Improvement of storage system upright piano cabinet using class based storage

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Abstract. The objective of this research is to reduce the process distance on storage and retrieval (S/R) by suggesting storage system of piano’s cabinets (piano’s parts) on the certain storage shelf. The object of the research is department of setting cabinet that obligated to bridge and organize cabinet’s supply from department of painting to department of assembly. Based on the planning and actual delivery of piano cabinets to department of assembly, it is found that only 33,3% deliveries were accomplished as recorded by data on April 2018. One of the causes is internal handling problem at the department of cabinet setting that takes longer time due to unorganized cabinet storage. After all data of “in-out stock” are resumed, later it will be processed by employing class-based storage method for material’s grouping. The data indicated that cabinet with material class A is dominated by top 4 requested models of piano and the comparison between initial storage system layout and the proposed one shows the difference on total distance of retrieval activities for 210 kilometers during 5 months of working. It could be concluded that the purpose of storage system could reduce the retrieval distance by 68%.

1. Introduction
PT. XYZ is one of the big companies in Indonesia that has established almost 40 years. PT. XYZ produces 2 classic pianos, which are upright piano (UP) and grand piano (GP) that marketed internationally. The international market company should maintain its high standard in production process, started from standard of quality, cost and the speed of production flow as well as its deliverance.

The problem that emerged in this research is the product’s flow of a department that considered as warehouse in PT. XYZ and functioned as temporary place (terminal) for cabinets (often called as piano’s parts) that have produced by other departments to be later distributed to department of assembly for assembling process. Warehouse of PT. XYZ is named as department of cabinet setting since it is designated to set the incoming piano’s cabinets.

Based on Table 1, it can be notified that the everyday data of delivery on April 2018 was not accomplished as daily plan. It shows that the target only reached 10 out of 40 or only fulfil 33,3% from total delivery planning.

According to field experts, in this case vice chairman of the group and foreman, there are two problems that interrupted the deliverance, which are: supply from previous department and handling of piano’s cabinet that emerged as internal problem. The experts assumed that supply problem is considered as complicated and complex, hence, it requires access to all departments for managing that. While for internal problem, which is handling, is recommended by the experts for further research. This issue is emerged by the unorganized cabinets of UP in department of setting. So, it takes extra time for operators to put the cabinets on the storage shelves as well as retrieve the cabinets to be filled in special
pushing shelf to department of assembly. Furthermore, longer search for cabinet location was generally occurred due to uncertain location. These issues should be minimized.

Table 1. Data plan and actual on case and side orders

| Date   | Case Plan | Case Actual | Side Plan | Side Actual | Target Unit Set Case | Target Unit Set Side |
|--------|-----------|-------------|-----------|-------------|----------------------|----------------------|
| 02-Apr-18 | 83        | 70          | 44        | 44          | Not Achieved         | Achieved             |
| 03-Apr-18 | 77        | 78          | 84        | 84          | Achieved             | Achieved             |
| 04-Apr-18 | 86        | 81          | 81        | 81          | Not Achieved         | Achieved             |
| 05-Apr-18 | 92        | 87          | 94        | 91          | Not Achieved         | Not Achieved         |
| 06-Apr-18 | 82        | 88          | 93        | 97          | Achieved             | Achieved             |
| 09-Apr-18 | 93        | 89          | 85        | 75          | Not Achieved         | Not Achieved         |
| 10-Apr-18 | 82        | 85          | 113       | 110         | Achieved             | Not Achieved         |
| 11-Apr-18 | 84        | 73          | 107       | 103         | Not Achieved         | Not Achieved         |
| 12-Apr-18 | 83        | 76          | 96        | 83          | Not Achieved         | Not Achieved         |
| 13-Apr-18 | 83        | 65          | 93        | 67          | Not Achieved         | Not Achieved         |
| 16-Apr-18 | 82        | 71          | 97        | 95          | Not Achieved         | Not Achieved         |
| 17-Apr-18 | 86        | 61          | 98        | 92          | Not Achieved         | Not Achieved         |
| 18-Apr-18 | 96        | 85          | 117       | 92          | Not Achieved         | Not Achieved         |
| 19-Apr-18 | 96        | 66          | 101       | 88          | Not Achieved         | Not Achieved         |
| 20-Apr-18 | 85        | 57          | 93        | 90          | Not Achieved         | Not Achieved         |
| 24-Apr-18 | 110       | 67          | 89        | 89          | Not Achieved         | Achieved             |
| 25-Apr-18 | 94        | 54          | 87        | 87          | Not Achieved         | Achieved             |
| 26-Apr-18 | 92        | 58          | 93        | 83          | Not Achieved         | Not Achieved         |
| 27-Apr-18 | 94        | 71          | 85        | 74          | Not Achieved         | Not Achieved         |
| 30-Apr-18 | 47        | 19          | 71        | 71          | Not Achieved         | Achieved             |

There are many references and previous researches regarding to class-based storage. A research by reference [1] defined the function of class-based storage to divide products to several classes, in which each class is situated at the certain area in the warehouse. This method is suitable for warehouse with flexibility and high storage activities. Other researcher, reference [2] argued that class-based storage could improve the accuracy in retrieval process and reduce the time wasted during that process. Besides, reference [3] have proven that class-based storage could enhance the speed accessibility on product’s movement conducted by operators.

Previous research as studied by reference [4] performed the observation on the best shelf for storing the shuttle and retrieval system by using class-based storage method. Shuttle Based Storage and Retrieval System was the latest technology on automatic system in terms of storing and retrieval, which was employed in the warehouse with high transaction, yet the crane could not possible to achieve the speed standards in reaching designated shelf. Warehouse utilisation assessment is also applied in this research as well as modelled it to identify initial assessment. After the implementation of class-based storage method, it showed that the warehouse with high transaction was the suitable one for the method. Therefore, the storage warehouse required lesser lifting activities (lifts) and less investment.

Reference [5] discussed about the productivity improvement on products’ order with manual retrieval and multi-level shelves. Storage warehouse with thousands of items will surely face difficult problems especially with the addition of new warehouse facilities, designated to stock numbers of items and materials. It leads to factors that should be considered such as the retrieval process, warehouse’s
dimension, material deliverance system, demands’ trend, product characteristics and others. It was also discussed that the utilization of class-based storage method is a possible solution for existing warehouse’s issues with distance and time as assessment’s measurement. The result of research was effective implementation on storage system as stated above by adjusting certain storage system type to order variation from consumers. In this case, it could be stated as the implementation of class-based storage method.

Other things that related to warehouse problems were studied by reference [6] by conducting layout optimisation of three-dimensional order picking warehouse. In this research, it was explained that the layout in warehouse is highly related to important aspects as material handling, cost for warehouse and storage capacity. Therefore, algorithm was established to determine lane depth, numbers of storage level, lateral depth and dimension of warehouse. It was designated to minimize the material handling cost and minimize the space. In establishing the algorithm, several parameters are applied to help designers in designing the warehouse, so it will not be fixed to certain values as well as assist the manager in decision making.

2. Research methodology
This research was conducted from March 2018 in PT. XYZ by performing observation at department of setting cabinet for existing activities. Beside observation, interview was also carried out to related parties, in this case vice chairman of field group and foreman. Primary and secondary data are also required to support the research. Primary data cover the layout condition at department of setting cabinet, which are overall dimension, space area of each part and the order of cabinet storage. While, secondary data include company’s data, which is In Out Stock activity data at this department. Those data are required to propose better cabinet storage system.

This research is initiated with problem identification at the department of setting cabinet that supported by literature studies. Hence, the problems could be well-maintained. The identification of problems that arose could be overcome by performing observation on existing system in this department. So, the requirement of system could be identified. Later, better cabinet storage system could be proposed, crucial actions could be retained to improve system, etc.

Next process is data collecting, for both primary and secondary data. Direct field observation was taken as primary data, such as interview with experts to reinforce data obtained, as well as field data collection about initial layout at department of setting cabinet, such as area coverage, storage area, distance among existing parts and the order of cabinet storage on the cabinet’s storage. After all information are obtained, data of operator’s step direction in retrieval process for the cabinet of certain piano’s model are also be gathered to be later converted in distance unit (meter). While, the secondary data will be In Out Stock activity data of the existing cabinets to identify the movement of the cabinets.

From all obtained data, data processing with class-based storage is conducted, by clustering the materials in warehouse by considering their certain similar characteristics, such as similarity in types, size or preferences of consumers. Later, data derived from In Out Stock activity will be organized from the cabinets that have the highest activity to the lowest, respectively. Next, the cabinets are classified into three groups, which are: class A, designated for materials/piano’s cabinets which has the highest activity, followed by class B and C.

The grouping of class materials/UP Piano’s cabinets at the department of setting cabinet that already gathered is proposed for the new layout system of cabinet storage in order to optimize handling activities. System of cabinet placement on the shelf is based on the earliest formed groups, class A is in line with point I/O or the exit point of piano’s cabinets, followed by cabinet on class B and class C, respectively. Two layouts of cabinet storage system before and after definitely have differences and comparable.
3. Results and discussion
After the process of observation and data collecting, several information is obtained to propose the storage system on piano’s cabinet, hence the handling activities at the department of setting cabinet could run well. Following are the results and discussions.

3.1. Department of setting cabinet
Department of setting cabinet is the key department in regulating previous department, which is department of buffing. Later on, existing cabinets will be organized to intended models to be assembled in department of assembly. The system is started from department of supply, department of buffing that including small buffing (for small size cabinets) and panel buffing (for larger cabinets). Those cabinets will previously be processed by quality control (QC). Later, the cabinets need painting process, which includes unstain painting, emulsion for PE (Black) cabinet, PM (Red) and PW (Wood-textured), as well as matte and glossy white for PWH (white). Besides, before conducting setting process and cabinet organizing to certain model, drilling process is inserted that designated especially for fall back cabinet, while screen logo process is carried out for fall center cabinet.

After all cabinet being painted, the finished cabinets are directly stored as one in the shelf-set as as proposed by the model (Fig. 1). While the other cabinets that unfitted to shelf-set due to excessive number will be stored in the storage shelf (Fig. 2).

From the intended system, apparently the cabinets that entering department of setting cabinet will skip the process storage process on the storage shelf for excessive cabinets since they are considered as waste that should be reworking, the shelf-set is sent to Assembly division. The intended system suggests the cabinets to be stuffed in the shelf-set and directly sent to Assembly division. Yet, previous production lines, such as buffing, sanding after spraying, basic sanding and wood works experiencing several issues that will cause uncertainty and unsynchronized number of cabinets inputted to department of setting cabinet with the request from Assembly division. It causes pile of unready cabinets that being stored in the storage shelf.

![Figure 1. Modeled shelf-set of piano](image1.jpg)

![Figure 2. Storage shelf for excessive cabinet for panel and small cabinet](image2.jpg)

![Figure 3. Storage shelf for excessive small cabinets](image3.jpg)
3.2. Cabinet storage layout (Initial)

From the layout of initial storage (Fig. 4), it could be seen that the cabinet placement is still based on the type of cabinets instead of piano’s model. Hence, to reach cabinets designated for piano model B, it needs the retrieval process to several storage shelves. Then, to identify the initial distance condition of retrieval for piano’s cabinets, 4 types of pianos are taken, in which B1 PE, B2 PE, B3 PE and U1J PE. Those types are mostly produced. Following is the distance calculation based on steps of operator and later will be converted to meter unit.

![Figure 4. Layout setting cabinet for retrieval distance piano model B1 PE](image)

**Description:**
- = Area Setting Cabinet
- = Not Area Setting Cabinet

| Table 2. Retrieval distance of piano cabinets B1 PE |
|----------------------------------------------|
| Model         | Cabinet                        | Distance (cm) |
|----------------|--------------------------------|----------------|
| B1 PE          | Fall Back, Hinge Strip          | 484.4          |
| B1 PE          | Fall Center                     | 557.5          |
| B1 PE          | Key Block                       | 170            |
| B1 PE          | Side Arm R/L                    | 225.1          |
| B1 PE          | Bottom Frame, Rail Pedal, Fall Front | 590.7     |
|                | Return to I/O Point             | 1568.8         |
| **Total**      |                                | **3596.5**     |

Later, above data could be used to calculate 3 other models, which are model B2, B3, dan U1J. After retrieval distance for 4 models of piano is obtained, the total distance will be multiplied with production
demand of designated piano model, or in PT. XYZ it is called as Plan Scheduling Index (PSI), for 5 months demand from January 2018 to May 2018. It is calculated to recognize the total distance conducted by operators to prepare cabinets of piano to shelf-set. It is necessary to figure out the total retrieval distance, in this case by excluding numbers of In Out activities frequency, but instead by employing PSI or piano’s demands for 5 recorded months. It is determined by considering the difference of In Out activities frequency for each model, due to uncertain inputted cabinets to department of setting cabinet. Hence, PSI is functioned better as multiplier of retrieval distance to compare initial storage system layout with the proposed one. Following is the total retrieval distance for 4 models of piano.

Table 3. Retrieval distance of piano’s upright cabinet (initial)

| Model | Distance (cm) | PSI Piano 5 months (January - May 2018) | Total Distance (cm) | Total Distance (m) |
|-------|---------------|----------------------------------------|---------------------|-------------------|
| B1 PE | 3596,5        | 3696                                   | 13292664            | 132927            |
| B2 PE | 4113,8        | 1906                                   | 7840903             | 78409             |
| B3 PE | 4056,3        | 1323                                   | 5366485             | 53665             |
| U1J PE| 4056,3        | 1209                                   | 4904067             | 49041             |
| Total |               |                                        | 314041              |                   |

From above 4 models, it could be notified that total distance of cabinet is 314041 meters or 314 km for 5 months. It considered as too much for retrieval activity.

3.3. In out stock data at the department of setting cabinet.

In determining classes for existing cabinets at this department as well as to organize the cabinets on the storage shelves, it takes In Out data for cabinets or Storage and Retrieval (S/R) at the existing stock condition. The data were taken from January 2018 to May 2018. Following are the data of In, Out and Stock at the department of setting cabinet.

Table 4. Data of in out frequency on piano’s upright cabinet

| Month | Total and Frequency | Model | Cabinet  | Total Frequency | Average of Frequency | Average of Stock |
|-------|---------------------|-------|----------|-----------------|----------------------|------------------|
| B1 PE |                     | KEY BLOCK | 334      | 67              | 56                   |
| B1 PE |                     | FALL BACK | 314      | 63              | 58                   |
| B1 PE |                     | S.ARM R  | 314      | 63              | 13                   |
| B1 PE |                     | HINGE STRIP | 314  | 63              | 45                   |
| B1 PE |                     | S.ARM L  | 314      | 63              | 13                   |
| B1 PE |                     | BOTOM | 313      | 63              | 7                    |
| B1 PE |                     | P.RAIL | 313      | 63              | 7                    |
| B1 PE |                     | FALL FRONT | 310  | 62              | 6                    |
| B1 PE |                     | F.CENTER | 302 | 60              | 1                    |

Above data is presumed as entire data that show incoming and outgoing piano’s cabinet at the Department Setting Cabinet and will be added on the column of 5 months total frequency. Data on the Table 4 has already organized started from the cabinet that has the highest In and Out activity to the lowest.
3.4. Class grouping.

Piano’s cabinet levelling on Table 4 could be classified into 3 classes, which are Class A, B and C. In which Class A is dominated by 84% of all in out frequency, while Class B takes 11% of In Out frequency and Class C is left with 5% from all In Out activities. Below is the classification of cabinet’s in-out activities.

| Model | Cabinet         | Total Frequency | Percentage of Utilization (%) | Total Percentage of Utilization (%) | Total Item (%) | Class |
|-------|----------------|----------------|------------------------------|-----------------------------------|----------------|-------|
| B1 PE | KEY BLOCK      | 334            | 2,92%                        | 84%                               | 42%            | A     |
| B1 PE | FALL BACK      | 314            | 2,75%                        |                                    |                | A     |
| B1 PE | S.ARM R        | 314            | 2,75%                        |                                    |                | A     |
| B1 PE | HINGE STRIP    | 314            | 2,75%                        |                                    |                | A     |
| B1 PE | S.ARM L        | 314            | 2,75%                        |                                    |                | A     |
| B1 PE | BOTOM          | 313            | 2,74%                        |                                    |                | A     |
| B1 PE | P.RAIL         | 313            | 2,74%                        |                                    |                | A     |
| B1 PE | FALL FRONT     | 310            | 2,71%                        |                                    |                | A     |
| B1 PE | F.CENTER       | 302            | 2,64%                        |                                    |                | A     |

Above data is presumed as entire data. It indicates that Class A is filled with 4 models of piano, which are B1, B2, B3, and U1J, in which the production and the demands for those models are quite a lot. Hence, to identify frequency percentage of In Out activity and numbers of material/cabinet of each class, it could be seen from Table 6 below:

| Class  | Numbers of Cabinets’ Types | Total Percentage of Utilization (%) | Percentage of Numbers of Items (%) |
|--------|-----------------------------|-------------------------------------|-----------------------------------|
| Class A| 59                          | 84%                                 | 42%                               |
| Class B| 33                          | 11%                                 | 24%                               |
| Class C| 47                          | 5%                                  | 34%                               |
| Total  | 139                         | 100%                                | 100%                              |

3.5. Cabinet storage layout (Proposed).

After grouping the piano’s cabinets into three classes, later it could be proposed the layout system of piano’s cabinet storage that supported by the proposed design of cabinets’ storage shelf. Later, it could be employed based on classes’ classification. Below is the proposed design of cabinets’ storage shelf, as shown by Fig. 5.

![Proposed cabinets’ shelf](image)
The shelf is the combination of storage shelf designated for small cabinets (made from woods and located at the upper position) with the storage shelf by bigger size as generally called as panel cabinets (made from iron and located at the lower position). This shelf could help in placing the cabinets in accordance with the class grouping.

The proposed layout system of cabinet storage could identify the steps of operator that later will be converted in meters. Next it will be calculated with production demand (PSI) for 5 months (January to May 2018). The calculation is made to identify the distance of operators for the recorded 5 months. Below is the proposed layout for storage system of cabinets.

![Proposed layout of cabinet setting retrieval distance for piano model B1 PE](image)

**Figure 6.** Proposed layout of cabinet setting retrieval distance for piano model B1 PE

| Model | Cabinet                                                                 | Distance (cm) |
|-------|-------------------------------------------------------------------------|---------------|
| B1 PE | Fall Back, Hinge Strip, Key Block, Side Arm R/L, Bottom Frame, Pedal rail, Fall Front | 399,2         |
| B1 PE | Fall Center                                                             | 557,6         |
|       | Return to I/O Point                                                     | 716,4         |
|       | **Total**                                                               | **1673,2**    |

**Table 7.** Proposed retrieval distance for piano’s cabinets B1 PE
Table 8. Retrieval distance on piano’s cabinets upright (proposed)

| Model   | Distance (cm) | PSI Piano 5 Months (January - May 2018) | Total Distance (cm) | Total Distance (m) |
|---------|---------------|----------------------------------------|---------------------|--------------------|
| B1 PE   | 1673.2        | 3696                                   | 6184147             | 61841              |
| B2 PE   | 798.4         | 1906                                   | 1521750             | 15218              |
| B3 PE   | 798.4         | 1323                                   | 1056283             | 10563              |
| U1J PE  | 1290.9        | 1209                                   | 1560698             | 15607              |
| Total   |               |                                        | 103229              |                    |

From 4 mentioned models, it can be concluded that the total distance of cabinets’ retrieval is 103229 meters or equal to 103 km for 5 months activities. The difference of this condition, if compared with initial layout system is quite high.

3.6. The comparison of layout system of initial cabinets’ storage with the proposed one.

After conducting data collection on the initial condition of layout system, it can be notified the placement of cabinets on the storage shelf. Later the distance that should be performed by the operators in conducting the retrieval can be identified, so as the proposed layout that has established based on In Out Stock activity at the department of setting cabinet. Following is the comparison between initial layout condition with the proposed one.

Table 9. Initial layout comparison with the proposed one

|                          | Initial Layout | Proposed Layout |
|--------------------------|----------------|-----------------|
| Numbers of Retrieval on Piano’s Cabinets (m) | 314041 | 103229 |

It can be seen clearly that the retrieval distance on the storage shelf for initial layout condition shows overall distance of 314,041 meters or almost equal to 314 km, while on the proposed layout, the distance covers 103,229 meters or almost equal to 103 km. Hence, the difference of two layouts is 210.812 or almost equal to 210 km. In percentage, it can be said that the reduce of retrieval distance reaches 68%. The difference is quite big considering the calculation that designated for 5 months. The results may higher if it applies for one-year period (12 months). It can be resumed that the proposed layout is able to reduce retrieval distance, so it is expected to be able to improve and optimize the warehouse activities at the department of setting cabinet.

4. Conclusion and suggestion

Based on the result of the research, it could be concluded that the storage system of cabinets for piano UP (Upright) at the department of setting cabinet could be performed by classifying the cabinets that previously grouped based on types of cabinets’ similarity to be grouped based on piano’s model. The existing grouping will be divided in three classes, which are class A, B and C. It needs to be concerned that Class A is filled with cabinets of piano model B1, B2, B3, and U1J. While, Class B and C are filled with cabinets from other models. Besides, those cabinets are stored on the shelves with proposed design to maintain good storing. The shelf consists of small shelf for small cabinets and main shelf for storing panel’s cabinets, which are placed vertically or horizontally.

Suggestions are advised for further research to perform wider research that could reach other aspects that possible for a research, such as studying the problems on uncertain cabinets supplies, complete layout problem at department of setting cabinet, considering other factors that influence handling duration in the process of storage and retrieval (S/R), and others.
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