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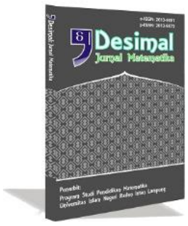

Application of de novo programming method in production planning at UMKM seasoning Opaque Tuntungan II

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ABSTRACT

Optimization is a way of solving mathematical problems to get optimal results. One way to solve optimization problems is to use a linear program. One of the developments of linear program models that can be used in optimization problems is de novo programming. This research uses de novo programming to maximize profits at UMKM Seasoning Opaque. Based on the results of the analysis with the POM-QM application, it can be concluded that the production of Tuntungan II seasoning opaque factory for 7 weeks is optimal with the production of 2,031 kg of salted seasoning opaque, 1,170 kg of regular spicy seasoning opaque, and 3,381 kg of round spicy seasoning opaque. Using the De Novo Programming method, it was found that the optimal production for 7 weeks of the opaque spice factory in Tuntungan II for 7 weeks had a profit of Rp12,317,240.

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INTRODUCTION

In Indonesia, many micro, small, and medium enterprises (UMKM) are sold on the outskirts of city and village roads. According to data from Kadin Indonesia, by 2023 the number of UMKM will reach 66 million. This data shows that the increase in the number of UMKM reached 1.52% from last year's number of only 65.46 million (Kadin Indonesia, 2024). To get optimal results and obtain maximum profits, micro, small, and medium enterprises (UMKM) must have proper production control and planning (Yulianto, Husna, & Syukri, 2020).

Production planning is a process of finding out how much to produce, how long, and what resources are needed to obtain certain products in order to realize the goal of meeting demand effectively (Isnaini, 2019). In production planning, every business will strive to achieve the highest possible level of profit. Improving the quality, usability, and shape of a product are some ways to optimize production problems (Vania & Helma, 2023). Production planning requires an

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estimator of the demand for products or services that the company is expected to provide in the future (Mardliyah, Fajar, & Badruzzaman, 2022). To solve the above problems, optimization is one method that can solve problems about production (Oktavia & Winanda, 2023).

Optimization is the achievement of the best state, that is, the achievement of a problem solution directed at the maximum and minimum limits (Astuti, Linawati, & Mahatma, 2013). The goal of optimization is to achieve the maximum possible results within certain constraints, namely minimizing effort and maximizing targeted results (Simanjuntak, 2017; Siregar, Sari, & Aprilia, 2024). There are two optimization methods, namely maximizing and minimizing. To maximize profit, manufacturing must be optimized through the use of certain inputs. Minimization, on the other hand, is the optimization of production to produce the lowest expenditure cost (Lubis, Dur, & Cipta, 2021). One way to solve optimization problems is by using linear programming (Novyanti, Marlina, Andiani, & Ruhiat, 2023).

A linear program is a mathematical model in linear form to determine an optimal solution by maximizing or minimizing the objective function to be achieved (Safitri, Kiftiah, & Pasaribu, 2024). Linear programming is a model consisting of three main components, namely decision variables, objective functions, and constraint functions. One model that can be used is De Novo Programming which is a development of linear programming. The De Novo Programming model ensures that raw materials or resources are used as effectively as possible and avoid waste.

Research related to the use of De Novo Programming has been carried out by several researchers. Budianti, Ramdani, & Respitawulan (2021) carried out production optimization using a de novo programming model with the simplex method and produced an optimal solution with a profit of IDR 47,685,060. Furthermore, Antika, Dur, & Aprilia (2023) conducted research that showed that production costs and monthly profits could be controlled within the desired limits. In research by Widarman, Yudha, & Kamal (2022), the results were obtained that were able to maximize greater profits up to IDR 28,408,941. Furthermore, Yusnita (2019) conducted research with results that showed the maximum profit obtained by the company was IDR 7,558,250.

In micro, small, and medium enterprises (UMKM), seasoning opaque Tuntungan II will show whether the production results at the opaque factory are optimal or not. Cassava opaque is one of the foods made from cassava with a round shape. Cassava opaque itself is a traditional food that is in great demand by the community (Primalasari & Octali, 2023). To get optimal results, linear programming is a widely used mathematical technique and is designed to facilitate the organization of operations in planning and determining decisions taken to allocate resources (Sari, Aprilia, & Rollingka, 2022). Linear programming analysis using the De Novo Programming model is used in solving production optimization problems because there is a linear bond between the level of profit, manufacturing aspects, and goods obtained in the industrial process (Antika et al., 2023).

METHOD

This research was conducted for 3 months with weekly data starting from 18 March 2024 to 17 May 2024. The location of this research was carried out at the Seasoning Opaque Factory on Jalan Persatuan No. 1 Tuntungan II, Hamlet 1, Pancur Batu District, Deli Serdang Regency, North Sumatra Province. The type of research used is applied research, namely, research carried out to find

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solutions to problems by providing solutions that are more practical in terms of their usefulness. Applied research is usually used directly in everyday life.

De Novo Programming is a development method of Linear Programming, that can design a system to be optimal. In solving optimization problems. The De Novo Programming approach can determine the best output combination and proposed use of resources based on the available budget (Oktavianto, Ngatilah, & Pulansari, 2017). In the De Novo Programming approach to solving optimization problems, a total approach is taken (Enny, 2009). De novo programming is a program that suggests a way to look at the system where, in addition to optimizing the existing system, it can also provide an optimal system design. This design focuses on making the optimal design of a system with high productivity that has several criteria (Susetyo, Asih, & Manullang, 2020).

The difference between the approach to optimizing a system and the approach to designing an optimal system is as follows:

a. The linear programming approach is an approach to optimizing a system where each resource constraint is considered to be predetermined, and if there is an incomplete use of resources (there are leftovers), then it is considered not to affect the productivity of the system.
b. Affects the productivity of the system. The de novo programming approach is an approach to design an optimal system where the resource constraints will be set in such a way that they do not produce (Iriani, 2012).

The formulation of the De Novo Programming approach in solving optimization (maximization) problems is composed of an objective function and a limited number of resources (m) to be used in production activities with the available budget based on (Budianti et al., 2021), namely:

Objective Function:

$$Z = C_1X_1 + C_2X_2 + \cdots + C_nX_n \qquad (1)$$

Constraints:

$$\begin{aligned} a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n &= X_{n+1} \\ a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n &= X_{n+2} \\ &\vdots \qquad (2) \\ a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n &= X_{n+m} \end{aligned}$$

Constraints:

$$P_1X_{n+1} + P_2X_{n+2} + \cdots + P_mX_{n+m} \le B \qquad (3)$$

Description:

C_j = Budget/raw material availability
a_{mn} = Raw material composition
X_{n+1} = Decision variable in the form of the number of resources that must be prepared
P_i = Unit price of resource$-i$
B = Total available capital

The above equation can be simplified into the form:

$$p_1a_{1j} + p_2a_{2j} + p_ma_{mj} = v_j \text{ for all } j \qquad (4)$$

Where;
$v_j =$ The variable cost of producing product$-j$ $(j = 1,2,3, \dots, n)$
$a_{1j} =$ The coefficient for $i = 1,2,3, \dots, m$ dan $j = 1,2,3, \dots, m$

The above equation can be explained more fully as follows:

$$\begin{aligned} v_1 &= p_1a_{11} + p_2a_{21} + \cdots + p_ma_{m1} \\ v_1 &= p_1a_{12} + p_2a_{22} + \cdots + p_ma_{m2} \\ &\vdots \qquad (5) \\ v_1 &= p_1a_{1n} + p_2a_{2n} + \cdots + p_ma_{mn} \end{aligned}$$

If Equations (4) and (5) are substituted, the following equation will be obtained:

$$p_1(a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n) + p_2(a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n) + \cdots +$$

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$$p_m(a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n) \leq B \quad (6)$$

From Equation 6, the following result is obtained:

$$v_1X_1 + v_2X_2 + \cdots + v_nX_n \leq B \quad (7)$$

After obtaining the results as in Equation 7, the De Novo Programming equation is obtained as follows:

$$Z = C_1X_1 - C_2X_2 - \cdots - C_nX_n$$
$$v_1X_1 + v_2X_2 + \cdots + v_nX_n \leq B$$
$$a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n \leq b_2 \quad (8)$$
$$X_1, X_2, \ldots, X_n \geq 0$$

RESULTS AND DISCUSSION

Imam Seasoning Opaque Factory is an UMKM located at Jalan Persatuan No. 01, Tuntungan II. This factory business is engaged in the production of seasoning opaque, where the products produced consist of 3 types, namely: quality 1 seasoning opaque, quality 2 seasoning opaque, and quality 3 seasoning opaque. The data used in this study are production data from March 18 – May 17, 2024. To maximize profits, the data used in this study are as follows:

a. Data on the composition of raw materials in making each type of seasoning opaque.
b. Raw material data and raw material availability per week.
c. Sales profit data for each type of seasoning is opaque.
d. Data on the amount of production of each type of seasoning opaque per week.

Data on the raw materials needed in each seasoning opaque production are listed in Table 1.

Table 1. Composition of Product Raw Materials

No.	Material	Type of Seasoning Opaque in Kg		
		X1	X2	X3
1	Sweet Potato	2	2	2
2	Garlic	0.01	0.01	0.02
3	Chili	0	0.015	0.0175
4	Coriander	0.0125	0.012	0.0125
5	Celery Leaves	0.0025	0.0030	0.0040
6	Salt	0.006	0.006	0.006

Where:
X_1 = Salty seasoning opaque
X_2 = Ordinary spicy opaque
X_3 = Round spicy opaque

Table 2. Product Availability and Pricing

No.	Material	Availability (Kg)	Price / Kg
1	Sweet Potato	31367	1300
2	Garlic	93	38000
3	Chili	66	25000
4	Coriander	56	15000
5	Celery Leaves	142	15000
6	Salt	70	15000

Table 3. Weekly Raw Material Availability Data

No.	Month	Raw Material (Kg)					
		Sweet Potato	Garlic	Chili	Coriander	Celery Leaves	Salt
1	18 March2024	4756	15	10	8	20	10
2	25 March2024	5115	10	8	8	20	10
3	01 April 2024	7076	18	12	8	22	10
4	15 April 2024	2615	15	10	8	20	10
5	03 May2024	562	10	8	8	20	10
6	09 May 2024	6154	15	10	8	20	10
7	17 May 2024	5076	10	8	8	20	10
	Total	31367	93	66	56	142	70

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Table 4. Advantages of Each Type of Opaque

Type of Opaque	Production Cost	Selling Price	Profit
X1	7675	10000	2325
X2	12670	15000	2330
X3	17135	20000	2865

Table 5. Weekly Production Data

No.	Data/Week	Seasoning Opaque Quality Type		
		(X1)	(X2)	(X3)
1	18 March 2024	60	169	450
2	25 March 2024	150	87	892
3	01 April 2024	300	125	500
4	15 April 2024	158	187	592
5	03 May 2024	585	245	100
6	09 May 2024	170	188	347
7	17 May 2024	150	169	500
	Total	2031	1170	3381

The data that has been collected previously will be solved using the following steps:

a. Decision Variable:

x_1 : Production quantity of salty spice opaque
x_2 : Production quantity of regular spicy opaque
x_3 : Production quantity of round spicy opaque

b. Objective Function:

The objective of this study is to increase potential profits. The objective function is based on Table 1, which provides the

$$\text{Maximize } Z = 2325x_1 + 2330x_2 + 2865x_3 \quad (9)$$

c. Constraint Function

The raw material cost constraint is obtained by multiplying the coefficients of each constraint function with the price per unit in Table 1 and 2 so as to obtain:

$$v_1 = 1300\ (2) + 15000\ (0.0125) + 15000\ (0.0025) + 38000\ (0.1) + 15000(0.006) = 3295 \quad (10)$$

$$v_2 = 1300\ (2) + 25000\ (0.015) + 15000\ (0.012) + 15000\ (0.0030) + 38000(0.01) + 15000\ (0.006) = 3678.88 \text{ menjadi } 3679 \quad (11)$$

$$v_3 = 1300\ (2) + 25000\ (0.0175) + 15000\ (0.0125) + 15000\ (0.0040) + 38000(0.02) + 15000\ (0.006) = 4135 \quad (12)$$

Next, find the total cost of raw materials by multiplying the availability of raw materials by the price per product in Table 2, thus obtained:

Raw material cost constraint:

$$\text{B} = 1300\ (31367) + 38000\ (93) + 25000\ (66) + 15000\ (56) + 15000\ (142) + 15000\ (70)$$
$$B = 49981100$$

By substituting variable costs (v_j) into the equation:

$$v_1x_1 + v_2x_2 + \cdots + v_nx_n \leq B$$

Thus obtained:

$$3295x_1 + 3678{,}88x_2 + 4135x_3 \leq 49981100 \quad (13)$$

Furthermore, compile Linear Programming constraints based on Table 1, so that it is obtained:

1) Sweet potatoes:
$$2x_1 + 2x_2 + 2x_3 \leq 31367 \quad (14)$$
2) Garlic:
$$0.01x_1 + 0.01x_2 + 0.02x_3 \leq 93 \quad (15)$$
3) Chili:
$$0.015x_2 + 0.0175x_3 \leq 66 \quad (16)$$
4) Coriander:
$$0.0125x_1 + 0.012x_2 + 0.0125x_3 \leq 56 \quad (17)$$
5) Celery Leaves:
$$0.0025x_1 + 0.0030x_2 + 0.0040x_3 \leq 142 \quad (18)$$
6) Salt:
$$0.006x_1 + 0.006x_2 + 0.006x_3 \leq 70 \quad (19)$$

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For constraints, x_1, x_2, x_3 is a constraint on product demand per week with a value of $x_1, x_2, x_3 \geq 0$

d. Developing the De Novo Programming model.

Based on Equations 13 to 19, the De Novo Programming model is obtained as follows:

Maximize $Z = 2325x_1 + 2330x_2 + 2865x_3$

Constraints

$3295x_1 + 3678.88x_2 + 4135x_3 \leq 49981100$
$2x_1 + 2x_2 + 2x_3 \leq 31367$
$0.01x_1 + 0.01x_2 + 0.02x_3 \leq 93$
$0.015x_2 + 0.0175x_3 \leq 66$
$0.0125x_1 + 0.012x_2 + 0.0125x_3 \leq 56$
$0.0025x_1 + 0.0030x_2 + 0.0040x_3 \leq 142$
$0.006x_1 + 0.006x_2 + 0.006x_3 \leq 70$
$x_1 \leq 2031$
$x_2 \leq 1170$
$x_3 \leq 3381$
$x_1, x_2, x_3 \geq 0$

The optimal value calculation is carried out using the POM-QM application to get the maximum production and profit results for seven weeks. The calculation results can be seen in Figures 1, 2, and 3.

(untitled) Solution

Cj	Basic Variables	2325 X1	2330 X2	2865 X3	0 slack 1	0 slack 2	0 slack 3	0 slack 4	0 slack 5	0 slack 6	0 slack 7	0 slack 8	0 slack 9	0 slack 10	Quantity
Iteration 1															
0	slack 1	3.295	3.679	4.135	1	0	0	0	0	0	0	0	0	0	49.981.100
0	slack 2	2	2	2	0	1	0	0	0	0	0	0	0	0	31.367
0	slack 3	0,01	0,01	0,02	0	0	1	0	0	0	0	0	0	0	66
0	slack 4	0	0,015	0,0175	0	0	0	1	0	0	0	0	0	0	56
0	slack 5	0,0125	0,012	0,0125	0	0	0	0	1	0	0	0	0	0	142
0	slack 6	0,0025	0,003	0,004	0	0	0	0	0	1	0	0	0	0	93
0	slack 7	0,006	0,006	0,006	0	0	0	0	0	0	1	0	0	0	70
0	slack 8	1	0	0	0	0	0	0	0	0	0	1	0	0	2.031
0	slack 9	0	1	0	0	0	0	0	0	0	0	0	1	0	1.170
0	slack 10	0	0	1	0	0	0	0	0	0	0	0	0	1	3.381
	zj	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	cj-zj	2.325	2.330	2.865	0	0	0	0	0	0	0	0	0	0	
Iteration 2															
0	slack 1	3.295	134,7144	0	1	0	0		0	0	0	0	0	0	
0	slack 2	2	0,2857	0	0	1	0	-114,2857	0	0	0	0	0	0	24.967,0
0	slack 3	0,01	-0,0071	0	0	0	1	-1,1429	0	0	0	0	0	0	2,0
2865	X3	0	0,8571	1	0	0	0	57,1429	0	0	0	0	0	0	3.200,0
0	slack 5	0,0125	0,0013	0	0	0	0	-0,7143	1	0	0	0	0	0	102,0
0	slack 6	0,0025	-0,0004	0	0	0	0	-0,2286	0	1	0	0	0	0	80,2
0	slack 7	0,006	0,0009	0	0	0	0	-0,3429	0	0	1	0	0	0	50,8
0	slack 8	1	0	0	0	0	0	0	0	0	0	1	0	0	2.031
0	slack 9	0	1	0	0	0	0	0	0	0	0	0	1	0	1.170
0	slack 10	0	-0,8571	0	0	0	0	-57,1429	0	0	0	0	0	1	181,0
	zj	0	2455,714	2865	0	0	0	163714,3	0	0	0	0	0	0	
	cj-zj	2.325	-125,7142	0	0	0	0		0	0	0	0	0	0	

Figure 1. Simplex Table Iteration 1 and 2

Cj	Basic Variables	2325 X1	2330 X2	2865 X3	0 slack 1	0 slack 2	0 slack 3	0 slack 4	0 slack 5	0 slack 6	0 slack 7	0 slack 8	0 slack 9	0 slack 10	Quantity
Iteration 3															
0	slack 1	0	2.488,2857	0	1	0			0	0	0	0	0	0	
0	slack 2	0	1,7143	0	0	1	-200,0	114,2857	0	0	0	0	0	0	
2325	X1	1	-0,7143	0	0	0	100,0	-114,2857	0	0	0	0	0	0	200,0002
2865	X3	0	0,8571	1	0	0	0	57,1429	0	0	0	0	0	0	3.200,0
0	slack 5	0	0,0102	0	0	0	-1,25	0,7143	1	0	0	0	0	0	99,5
0	slack 6	0	0,0014	0	0	0	-0,25	0,0571	0	1	0	0	0	0	79,7
0	slack 7	0	0,0051	0	0	0	-0,6	0,3429	0	0	1	0	0	0	49,6
0	slack 8	0	0,7143	0	0	0	-100,0	114,2857	0	0	0	1	0	0	1.830,9998
0	slack 9	0	1	0	0	0	0	0	0	0	0	0	1	0	1.170
0	slack 10	0	-0,8571	0	0	0	0	-57,1429	0	0	0	0	0	1	181,0
	zj	2325	795,0001	2865	0	0	232500	-102000	0	0	0	0	0	0	
	cj-zj	0	1.535,0	0	0	0			0	0	0	0	0	0	
Iteration 4															
0	slack 1	0	1.611,5	0	1	0		0	0	0	0	-1.227,5	0	0	
0	slack 2	0	1,0	0	0	1	-100,0	0	0	0	0	-1,0	0	0	
2325	X1	1	0	0	0	0	0	0	0	0	0	1,0	0	0	2.031,0
2865	X3	0	0,5	1	0	0	50,0	0	0	0	0	-0,5	0	0	2.284,5001
0	slack 5	0	0,0057	0	0	0	-0,625	0	1	0	0	-0,0063	0	0	88,0562
0	slack 6	0	0,001	0	0	0	-0,2	0	0	1	0	-0,0005	0	0	78,7845
0	slack 7	0	0,003	0	0	0	-0,3	0	0	0	1	-0,003	0	0	44,107
0	slack 4	0	0,0062	0	0	0	-0,875	1	0	0	0	0,0088	0	0	16,0212
0	slack 9	0	1	0	0	0	0	0	0	0	0	0	1	0	1.170
0	slack 10	0	-0,5	0	0	0	-50,0	0	0	0	0	0,5	0	1	1.096,4999
	zj	2325	1432,5	2865	0	0	143250	0	0	0	0	892,5	0	0	
	cj-zj	0	897,5	0	0	0		0	0	0	0	-892,5	0	0	

Figure 2. Simplex Table Iteration 3 and 4

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Iteration 5															
0	slack 1	0	0	0	1	0		0	0	0	0	-1.227,5	-1.611,5	0	
0	slack 2	0	0	0	0	1	-100,0	0	0	0	0	-1,0	-1	0	
2325	X1	1	0	0	0	0	0	0	0	0	0	1,0	0	0	2.031,0
2865	X3	0	0	1	0	0	50,0	0	0	0	0	-0,5	-0,5	0	1.699,5001
0	slack 5	0	0	0	0	0	-0,625	0	1	0	0	-0,0063	-0,0058	0	81,3287
0	slack 6	0	0	0	0	0	-0,2	0	0	1	0	-0,0005	-0,001	0	77,6145
0	slack 7	0	0	0	0	0	-0,3	0	0	0	1	-0,003	-0,003	0	40,597
0	slack 4	0	0	0	0	0	-0,875	1	0	0	0	0,0088	-0,0062	0	8,7087
2330	X2	0	1	0	0	0	0	0	0	0	0	0	1	0	1.170
0	slack 10	0	0	0	0	0	-50,0	0	0	0	0	0,5	0,5	1	1.681,4999
	zj	2325	2330	2865	0	0	143250	0	0	0	0	892,5	897,5	0	12.317.242,
	cj-zj	0	0	0	0	0		0	0	0	0	-892,5	-897,5	0	

Figure 3. Simplex Table Iteration 5

The optimal solution based on calculations using the POM-QM application can be seen in Figure 4.

	X1	X2	X3		RHS	Dual
Maximize	2325	2330	2865			
Constraint 1	3295	3679	4135	<=	49981100	0
Constraint 2	2	2	2	<=	31367	0
Constraint 3	,01	,01	,02	<=	66	143250
Constraint 4	0	,015	,0175	<=	56	0
Constraint 5	,0125	,012	,0125	<=	142	0
Constraint 6	,0025	,003	,004	<=	93	0
Constraint 7	,006	,006	,006	<=	70	0
Constraint 8	1	0	0	<=	2031	892,5
Constraint 9	0	1	0	<=	1170	897,5
Constraint 10	0	0	1	<=	3381	0
Solution->	2031	1170	1699,5		12317240	

Figure 4. Optimal Solution 7 Weeks

It can be seen that by producing 2,031 kg of salted seasoning opaque, 1,170 kg of ordinary spicy seasoning opaque, and 1,699.5 kg of round spicy seasoning opaque. Then the seasoning opaque factory in Tuntungan II for 7 weeks earned a profit of Rp 12,317,240.

CONCLUSIONS AND SUGGESTIONS

In the production of seasoning opaque Imam Tuntungan II, it is wanted to see if their production is optimal or still has other optimal solutions. So that research was conducted using the De Novo Programming method, and with the results of the above data analysis using the POM-QM application, it was found that the optimal production for 7 weeks was to produce 2,031 kg of salted seasoned opaque, 1,170 kg of ordinary spicy spice opaque, and 1,699.5 kg of round spicy spice opaque. From the above trial, it is concluded that the production results of the imam spice opaque factory in Tuntungan II have been optimal with the original production of 7 weeks with the production of salted spice opaque as much as 2,031 kg, ordinary spicy spice opaque as much as 1,170 kg, and round spicy spice opaque as much as 3,381 kg.

For further research, it is hoped that modifications can be made by developing or adding the latest variables and constraints to the de novo programming model.

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