New Approach to Improving Site Operations of Distribution Centers with IoT Technology

● Kazuki Fujita

Yamato Logistics Co., Ltd. operates many distribution centers as a logistics partner of various companies. Those companies include Fujitsu's customers, where improvement activities for various site operations have been carried out to flexibly accommodate increases in the volume of items handled and new logistics processing operations necessitated by the addition of new products and volume variations between busy and slack seasons. Anticipating future business expansion of partner companies, Yamato Logistics has been looking for a way to improve site operations and achieve greater efficiency and accuracy. To this end, Fujitsu worked with Yamato Logistics to devise a new approach to improving site operations that would solve the problems inherent to the existing approach. A major measure was the visualization of site operations through IoT technology to convert operations into quantitative data. Further, the conditions of a superior distribution center were visualized to establish the ideal form of distribution centers. This has made it possible to accurately grasp the problems at operating distribution centers and predict the degree of improvement possible. This paper describes the approach to improving site operations at distribution centers devised by Fujitsu.

1. Introduction

Logistics channels form networks that extend over the whole of Japan much like a vascular system. The logistics industry, which sustains Japan with the distribution of parcels (the "blood" coursing through the channels), has been supporting the Japanese economy for a long time, but the industry is now reaching a turning point. Until now, the focus was on improving services, resulting in advances such as delivery time specification and same-day delivery, but improvements of this kind are reaching their limits as Japan's labor shortage grows more acute, forcing logistics companies in 2017 to make changes in the level of services that they can offer and raise delivery charges to put brakes on the number of parcels handled.

E-commerce, a major driver of logistics demand, has been recording average annual sales growth of around 7% per year.[1] As a result, the number of parcels handled by courier services has been increasing year after year, reaching 3.7 billion pieces in FY2015.[2]

This increase in the number of parcels is having a major impact on distribution centers, which are the equivalent of the heart that pumps out blood through blood vessels. The distribution centers operated by Yamato Logistics Co., Ltd. are no exception. Faced with an ever rising number of parcels and products, they are being challenged daily to improve site operations.

Yamato Logistics have independently conducted qualitative analysis such as business flow analysis and interviews with workers, and quantitative analysis of the data output from their Warehouse Management System (WMS), in order to improve the site operations of their distribution centers. However, since it is difficult to predict the cost-effectiveness of improvements and it takes a considerable amount of time to perform analyses, they were seeking ways to further accelerate improvement.

In order to solve the problem faced by Yamato Logistics, Fujitsu focused on the distribution center sites, devising a new approach to improving site operations by visualizing site operations through the use of IoT technology.

This paper describes the operations performed by distribution centers, the mechanisms behind the occurrence of problems, the conventional approach to improving site operations, a new approach to improving site operations as an example of knowledge integration, and future tasks.

2. Operations of distribution centers

The operations performed by distribution centers vary depending on the industry and the type of parcels handled. At the Yamato Logistics-operated distribution centers covered in this paper, the following operations are carried out (**Figure 1**).

1) Receiving inspection

After the parcels are brought in by trucks or the like and they are unloaded, verification is performed to check that the contents match the contents listed on the bill of parcels.

2) Shelving

Following the receiving inspection, the items are carried by forklift or the like to the specified storage shelves.

3) Replenishment

Items stored on storage shelves are transferred to picking shelves. There are two main types of replenishment. One type is regular replenishment, which consists in placing a predetermined quantity of items for each parcel before picking begins, and the other type is emergency replenishment, which consists in performing replenishment only when the number of items on the shelves has decreased to a certain level.

4) Picking

Based on the shipping instructions, a container is automatically carried by belt conveyor to the work table (picking station) for the picking shelf that contains the items to be shipped. A worker removes the specified quantity of items from the designated picking shelf and places them in the container. Once all the items to be picked at the station have been placed in the container, the worker sends out the container from the station to the belt conveyor. The container moves to the respective stations until filling of the order in the shipping instructions is completed, upon which the container is transferred to the shipping inspection area.

5) Shipping inspection

The items are removed from the filled container brought in by the belt conveyor, and whether the item types and quantities match the shipping instructions is verified. Upon completion of the shipping inspection, the items are placed back in the container, which is returned to the belt conveyor.

6) Packing

The items are then removed from the container and placed in a packing box for shipping. Once all the items have been packed, the packing box is closed with tape, the shipping label is applied to the box, and the box is placed on a shipping rack.

7) Loading

When the shipping truck arrives, the shipping rack is loaded onto the truck.

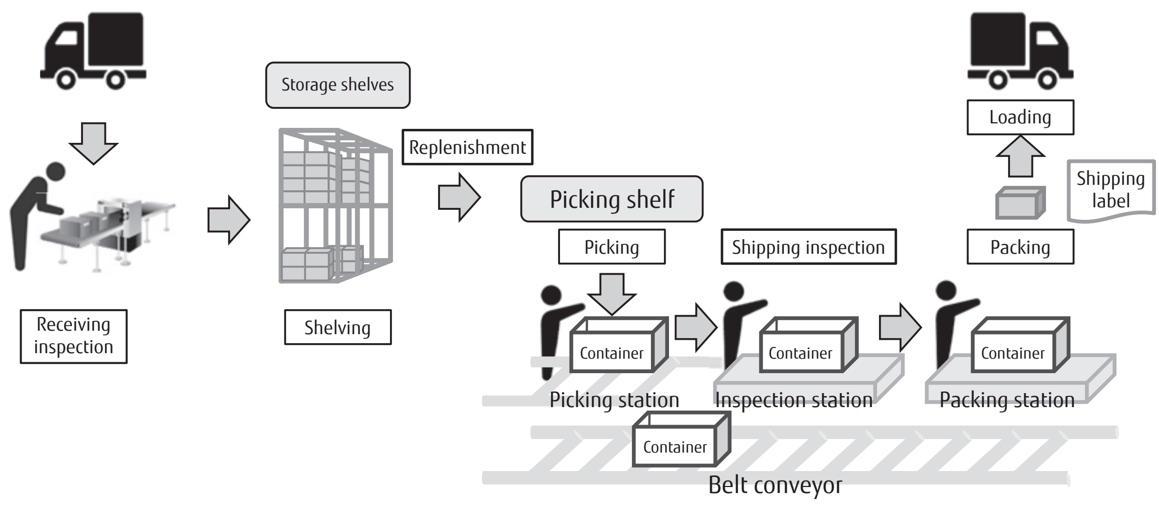

Figure 1
Site operations of distribution centers.

3. Mechanism of problem occurrence at distribution centers

A situation arose at distribution centers operated by Yamato Logistics where the operation time for certain operations deviated from the scheduled operation time when operations were started. As the result of analyses, the problem was found to be caused by a lowering of operational efficiency, as follows.

1) Increase in workload due to strengthening of misdelivery prevention check

Misdelivery means the delivery of wrong parcels to end users. The following are examples of misdelivery.

- The delivery destination is correct, but the delivered parcel is incorrect. This occurs when picking is done incorrectly and this is not detected by the shipping inspection.
- The delivery destination itself is incorrect. This is due to incorrect label application after packing.

To prevent misdelivery, double checks are carried out during inspection and packing operations, but this causes increased workload.

2) Increase in workload due to shipping inspection error

The following are two cases that result in error detection during shipping inspection. Both are caused by incorrect picking.

- One case is that of items not included in the shipping instructions getting mixed in, or the quantity of picked items exceeding that stated in the shipping instructions. In this case, a shipping inspection must be carried out again after removal of the excess items, and the excess items must be returned to their original shelves, causing additional work.
- The other case is that of a lesser quantity of items than that stated in the shipping instructions being picked. In this case, since the shipping inspection cannot be completed, the missing items must be picked, causing extra work.

3) Increase in operation time due to stoppage of containers

Containers are automatically transported to stations by the belt conveyor, but if the following problems arise, subsequent containers stop moving along and stoppage occurs. As a result, waiting time for operations increases, causing a decrease in work efficiency.

- A buildup of containers occurs at a specific station.
- Picking takes time
- Emergency replenishment has not been completed and as a result picking cannot be done.

4. Conventional site operations improvement approach and challenges

The conventional site operations improvement approach to solving problems consists in identifying problems by the following methods.

1) Workflow analysis

As described in previous sections, the various operations are interrelated in a complex manner. Workflow analysis is a method to identify these interrelations, reorganizing workflows based on consideration of time sequences, and clarifying where problems actually stem from.

However, in this approach, the quantitative data required for analysis often cannot be acquired, which means that the findings tend to be of a qualitative nature. This makes it difficult to quantitatively assess the appropriateness of improvement measures and their effectiveness.

2) Interviews with workers

Workers in the workplace often experience situations that are easy for managers to miss. Therefore, by interviewing workers, it is possible to identify the following kinds of small problems.

- The picking shelves are too high, making it difficult to take items down.
- During packing, the advertisement leaflets to be included in the box are in a pile, making it difficult to take the required number of sheets.

Until now, the evaluation of such problems was based on qualitative interviews, but analytical methods based on quantitative criteria are separately required to quantitatively evaluate the influence of problems and the effect of improvements.

3) WMS output analysis

This approach consists in using the data output by the WMS to identify problems, allowing quantitative analysis. An example is the analysis of items that are shipped frequently and reconsideration of the way items are arranged on picking shelves.

However, the data output from the WMS often consists of information at the end of the workday, such as daily work reports, making it difficult to determine intra-day fluctuations and biases. Further, because the WMS cannot acquire on-site data such as waiting time of work processes, walking time of workers, and operation times, the investigation of the root cause(s) takes a long time.

Although Yamato Logistics themselves tried out various things, carrying out analyses using complementary data to rectify the above-noted issues, they still were searching for a decisive solution.

5. New site operations improvement approach

In the conventional site operations improvement approach, the lack of quantitative data is a problem, but this can be solved by means of the extension of the conventional system (by increasing the number of measurement points), and the addition of measuring tasks (whereby the workers themselves measure operation times). However, in situations where predicting improvement effects is difficult, it is not easy to calculate the cost effectiveness of quantitative data acquisition, and Yamato Logistics thus was in a predicament.

Fujitsu responded by devising in collaboration with Yamato Logistics a new approach to site operations improvement to acquire quantitative data at low cost and allow highly accurate prediction of the impact of improvements. This method allows prediction of the effect of operational improvements by comparing centers with other, superior, distribution centers. Such comparison is facilitated by the introduction of inexpensive IoT products and the visualization of site operations in an automatic and mechanical manner.

1) Visualization of site operations through the use of IoT technology

While the conventional site operations improvement approach allows the qualitative grasp of existing conditions, the lack of quantitative data in the work processes results in insufficient accuracy and makes it difficult to predict improvement effects. The solution is to use IoT technology to automatically and mechanically acquire quantitative data and visualize site operations.

2) Visualization of a superior distribution center to define the ideal form

Of the various distribution centers operated by Yamato Logistics, the distribution center boasting the highest operation quality and operational efficiency is visualized. That distribution center is defined as the ideal to be striven for in making improvements.

This approach has the following merits.

- It allows the quantitative representation of an ideal that is attainable. For example, instead of using vague expressions such as "shorten the time expended for picking work," a specific numerical value such as "3 seconds per picking item" can be set. Further, this is a realistic value demonstrated to be attainable at the superior distribution center.
- Since it is possible to compare the current state and the ideal with the same granularity and precision, the problem that is being worked on can be grasped quantitatively. Moreover, the improvement effect can be grasped quantitatively in advance. For example, if the existing picking operation takes 5 seconds per picking item, compared with 3 seconds at the ideal distribution center, the improvement effect can be calculated as 2 seconds per picking item.
- Detection of problems that would have gone undetected in the conventional site operations improvement approach can be expected. For example, time-tested operations that have gone on without hitches for a long time would not be examined in the conventional approach. However, quantitative comparison with the ideal can reveal the existence of a higher operating level, opening the way for further improvement.

6. Future tasks

1) Validation of new site operations improvement approach

We are currently working on the visualization of site operations at the distribution centers operated by Yamato Logistics through the use of IoT technology. First, targeting picking operations, which involve the most extreme movements of people and things, we acquired quantitative data using video cameras and video analysis software (**Figure 2**). Going forward, we aim to visualize site operations of distribution centers selected for improvement, and verify the usefulness of the proposed approach to improving site operations.

2) Combination of IoT and WMS

By incorporating into the WMS in-situ quantitative data acquired with IoT technology, we will implement

Figure 2
Video capture for quantitative data acquisition.

new functions such as those described below within the WMS, leading to further improvement of site operations.

- Collect data about picked items and their quantities via sensors for feeding to the WMS, and compare these data with the shipping instructions. Whenever a picking error occurs, raise the alarm on the spot to prevent the occurrence of shipping inspection errors.
- Acquire video data from the video cameras installed at the site and display the operation speed and any container stoppage in real time. Further, use also the shipping instruction information held by the WMS to predict container stoppages and in a timely manner assign workers to locations where stoppages are likely to occur.
- Collect data on the remaining number of items on the picking shelves via sensors to feed to the WMS, and determine the necessity of replenishment. Through the above, prevent delays in picking operations due to insufficient replenishment.

7. Conclusion

This paper provided an example of knowledge integration, describing a new approach developed by Fujitsu in collaboration with Yamato Logistics for improving site operations at distribution centers through the use of IoT technology.

We plan to press forward with Yamato Logistics to improve site operations at distribution centers by promoting visualization of site operations through the new improvement approach described in this paper, with the possible incorporation of AI.

References

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Kazuki Fujita
Fujitsu Ltd.
Mr. Fujita is currently engaged in the development of logistics systems and the proposal of solutions for improving site operations of distribution centers.

