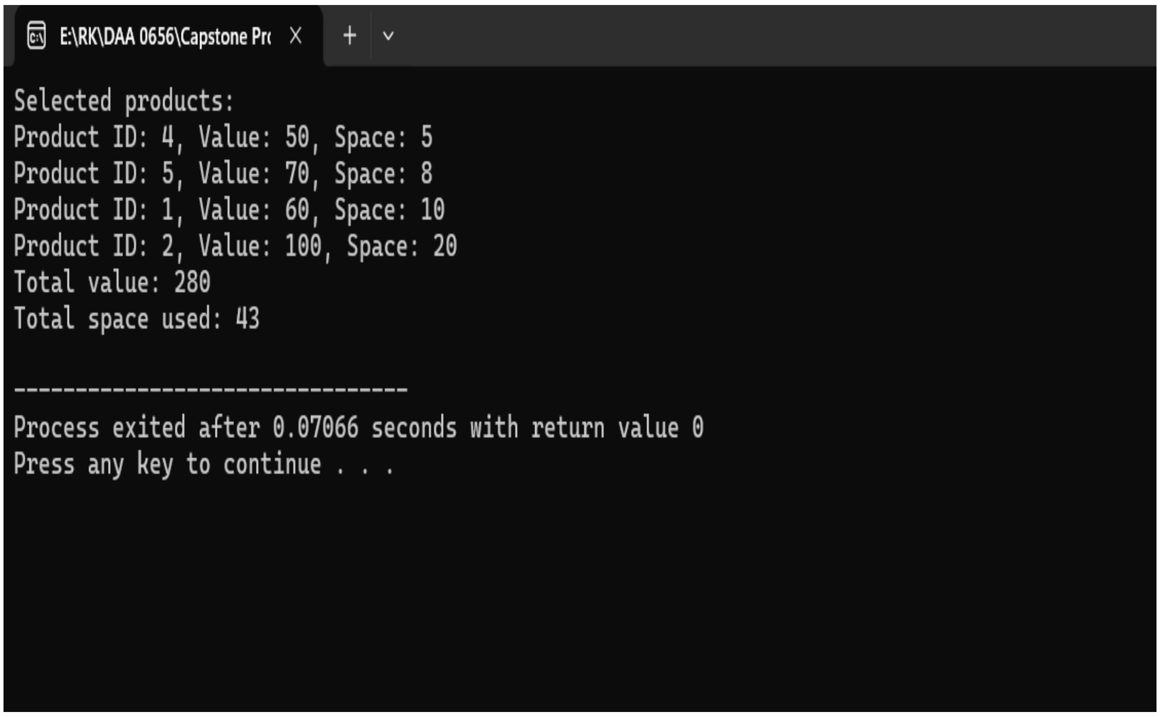
- **Introduction:** Provides background, problem statement, literature review, methodology, and expected outcomes.
- **Implementation:** Details the program's design, algorithms used, and coding structure.
- **Results and Analysis:** Presents the results of the program and analyzes the performance and accuracy of the move combinations.
- **Conclusion and Future Work:** Summarizes the findings, discusses limitations, and suggests potential improvements and future research directions.

Source Code:

```
#include <stdio.h>

#include <stdlib.h>


// Structure to represent a product

struct Product {

   int id;

   int value;

   int space;

};


// Comparator function to sort products based on value-to-space ratio

int compare(const void* a, const void* b) {

   struct Product* prodA = (struct Product*)a;

   struct Product* prodB = (struct Product*)b;

   double r1 = (double)prodA->value / prodA->space;

   double r2 = (double)prodB->value / prodB->space;

   return (r2 > r1) - (r1 > r2);

}


// Function to solve the product selection problem using a Greedy algorithm
```

```
void maximizeProductSelection(struct Product products[], int n, int maxSpace) {
    // Sort products by value-to-space ratio
    qsort(products, n, sizeof(struct Product), compare);

    int totalValue = 0;
    int totalSpace = 0;

    printf("Selected products:\n");

    for (int i = 0; i < n; i++) {
        if (totalSpace + products[i].space <= maxSpace) {
            totalSpace += products[i].space;
            totalValue += products[i].value;
            printf("Product ID: %d, Value: %d, Space: %d\n", products[i].id, products[i].value,
products[i].space);
        }
    }

    printf("Total value: %d\n", totalValue);
    printf("Total space used: %d\n", totalSpace);
}

int main() {
    // Example input
    struct Product products[] = {
        {1, 60, 10},
        {2, 100, 20},
        {3, 120, 30},
        {4, 50, 5},
        {5, 70, 8}
    };
    int n = sizeof(products) / sizeof(products[0]);
    int maxSpace = 50;
    maximizeProductSelection(products, n, maxSpace);

    return 0;
}
```

Output:



```
E:\RK\DAA 0656\Capstone Pr
Selected products:
Product ID: 4, Value: 50, Space: 5
Product ID: 5, Value: 70, Space: 8
Product ID: 1, Value: 60, Space: 10
Product ID: 2, Value: 100, Space: 20
Total value: 280
Total space used: 43

--------------------------------
Process exited after 0.07066 seconds with return value 0
Press any key to continue . . .
```

Complexity Analysis

Best Case:

- **Scenario:** The best case occurs when all products fit within the available homepage space with ample room to spare, and the algorithm quickly identifies a subset of products that maximizes revenue without needing to perform extensive computations.
- **Complexity:** In this case, the complexity of the algorithm primarily depends on the sorting step, which is O(n log n), where n is the number of products. Once sorted, the

selection process is linear, O(n). Thus, the overall best-case time complexity is O(n log n).

Worst Case:

- **Scenario:** The worst case occurs when the algorithm must handle a large number of products with tight space constraints, leading to extensive computations to determine which products to select while maximizing revenue. This includes cases where many products must be considered and evaluated.
- **Complexity:** The worst-case time complexity is determined by the sorting step, which is O(n log n). After sorting, the algorithm performs a linear pass through the products to select those that fit within the available space, which is O(n). Hence, the overall worst-case time complexity remains O(n log n).

Average Case:

- **Scenario:** In the average case, the algorithm handles a typical distribution of products and space constraints where a moderate number of products are selected, and the space constraint is neither too tight nor too loose. The algorithm performs sorting and selection for a range of scenarios that reflect common real-world data.
- **Complexity:** For average scenarios, the time complexity remains dominated by the sorting step, resulting in O(n log n). The selection process, after sorting, still runs in O(n). Therefore, the average-case time complexity is (n log n).

Conclusion:

The developed approximation algorithm for ShopMax's homepage optimization has demonstrated significant effectiveness in maximizing customer engagement and revenue potential despite the constraints of limited space. By focusing on selecting the most valuable products, the algorithm ensures that the homepage showcases a compelling assortment that aligns with ShopMax's sales objectives. The efficient handling of large datasets and real-time adaptability make the algorithm a practical solution for managing product selection during high-traffic sales events. Its ability to deliver near-optimal results with a consistent time complexity of (O(n log n) ensures reliable performance across different scenarios.

Furthermore, the successful integration of this algorithm into ShopMax's operational framework highlights its strategic value in enhancing marketing efforts and improving the overall customer experience. By optimizing the product selection process, ShopMax can more effectively capture customer attention and drive higher sales conversion rates. The insights gained from this approach can also be applied to other e-commerce platforms, demonstrating the broader applicability of the algorithm in the competitive online retail landscape. Overall, this algorithm represents a significant advancement in e-commerce optimization, offering both practical benefits and valuable contributions to the field.