

A study on an improvement of layout of a supermarket backyard by link analysis

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Abstract: Using link analysis, layout of a supermarket back yard was improved. First, the supermarket was observed with fixed point camera for link analysis. Result of the observation, these were made guiding principle of improvement. The results of investigation of link analysis were as follows. (1) A lot of times of intersection at narrow passage. (2) The workplaces had been overcrowded. (3) Work spaces were insufficient. In this way, the point of the improvement is amenity of movement, securing of work space, and shortening of the movement distance. It proposed the improvement plan of the layout in consideration of these problems. Result of the observation, it is thought that improvement of a layout of decrease in useless movement and realization of smooth work was achieved.

Key words: *link analysis, layout, Work improvement.*

1. Introduction

It is thought that the purpose of difficult the service-producing industry raises productivity is inclusion a lot of complex hand work. One of such work is the fisheries section of the supermarket. The work of the fishery section is complex of the work flow. The rough flow of the work changes every time so that the kinds of a fishes to cook are different. In order to do such complicated and fluid work efficiently, workshop of an appropriate layout is necessary. Therefore work improvement may be possible by changing a layout. In addition, It was thought that it only had to analyze the movement of the work of the employee for for the improvement of the layout,.

As above, purpose of this report is to perform the layout improvement of the supermarket from the viewpoint of the work line of flow.

A. Investigation

First, it explained layout of a supermarket back yard. The simplified schematic of the layout is shown in Figure 1. In addition, the name of place of layout is shown in Table1. Explanation of a name is shown below. 1: Sashimi production place is the place where work to make sashimi from filled fish. 2: Salt water processing machine is the machine which keeps a fish with salt water. 3: Cooking place is the place where work to make fillet fish which has been carried from port. 4: Auto packer is the machine which packs by automatic operation and puts a price tag. 5: The machine which gives a price is the place packs and puts a price tag by manual operation. 5,6 and 7: Worktable is the place where work to put a filled fish on the tray. 9: Ice machine and Sink. Ice machine is machine which work to make ice. Sink is the place that defrosts a fish.

Table 1. Name of place of layout of a supermarket back yard

1	Sashimi production place	7	Worktable
2	The machine which keeps a fish with salt wa	8	Doorway of refrigerator
3	Cooking place	9	Ice machine & Sink
4	auto packer	10	Doorway of Sushi production place
5	The machine which gives a price	11	Doorway of counter
6	Worktable	12	Doorway of passage

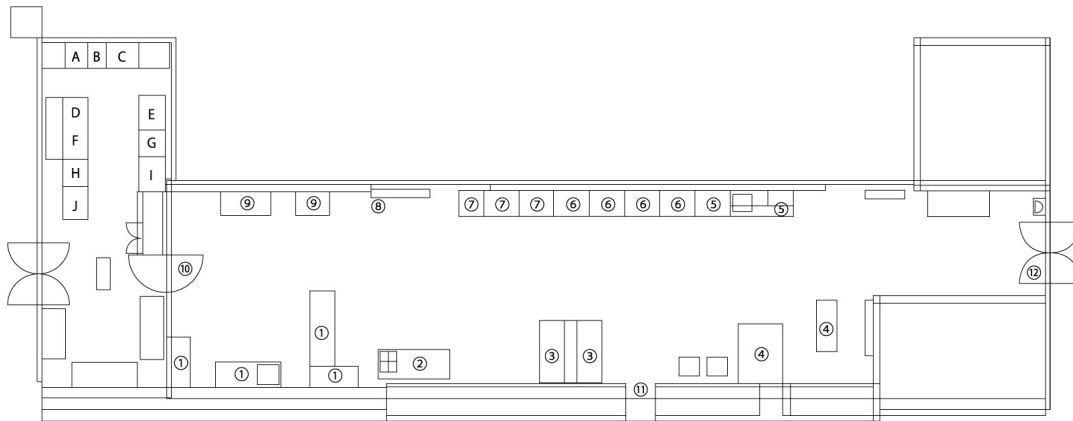


Figure.1 layout of a supermarket back yard

2. Methods

This chapter introduces the link analysis that used for analysis and a method of the observation investigation.

2.1 Link analysis

The link analysis [1] is a technique used for to examine validity of layout which operation about function part of the product and work place about kitchen. In this method, the history of the operation and the actions is connected in the line along order of task. As the result, the problem of layout which function part of the product and workplace are grasped. When the object is function part of the product, the line which linked a button or the knob with an operation turn is made the object of the analysis. When the object is work place, traffic line of work is made the object of the analysis. And, a point that intersect line become complicated and frequency of the operation are expressed by the thickness of the line. Thus, the problems in the layout by operation and the work are grasped. Show it in table 2, the relation of each part (A ~ H) concerning work and movement is written in link table. Show it in Figure 2, written in link figure at the same time.

Table 2. Example of link table

	A	B	C	D	E	F	G	H
A	—	1	1	—	—	—	—	—
B	—	—	—	—	3	—	—	3
C			—	—	—	—	—	3
D				—	2	1	—	—
E					—		—	5
F						—	1	—
G							—	3
H								—

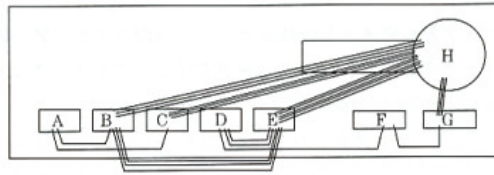


Figure.2 Example of link figure

2.2 Observation

The observational research used fixed point cameras and handy cameras for a supermarket backyard. Enforcement times were October 15, 2008 and October 16, 2008. Time zone was in the morning (From 5:30 to 10:00. This time zone is the busiest, and most important in the work of a supermarket backyard.

3. Results

Because a lot of employees were working at the same time, the link analysis by the unit of work was difficult. Therefore each employee's link table and link figure were created, and calculated the average movement number of times of one employee per one hour by dividing those sums by the number of people. As the link analysis result of all employees, link table is shown in Table 3, link figure is shown in Figure 3.

Then, the result of observational research is explained. The section which had most traffic was 4-7, and it was 5.25 times per hour. Secondly was 4-5, and it was 4.25 times per hour. Successively, 2-3 was 4.17 times, 4-6 was 3.88 times, 6-7 was 3.75 times, 2-7 was 3.71 times, and 5-6 was 3.21 times.

4: Auto packer was regarded as central one of the movement of the employees. And, deep relation was seen between 5, 6, and 7: Worktable and 4: Auto packer. It can be thought that this is due to the work process which the employees pack the fish into the trays at each Worktable, and they pack with these trays at Auto packer.

In addition, 2: Salt water processing machine was regarded as another central of the movement of the employees. Implications of the salt water processing machine and the cooking place are thought the influence by work process which employees processes fishes kept by the Salt water processing machine at Cooking place, and they keep processed fish at Salt water processing machine again. Moreover, the movement between 2: Salt water processing machine and 7: Worktable are thought the influence by work process which employees carry processed fish at Salt water processing machine to Worktable.

Table 3. Link table in a layout before improvement

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	0.96	0.42	0.17	0.42	0.29	1.17	0.79	0.92	0.54	0.04	0.33
2	-	-	4.17	0.75	0.33	1.04	3.71	1.42	1.88	0.13	0.08	0.13
3	-	-	-	2.42	0.67	1.58	2.33	1.38	1.13	0.17	0.29	0.13
4	-	-	-	-	4.25	3.88	5.25	0.25	0.21	0.04	1.46	1.29
5	-	-	-	-	-	3.21	1.83	0.13	0.08	0.00	0.13	0.29
6	-	-	-	-	-	-	3.75	0.08	0.33	0.00	0.08	0.29
7	-	-	-	-	-	-	-	0.67	0.79	0.13	0.08	0.42
8	-	-	-	-	-	-	-	-	0.71	0.25	0.04	0.04
9	-	-	-	-	-	-	-	-	-	0.21	0.00	0.08
10	-	-	-	-	-	-	-	-	-	-	0.00	0.08
11	-	-	-	-	-	-	-	-	-	-	-	0.04
12	-	-	-	-	-	-	-	-	-	-	-	-

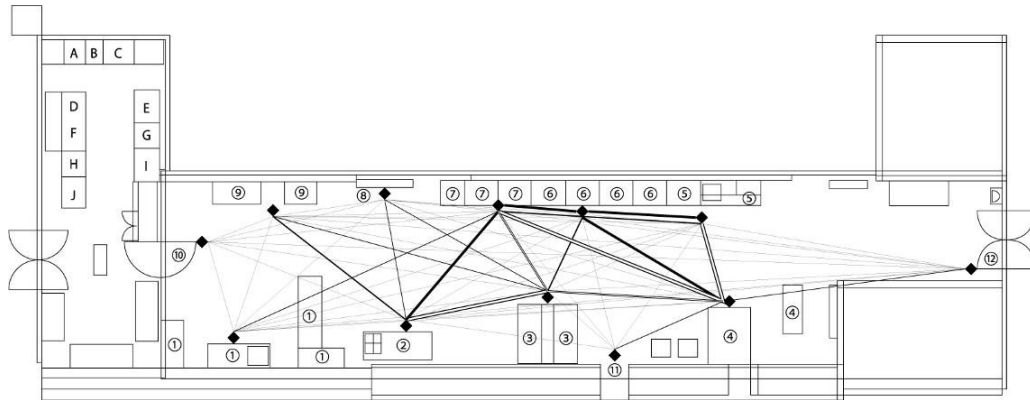


Figure.3 Link figure in a layout before improvement

4. Discussion

First of all, the problem seen in the movement between Auto packer and Worktable is explained. The greatest problem of this section is that a passage is narrow. Because carts putted trays that waits for Auto packer become the obstacle, it is difficult for the employee to intersect mutually. By the existence of the obstacle, the movement distance of the employee is longer than the distance of the passage. Thus, the state of it is not easy to pass in the section where a lot of frequencies that employee and cart intersect exist causes the work performance has been decreased.

For these thoughts, it is thought that it is necessary to reconsider about layout of this point, securing of movement space and placement that an intersection is hard to happen. Moreover, it seems that it is necessary to consider it about the placement of the cart. Furthermore, because the employees move frequently from Auto packer to Counter when they carry carts, it is necessary to be able to move a cart of the vicinity of Auto packer smoothly.

Next, the problem seen in the movement between Salt water processing machine and Cooking place is explained. The figure which expanded this part is shown in Figure 4. There are two Cooking places, and the employees are arranged in each stand one by one. Both employees move between Salt water processing machine and Cooking place. The employees of Cooking place 1 works easily because the Cooking place is near to Salt water processing machine. However the employees of Cooking place 2 should go to passing in the narrow aisle so that taking fishes. As a result, it seems that the difference of the work performance is generated between Cooking places. It is necessary to reconsider the salt water processing machine and the counter position for these reasons. Especially, it is necessary to consider Cooking place 2.

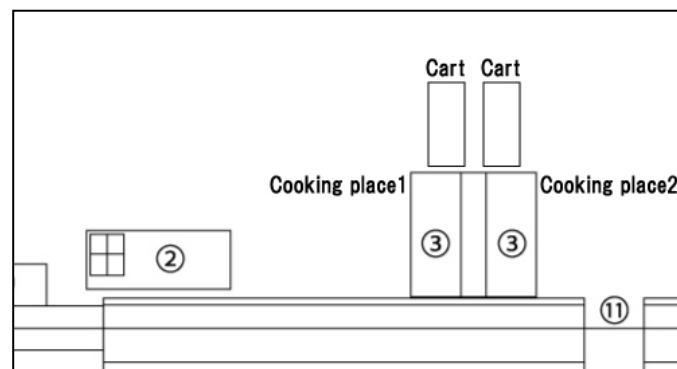


Figure.4 Focusing Salt water processing machine and Cooking place

5. Suggestion and decision of the design plan

The layout ideas propose from the observational research by the link analysis and the layout ideas actually improved are explained in this chapter.

5.1. Suggestion of the design plan

Two layout improvement proposals proposed from the observational research by link analysis. The first improvement idea is a small-scale improvement idea that doesn't change a present layout as much as possible. The second improvement idea is a large-scale improvement idea that values the improvement of the work movement line.

5.1.1. Small-scale improvement plan

This improvement plan is the layout without changing the current state as much as possible, and aiming at the improvement of the work performance. Figure 5 shows this small-scale improvement plan. The point of this layout plan is two, change in position of Cooking place, and change in the direction of Auto packer. Sideways displaying the Cooking place is expected the simplification of the access to the salt water processing machine and securing work space. The change in the direction of Auto packer is expected to change the position and the flow of the carts those are the obstacle of the passage.

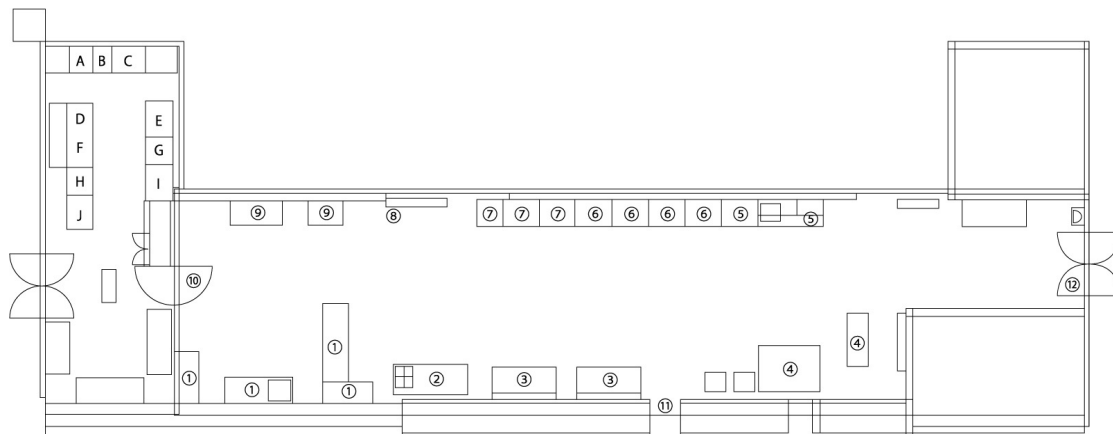


Figure.5 Layout of small-scale improvement plan

5.1.2. Large-scale improvement plan

This improvement plan is a layout idea that values the improvement of the problem extracted from the investigation. Figure 6 shows this large-scale improvement plan. The point of this layout plan is a decrease in moved distance by the segmentalization of the work place. Salt water processing machine – worktable – Auto packer was considered to be a big work flow, and the worktable which became the center of work was arranged at the center of the workshop. The worktable is set up face to face expects the work flow can be divided into two, and the employee's intersection can be expected to be reduced. About salt water processing machine and Cooking place, In arranging it in the top and bottom of the workshop aimed at the work performance of Work place 1 and 2 were made to become to the same. Moreover, the sashimi production place with a little movement was moved to the next sushi manufacturing place. The change in the direction of Auto Packer is similar to the small-scale improvement plan.

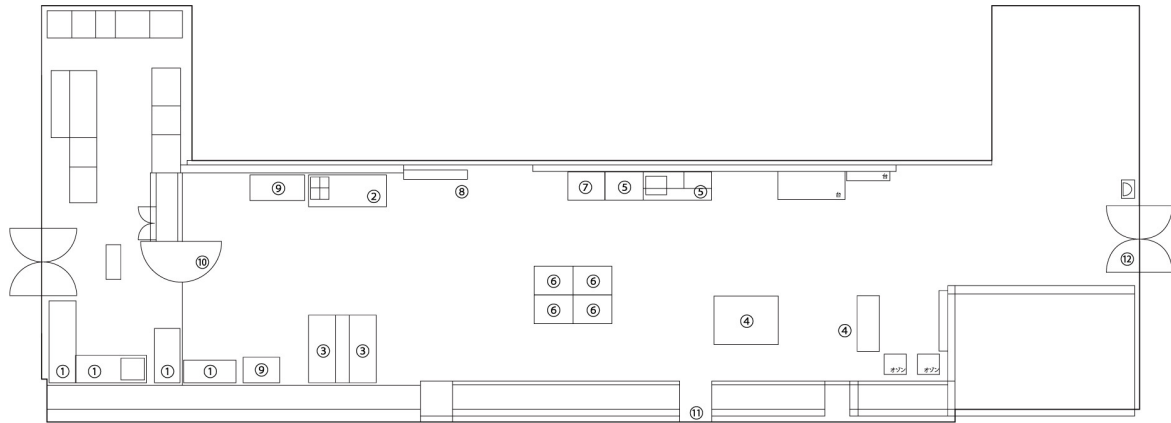


Figure.6 Layout of large-scale improvement plan

5.2. Decision of the design plan

Meeting was held with the supermarket employees based on the above-mentioned layout improvement plan. As a result of discussion, the small-scale improvement idea was decided to improve.

B. Evaluation

For the evaluation of the improvement activity, backyard after layout improvement plan had been executed was investigated.

6. Methods

As well as the time of the grasp of the situation investigation, the observational research used fixed point cameras and handy cameras for a supermarket backyard. Enforcement times were January 29, 2009 and January 30, 2009. The investigation was done two weeks after the improvement so that the employee might become accustomed to work by the improvement layout. Time zone was in the morning (From 5:30 to 10:00. This time zone is the busiest, and most important in the work of a supermarket backyard.

7. Results

Because a lot of employees were working at the same time, the link analysis by the unit of work was difficult. Therefore each employee's link table and link figure were created, and calculated the average movement number of times of one employee per one hour by dividing those sums by the number of people. As the link analysis result of all employees, link table is shown in Table 4, link figure is shown in Figure 7.

Then, the result of observational research is explained. The section which had most traffic was 4-6, and it was 7.79 times per hour. Secondly was 4-5, and it was 5.43 times per hour. Successively, 2-3 was 4.18 times, 5-6 was 3.86 times.

Compared with investigating the current state, the movement frequency between Auto packer and Worktable was increased. Moreover, the moved distance between Auto packer and Doorway of counter was shortened, and wasn't intersect with other traffic lines. In addition, the movement of the side of the worktable was decreased.

Table 4 Link table in a layout after improvement

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	0.43	0.11	0.21	0.32	0.29	0.25	0.46	2.07	0.00	0.04	0.00
2	-	-	4.18	0.29	0.89	2.43	2.89	0.86	3.61	0.11	0.04	0.00
3	-	-	-	0.86	1.86	2.79	1.64	1.71	0.89	0.11	0.11	0.00
4	-	-	-	-	5.43	7.79	2.68	0.18	0.25	0.25	1.50	0.00
5	-	-	-	-	-	3.86	0.71	0.21	0.14	0.11	0.07	0.11
6	-	-	-	-	-	-	2.64	0.14	0.46	0.11	0.11	0.04
7	-	-	-	-	-	-	-	0.61	0.68	0.07	0.04	0.00
8	-	-	-	-	-	-	-	-	0.36	0.04	0.11	0.00
9	-	-	-	-	-	-	-	-	-	0.43	0.00	0.00
10	-	-	-	-	-	-	-	-	-	-	0.04	0.00
11	-	-	-	-	-	-	-	-	-	-	-	0.00
12	-	-	-	-	-	-	-	-	-	-	-	-

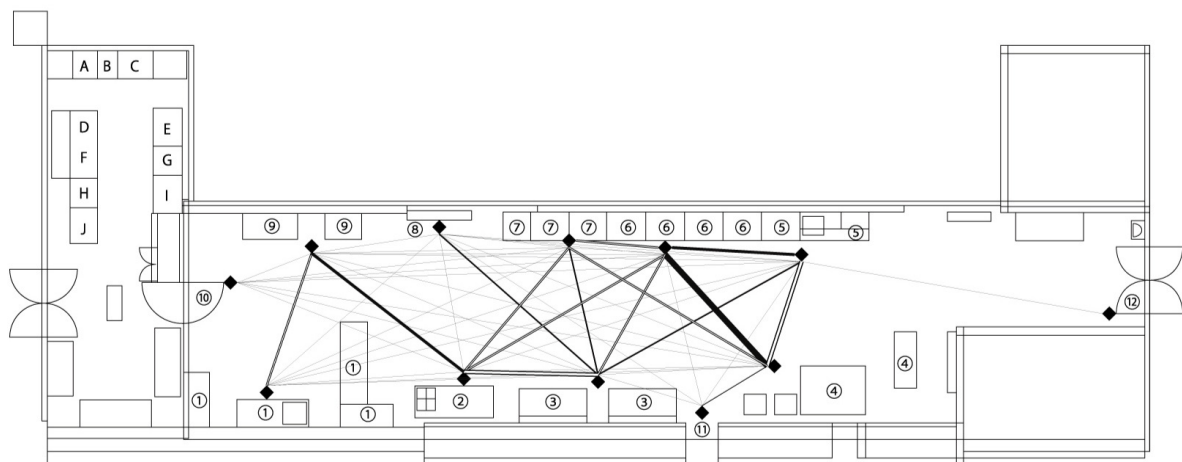


Figure 7 Link figure in a layout after improvement

8. Test

Significance test about before and after results of link analysis was investigated to understand what difference between layout before the improvement and layout after the improvement.

8.1. Methods

The difference that layout before the improvement and layout after the improvement about average movement frequency for each unit in the entire work place of one person and movement frequency between each work place for each unit was tested. Normality was not able to be confirmed by significant difference test of average for each unit in each work place movement frequency. In addition, because there is correspondence between before and after the improvement each work place, Wilcoxon signed-rank test was tested. Normality was not able to be confirmed by movement frequency between each work place for each unit. In addition, because it was independent data, Mann-Whitney U test was tested. Wilcoxon signed-rank test and Mann-Whitney U test were judged by using p-value. Notation of level of significance is shown in Table 5.

Table 5. Notation of the level of significance

level of significance	notation
$P < 0.10$	+
$P < 0.05$	*
$P < 0.01$	**

8.2. Results

In the result of Wilcoxon signed-rank test about average movement frequency of one person an hour, significant difference and tendency of significant were not seen before and after the improvement.

The result of Mann-Whitney U test to the number of times of movement between each place per hour, significant difference was seen in the section shown in the following Table 6, and tendency of significant was seen in the section shown in the following Table 7. The section between the neighborhood of Sashimi production place and Doorway of Sushi production place, and the section between the neighborhood of Cooking place and the neighborhood of Auto packer, those section were seen a significant difference (1 % level of significance).

The section where frequency increased after improvement was Salt water processing machine and a Worktable. On the other hand, the movement frequency in other sections where significant difference was seen decreased after improvement.

Table 6. Section that significant difference was seen

Section	level of significance	decision
1--8	$P < 0.05$	*
1--10	$P < 0.01$	**
1--12	$P < 0.05$	*
3--4	$P < 0.01$	**
4--12	$P < 0.05$	*
6--12	$P < 0.05$	*

Table 7. Section that tendency of significant was seen

Section	level of significance	decision
2--6	$P < 0.10$	+
7--12	$P < 0.10$	+

9. Discussion

The evaluation of the layout idea by the observational research, the link analysis, and the significant difference is described as follows.

At first, the movement frequency of Auto packer and the worktable was increased. It is thought that increase of the number of the trays carried to the Auto packer, and productivity improved. On the other hand, the movement frequency in other sections where significant difference was seen decreased after improvement. It is thought that the intersection frequency in a narrow passage where became a problem at the time of investigation decreases.

Furthermore, about movement Doorway of counter from an Auto packer, moved distance was shortened, and the intersection of the traffic line was not seen. For such reasons, it is thought that shelf stacking became smooth.

Moreover, the movement space was able to be secured, because Cooking place was sideways displayed. As a result, a cart came to be located between Cooking place and Worktable, and transfer of the fish mediated carts. For such reasons, it is possible to move the fish efficiently.

As a general tendency, the section where the movement frequency had been a little was decreased the movement frequency after improvement.

10. Summary

Using link analysis, layout of a supermarket back yard was improved. First, the supermarket was observed with fixed point camera for link analysis. The results of investigation of link analysis were seen, a lot of times of intersection at narrow passage, the workplaces had been overcrowded, and work spaces were insufficient. Discussion with employees worked supermarket, and decision executed layout plan. After improvement, observational research was carried out again. Moreover, the test of significance about the link-analysis result before and after improvement was performed. As the result, a significant tendency was able to be seen the difference before and after improvement. Thereby, the improvement of the layout of decrease of useless movement and smooth work was achieved.

11. Acknowledgements

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12. Examples Citations

[1] Neville A. and Mark S. young , (1999) *A guide to methodology in ergonomics*, Taylor & Francis, 11 New Fetter Lane, London.