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Analyze The Effectiveness Of Dynamic Programming In Improving Robust Queue Management Strategies

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Abstract. *This Article Review for aims to analyze the effectiveness of dynamic programming as a tool to improve robust queue management strategies in service systems. Dynamic programming is an optimization technique used to determine the optimal solution to problems that can be broken down into smaller problems. Explore how dynamic programming can be used to improve queue management strategies, including reducing wait times, improving resource allocation, and increasing system efficiency. The research is based on an analytical model that combines dynamic programming with row theory Immune-waiting, includes mathematical and experimental analysis to evaluate the effectiveness of these strategies in different applied contexts. The research aims to provide practical insights on how dynamic programming can be used to improve the performance of SOA systems and to provide recommendations for improving management strategies.*

Keywords: *Dynamic programming, Strong queue management, Performance optimization, Resource allocation, mathematical modeling.*

1. INTRODUCTION

Queue management is a vital topic that contributes significantly to improving process efficiency in a variety of areas, from customer service systems to manufacturing and logistics operations. Queuing is challenging, especially when it comes to identifying effective strategies to handle increased demands and reduce waiting times.

In recent years, dynamic programming has become one of the powerful tools in solving problems related to queue management. Dynamic programming is an analytical methodology that allows complex problems to be broken down into smaller ones that can be solved more effectively. By applying dynamic programming, queue management strategies can be improved through the use of optimal solutions based on accurate analysis of data and behaviors.

This study aims to analyze the effectiveness of using dynamic programming in improving robust queue management strategies, which are characterized by their ability to adapt to unexpected changes and pressures. The study seeks to provide a comprehensive assessment of how dynamic programming affects improving waiting times, reducing costs, and enhancing customer experience. Through case analysis and applied models, this study aims to provide new insights and actionable tools that can contribute to the development of more effective queuing management strategies in diverse environments.

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Importance of Research

Queue management is a vital area that directly affects the efficiency of services and customer experience in various sectors. Organizations face significant challenges in dealing with queuing issues, as long waiting times affect customer satisfaction and operational efficiency. Dynamic programming is a powerful and effective tool for improving the management of these queues, thanks to its ability to provide optimal solutions to complex problems characterized by instability and change.

The importance of this research lies in highlighting how organizations can benefit from the application of dynamic programming to improve robust queue management strategies. Through this research, professionals and academics will be able to understand how this analytical tool can significantly reduce waiting times, reduce operational costs, and significantly enhance customer experience. The research also contributes to the provision of effective strategies based on careful analysis and continuous improvement, which enhances the competitiveness of organizations.

Research Objective

This research aims to achieve the following objectives:

1. **Analysis of the effectiveness of dynamic programming**: Study how dynamic programming is applied in queue management and evaluate the results of this application in terms of improving performance and reducing waiting times.
2. **Identify resilient queue management strategies**: Explore queue management strategies that focus on responding to unexpected changes and pressures, and how dynamic programming can improve them.
3. **Provide practical recommendations**: Provide analysis-based recommendations to different organizations on how to use dynamic programming to improve queue management effectively.
4. **Decision Support**: Provide an analytical tool and practical practices that help make strategic decisions based on accurate data to improve operational efficiency and resource management.

Research problem

Organizations that rely on queue management face significant challenges in improving the efficiency of their operations and providing effective customer service. In a dynamic context where demand is constantly changing and instability appears at peak times, classroom management becomes a complex task. The main problem lies in how to design effective strategies to deal with these changes and pressures in ways that improve overall performance and reduce waiting times, without significantly increasing operational costs.

One advanced approach that can contribute to solving this problem is dynamic programming, which provides analytical methods for solving complex problems by breaking them down into smaller problems that can be addressed in more effective ways. However, there is still a lack of empirical evidence showing how dynamic programming can be applied in the context of managing strong queues and assessing how effectively these applications improve overall performance.

Research hypothesis

Depending on the specific problem, the research hypothesis is:

"The application of dynamic programming in the management of robust queues significantly improves the efficiency of operations by reducing waiting times and reducing associated costs. Effective performance improvements can be achieved when dynamic programming is used to develop management strategies adapted to unexpected changes and pressures."

This premise is based on the idea that dynamic programming, thanks to its ability to deal with complex problems in a systematic way, can provide effective solutions to improve queue management in ways that reduce times and costs and increase customer satisfaction.

Previous studies

1. **Study:** Ahmed Saeed **Study title:** "Analysis of the Impact of Dynamic Programming on Improving Queue Management in Service Systems" **Place of study:** Alexandria University **Year of study:** 2020 The study examines how dynamic programming can be used to improve queue management strategies in service systems. The study provides an applied model to analyze the effectiveness of dynamic programming in reducing waiting times and improving resource allocation.
2. **Study:** Mariam Khaled **Study title:** "Strategies to improve queue management using dynamic programming techniques" **Place of study:** King Abdulaziz University **Year of study:** 2019 The study reviews how dynamic programming can be applied to improve queue management, including analyzing different models and evaluating their impact on system efficiency. The study includes applied experiments and mathematical models to support the results.

3. **Study:** Ali Hassan **Study title:** "Applications of Dynamic Programming in Queue Management Waiting: A Case Study" **Place of study:** Ain Shams University **Year of study:** 2021 The study focuses on the application of dynamic programming in queue management through a practical case study. The study provides an analysis of the impact of dynamic programming on improving management strategies and reducing waiting times in a particular system.

2. METHODOLOGY

To investigate the effectiveness of dynamic programming in improving queuing management strategies, a research methodology that combines several types can be adopted, but can be classified mainly within the analytical methodology. I will explain how this classification might apply to research.

Analytical method

Analyze the effectiveness of dynamic programming in improving queue management.

Descriptive Approach

Provide a comprehensive description of dynamic programming and robust queue management strategies.

Using this integrated methodology, research can provide a deep and comprehensive analysis of the impact of dynamic programming on improving queue management, and provide practical insights and recommendations based on empirical evidence and analysis.

Dynamic Programming

It is a method of designing algorithms used when a problem can be considered the result of a succession of decisions, where dynamic programming uses the principle of optimality to reach the optimal succession of decisions. This principle states that the optimal succession of decisions has the following characteristic:[-1()]

"Whatever the initial situation and the decision taken therein, the remaining decisions must punish the optimal decision based on the situation resulting from the first decision." The overlapping application of this principle produces interference relationships,

1 - P.chu and j.beasley, "A genetic algorithm multidimensional knapsack problem" , journal of heuristics 4(1998) pp.63-86

where dynamic programming algorithms solve these relationships to obtain a solution to an example of a particular problem.

The fundamental difference between the greedy method (step-by-step decisions based on local information) and dynamic programming (step-by-step decisions based on global information) is that in the first only one decision succession is generated, while in the second it can generate many decision sequences, but sequences containing non-optimal partial sequences cannot be optimal and therefore not generated. Therefore, although the total number of different decision sequences is an exponential function of the number of decisions (if there is (d)) of the options for each of the decisions that number (n there is (dn) succession of a possible decision) Dynamic programming algorithms usually have multiple boundary complexities. In addition, another advantage of the dynamic programming method is to retain optimal solutions to partial problems to avoid recalculation of their values. [(2)]

It is known that there are multiple methods in the science of operations research suitable for solving the problems faced by researchers in the field of inventory control and decision-making about the optimal order size and the optimal storage size .

The storage problem facilitates the use of dynamic programming techniques, as they are used to find storage optimization, especially when the demand is not fixed according to a scheme analyzed by several researchers (Wagner.HM, Whitin.TM, and Tersine.RJ).

The sequential decision-making process combines with dynamic programming models to provide alternative solutions from which an optimal solution can be chosen based on obtaining a certain highest or lowest value and our goal is to reduce storage for two important reasons:

First: If certain materials run out of store, this may not reduce profits, but may lead to permanent loss, and dynamic programming has been found to address this situation.

Second: The time difference between determining an order and receiving it by a specific store, i.e. refilling the same store at the beginning of the time period, while that store can place orders at any time.

Several problems in this aspect [3]have been studied before, including:

- First: Request materials that were expected exactly for the model itself.
- Second: He has given described data on a quarterly basis.

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2 - Bansal.K, Vadhavkar.s, and Gupta.A(1997) "Neural Network based data mining applications for medical inventory problems" , to appear international journal in Agile manufacturing

3 - Al-Saadi, Donia Ahmed "The Use of Dynamic Programming in the Analysis of Storage Models", Master Thesis, College of Administration and Economics, University of Baghdad (1999).

Third, some types of data require special processing. It may involve finding a higher profit for the problem at hand . The use of dynamic programming helps to find a balance between customer satisfaction and the need to reduce storage levels .

In other words,

Dynamic programming (DP) is a special method of optimization and the term (method) has been used deliberately because dynamic programming is not a special algorithm such as Euclid's algorithm, which is a well-known method for finding the greatest common denominator of any two integers, or as Dentin's Simplex algorithm, which is a set of known rules to solve the problem of linear programming [4].

DP represents one of the methods of finding the optimal mathematical solution by building a series of related and interrelated relationships for decisions that determine the functioning of the operation of any system, as the decision-making process for multiple stages turns into a series of single stages of decision-making. Dynamic programming begins with a small part of the problem to reach the optimal solution for this part and then gradually takes another part of this problem and reaches another model solution, taking into account the first part and so on until the problem is solved to the fullest and from all aspects. [(5)]

Front and rear calculations in the concept of dynamic programming

There are two methods for calculating the values of functions from which we get the optimal solution to the problem in general:

First method

This method is based on the values of the ascending functions, as the value of the first function (initial) is first calculated, for example (F1) and using the iterative equation, in the first stage, then F2 is calculated in the second stage, and so we advance by calculating the other functions until we reach the function (FN) that represents the final function. This method is called the forward computation method.

4 - Al-Naseh, Mark Salim, "Daily Operation of the Khamma Reservoir", Master Thesis, College of Engineering, University of Baghdad (1992).

5 - 23- Egbelu, pius j. , AND Lehtihet ,Amine(1990) "operation Routing with lot sizing consideration in A manufacturing system" International journal of production Res vol,28 . No.3 ,pp.503-515

Second method

It is the exact opposite of the first method as the functions are arranged in descending order. Under this method, the iterative equation is used to find the return value of the last stage (N) and then gradient down to find the values of the other stages until we reach the first stage, and this method is called the Back computation method.

Distinctive characteristics of problems that can be solved using dynamic programming method: [6]

There are four features that distinguish the problems that the DP method can be applied to:

1. The problem to be solved by the method (DP) must be divisible into stages, as the decision is taken at each stage and in the storage system, and to determine the optimal order size for the materials involved in the multi-period production process, the stages represent different points in time.
2. Each stage of the problem must have a specific number of associated state variables
3. The effect of the decision at each stage of the problem is to convert the current state vector into a state vector associated with a future stage.
4. Forming an iterative mathematical relationship that gives the optimal solution to each stage of the problem and depending on the situation associated with it.
5. At each given current case and stage of the problem, the optimal succession of decisions depends on the decision taken in the previous stage .
6. To solve any storage system problem using the DP method, we must provide a goal function that "serves as a measure of efficiency" and limitations depending on the nature of the problem.

Dynamic programming style with dominance technique for the problem of bag subscription

Since we used the method of dynamic programming with dominance technique to solve the problem (KP i(Ci)) as dominance (control) can be clarified, that the dominant solution (w,p) is an element of a set of possible solutions to the problem as any other solution $(w'.p')$ does not improve the target function at the same time, i.e. it $p \geq p', w \leq w'$ (so (w,p) is an optimal solution to the problem as the dynamic programming algorithm will start by solving a small

6 - Ali, Ghaleb Ahmed (2007) "Definition of polarization parameters for cathode protection using neural network" Master thesis submitted to the Department of Metallurgical Engineering / University of Technology

part of the problem and reaching the optimal solution for this part and then gradually take another part of the problem and reach another typical solution until the problem is solved to the fullest and in each step we will try to reduce the values of (Ci) to (C^*_i) Without general loss in this part, we will provide a dynamic programming algorithm to solve the problem of the bag as well as estimate the maximum and minimum needs during decision-making.

As a result, dynamic programming algorithms with dominance technique were used to solve the problem ($KP_i(C_i)$) [22,40,46,47].

The problem of the bag (KSP), whether it is maximizing or decreasing (shrinking) a goal function, is a mathematical problem with the constraint of the bag problem [7] The problem consists of N) of units divided into (m) of different classes .The model (2-1) is an extension of the model of the ordinary bag issue.

$$KSP\begin{cases} \max\min\left\{\sum_{i\in M}\sum_{j\in N} p_{ij}.x_{ij}\right\} = z(KSP) \\ s.t.\sum_{i\in M}\sum_{j\in N} w_{ij}.x_{ij} \le C \ldots\ldots\ldots\ldots\ldots\ldots(2-1) \\ x_{ij} \in \{0,1\}.i \in M, j \in N_i \end{cases}$$

Whereas:-

x_{ij} :

Whereas:-

represent decision variables

P_{ij} : Represents the cost of purchase

w_{ij} : represents the weight of

N_i: represents the number of units (materials) (J) divided into (m) of classes (I)

Z(KSP): The target function of the pouch problem In this aspect, we want to calculate the partial group of units within the problem model according to the available capacity, provided that the minimum profits are associated with the maximization of different varieties .

Also:

$C, X_{ij}.P_{ij}$: represents a positive setting, and we assume that

$$\sum_{i\in m}\sum_{j\in n} Wij\rangle C \cdots\cdots\cdots\cdots\cdots\cdots \quad (2-2)$$

7 - Dranoff, J.S., Milten, L.G, Stevens, W.F and Wanniger, L.A "Application of Dynamic programming to counter current flow processes" , j.opi.res, soc, vol.9 , 3.pp.388-401

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Whereas, the method of solving the problem (KSP) provides for the division of the original problem (knapsack problem) into (n) of sub-problems [8]

For each $(m \in i)$ we will define the original problem as follows:

$$(KP_i(C_i))\begin{cases} \max \sum p_{ij}.x_{ij} = z(KP_i(C_i)) \\ S.T. \sum w_{ij}.x_{ij} \le C_i \text{.............................}(2.3) \\ x_{ij} \in \{0,1\},\ j \in N_i \end{cases}$$

So the target function will find the set of costs that are calculated by the iteration equation for dynamic programming ($C^*1, C^*_2, \ldots\ldots\ldots, C^*_m$)

From this we conclude that $\Sigma C^*_i \le C$ .... (2-4) and

$$\min_{i \in m}\{z(KP_i(C_i^*) = z(KSP)\} \cdots\cdots\cdots\cdots\cdots\cdots\cdots (2-5)$$

If (p)P,z represent the optimal value, moreover, the upper and lower limits of (P)z will be symbolized respectively. $\underline{z}(P), \bar{z}(p)$

Calculation of tables

The weight and cost values in the first table of the calculation methods in the concept of dynamic programming (zero) i.e. Lio = (0.0) until the last table is reached in step (Lik) where the optimal solution is obtained (a certain storage level and the accompanying return by the method of background calculations in the concept of dynamic programming) as follows:

$$L_{ik} = L'_{ik} - D_{ik} \text{...}(2-6)$$

Whereas,

$$L'_{ik} = L_{i(k-1)} + \{\min f(w_{ik}, p_{ik})\} \text{...}(2-7)$$

$$= L_{i(k-1)} U\{w + w_{ik}, p + p_{ik}) \,|\, (w,p) \in L_{i(k-1)}\, and. w + w_{ik} \le C_i\} \text{.........................}(2-8)$$

Dick: Represents cases dominated by the L'_{ik}

L'_{ik}: The last table is represented in dynamic programming method

The following algorithm shows the solution method until the last table () is reached[9].

Algorithm - 1 -: next list

Procedure	Next list
step1. Input Step 2. Output	A Knapsack problem (KP_i) A list L $_{i(k-1)}$ The next list L_{ik}
Step 3. Ĺik = Li(k-1) + {min f(w ik,pik)} step4. L_{ik} = Ĺik-Dick	

8 - 25- G.B.Dantzag, "discrete variable extrenum problems" , operations research , vol.5 ,pp 266-277, 1957.
9 - J.R.Brown "Bounded Knapsach sharing "Mathematical programming , vol.67, P.P 343 382,1994

Ellipsis using upper limits:

In order to choose the highest value of the state (w,p) from the calculation table of the dynamic programming method, the state variables (w,p) were deleted from the returns of the individual stage and accordingly they will be deleted from the total return because the optimization technique decreases its efficiency as the number of variables increases in this case it must solve exactly the problem of the following continuous linear bag [25] and the benefit of the deletion process is to reduce the tables of dynamic programming calculations.

$$(LP_i^{(w,p)}(C_i))\begin{cases} \max p + \sum_{j=k+1}^{n_h} p_{ij}.x_{ij} \\ s.t. \sum_{j=k+1}^{n_i} w_{ij}.x_{ij} \le C_i - w \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2-9)$$

$$X_{ij} \in [0,1],\ j \in \{k+1,\ldots\ldots\ldots n_i\}$$

And we have

$$\overline{Z}(w,p) = [Z(Lp_i^{(w,p)}(C_i)] \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2-10)$$

$$\overline{Z}(w,p) \le \underline{Z}(KSP) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2-11)$$

On the other hand if So cases (W,P) can be deleted.

Solve the model using dynamic programming:

The dynamic programming method used addresses the problems of storage planning of materials involved in the production process on which demand is known but variable from time to time. Dynamic programming is a technique for solving problems whose solutions satisfy the repetition of relationships with sub-problems.Dynamic programming solves all sub-problems and the results are placed in tables. Tables are then used to obtain the solution to the original problem.

The efficiency of the method depends on the accuracy of the amplitude and minimum limits of the problem (KSP) $\underline{Z}$ as well as understanding how the values are calculated and how the use of dynamic programming to find an ideal solution to the problem will be described. [10]

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10 - Boyer.V, El Baz.D & Elikhel.M (2009)
"A dynamic programming method with dominance technique for the knapsack sharing problem"
CNRS; LAAS; 7 avenue du colonel Roche, F-31077 Toulouse, France

The main method of using dynamic programming to solve the problem (KSP)

Dynamic programming is used to solve all $KP_i(C_i)$) problems as the minimum problem **(KSP)** $\underline{Z}$ is calculated by the method of Greedy heuristics [11]

Saturated programming techniques are used in optimization problems to create a series of sub-optimizations that are hoped to converge to optimal value, as the possible strategies for using them in the manner of saturated experiments are:

1. Choose the units that have the highest value from the existing units as this increases the resolution of the problem as quickly as possible.
2. Choose the units that have the lowest possible weight

Strategies for managing robust queues

The manager needs to take advantage of a set of methods and techniques to solve the problems he encounters when providing the service and negatively affects its quality. Among the quantitative methods are queue models that address the time it takes to provide a service and the resulting length to the phenomenon of waiting at the bank level.

Origin and development of the theory

The origin of the theory of queues dates back to 1909, where the Danish telephone engineer Erlang ERLANG carried out a study with the aim of solving the problem of congestion in the telephone call exchange center by workers, at first he studied the delay time for one worker in the transfer, and then circulated the results of his research to a number of workers, and these studies were published in 1913 under the title ANALYSE OF TELEPHONE ERVICEDELAYS TO VARING DEMANDESTHIS THEORY HAS BEEN MODIFIED BY MANY INTERESTED RESEARCHERS FROM ENGEST., BOREL KENDAL KOLMOGROV (KHINTCHINE).[12]

The theory is concerned with the development of mathematical methods necessary to solve problems related to situations that are characterized by choke points, or the formation of waiting queues as a result of the arrival of the requesting units to the service and waiting for their turn to receive them. Provided that access to the place of service performance is random and follows a certain distribution, and the time of service performance for each unit can take a

11 - 42- Sheathe. Dipti, , Hristakeva.maya (2005), "different approaches to solve 0/1 knapsack problem ", computer science. Department. Simpson College, Indianola, A 50125

12 Faure (R) et autres, précis de Recherche opérationnelle, G , Dunod, paris,5 ed,2000p255.

random form and according to a specific distribution. It is also provided as a measurement of the ability of the service center to achieve the purpose for which it was established, and this is done by means of an accurate mathematical measurement of the average time of Wait for service[13]**.** Therefore , the queue theory is a probabilistic tool that allows the function of a server center to be modeled [14].

Some areas of application of queue theory

Among the areas that are taken advantage of we mention:

1. **Planning performance positions:** It means determining the spaces necessary for the production activity, its facilities and requirements, and distributing the production or service performance positions in and around the building to facilitate the flow of units in the system.[15]
2. **Analysis of the optimal costs of waiting lines**: The problem of costs and how to address them forces the decision maker to think about expanding the scope of service provision in order to reduce waiting time, taking into account the issue of costs and the resulting lost financial burdens.[16] The costs of the waiting phenomenon are :
    a. **Service cost**: It is called the cost of energy and is the cost of maintaining the ability of the system to provide the service.

In. Waiting cost: It is related to customers waiting for service.

C- Determining service performance levels: The application of classroom models enables the organization to answer the following questions:

- What is the average time a customer takes in front of a service center?
- What is the average number of customers waiting in line for service?

13 See Mohamed Tawfiq Al-Madi, Quantitative Methods in the Field of Management, University House, Alexandria, 1999, p.338.

14 Doubosson (M) et Rousseau(M),Le service global international- strategie international de développement dans les services,Maxime ,Paris ,1997p328.

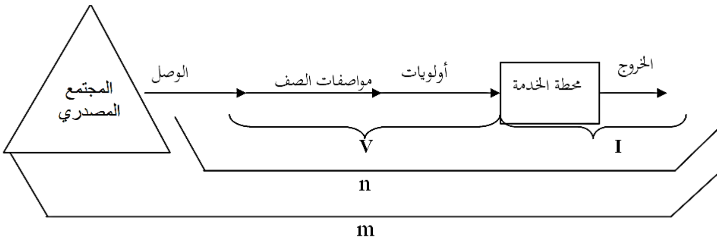
15 Ahmed Sayed Mustafa, Production and Operations Management in Industry and Services, University House, Alexandria, Fourth Edition, 1999, p. 301.

16 Al-Musawi Abdul Rasoul, Introduction to Operations Research, Dar Wael, Amman, first edition, 2001, p. 280.

The answer to these questions enables to determine the level of quality of services provided by it.[17] In some service institutions, sometimes they cannot study the model and make a decision based on the cost because it cannot be determined accurately, especially with regard to the cost of waiting for the customer, and here another criterion has emerged, which is the preferred level of service, that is, the pursuit of a certain level of service depending on the decision maker. This is done by determining the appropriate limits for the values of the indicators concerned with the evaluation, including the waiting period that can be acceptable to the customer, the time when the units requesting the service stay in the system, and the optimal number of centers that achieve the previous indicators is determined. [18]

Essential Components of Queues

The service delivery process can be described as an influx of customers to the service center, where they line up in one or several rows of varying length, and each one receives the service when their turn arrives. This phenomenon can be represented as follows:



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Where: m : the number of units that we can find in the phenomenon.

n : the number of units in the system.

V : the number of units in the class.

I : number of units in service.

From the diagram, we can see that the phenomenon of queues consists of the following elements:

[17] Zolinger(M), Lamarque(E),Marketing et stratégie de la banque,Dunod,Paris, 4 ed,2004,p52.

[18] Anaam Baqia and Dr. Ibrahim Nayeb, Operations Research, Algorithms and Computer Programs, Dar Wael, Jordan, first edition, 1999, p. 374.

1. Source Community

It is all the units that can apply for service, and is thus the source from which customers flow. The approach to queuing the problem depends on whether the source community is unlimited or the source community is limited.[19]

2. Arrivals specifications

These distinctive characteristics are intended for customers coming to the service center, and the most important of these features are the following:

- **A- The degree of control over the number of arrivals:** In many cases, the number of arrivals in different periods can be estimated in a way that makes us able to control the process of the phenomenon, and we also find some other cases in which it is difficult to control the number of arrivals model, and these are the most common in practical life.
- **B- Authority of arrivals to receive the service:** This means the number of combined units that apply for the service, the dealing unit may be one unit , and it may be more than one unit**.**
- **C- Arrival pattern:** Customers may arrive at the service station according to a known and specific schedule, or customers may arrive randomly, which can be estimated using probability theory.[20]
- **D- Service recipient behavior:** Most models assume that when the service recipient arrives, he will wait until he receives the service, and will not change the service station or the row he reached [21]. However, the reality is otherwise, as we find some customers in many cases refusing to join the queue, and there is another category where they join the queue but quickly leave without receiving the service. We can also encounter another type of customer where they change line.

2. Queue specifications: Among its most important features:

- **A- Queue length:** There are two types: the row with a specified length and the row with an unspecified length**.** [22]
- **B- Number of queues:** Waiting lines can be single or multiple.[23]

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[19] Sonia Mohamed El-Bakry, The Use of Quantitative Methods in Management, University House, Alexandria, 1997, p. 375.

[20] Muhammad Tawfiq Madi, previous reference , p. 343.

[21] Galal Ibrahim Al-Abed, The Use of Quantitative Methods in Making Administrative Decisions, Alexandria University House, 2004, p.424.

[22] Muhammad Abdul Aal Al-Nuaimi and others, Operations Research, Wael Publishing House, Jordan, 1999, p. 388.

[23] See: Dr. Anaam Baqia and Dr. Ibrahim Nayeb, previous reference , p. 340.

C- Priorities: This refers to the waiting line system, i.e. the order in which units are supplied with the service they request and are often first served first.[24]

3. Service Station Characteristics

They vary in the performance of their mission according to the quality of service provided, and usually a system can have a single or multiple service port. The customer can also receive the service in one or several stages.

4. The most important probability distributions used in queuing theory

We often find that these random values are subject to two types of theoretical distributions, customer arrival often follows Poisson's theoretical distribution, and service intervals follow the exponential distribution. But this does not negate the existence of other theoretical distributions that can be followed by both access and service intervals.

A- Poisson distribution: It is called the law of small probabilities, and it is used in many random operations that generate their vocabulary in a specific unit of time or space. Such as the number of customers who arrive at a bank every 5 minutes, and it can be said that the arrival of customers to service centers follows the Poisson distribution if the conditions of Poisson's contexts are met, which are:[25]

The probability of an event in the period Δt is realized depends only on the length of the period. It can be expressed by the constant arithmetic mean of the number of incidents per unit of time, i.e., the probability of moving from the state λn to λn-1 is equal, where $\lambda_n = \lambda$

The number of accidents occurring in a given period is independent of the number of accidents in previous periods.

The probability of two events occurring in the same period is very small. Only one event can be realized during the period Δt .

We write the general formulas of Poisson's law as follows: $P_n(t) = \frac{(\lambda t)^n}{n!} e^{-\lambda}$

B- Exponential distribution: It is used to analyze the number of customers arriving in a certain period of time, as well as the intervals between two consecutive arrivals. It is also

[24] Ahmed Fahmy Galal, Introduction to Operations Research and Administrative Sciences, Dar Al-Fikr Al-Arabi, Cairo, 1999, p. 183.

[25] Carton (D), Processus Aléatoire utilisées en recherche opérationnelle ,Masson, Paris, 1975

used in the study of service times.[26] The exponential distribution is defined by the following formula:

$$P_n(t) = \mu e^{-\mu t}$$

Mathematical treatment of queue models

Researchers who worked in the field of queue theory were able to develop mathematical models aimed at studying the behavior of queue systems and determining their indicators easily and quickly. Due to the large number of these mathematical models, we focus in this study on the models that follow the Poisonic distribution in the process of accessing units, and the exponential distribution of service times.

μ: Service performance rate. ***λ***: Customer reach rate.

LQ: The average number of units in a class. ***LS***: The average number of units in the system.

WQ: Average Time Spent in Class ***WS:*** Average Time Spent in System

3. CONCLUSIONS:

1. Despite the challenges that organizations may face when implementing dynamic programming solutions, the results demonstrated that significant performance improvements can be achieved through thoughtful and data-driven strategies.
2. Through data analysis and applied models, the study proved that applying dynamic programming can improve the efficiency of operational processes, reduce waiting times and enhance customer experience.
3. Dynamic programming has been shown to provide a robust analytical framework that can handle the complex challenges organizations face in managing queues.
4. Dynamic programming has been proven to improve queue management performance by reducing waiting times and offering adaptive solutions to unexpected changes.
5. Applying dynamic programming can reduce the operational costs associated with queue management by improving resource allocation and managing orders more effectively.
6. By reducing wait times and improving process efficiency, dynamic programming can contribute to enhanced customer satisfaction and the overall service experience.

[26] Pfaffenberger (R) et Patterson (J), Statistical methods for business and economics,1977 p201.

7. Dynamic programming provides flexible solutions adapted to different changes and pressures, making it an ideal tool for managing robust rows facing fluctuations in demand and unstable conditions.

4. RECOMMENDATIONS

1. Encourage organizations to adopt dynamic programming as part of queue management strategies to improve performance and efficiency.
2. Investing in the development of application models for dynamic programming that suit the requirements of different institutions to ensure the best results.
3. Provide training and rereferences to staff and supervisors on how to use dynamic programming effectively, making the most of available analytical tools.
4. Support future research that explores more practical applications of dynamic programming in different contexts, helping to improve strategies and expand their use.
5. Implement a system to monitor and evaluate performance after the application of dynamic programming to ensure the achievement of the desired goals and identify areas of continuous improvement.

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