An Inventory Model for Deteriorating Items with Soft Computing Techniques and Variable Demand

A K Malik, Yashveer Singh

Abstract— ***Inventory has always been the foundation of conducting business in any organization. Holding and managing of an inventory is essential for efficient and smooth running of any business organization be it a manufacturing industry, an educational institute, a five star hotel, a hospital and a printing press etc. The proper utilization of space is also a critical component in business world, whether one is a manufacturer, retailer or a wholesaler. Business organizations mainly focus on improving the customer services and reduce the inventory costs in such a manner so that profit can be maximum. Our objective in this paper is to provide a general review for the application of soft computing techniques like fuzzy logic and genetic algorithms to use for improve the effectiveness and efficiency for various aspect of inventory management.***

Keywords: Inventory Control, Demand, Enterprise Resource Planning (ERP), Soft Computing, Genetic Algorithm, Fuzzy Decision.

I. INTRODUCTION

Inventory is the lifeblood for any business organizations i.e., it is the biggest asset and often inefficiently managed. In business organization, inventory management is one of the major core competencies to compete in the global market place. The most important purpose served by the stores is to provide the uninterrupted service to the manufacturing divisions. Inventories represent a substantial portion of the total assets of a company and considerable effort is required to control the inventories. The purpose of inventory in any business is to decrease the cost of set up and shortage cost. Whenever demands of customers are not fulfilled then good-will of the customers may be lost and the cancellations of orders i.e., result may be in the lost of business. The only solution for that type of problems is the upkeep of inventory.

Soft computing is likely to play a very important role in science and engineering, but eventually its influence may extend much farther. Many ways, soft computing represents a significant paradigm shift in the aims of computing - a shift which reflects the fact that the human mind, unlike present day computers, possesses a remarkable ability to store and process information which is pervasively imprecise, uncertain and lacking in category. Soft computing techniques are more powerful and efficient as they provide the feasible and less costly solutions compared to hard computing techniques. It is a multi-disciplinary field. Soft Computing is a fusion of methodologies that were designed to model and enable solutions to the real world problems which are not modeled, or too difficult to model, mathematically. These problems are typically associated with fuzzy, complex, and dynamical systems, with uncertain parameters. These systems are the ones that model the real world and are of most interest to the modern science.

Recent developments in sciences and computers have led to improved modelling and understanding of situations in all areas of human activity. In effect, the role model for soft computing is the human mind. With the fuzzy logic based technique, imprecision, uncertainty and human oriented knowledge representation is possible; still self learning and generalization of rules can not be possible. There are several methods for soft computing family from which Fuzzy Logic (FL) and Genetic Algorithm (GA) are the most important techniques. A system based on the fuzzy logic known as fuzzy control system. Generally, control systems modeling have been based upon the use of mathematical techniques to the model (input/output) relationship of the system in question. Many real-world systems however, may not be as readily described mathematically due to the complexity of the components of the plant and the interaction between them, and consequently, the model may be subject to certain assumptions or conditions. In such models, the degree of mathematical precision required to completely describe every aspect of the process, is either prohibitive or non-trivial. In addition, for actual implementation of such systems, heuristics, gained through human experience, are often employed in the tuning of the final controller. The use of Fuzzy Logic has an important application in the area of control system design where human expert knowledge, rather than precise mathematical modeling, of a process or plant is used to model/implement the required controller. Human expert knowledge is based upon heuristic information gained in relation to the operation of the plant or process, and its inherent vagueness offers a powerful tool for the modeling of complex systems. Generally without a fuzzy rule we can solve our problem by genetic algorithm but its result is not good. So improving the performance of genetic algorithm and result we use embedding fuzzy rules.

The application of soft computing techniques has mainly two important advantages. First, it solve the non-linear problems and second is introducing the human knowledge such as recognition, learning, understanding and others field of soft computing.

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Enterprise Resource Planning systems efficiently concerning real-time planning and manufacturing, material procurement and inventory monitoring, customer and supplier management. Enterprise Resource Planning (ERP) systems are business management tools that automate and integrate for all company facets, including real-time planning, manufacturing, sales, and marketing. These processes produce large amounts of enterprise data that are used by managers and employees to handle all sorts of business tasks such as inventory control, order tracking, customer service, financing and human resources. Thus our aim in this paper is to study how to carry out optimal procurement planning to meet the material requirements of production and to minimize total inventory cost including purchasing, ordering, and holding costs, and penalties for shortages with discrete time-varying demand and different discount prices. The procurement of purchase planning is to obtain the optimum material stock replenishment strategy to minimize the total inventory cost (which includes purchasing, ordering, and holding costs and penalties for shortages). Inventory control planning mainly based on EOQ model. The basic assumption of EOQ is that demand is independent and described by a mean value with unprotected white noise. In fact, it is assumed that demand is a constant equal to its mean. Today's inventory control models for time-varying demand have recently attracted a great deal of research which helps to develop the interest of researcher in this field. In real life situations, demand is not constant so take the demand rate is usually in terms of a linear, exponential, quadratic, time-varying, production dependent, multivariate, or some other stock-dependent function. The study of deteriorating items with inventory model started **Ghare** and **Schrader (1963)** who established the inventory model for constant rate of decay.

The concept of soft computing techniques (fuzzy logic) first introduced by **Zadeh (1965).** The invention of soft computing techniques (fuzzy set theory or fuzzy logic) by the need to represent and capture the real world problem with its fuzzy data due to uncertainty. Instead of ignoring or avoiding uncertainty, **Zadeh** developed a set theory to remove this uncertainty. It is to use hybrid intelligent methods to quickly achieve an inexact solution rather than use an exact optimal solution via a big search. Since Genetic Algorithms are good for adaptive studies and fuzzy logic can be used to solve complex problems using linguistic rule-based techniques. **Silver** and **Peterson (1985)** discussed on decision systems for inventory management and production planning. **Zimmermann (1985)** gives a review on fuzzy set theory and its applications. **Bard** and **Moore (1990)** discussed a model for production planning with variable demand. **Avraham (1999)** presented a review on enterprise resource planning (ERP).

Yao and Lee (1999) presented a fuzzy inventory model with and without backorder for fuzzy order quantity with trapezoidal fuzzy number. **Tang et al (2000)** presented a multi-product planning and scheduling using genetic algorithm approach. **S. D. Levi et al (2000)** give a review on designing and managing of the supply chain. **Y.W. Zhou (2003)** proposed a Multi-warehouse Inventory Model for Items with Time-varying Demand and Shortages**.** **Papadrakakis** and **Lagaros (2003)** discussed about soft computing methodologies for structural optimization. **Sundarraj** and **Talluri (2003)** developed a multi-period optimization model for the procurement of component-based enterprise information technologies. **Wang et al (2003)** presented a fuzzy decision embedded genetic algorithm for the fuzzy due date bargaining problem and suggested an idea to the quantification of fuzzy rule. This idea has been successfully applied to some practical problems such as partner selection, and production planning and scheduling. **Balkhi** and **Benkherouf (2004)** discussed on an inventory model for deteriorating items with stock dependent and time-varying demand rates. **Yung et. al (2007)** discussed on procurement planning of time-variable demand in manufacturing system based on soft computing techniques. **Malik et. al (2008)** considered a two warehouse inventory model for deteriorating items under time dependent demand and FIFO dispatching policy. **Singh** and **Singh (2008)** considered the fuzzy inventory model for finite rate of replenishment using signed distance method. **Singh** and **Malik (2010)** considered an optimal ordering policy with linear deterioration, exponential demand and two storage capacities. **Malik** and **Garg (2010)** give a review on Supply chain management. **Singh** and **Malik (2011)** presented an inventory model with stock-dependent demand and two storage facilities.

In this paper proposed an inventory problem based on procurement planning, using the fuzzy decision embedded genetic algorithm. Using the assumption of planning maker's experiences, we present some new decision rules for the problem. To avoid the complex real optimization, here we conclude that four order strategies for different situations for inventory and demand. This model has a good potential to be embedded in ERP systems or be directly applied to purchase sections of practical enterprises.

II. NOTATION AND ASSUMPTIONS

The following notation is used throughout the entire paper.

T The planning horizon

$D_i(t)$ The demands for material *i* at time t; (i = 1, 2, …., n; t =1; 2,….,; T).

C_O The ordering cost

C_{Hi} The holding cost for a unit of material *i* for a given time (i = 1; 2, ……., n).

C_{Di} The deteriorating cost for a unit of material *i* for a given time (i = 1; 2, ……., n).

$I_i(0)$ The initial inventory level of material (i = 1, 2, ……., n).

C_{Si} The shortage penalty cost of material *i* for a unit shortage.

W The warehouse capacity for the manufacturer is limited.

Sv_i The space volume of material *i* for one unit.

C_P The limitation of cash flow for purchase each day. (According to financial control by the manufacturer).

The model of the inventory problem is based on the following assumptions:

(i) The purchasing cost for material *i* is the discounted depending on the quantity of the order and is described by a segment function as the following:

$$C_i(p_i)=\begin{cases} C_i^1, & Q_i^1 \le p_i \prec Q_i^2 \\ C_i^2, & Q_i^2 \le p_i \prec Q_i^3 \\ C_i^3, & Q_i^3 \le p_i \end{cases}, \quad i=1,2,.....,n$$

Where $C_i^1 \ge C_i^2 \ge C_i^3$ are the discounted costs for different order quantities $Q_i^1,\ Q_i^2\ and\ Q_i^3$ of material *i*, *i*=1, 2, ……… , n.

III. MATHEMATICAL MODEL

Our objective in this paper to get optimum procurement planning {$p_i(t)$, $i = 1, 2, ……. , n$; $t = 1, 2, ……. ,T$} so that to minimize the total inventory cost including ordering, holding, and purchasing costs, and a possible shortage penalty. The inventory model can be described in the following terms:

$$\begin{aligned} \underset{p}{Min}\, Z(p) = \sum_{t=1}^{T} C_O \operatorname{sgn}\left[\sum_{i=1}^{n} p_i(t)\right] + \sum_{i=1}^{n} \{[C_i(p_i)p_i(t)] \\ + C_{H\,i}\sum_{i=1}^{T}[p_i(t)-D_i(t)+I_i(0)]^{+} \\ + C_{D\,i}\sum_{i=1}^{T}[p_i(t)-D_i(t)+I_i(0)]^{+} \\ + C_{S\,i}\sum_{i=1}^{T}[D_i(t)-p_i(t)-I_i(0)]^{+} \Big\} \end{aligned}$$

s.t. $\sum_{i=1}^{n} Sv_i \sum_{i\,i=1}^{T}[p_i(t)-D_i(t)+I_i(0)]^{+} \le W,\ t=1,2,....,T$

$$\sum_{i=1}^{n} C_i(p_i)p_i(t) \le C_P,\ t=1,2,......,T$$

$$p_i(t) \ge 0,\ i=1,2,....,n;\ t=1,2,......,T$$

Where

$$\operatorname{sgn}\{y\} = \begin{cases} 1, & y \succ 0 \\ 0, & y = 0 \\ -1, & y \prec 0 \end{cases}$$

known as the signal function and $[y]^+$ means max{0, y}, and. this inventory model includes some non-analytic terms like as $[y]^+$, sgn{y}, and the segment function $C_i(p_i)$, so it cannot be solved using generally mathematical programming techniques. Therefore, this type of problems solve by intelligent algorithm or soft computing method which is only unique choice in order to obtain a solution.

IV. BINARY ENCODING SCHEME

Here the problem is a nonlinear and non-analysis constrained real optimization problem which includes of real variables $p_i(t)$, i = 1, 2, …… , n; t = 1, 2, …….. , T is equal to n×T. Here we encoding the chromosomes of the genetic algorithm using a binary string because taking gene representations it becomes inefficient. Let

$$y_t = \begin{cases} 1, & when\ time\ duation\ t\ is\ an\ order\ point \\ 0, & when\ time\ duation\ t\ is\ not\ an\ order\ point \end{cases}$$

If we take T = 5 for y = [1 0 1 0 1], it means there is an order in periods 1, 3, and 5. Thus the problem remains how to obtain the optimal order quantities for all materials in some cases where the next point is fixed.

V. ORDER STRATEGIES

By using the decision maker (managers) experience of procurement planning, there are some choices of possible order strategies for a material (i) When no order has been placed, (ii) When the order has been placed just to meet the demand and (iii) When the order has been placed just on the discount points. Suppose t_0 is the current and t_1 is the next order points, and d_i is the demand for material *i* from t_0 to (t_1 -1), i.e. $d_i = \sum_{u=t_o}^{t_1-1} D_i(u)$

Here L is the duration length of the order cycle t_1-t_o and $I_i(t_0-1)$ is the initial inventory of material *i*, *i* = 1, 2, ……, n. The possible order strategies for the material as follows:

(i) *When no order has been placed.*
In this case, the order quantity is $p_i(t_0) = 0$ and operating cost is

$$OC_i^1 = \sum_{u=t_o}^{t_1}\left(C_{Hi}\left[I_i(t_0-1)-\sum_{t=t_o}^{u}D_i(t)\right]+C_{Si}\left[\sum_{t=t_o}^{u}D_i(t)-I_i(t_0-1)\right]^{*}\right)$$

(ii) *When the order has been placed just enough for the duration.*
In this case, there is no shortage penalty and order just enough for demand then the order quantity is $p_i(t_0) = d_i - I_i(t_o-1)$ and operating cost is

$$OC_i^2 = d_i C_i(d_i) + \sum_{u=t_o}^{t_1-1} C_{H\,i}\left[I_i(t_0-1)+d_i-\sum_{t=t_o}^{u}D_i(t)\right]^{+}$$

(iii) *When the order has been placed just on the discount point* Q_i^2.
In this case there is no matter for d_i is, the order quantity is $p_i(t_0) = Q_i^2$ and operating cost is

$$\begin{aligned} OC_i^3 = Q_i^2 C_i^2 + \sum_{u=t_o}^{t_1-1}\Bigg(C_{H\,i}\left[I_i(t_0-1)+Q_i^2-\sum_{t=t_o}^{u}D_i(t)\right]^{+} \\ + C_{S\,i}\left[\sum_{t=t_o}^{u}D_i(t)-Q_i^2-I_i(t_0-1)\right]^{+}\Bigg) \end{aligned}$$

(iv) *When the order has been placed just on the discount point* Q_i^2.
In this case there is no matter for d_i is, the order quantity is $p_i(t_0) = Q_i^3$ and operating cost is

$$\begin{aligned} OC_i^4 = Q_i^3 C_i^3 + \sum_{u=t_o}^{t_1-1}\Bigg(C_{H\,i}\left[I_i(t_0-1)+Q_i^3-\sum_{t=t_o}^{u}D_i(t)\right]^{+} \\ + C_{S\,i}\left[\sum_{t=t_o}^{u}D_i(t)-Q_i^3-I_i(t_0-1)\right]^{+}\Bigg) \end{aligned}$$

After obtain the order strategy we find the best order strategy by comparing their operating costs, i.e.,

$$OS_i^u = \min_{u}\{OC_i^u;\quad u = 1, 2, 3, 4\}$$

VI. FUZZY FACTORS AND DECISION RULES

In this inventory model we use some factors which are require to effected decisions as follows:

A_1. For a given chromosome a higher ordering cost.
A_2. For a given chromosome a higher holding cost.
A_3. If daily purchase exceeds the amount of money allotted to the purchase then penalty exists.
A_4. If total inventory exceeds the stock capacity then penalty exists.
A_5. For a given chromosome a higher shortage cost.
A_6. For a given chromosome a higher purchasing cost.
A_7. For a given chromosome a minimum total cost.

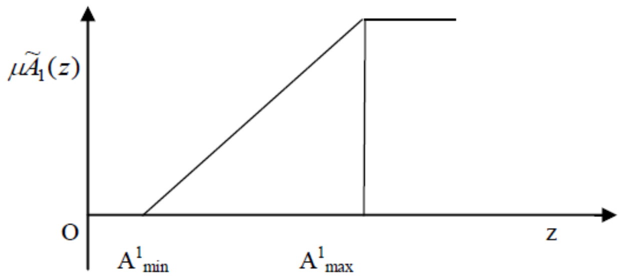
When penalty exists then the membership functions will be 1, otherwise 0. This means the factors 3 and 4 are crisp. We know that the ordering cost and holding cost are contradictory. If ordering cost is higher that means more order times and a lower holding cost. Let A^1min and A^2max be the ordering cost and holding cost in a feasible solution with the lesser order times, respectively. Let A^1max and A^2min be the ordering cost and holding cost of the feasible solution with maximum allowed order times. Using these conditions, we described a pair of fuzzy factors by the following membership functions:

$$\mu\widetilde{A}_1(z)=\begin{cases}1 & z\geq A^1_{\max}\\ \dfrac{z-A^1_{\min}}{A^1_{\max}-A^1_{\min}} & A^1_{\min}\leq z\leq A^1_{\max}\\ 0 & z\,\langle\, A^1_{\max}\end{cases}$$

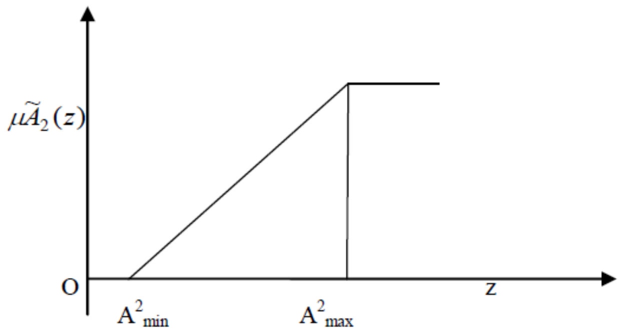
and

$$\mu\widetilde{A}_2(z)=\begin{cases}1 & z\geq A^2_{\max}\\ \dfrac{z-A^2_{\min}}{A^2_{\max}-A^2_{\min}} & A^2_{\min}\leq z\leq A^2_{\max}\\ 0 & z\,\langle\, A^2_{\max}\end{cases}$$

Where $\widetilde{A}_1$ and $\widetilde{A}_2$ denoted for fuzzy factors A_1 and A_2.



(i) The graph of membership function of Factor A_1



(ii) The graph of membership function of Factor A_2

Also we can find membership function for the other fuzzy factors A_5, A_6 and A_7 as above. Using the decision maker (managers) experience there are four decisions may be possible for improving the purchase planning are as follows:

Decision 1. Repairing the feasibility of a chromosome for improving the purchasing planning.

Decision 2. Give one more order when shortages and holding cost is higher but ordering cost is lower.

Decision 3. Cancel one more order when higher ordering cost and higher purchasing cost (i.e., no discounts) and holding cost is lower.

Decision 4. Unchanged the chromosome when total operating cost is lower.

After obtain these decision rules we find the best decision for the improvement of the given chromosome, i.e.,

$$k^{*}=\{\mu_{D1},\mu_{D2},\mu_{D3},\mu_{D4}\}.$$

VII. FUZZY DECISIONS BASED GENETIC ALGORITHM

The fuzzy decision based genetic algorithm procedure is mainly to find out the best order for demand, purchases and inventories by the genetic process. For each chromosome with fixed order points, we determine the best order strategy with a lower operating cost for each order cycle. After the order strategies for all order cycles of the chromosome are fixed, we calculate its ordering, holding, and purchasing costs, and shortage penalty, and check its feasibility. In genetic algorithm we take up two cutting crossover and an alternating mutation. The step-by-step procedure for genetic algorithm/fuzzy decision can be described as follows:

Step-1. First we specify the parameters which are used in genetic algorithm, P used for population size, G for the maximum number of generations, P_C for the crossover probability and P_m for the mutation probability.

Step-2. Now generate the initial population y(*j*), *j* = 1, 2, ……., NP, randomly. Set the iteration index K = 0.

Step-3. Using the decision maker (managers) experience, determine the parameters to specify the fuzzy factors: A^umin, A^umax, u = 1, 2, 5, 6, 7.

Step-4. For the chromosome y(*j*), *j* = 1, 2, …….., P, find the best order strategy for each order cycle and find the ordering, holding, purchasing, and shortage costs, and total inventory costs Z(*j*).

Step-5. if K > G and K ← K+1 then go to Step 10; otherwise, go to steps 6 to 9.

Step-6. Find the membership values of all fuzzy factors and select the best decision to improvement of chromosome. Obtain the total cost of the revised chromosome Z'(j).

Step-7. If Z'(j) < Z(*j*) then change the original chromosome by the revised one, otherwise no changed in the original chromosome.

Step 8. As per assuming the probabilities Pc and Pm, select the chromosomes to perform crossover and mutation.

Step 9. Update the population using propositional selection and update the best achieved solution y* and best value Z*, and go to the step 4.

Step 10. After getting the best achieved solution y* and best value Z* stop this procedure.

VIII. CONCLUSIONS

In this paper we discuss the inventory model with variable demand and soft computing techniques. The proposed model can simplify planning optimization procedures for order strategy selection and fuzzy decision rules. Thus a fuzzy decision embedded genetic algorithm can solve these types of non-linear programming problems easily and efficiently.

The proposed inventory model can be modified in further research such as exponential, linear, stock dependent, variable holding cost, production dependent, inflation and partial backlogging etc.

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REFERENCES

1. E. A. Silver, R. Peterson, (1985) Decision Systems for Inventory Management and Production Planning, John Wiley & Sons, New York.
2. Ghare, P.M., Schrader, G.P., (1963). A model for an exponentially decaying inventory. Journal of Industrial Engineering, 14 (5), 238–243.
3. H. J. Zimmermann. Fuzzy Set Theory and Its Applications. Kluwer-Nijho®, Hinghum, Netherlands, 1985.
4. J. F. Bard, J. T. Moore. (1990) Production Planning with Variable Demand. Omega, vol. 18, no. 1, pp. 35-42.
5. M. Papadrakakis, N. D. Lagaros. (2003) Soft Computing Methodologies for Structural Optimization. Applied Soft Computing, vol. 3, no. 4, pp. 283-300.
6. Malik, A. K. and Garg C. P. (2010), "Supply chain management-an overview", International Journal of Logistics and Supply chain management, Vol. 2, No. 2, 2010, 97-101.
7. Malik, A.K, Singh, S.R. and Gupta, C.B., (2008). An inventory model for deteriorating items under FIFO dispatching policy with two warehouse and time dependent demand, Ganita Sandesh 22(1), 47-62.
8. R. P. Sundarraj, S. Talluri. (2003) A Multi-period Optimization Model for the Procurement of Component-based Enterprise Information Technologies. European Journal of Operational Research, vol. 146, no. 2, pp. 339-351.
9. S. D. Levi, P. Kaminsky & S. E. Levi, (2000) Designing and managing the supply chain. (McGraw-Hill, Illinois).
10. Singh, S.R., Malik, A.K., (2010). Optimal ordering policy with linear deterioration, exponential demand and two storage capacity, International Journal of Mathematical Sciences, 9(3-4), 513-528.
11. Singh, S.R. and Malik, A.K. (2011), "An inventory model with stock dependent demand with two storages capacity for non-instantaneous deteriorating items, International Journal of Mathematical Sciences and Applications",1(3), 1255-1260.
12. Singh S.R. and Singh C. (2008). Fuzzy Inventory Model for finite rate of Replenishment using Signed Distance Method. International Transactions in Mathematical Sciences and Computer, 1(1), 27-34.
13. S. Avraham. Enterprise Resource Planning (ERP): the Dynamics of Operations Management, Kluwer Academic Publishers, Boston, 1999.
14. W. H. Ip, Y. Li, K. F. Man, K. S. Tang., (2000) Multi-product Planning and Scheduling Using Genetic Algorithm Approach. Computers & Industrial Engineering, vol. 38, no. 3, pp. 283-296.
15. Yao J.S. and Lee H.M., (1999). Fuzzy inventory with or without backorder for fuzzy order quantity with trapezoidal fuzzy number. Fuzzy Sets and Systems, 105, 311-337.
16. Y. Yi, D. Wang, (2003). Soft Computing for Scheduling with Batch Setup Times and Earliness-tardiness Penalties on Parallel Machines. Journal of Intelligent Manufacturing, vol. 14, no. 3-4, pp. 311-322.
17. Yung, K. L., W. Ip and D. Wang (2007). Soft Computing Based Procurement Planning of Time-variable Demand in Manufacturing System. International Journal of Automation and Computing, 04 (1), 80-87.
18. Y.W. Zhou, (2003). A Multi-warehouse Inventory Model for Items with Time-varying Demand and Shortages. Computers & Operations Research, vol. 30, no. 14, pp. 2115-2134.
19. Z. T. Balkhi, L. Benkherouf, (2004). On an Inventory Model for Deteriorating Items with Stock Dependent and Time-varying Demand Rates. Computers & Operations Research, vol. 31, no. 2, pp. 223-240.

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