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Improvement of Warehouse Facility Layout Using Dedicated and Class-based Storage Methods at PT Mitra Sarana Mahadana

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ABSTRACT

PT Mitra Sarana Mahadana is a company engaged in the sale of PVC ceilings, PVC ceiling trim, and hollows. However, the products stored at this company are stored randomly, causing product damage when product pick-up is carried out. In addition, this random placement also causes a long search time to find a particular product so that time causes product retrieval to be inefficient and product damage causes storage to be ineffective. Therefore, improvements are needed using dedicated storage methods, class-based storage, and proposed improvements simulated using Arena. This study resulted in a conclusion in the form of a dedicated storage method succeeded in reducing the travel distance by 46.56% from the actual distance of 9,056.57 meters to 4,840.05 meters. From the simulation results, it was found that the dedicated storage method succeeded in reducing the product transfer process time by 79.85% from the actual time of 130 seconds to the proposed condition time of 26.2 seconds.

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INTRODUCTION

Warehouse is an important part in providing services and running the operation process in a company. Activities that can be carried out in the warehouse are searching, retrieving, receiving, storing, and delivering orders to consumers. The purpose of the warehouse is to maximize resources such as space, tools, and workers and meet customer satisfaction by delivering products quickly and in good condition. There are several things that need to be maximized in designing a warehouse, namely space, equipment, workers, material access, and material security [1].

PT Mitra Sarana Mahadana is a company that sells mild steel, hollow steel, roofing, and PVC (Poly vinyl chloride) ceilings. Currently, PT Mitra Sarana Mahadana has four branch stores with two branches focusing on PVC ceiling sales, one branch focusing on steel sales, and one branch selling both. The branch of PT Mitra Sarana Mahadana that located on Jalan Raya Serang – Cibarusa, Sukaragam, Serang Baru District which focuses on selling PVC ceiling products that have a random storage layout.

PVC ceilings are stacked with different variations of motifs as shown in Figure 1. This makes it difficult for workers to find scattered variations and pick up products from storage. In addition, irregular buildup of PVC ceiling products also causes damage when product movement is carried out from storage to transport cars. The damage that occurs to PVC ceiling products is a product of abrasions and fractures.

With product damage due to irregularity of products stored in the warehouse, PT Mitra Sarana Mahadana currently has poor warehouse conditions which causes inefficient product picking time and damage to products causing ineffective storage. Therefore, it is necessary to rearrange the storage location of PVC ceiling and steel products. There are several methods that can be used to solve this problem, such as special storage methods, class classification, random storage, and split storage. To solve this problem, improvements are needed by using methods that can allocate items in specific slots such as dedicated storage methods and class-based storage methods.

Dedicated storage methods are methods used to determine the storage location of a product in a predetermined place. In dedicated storage methods, the amount of storage specified by each product must be equal to the maximum level of product inventory. Meanwhile, the class-based storage method is a method of storing products by dividing items into certain classes according to the type of product movement. By comparing the two methods, it is expected to produce a layout with the most optimal time and distance.

Figure 1. Storage of goods at PT MSM

RESEARCH METHOD

Literature Studies

At this stage, researchers conduct literature studies to add references to researchers in analyzing problems and finding solutions to problems. The literature that researchers use is books, journals, or scientific papers that have the same topic or method as this study, namely dedicated storage and class-based storage.

Warehouse

According to [2], a warehouse is defined as a place to store various products that have both small and large quantities. Warehouse also has a mission, which is to deliver products to customers without any damage or deficiencies in the initial form or function of the product [1].

Dedicated Storage Method

According to [3], dedicated storage is a storage method with a predetermined storage location for each product stored. The number of slots provided is equal to the maximum inventory level of a product.

There are two types of dedicated storage, namely part-number sequence storage and throughput-based storage. In part-number sequence storage, product placement is based on part numbers at fixed locations. In this type, the smaller the part number, the closer the part storage area is to the input and output points. Meanwhile, for throughput-based storage, storage is based on the amount of throughput and space needs of objects you want to store [4].

Class-based Storage Method

There are two types of class classification, namely by grouping goods based on class classification or based on product size. For the class classification method based on product size is a storage method by grouping products based on their type or characteristics. Then, for the class classification method that uses class classification, there are three class divisions, namely class A, B, and C. Class A is a class with the number of Storage/Retrieval (S/R) 80% of the total S/R, class B 15% of the total S/R, and class C 5% of the total S/R. To minimize the time needed for storage and retrieval, then class A is placed near the I/O point.

Distance Measurement

According to [5], in measuring distance, there are several ways that can be done, namely Euclidean, rectilinear, Chebyshev, and aisle distance. Measurements are made based on the availability of qualified personnel, time to collect data, and the type of material handling system to be used.

Aisle Distance

This measurement is measured based on the actual distance traveled by the material handling tool. This measurement is done by summing up each distance traveled by the material handling tool. Measurements are usually carried out at the planning or evaluation stage.

Simulation

According to [6], simulation is the imitation of real conditions by using computer models to evaluate and improve system performance. Typically, simulations are used using Arena software that can model to estimate dynamic behavior in a system. By using simulations, failures in directly implementing the model can also be avoided. Repairs that can take months to years can be avoided by using simulations within days or hours.

Field Studies

At this stage, researchers conducted observations and field interviews with PT Mitra Sarana Mahadana located on the Cikarang – Cibarusah Street, Bekasi, West Java. Observation is

carried out by directly observing the storage place and interviewing the owner of this company. Researchers also collected data and documented observations to support this study.

Data Collection

At this stage, researchers collect data to support research needs. Data collection was conducted at PT Mitra Sarana Mahadana from June-October 2023 with interviews and observations. The primary data used in this study are the type and characteristics of products stored in the warehouse, the current warehouse layout, and the time to store goods. Then, there is also secondary data used in this study is the number of products entering and leaving the warehouse.

Data Processing and Analysis Stage

At this stage, researchers process data such as calculating throughput, space require-ments, and making improvement proposals using dedicated storage and class-based storage methods. Then, researchers also simulate actual conditions and proposed conditions as well as verify and validate.

Final Stage of Research

At this stage, conclusions and suggestions are drawn from the results of data processing, and data analysis that has been carried out.

RESULT AND DISCUSSION

Space Requirements Calculation

The calculation of room requirements is carried out to determine the number of slots needed by a type of product stored in the warehouse. Products stored in PT Mitra Sarana Mahadana's warehouse have different sizes. Therefore, researchers determine the size of the slots in each product based on the size of the box for each product. The slot sizes used are as follows:

Table 1. Slot Type and Size

Slot Type	Slot Size		Floor Area/Slot (m2)
	p (cm)	l (cm)	
A	600	20	1,2
B	500	20	1
C	400	20	0,8
D	30	30	0,09
E	60	30	0,18
F	15	10	0,015

After determining the type of slot and its size, researchers then determine the type of slot that best suits the product. The slot types of each product can be seen in the following table:

Table 2. Assignment on Slot Type

Code	Slot	Code	Slot	Code	Slot	Code	Slot
B11	C	K11	C	K103	A	M3	C
B12	B	K12	B	K111	C	M4	C
B13	A	K13	A	K112	B	M5	C
B21	C	K21	C	K113	A	M6	C
B22	B	K22	B	K121	C	M7	C
B23	A	K23	A	K122	B	M8	C
B31	C	K31	C	K123	A	M9	C

Code	Slot	Code	Slot	Code	Slot	Code	Slot
B32	B	K32	B	K131	C	M10	C
B33	A	K33	A	K132	B	M11	C
B41	C	K41	C	K133	A	M12	C
B42	B	K42	B	L11	C	M13	C
B43	A	K43	A	L12	C	M14	C
B51	C	K51	C	L13	C	M15	C
B52	B	K52	B	L14	C	M16	C
B53	A	K53	A	L21	C	M17	C
B61	C	K61	C	L31	C	M18	C
B62	B	K62	B	L32	C	M19	C
B63	A	K63	A	L41	C	M20	C
B71	C	K71	C	L42	C	O11	E
B72	B	K72	B	L43	C	O12	E
B73	A	K73	A	L44	C	O13	E
F11	D	K81	C	L51	C	O14	E
F12	D	K82	B	L52	C	O15	E
F13	D	K83	A	L53	C	O16	E
G11	C	K91	C	L61	C	O17	E
G12	B	K92	B	L71	C	O18	E
G13	A	K93	A	L81	C	P11	F
H11	C	K101	C	M1	C	P12	F
H12	C	K102	B	M2	C	P21	F
						P22	F

Throughput Calculation

Due to no material handling used in this warehouse, the number of transfers per lift is the maximum limit that can be lifted by two workers simultaneously. For example, here is a throughput value calculation for a product with code B11:

$$Throughput = \frac{Average\ Input + Output}{Number\ of\ transfer\ per\ lift}$$

$$Throughput = \frac{15{,}0 + 6{,}2}{15}$$

$$Throughput = 1{,}41$$

From the calculation results for each item, a throughput value can be seen in the table below.

Table 3. Throughput Calculation

Code	Average Input	Average Output	Number of Transfer per Lift	*Through-put*
B11	15,00	6,2	15	1,41
B12	33,00	31,4	15	4,29
B13	15,00	14,8	15	1,99
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...

Code	Average Input	Average Output	Number of Transfer per Lift	*Through-put*
P11	6720,00	180,8	3360	2,05
P12	3840,00	75,8	1920	2,04
P21	400,00	90,0	2000	0,25
P22	400,00	120,0	2000	0,26

Actual Layout

Figure shown below Is actual layout of PT Mitra Sarana Mahanada

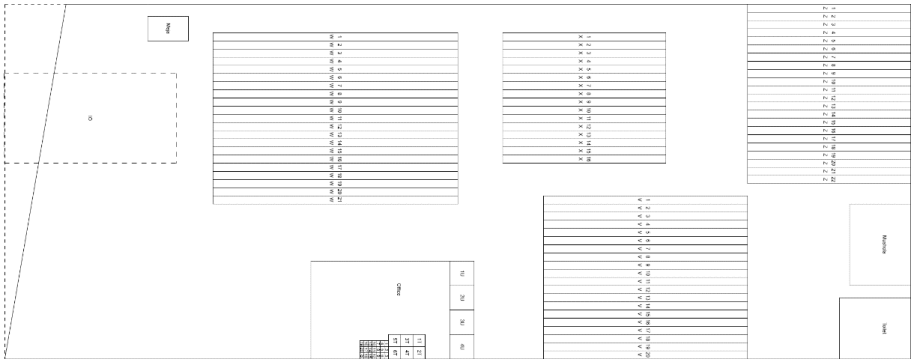

Figure 2. Actual Layout

Total Distance Traveled on Actual Layout

In Table 4 there is a slot with an empty product code caused by storage at PT Mitra Sarana Mahadana which is random. If the researcher records every product in each slot, the value of the total dij*(T/S) will be very large because each product may be in each storage slot. Therefore, researchers make assumptions by calculating and averaging the T/S value per product size. Then, for slots with products that have been placed are slots that only contain these products.

From the results of the calculations that have been done in Table 4, the result of the total value of dij*(T/S) or the total distance traveled by the product is 9056.57 meters.

Table 4. Calculation of dij*(T/S) on Actual Layout

No. Slot	Code	T/S	dij (Meter)	dij*T/S
1W	-	4.29	5	21.45
2W	-	4.29	4.8	20.59
3W	-	4.29	4.6	19.73
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
18S	P12	2.04	14.35	29.27
19S	P12	2.04	14.15	28.86
20S	P12	2.04	14.3	29.16
Total dij*(T/S)				**9056.57**

Proposed Layout Using Dedicated Storage

Figure shown below Is proposed layout using dedicated storage.

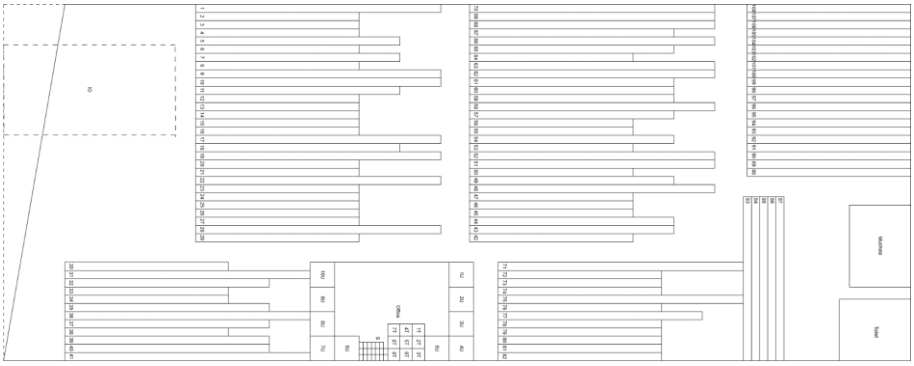

Figure 3. Proposed Layout Using Dedicated Storage

Proposed Total Distance Traveled Using Dedicated Storage

Table 5. Calculation of dij*(T/S) on Proposed Layout Using Dedicated Storage

No. Slot	Code	T/S	dij (Meter)	dij*(T/S)
1	K33	5,80	4,6	26,68
2	K81	6,59	4,4	28,98
3	L43	6,62	4,2	27,82
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
144	P12	2,04	14,2	28,9606
145	P12	2,04	14,35	29,2665
146	P12	2,04	14,15	28,8586
147	P12	2,04	14,3	29,1646
Total dij*(T/S)				**4840,06**

From the calculation of dij*(T/S) or the total distance traveled by the product is 4840,06 meters. From these results, comparing to the distance traveled by the product on actual layout is 9056,57 meters, there is a decrease of 46,56% on distance traveled by the product.

Proposed Layout Using Class-based Storage

Figure shown below Is proposed layout using class-based storage.

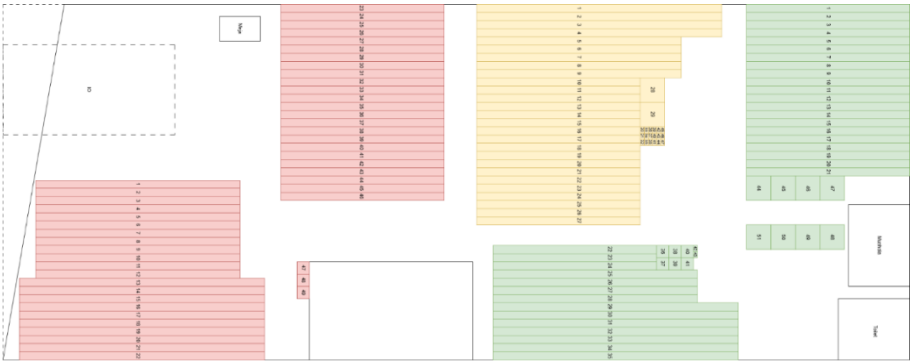

Figure 4. Proposed Layout Using Class-based Storage

Proposed Total Distance Traveled Using Class-based Storage

Table 6. Calculation of dij*(T/S) on Proposed Layout Using Class-based Storage

No. Slot	Code	T/S	dij (Meter)	dij*(T/S)
1A	K42	21,19	4,6	97,46
2A	K72	11,95	4,8	57,34
3A	G12	9,24	5	46,20
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
50C	O18	0,70	21,5	15,05
51C	O18	0,70	20,9	14,63
48C	O13	0,05	22,7	1,14
Total dij*(T/S)				**5612,70**

From the calculation results, the total value of dij*(T/S) or the total journey passed by the product is 5612,70 meters. From these results, comparing to the distance traveled by the product on actual layout is 9056,57 meters, there is a decrease of 38,03% on distance traveled by the product.

Proposed Layout Using Class-based and Dedicated Storage (Class Classification by Type and Size)

Figure shown below Is proposed layout using class-based and dedicated storage with class classification based on type and size.

Figure 5. Proposed Layout Using Class-based and Dedicated Storage with Classification Based on Type and Size

Proposed Total Distance Traveled Using Class-based and Dedicated Storage (Class Classification by Type and Size)

Table 7. Calculation of dij*(T/S) on Proposed Layout Using Class-based and Dedicated Storage with Classification based on Type and Size

No. Slot	Code	T/S	dij (Meter)	dij*(T/S)
1V	B42	3,32	6,6	21,91
2V	K112	3,69	6,4	23,64
3V	K62	4,09	6,2	25,38
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
17S	P12	2,04	14,2	28,96

No. Slot	Code	T/S	dij (Meter)	dij*(T/S)
18S	P12	2,04	14,35	29,27
19S	P12	2,04	14,15	28,86
20S	P12	2,04	14,3	29,16
Total dij*(T/S)				**7180,34**

From the calculation results, the total value of dij*(T/S) or the total journey passed by the product is 7180.34 meters. From these results, comparing to the distance traveled by the product on actual layout is 9056,57 meters, there is a decrease of 20,72% on distance traveled by the product.

Proposed Layout Using Class-based and Dedicated Storage (Class Classification by Type and Motif)

Figure shown below Is proposed layout using class-based and dedicated storage with class classification based on type and motif.

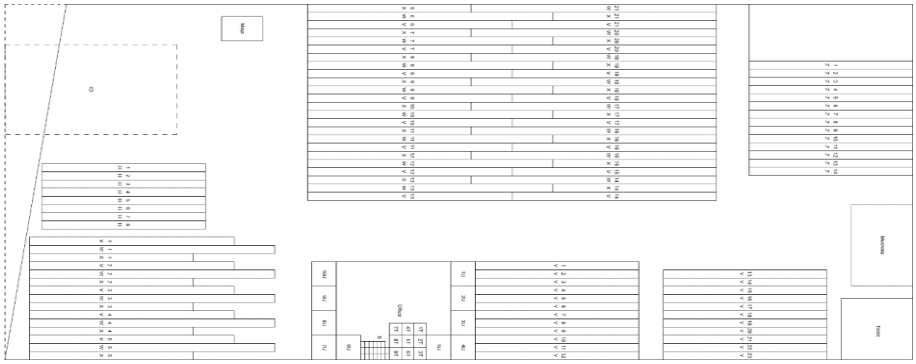

Figure 6. Proposed Layout Using Class-based and Dedicated Storage with Classification Based on Type and Motif

Proposed Total Distance Traveled Using Class-based and Dedicated Storage (Class Classification by Type and Motif)

Table 8. Calculation of dij*(T/S) on Proposed Layout Using Class-based and Dedicated Storage with Classification based on Type and Motif

No. Slot	Code	T/S	dij (Meter)	dij*T/S
1V	B62	2,04	10	20,40
2V	K12	1,36	10,6	14,42
3V	B72	0,97	11,2	10,90
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
19S	P12	2,04	14,15	28,86
20S	P12	2,04	14,3	29,16
Total dij*(T/S)				**8254,52**

From the calculation results, the total value of dij*(T/S) or the total journey passed by the product is 8254,52 meters. From these results, comparing to the distance traveled by the product on actual layout is 9056,57 meters, there is a decrease of 8,86% on distance traveled by the product.

Simulation Model

To do the time calculation, researchers will use simulations in this study. The simulation application that researchers used was Arena Simulation 14. The simulation is carried out while still using the calculation method that has been calculated before. The number of simulations that the researchers design will amount to five simulations, namely simulations of actual warehouse conditions, simulation of proposals using dedicated storage placement, simulation of proposals using class-based storage placement, simulation using placement with class-based storage and dedicated storage (grouping of types and sizes), and simulation using placement of class-based storage and dedicated storage (grouping of types and motif).

Recapitulation of Average Time Process on Actual Layout

Table 9. Average Process Time on Actual Layout

Replication	Observation Number (s)									
	1	2	3	4	5	6	7	8	9	10
Average Process to Location W	111	113	117	112	114	111	111	111	109	113
Average Process to Location X	126	129	127	124	130	125	129	125	127	126
Average Process to Location V	126	127	126	130	126	127	128	127	126	128
Average Process to Location Z	148	157	153	152	154	154	159	151	153	155
Average	**127,8**	**131,5**	**130,8**	**129,5**	**131**	**129,3**	**131,8**	**128,5**	**128,8**	**130,5**

By using recapitulation data, researchers can find out the average time of the process of picking or storing goods at PT Mitra Sarana Mahadana. The calculation of the average time is as follows:

$$Average\ Process\ Time = \frac{127{,}8 + 131{,}5 + \cdots + 130{,}5}{10}$$

$$Average\ Process\ Time = 130\ s$$

From these calculations, it can be seen that the average processing time is 130 seconds.

Actual Simulation Model

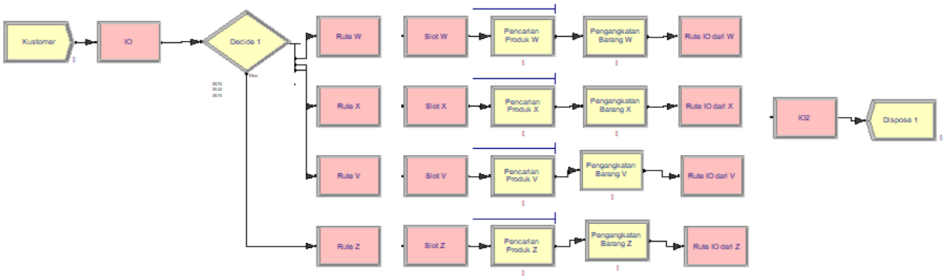

Figure 7. Simulation on Actual Model

For expressions that researchers use in each process can be seen in table below:

Table 10. Distribution of Duration Used on Actual Model

Proses	Distribution of Duration
Travel from IO to W location	1.5 + WEIB(0.911, 1.91)
Search for goods at location W	NORM(92.1, 1.37)

http://doi.org/10.54378/joseon.v1i02.7473

Proses	Distribution of Duration
Travel from W to IO location	2.5 + WEIB(1.43, 4.59)
Travel from IO to X location	7.5 + WEIB(1.43, 4.59)
Search for goods at location X	89.5 + LOGN(2.51, 2.87)
Travel from X to IO location	TRIA(11.5, 12.8, 13.5)
Travel from IO to V location	TRIA(7.5, 8.8, 9.5)
Search for goods at location V	89.5 + 5 * BETA(1.26, 1.26)
Travel from V to IO location	TRIA(11.5, 12.5, 13.5)
Travel from IO to Z location	TRIA(14.5, 15.8, 16.5)
Search for goods at location Z	NORM(105, 2.79)
Travel from Z to IO location	TRIA(17.5, 19.1, 19.5)
Goods lifting	TRIA(3.5, 4.8, 5.5)
Drop off goods	TRIA(8.5, 9.2, 10.5)

Verification on Actual Simulation Model

The verification carried out in this research simulation is the examination of the simulation model. The simulation in this study was carried out by running experiments on the model and produced no errors which means there were no errors in the process and the model was as desired. Through this, it can be known that the model is verified.

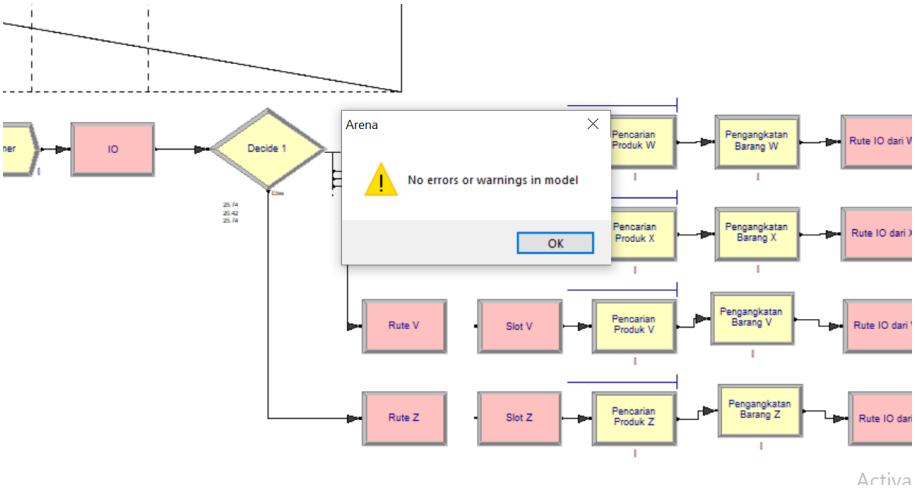

Figure 8. Simulation Verification on Actual Model

Replication on Actual Simulation Model

After going through the verification process, the next step is to determine the number of replications. The following is the average result of the simulation time that was run for 10 hours and replicated ten times.

Table 10. Simulation Results on Actual Model

Replication	Simulation Result (hour)	Simulation Result (second)
1	0,0368	132,54
2	0,0372	133,75
3	0,0359	129,36
4	0,0405	145,62
5	0,0364	131,22
6	0,0350	126,13
7	0,0401	144,22

Replication	Simulation Result (hour)	Simulation Result (second)
8	0,0540	194,44
9	0,0393	141,42
10	0,0367	132,11

Then, the researcher calculated the number of replications needed and produced the minimum number of replications as follows.

1. Average time in actual simulation model

$$\bar{x} = \sum_{i=1}^{n} x_i$$

$$\bar{x} = \frac{132{,}54 + 133{,}75 + \cdots + 132{,}11}{10}$$

$$\bar{x} = 141{,}08\ second$$

2. Standar deviation calculation

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

$$S = \sqrt{\frac{(132{,}58 - 141{,}08)^2 + \cdots}{10-1}}$$

$$S = 19{,}84$$

3. Calculation of halfwidth from ten simulation with alpha value = 5%

$$t_{n-1,\frac{\alpha}{2}} = 2{,}26216$$

$$hw = \frac{\left(t_{n-1,\frac{\alpha}{2}}\right) xS}{\sqrt{n}}$$

$$hw = \frac{(2{,}26216)x19{,}84}{\sqrt{10}}$$

$$hw = 14{,}19$$

Validation on Actual Simulation Model

The t-test is used to compare actual conditions with simulated system conditions. The decision-making criteria are as follows:

μ_1 = average product transfer time under actual conditions.

μ_2 = average product transfer time under simulated system conditions.

H_0 = average actual product movement time is different from the product movement time in the simulation model.

H_1 = average actual product movement time is equal to product movement time in the simulation model.

With: H_0: $\mu_1 = \mu_2$ and H_1: $\mu_1 \neq \mu_2$

By using SPSS software, the results of the t test are obtained as follows:

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Simulasi - Aktual	11.15600	20.33530	6.43058	-3.39099	25.70299	1.735	9	.117

Figure 8. t-test Calculation on Actual Model

From the table, it can be seen that the value of t_{calc} is 1.735 with a value of t_{table} (df=9; 0.05) has a value of 2.26216. From these results it can be seen that t_{calc}<t_{table}, which means that it H_1 accepted and it can be concluded that the average actual product movement time equal to product movement time in the simulation model.

Simulation Model Using Proposed Method

The design of simulation models is made by modifying real models based on proposed improvements. The following is the layout of the simulation model that the researchers have made.

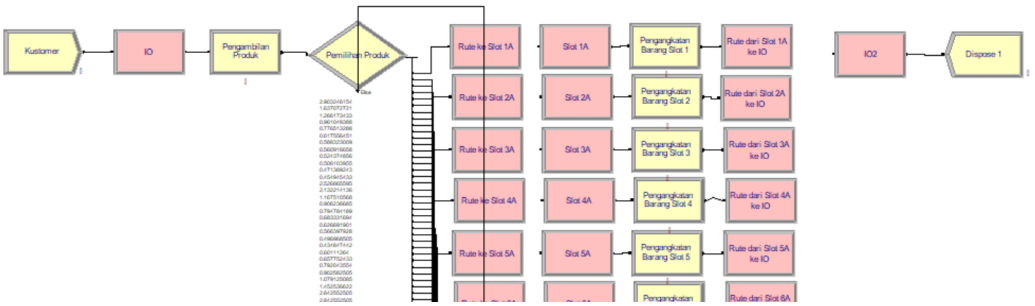

Figure 9. Simulation Model on Proposed Layout

The simulation model that the researchers made for each proposed model has the same shape, but the time calculation is different.

Verification of Simulation Using Proposed Layout

Simulation in this study was carried out by running the model and produced no errors which means there were no errors in the process and the model was as desired. Through this, it can be known that the model is verified.

Figure 10. Verification Model on Proposed Layout

Replication on Proposed Layout Simulation Model

The table below is time data and a recapitulation of calculations in each proposed method.

Table 11. Simulation Results on Dedicated Storage Model

Replication	Simulation Result (hour)	Simulation Result (second)
1	0,00783	28,18
2	0,00690	24,82
3	0,00660	23,77
4	0,00803	28,91
5	0,00715	25,74
6	0,00698	25,12
7	0,00681	24,51
8	0,00914	32,92
9	0,00708	25,47
10	0,00626	22,55
Average (second)		26,20

Table 12. Simulation Results on Class-based Storage Model

Replication	Simulation Result (hour)	Simulation Result (second)
1	0,00866	31,18
2	0,00756	27,23
3	0,00723	26,01
4	0,00771	27,75
5	0,00746	26,85
6	0,00796	28,67
7	0,00731	26,33
8	0,00960	34,57
9	0,00805	28,99
10	0,00700	25,21
Average (second)		28,28

Table 13. Simulation Results on Class-based Storage & Dedicated Storage Model (Group by Type and Size)

Replication	Simulation Result (hour)	Simulation Result (second)
1	0,01035	37,27
2	0,00913	32,86
3	0,00864	31,11
4	0,00754	27,13
5	0,00857	30,86
6	0,00847	30,50
7	0,00868	31,24
8	0,00888	31,96
9	0,00844	30,40
10	0,00835	30,05
Average (second)		31,34

Table 14. Simulation Results on Class-based Storage & Dedicated Storage Model (Group by Type and Motif)

Replication	Simulation Result (hour)	Simulation Result (second)
1	0,01060	38,17
2	0,00944	34,00
3	0,00923	33,22
4	0,00894	32,18
5	0,00935	33,67
6	0,00900	32,40
7	0,00945	34,04
8	0,00988	35,55
9	0,00927	33,35
10	0,00917	33,00
Average (second)		33,96

With the same calculation as the replication calculation above, the following results are obtained.

Table 15. Calculation of Number of Replication on Proposed Simulation Model

Proposed Layout	Average	Standar Deviation	Half-width	Number of Replication
Dedicated Storage	26,20	121,13	86,65	0,10
Class-based Storage	28,28	118,93	85,08	0,10
Dedicated and Class Based Storage (Classification by Type and Size)	31,34	115,71	82,77	0,09

Proposed Layout	Average	Standar Deviation	Half-width	Number of Replication
Dedicated and Class Based Storage (Classification by Type and Motif)	33,96	112,93	80,79	0,08

From the following table it can be seen that the minimum number of replications of each proposal is one replication. Thus, there is no need for replication changes because the replication needed is smaller than the replication that has been done.

Performance Test on Simulation Using Proposed Layout

The t-test is used to compare actual conditions with simulated system conditions. The decision-making criteria are as follows:

μ_1 = average product transfer time under actual conditions.

μ_2 = average product transfer time under simulated system conditions.

H_0 = average actual product movement time is different from the product movement time in the simulation model.

H_1 = average actual product movement time is equal to product movement time in the simulation model.

With: H_0: $\mu_1 = \mu_2$ and H_1: $\mu_1 \neq \mu_2$

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Aktual - DS	114.88200	17.46275	5.52221	102.38990	127.37410	20.804	9	.000
Pair 2	Aktual - CB	112.80200	17.85167	5.64519	100.03168	125.57232	19.982	9	.000
Pair 3	Aktual - CBDSJU	109.74300	20.09972	6.35609	95.36453	124.12147	17.266	9	.000
Pair 4	Aktual - CBDSJMT	107.12300	19.44456	6.14891	93.21320	121.03280	17.421	9	.000

Figure 11. t-test Calculation on Proposed Simulation Model

From the results of the t test, it can be seen that each proposed improvement results that $t_{table} < t_{cal}$ so that it can be concluded that H_0 is accepted and the average time of actual product movement with simulation is not the same.

Analysis of Improvement Results

Researchers then compared each type of proposal to find out which type of layout provided the greatest reduction in distance and time. Here's a comparison of each type of proposal layout:

Table 16. Improvement Results

Proposed Layout	Distance (m)		% Decrease of Distance	Average time (s)		% Time Decrease
	Actual	Proposed		Actual	Proposed	
Dedicated Storage	9056,57	4840,055	46,56%	130	26,20	79,85%
Class-based Storage	9056,57	5612,701	38,03%	130	28,28	78,25%
Dedicated and Class Based Storage (Classification by Type and Size)	9056,57	7180,338	20,72%	130	31,34	75,90%
Dedicated and Class Based Storage (Classification by Type and Motif)	9056,57	8254,516	8,86%	130	33,96	73,88%

CONCLUSION

From the results of this study can be obtained the following conclusions:

1. After modeling with Arena software, it was concluded that the simulation model based on a special storage method succeeded in reducing the average product transfer time by 79.85% from the actual condition time by 130 seconds and the proposed condition time by 26.2 seconds.
2. By using aisle distance measurements and placing products based on dedicated storage methods, class-based storage, class-based and dedicated storage by grouping products by type and size, and class-based and dedicated storage by grouping products by type and motif or product type. Of the four types of products, the highest percentage reduction was obtained using a dedicated storage method with a distance reduction of 46.56% from the actual distance of 9,056.57 meters to 4,840.05 meters at the proposed distance.
3. Based on these two conclusions, the best proposal that can be given to PT Mitra Sarana Mahadana with the basic criteria of time and distance is a proposal using a dedicated storage method.

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