A Method for Problem Identification and Improvement on Information Flow and Physical Distribution -Flow Diagram and Checkpoints for Problem Identification-

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Abstract

This paper investigates a method for analyzing information flow and physical distribution flow among various related sections and organizations. Based on the idea of comparing ideal flow pattern and current flow pattern, the paper presents a procedure for identifying problems and improvement ideas.

The paper first proposes a tool named flow diagram, in order to visually represent flow pattern, whose vertical axis represents time and horizontal axis refers to sections and organizations relevant to information and physical flows. The flow diagram can be categorized into three types; "current level" that represents current flow pattern, "ideal level" that depicts an extremely simplified pattern, and "target level" that corresponds to the practical goal of flow pattern improvement. The paper then discusses causes of gaps between the current level and ideal level, which are categorized into three groups, such as "multi-stage" in which flow passes through multiple sections from start to the end, "inverse flow" in which flow goes backward between two sections, and "diversion-confluence" in which flow is once diverged and then combined later. These causes can be utilized as checkpoints for identifying problems.

In conclusion, the paper presents a procedure for listing problems and improvement ideas using the flow diagram and checkpoints, and provides an actual case of order fulfillment process of generic goods, where an actual pharmaceutical company is analyzed using the procedures discussed in this paper, and improvement ideas are listed and represented on a target level flow diagram.

1. Introduction

Looking at flows of information and goods between sections within a company, we will notice that there are many cases in which delivery lead time is prolonged because of unproductive confirmation and adjustment caused by those intricate and interrupted flows at each section. Take, for instance, the order fulfillment process and the physical distribution operations. We will see that communication and confirmation of information concerning order acceptance - entry and planning - management of physical distribution are taking place in various sections of company. As the number of sections increases, planning and management of information and goods flows become more complex, and this will cause a higher incidence of orders mishandling, delivery mistakes and out-of-stock conditions. As a result, workload is increased unnecessarily and delivery is delayed because of the need to re-do work and deal with the aftermath.

Nowadays innovation of information technology and equipment for physical distribution are rapidly advancing, which accelerates the price reduction of hardware components. Therefore, companies tend to hastily acquire innovations in information systems and distribution facilities without first fixing defective flows of information and goods such as duplications and jamming up. In such cases, management will end up with a heavy financial burden resulting from the technology investment, along with messy maintenance systems and equipment.

For example, an automated warehouse with advanced sorting functions introduced without sufficient improvement of the packing system will only create problems of halted goods flows once any trouble occurs. Recovering from such a blow to the system would require enormous effort. As another example, if an inefficient bill processing system containing a lot of

unneeded information is not streamlined before computerization, the system will end up unnecessarily large, and will require a great deal of logic just to get ready to process unneeded items. In addition, it will create secondary inefficiency and waste, such as requiring manual rework on computer printed bills.

As indicated in these examples, systematization of flows of information and goods without cleaning up inherent inefficiency and waste in existing flows will not really streamline actual operations. At best it will only benefit a few sections with haphazard improvement. Usually essential problems concerning flows of information and goods to be corrected are potentially scattered in internal sections and business partners, and thus cannot easily be discovered through an analysis of activities of a specific single section. In order to throw light on those problems, it is necessary to devise a methodology to facilitate a study of solutions to those problems through analysis of flows of information and goods from a cross-functional point of view.

As to the means of analysis of flows of information and goods, there are Process Analysis in the field of IE [6], and IDEF and Data Flow Diagram (DFD) widely used in the field of Information System Analysis [1][4]. However, since Process Analysis deals with goods flows and IDEF and DFD mainly deal information flows, both analysis methods have their limitations in the application of simultaneous analysis of flows of information and goods. Also, analysis methods characterized by an emphasis on descriptive aspects of business process cannot be deemed fully qualified as a design- oriented methodology that would come up with problem-finding and solving ideas from the studied flows of information and goods. Cross functional managerial reform techniques represented by BPR are not so advanced as to be referred to as concrete analysis and improvement methodologies from a systematic aspect, although they are effective after a fashion as techniques to help present concepts and orient improvement activities [5].

The purpose of this study is based on the above goal, namely to present a technique for problem identification and finding clues for solutions regarding flows of information and goods by using the particular example of order fulfillment process of generic goods within an actual pharmaceutical company, herein called company A. We devised a “distribution information flow pattern diagram” (referred to hereafter as flow diagram) which represents information flows between various sections engaged in order fulfillment process and corresponding goods flows. Those patterns in the diagram are then analyzed to afford clues on problem identification and solving. Next we depict the ideal flow of information and goods and compare them with the flows reflecting actual operations. This comparison will help provide a perspective to systematically discover problems. We also propose a technique to search for the optimal improvement level by depicting a target level flow on the diagram.

2. Flows of information and goods in a manufacturing company

In order to consider the simplest and most straightforward pattern of flows of information and goods between the customer and company, let us examine the situation in which a consumer gets merchandise he wants to buy by placing an order to a company.

The simplest flow pattern is, order information is communicated from the consumer to the company’s manufacturing department. In return, the merchandize is directly delivered from the manufacturing department to the consumer ([2], see **Fig. 1**).

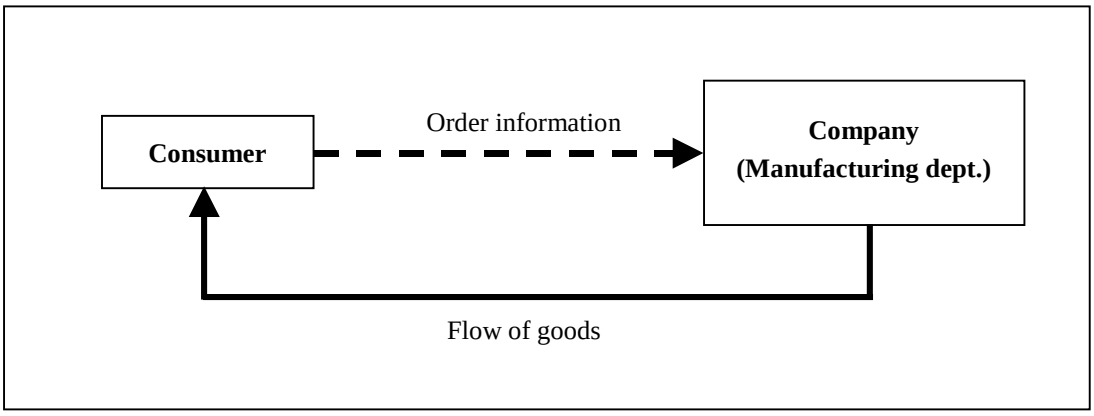

Fig. 1 The simplest flow of information and goods in manufacturing company

This kind of simple flow pattern has the following two characteristics:

(1) The number of flows is limited, as there are only one information flow and one goods flow between the two sections involved, the consumer and manufacturing department of the company.

(2) The information flow corresponds to the goods flows on a one-to-one basis. In addition each flow is unidirectional.

If such relationship characterized by “a single flow” each way and if “one-to-one correspondence between flows of information and goods” exists between a consumer and the manufacturing department of a company, then there is little or no chance of inefficiency and waste within the verification and re-sending of the information. This is because order information flows directly from the consumer to the manufacturing department and goods flows directly in the opposite direction, and is only done upon the reception of the order information from the consumer.

In this study, this pattern is regarded as the ideal pattern to refer to in the analysis to follow (Note 1). However, in the real world of enterprise activities, this kind of ideal pattern is not realized because many other sections and organizations involved in flows of information and goods. For example, a consumer’s order information is first communicated to a retailer, who then purchases the merchandise from the designated wholesaler. In turn the wholesaler, by placing an order, procures the merchandise from the sales department of the company. This order information is once staged in the information systems department whose responsibility is to control order information from the sales department. Then the information is transferred to the production control department, which issues manufacturing and shipment instructions to the manufacturing department. On the other side, the merchandise outputted from the manufacturing department is temporarily stored in a warehouse. It is then conveyed to large warehouses or distribution centers situated in multiple locations in the country and then shipped to a retailer, who then delivers it to the consumer. Thus, in enterprise activities in the real world, multiple sections and organizations are involved in flows of information and goods that make the flow pattern complicated, and in turn cause long delivery lead times.

3. Description of flow diagram

3.1 The composition of flow diagram

Flow diagram is a diagram made of a plane which displays sections and organizations involved in flows of information and goods in the horizontal axis and signifies the elapse of the time in the vertical axis. By these coordinates, the flows of information and goods are represented by arrows with time sequence numbers [3]. Dotted line arrows represent information flows and solid line arrows represent goods flows, so that both flows are distinguishable.

Fig. 2 illustrates the current flows of information and goods in the order fulfillment process of generic goods in company A. The sections and organizations involved include the following: a consumer as the source of the order information, retailers (drugstore), wholesalers, distribution centers, administration department (including the sales department of company A), distribution centers of company A (run by a subsidiary at four domestic locations), and the manufacturing plants (also at four domestic locations).

In order to display information flows by left-to-right arrows in the flow diagram, sections and organizations initiating flows are laid out from left to right in the order of consumer at the left edge, retailer, wholesalers etc…to manufacturing plant of company A at the right edge. Flows of information and goods thus exhibited in a flow diagram will facilitate visualization of the points at which flows of information and goods are entangled and those segments that cause lengthy lead time. **Fig. 2**, for example, discloses facts that the pattern of distribution of merchandise from a wholesaler is complex and the flow of information on shipping orders reach the manufacturing plant in large numbers.

3.2 Three levels of flow diagram

In this study to facilitate identification of problems and improvement ideas, we will be distinctively using three kinds of flow diagram. These are flow pattern diagrams of **(1) Current level, (2) Ideal level,** and **(3) Target level**. The significance and functions of each of them are portrayed below.

(1) Current level flow diagram

As shown in **Fig. 2** this is a flow diagram that indicates flows of information and goods of the status quo. It serves an important role in problem identification.

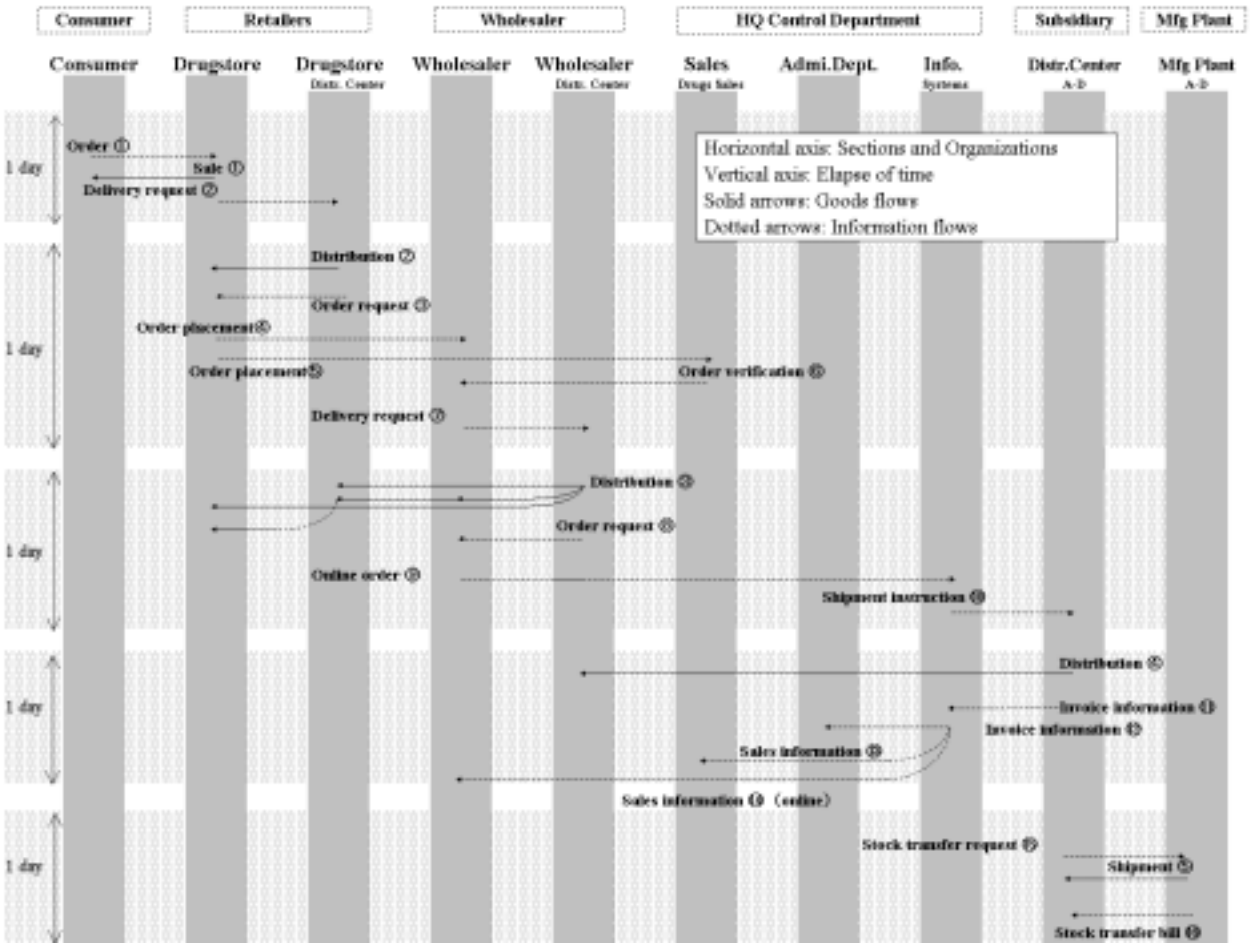

Fig. 2 Current level flow diagram (a case of Company A)

(2) Ideal level flow diagram

This is a flow diagram indicating the simplest pattern of flows of information and goods with no room for further simplification. This pattern is crafted by screening out all conditions not considered essential from a viewpoint of what social mission a company is supposed to fulfill. The model illustrated in **Fig. 1**, which consists only of a consumer and manufacturing department of a company generating a single unidirectional flows of information and goods respectively, is positioned as an ideal level flow diagram. This diagram plays the important role of facilitating easier problem identification by depicting a contrast to the current level flow diagram as well as the role of depicting an ultimate goal of improvement.

(3) Target level flow diagram

This is a flow diagram positioned halfway between the ideal level and current level flow diagrams. It portrays the pattern of flows of information and goods to be pursued as a target taking into consideration the requirements for improvement and the competence of each entity to implement the solution. The target level flow diagram can be freely set anywhere between the ideal level and current level flow diagrams. The modus operandi to utilize the flow diagram scheme, therefore, is as follows. First develop a doable target level diagram by considering the given conditions such as timeframe, manpower and budget to complete the improvement project. Then each section negotiates possible improvement of flows of information and goods with other sections concerned by referencing the developed target level flow diagram. If necessary, change the target of improvement and reflect it in the diagram. This cut and try method will make practical goal setting possible.

Fig. 3 conceptually illustrates the relationship between the current level, ideal level, and target level flow diagrams. As the target level flow is lowered from the ideal level towards the current level flow, the number of acceptable constraints increases, which in turn will increase the number of sections concerned as well as the number of flows of information and goods necessary to fulfill the objectives. This relationship can be conceptually delineated by a triangle with the ideal level flow at the apex and the base widening towards the current level flow. A target level flow is arbitrarily set somewhere between the apex and base.

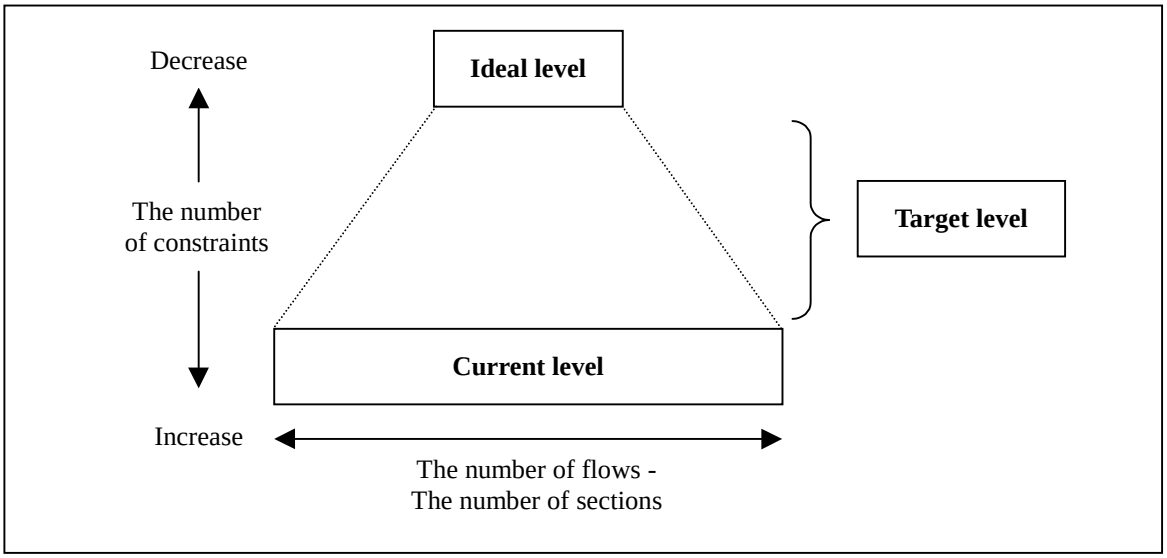

Fig. 3 Three levels of flow diagram

4. Checkpoints for problem identification

Checkpoints for problem identification are derived from a comparison between a current level and ideal level flow diagrams discussed in section 3.2. By examining the differences between the two levels with regard to patterns of flows, we can understand potential causes of inefficiency and waste in operation and we can narrow down major problems. A close look at causes creating problematic flows will systematically shed light on problems hidden in actual operations. In this study we categorize checkpoints into three kinds, **(1) multi-stage, (2) inverse flow,** and **(3) diversion-confluence,** in order to devise approaches to problem determination (Note 2) .

4.1 Multi-stage

Where there are multi-stage flows of information and goods, there are multiple sections involved in flows of information and goods from start to the end (**Fig. 4**). As sections intervene from start to the end to cause multi-stage flows, flows of information and goods become complicated. This situation causes longer delivery lead times and increases the possibility of unproductive work such as verification, making, managing and transcribing bills on the information side. On the goods side, it creates such jobs as unloading and temporary storing of goods. In this aspect multi-stage flows are responsible for altering a system from one with desirable pattern of flows as indicated in **Fig. 1**.

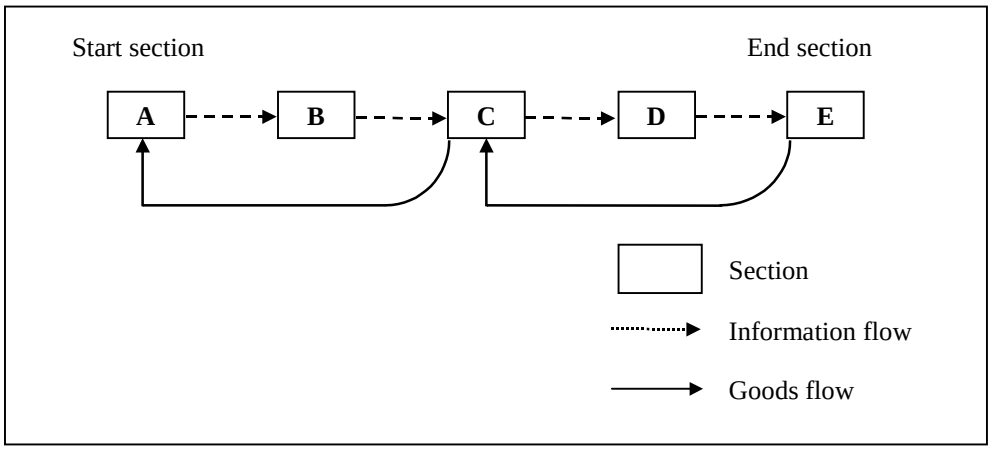

Fig. 4 Multi-stage flows of information and goods

4.2 Inverse flow

Inverse flow of information is a term used to describe a situation where a section, having received a piece of information, transmits another piece of information in the opposite direction to confirm the contents of the received information or inquire about it. Information flows for verification or inquiries are shown as arrows going from right to left in **Fig. 5**. Repetitious confirmation with the consumer about the contents of the order by sales department staff is a frequently observed example of the occurrence of such inverse flow of information. If the inverse flow occurs, the information is halted to cause lengthy delivery lead time, and also the number of information flows increase in the whole system and the workload of information management administration multiplies respectively, which is undesirable.

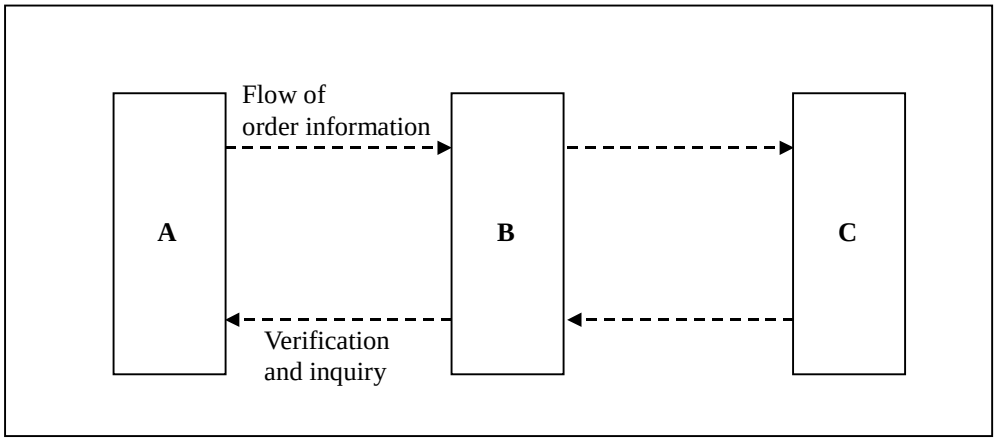

Fig. 5 Inverse flows of information

4.3 Diversion-confluence

Diversion-confluence is a term used to describe a situation where a piece of information is fanned out to multiple sections in need of receiving it in parallel. Later the branched off information flows join together into a single section. If the information flow branches off as illustrated in **Fig. 6**, the following kinds of work become necessary. Namely, multiple sections, having received information in parallel, need to verify the sameness of contents each other (section B and C in **Fig. 6**) and the object section D needs to summarize the confluent information received from multiple sections. Also, if there is any discrepancy found between pieces of information summarized, each section must get involved in the work to search for the cause of the error. In the case of **Fig. 6** extra work is loaded on sections B, C and D for information verification and on all the sections for coordination of their activities.

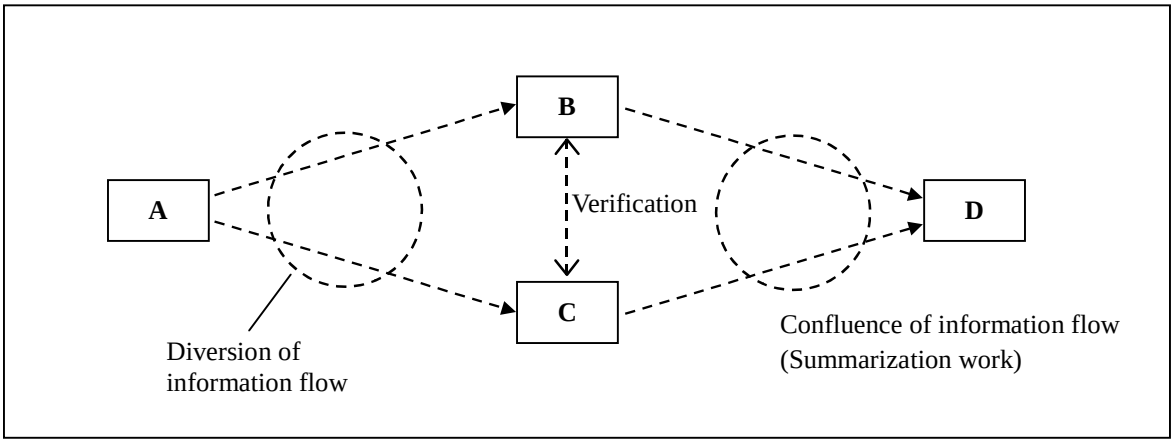

Fig. 6 Diversion-confluence flows of information

5. Application to the case of company A

In this section we will be analyzing patterns of flows of information and goods in order fulfillment process of generic goods

in pharmaceutical company A as a model. Concretely, we are first going to develop a current level flow diagram by looking into flows of information and goods at the company, starting with a drugstore selling merchandise to the customer off the shelf, and ending with stock replenishment at every entity by the manufacturing plant. Then we list problems and ideas for solutions to develop a target level flow diagram.

5.1 Drawing current level flow diagram and ideal level flow diagram

At first, for drawing a current level flow diagram, we resolved that sections involved in order fulfillment at company A would be the 10 sections starting out with a consumer and ending up with the manufacturing plant as shown in **Fig. 2**. Next, we determined company A's span of process of order to be as follows. It starts with a drugstore selling merchandise to the customer off the shelf, which changes the stock in the store. It ends when a series of stock replenishment activities subsequently carried out at all intermediate sections is completed. Following all those preparations we conducted detailed interviews with the sections concerned. The resulting current level flow diagram is illustrated in **Fig. 2**.

On the other hand, for the development of an ideal level flow diagram, we next elected the following two items as bare minimum conditions.

(1) We cannot ignore legal requirements such as observing administrative guidance and abiding by the Pharmaceutical Affairs Law as company A's merchandise is drugs. This condition does not affect the development of the current level flow diagram. However, it implies that we must not draw a diagram that precludes the section (administration section of headquarters control department in **Fig. 2**) responsible for such information flows associated with the verification of a recall order and customer claims and with management of callback operations.

(2) In drawing an ideal level flow diagram we do not consider a scheme in which wholesalers are bypassed in order information communication. This is because wholesalers support company A by playing an important role in distribution and inventory control of medicines for family and medical doctors' use other than over-the-counter drugs, even though they do not belong to company A's management

The diagram indicated in **Fig. 7** is an ideal level flow diagram with the above two conditions taken into consideration, in which there is no more room for further improvement.

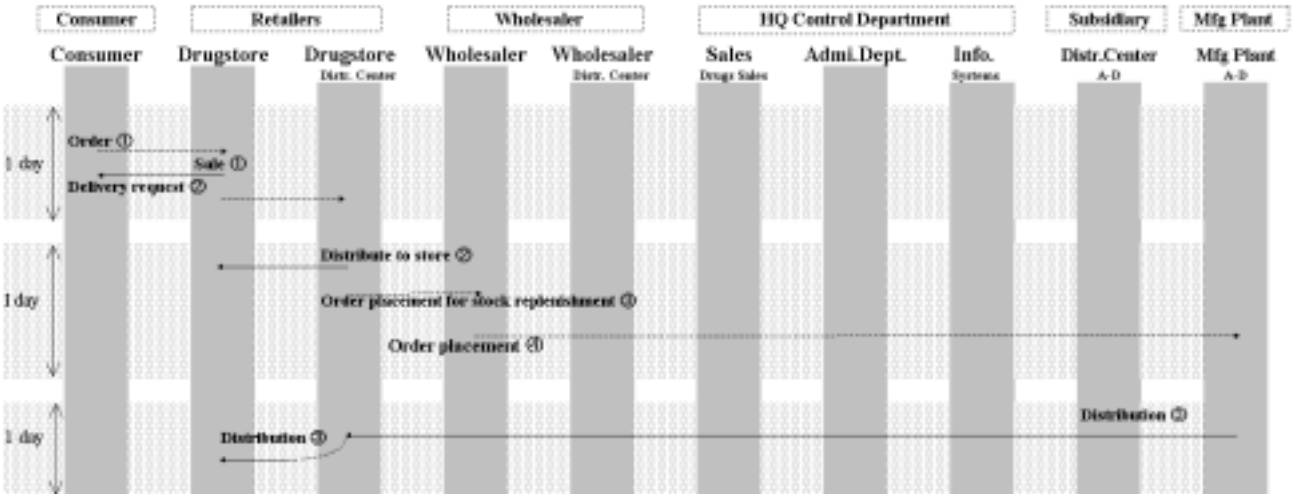

Fig. 7 Ideal level flow diagram (a case of Company A)

5.2 List problems

Comparing the current level flow diagram in **Fig. 2** and the ideal level flow diagram in **Fig. 7**, our finding is that the number of sections involved in flows of information and goods is 5 in the ideal level and 10 in the current level, whereas the total number of arrows of flows of information and goods is 7 in the ideal level and 21 in the current level which is 14 arrows greater than in the ideal level. 12 of 14 flows are information flows. While the difference in the number of sections is 5 between the ideal level and current level, that of arrows of information flows is 12, which is more than double the former. Viewed this way a comparison between the ideal level and current level flow reveals that the increased sections will not only create multi-stage flows of information but they will also get information flows complicated by secondarily inducing inverse

flow, diversion-confluence flow, which is undesirable. Proof is in the long delivery lead time of 5 days necessary for the replenishment of stocks.

In addition, by looking at **Fig. 2** from the standpoint of the approaches to problem identification discussed in Chapter 4, we get such concrete problems such as the following. (Circled numerals in parentheses correspond to the numbers tagged to information or goods flows in the current level flow diagram (**Fig. 2**)).

(1) In the flows of information from a drugstore there is the occurrence of inverse flow and diversion-confluence flow (information flows ④, ⑤ and ⑥).

Order information originating from a drugstore fans out simultaneously to the wholesaler and drug sales of company A because their roles are not clearly defined. As the result, undesirable things and wasteful work are created such as duplication of orders and verification of order contents at the wholesaler.

(2) Multi-stage flows occur on the order information flowing from the wholesaler to the headquarters of company A (information flows ⑧, ⑨, ⑩ and ⑮).

The order information originating form the wholesaler's distribution center is first communicated to the wholesaler's store. It then passes, in multiple stages, through the information system department and the distribution center of a subsidiary.

(3) Involvement of the information systems department in information processing causes multi-stage flows (Information flows ⑨ - ⑭).

Because the information system department supervises operations on all information flows (coordination/confirmation, program development, logging and management of information flows), information concerning orders and stocks is temporarily pooled at this department and then it is communicated as shipping order and inventory information, respectively, to the distribution center and sales departments. It is difficult to get information flows synchronized with goods flows due, among others, to timing constraint of information output from the online processing being one time in the morning and one time in the afternoon.

(4) Diversion of goods flows from the wholesaler's distribution center is observed (goods flows ③).

There are three distribution routes available to a drugstore, namely the direct route, the route via the distribution center, and the route ending at the distribution center. Therefore, administrative work is necessary to determine the selection of a route and division of lots.

(5) Inverse flows of information is observed between the distribution center of company A's subsidiary and the manufacturing plant (Information flows ⑮ and ⑯) .

Since the distribution center and manufacturing plant are located at different sites, the merchandise distribution between them is performed on a bill exchange basis. Therefore, the distribution center is required to administer the issuance of requests for stock transfer and reception of bills from the manufacturing plant and process them. Workload on these tasks gets heavier as product lines diversify. Also, in terms of physical distribution, double holding of stock occurs at the distribution center and manufacturing plant, which results in additional workload for warehousing products and extra expenses on storage and other charges.

In order to work out concrete proposals on improvement in flows of information and goods, first list ideas for the solution for each of the problems enumerated in the previous work. Then, set a target of improvement by taking into consideration conditions imposed and the timeframe given for the improvement activities. Lastly, pick proposals on improvement considered feasible from among listed ideas.

5.3 Make a list of ideas for possible solutions and target level flow diagram

Priority of solutions to company A's problems as identified earlier is to eradicate multi-stage flows of information and goods in the company's operations, the effect of which is great. As the first step towards this goal, we looked into each one of the sections involved in flows of information and goods in the current level flow diagram (**Fig. 2**) from a standpoint of whether or not it can be eliminated in the next few years. We did this analysis by taking into consideration company A's position in the market and industry trends in over-the-counter drugs. We found that it will be difficult to eliminate wholesalers if we consider the circumstances of distribution channels for medicines and drugs as a whole. On the other hand, we consider it is feasible to transfer the distribution functions to the manufacturing site by establishing a plant and distribution center back-to-back at a site. Implementation of this in the near future seems to be possible with the leadership of top management once an internal consensus on the solution is reached with a convincing scenario on a trade-off between transportation efficiency and distribution administration efficiency. Also it is technically possible to transfer to the manufacturing plant such functions as

order processing, inventory control, sales confirmation and coordination performed today by the information system department.

On the other hand, however, we understand that it is and will be impossible for the company to process the reception of orders from a drugstore without the involvement of drug sales in the handling of the order information because it affects the basis of the company's channel policy. After all of these deliberations the sections subjected to future elimination for the reduction of multi-stage flows are narrowed down to company A's subsidiary distribution company, managing physical distributions, and the information systems department that controls information flows. If we eliminate those two organizations we can solve problems (2), (3), and (5) of the five problems described before.

As to problem (1), the introduction of mobile terminals will help solve it. With a mobile terminal a drug salesman can input the order information he received from a drugstore directly to the company A's information control. Here inverse flow does not occur. In the present system, a salesman must first go to the trouble of turning the order information in to the wholesaler for the purpose of verification of the order entry (Information flows ⑥ in **Fig. 2**). Then the wholesaler places orders anew online to the information control department of company A (Information flows ⑨ in **Fig. 2**). This causes inverse flows of information. Similarly as to problem (4) it is considered possible to lighten the workload for assorting merchandise by deliver-to locations and splitting up a lot by devising such measures as printing a bar coded deliver-to address on the address label, although diversion itself is not eliminated.

Fig. 8 indicates a target level flow diagram that encompasses all the ideas for the solution discussed above. In this flow diagram both the drugs sales department of company A and the wholesalers receive orders from a drugstore in parallel as before. Information received by the drugs sales department, however, is sent directly to the manufacturing plant. Also information to verify the sales is sent by the manufacturing plant to both the sales department and wholesaler, but since the control of information flows is done by the manufacturing department, we can greatly reduce the quantity of stocks doubly held at the manufacturing plant and distribution center and cut down on exchanges of bills caused by this. If we adopt the target level flow diagram in actual business the workload in the manufacturing department will disproportionately increase compared to other departments. Therefore, it is important for the parties concerned to make necessary adjustments by conferring with each other in front of the flow diagram in **Fig. 8**. If an agreement is reached by all, then all departments concerned should collaborate with each other toward the realization of a system with the target level flows.

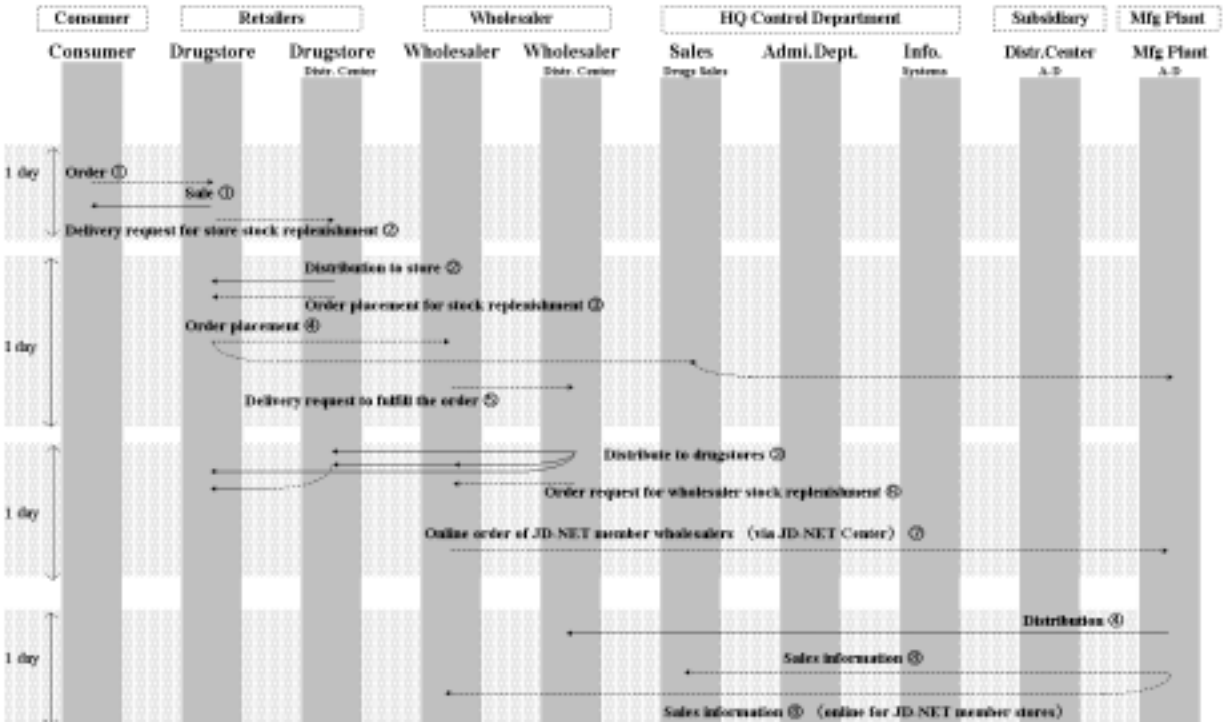

Fig. 8 Target level flow diagram (a case of Company A)

6. Conclusions and further study issues

In this study we proposed a method accompanied by an analytical procedure to systematically identify problems and help

find improvement ideas concerning flows of information and goods in enterprise activities. Then, we applied the procedure to a case of the order fulfillment process of company A and came up with a list of problems and ideas for solutions.

We believe that the flow diagram and technique to formulate ideas for solutions can be generally applicable to any case in which we need to identify inefficiency and waste in flows of information and goods for improvement. Also this technique can be used widely by everybody, as it is not made based on high level theory and concept. In particular, the concept of the level of a flow diagram plays a very important and practical role as a tool to enable us to objectively deliberate desirable mode of flows of information and goods, set an attainable target considering the timeframe and budget given for the improvement, and share objectives of improvement with each other. This is because the concept helps free us from a fixed idea that we cannot drastically move beyond the status quo of operations.

However, there remain two major problems in this study. The first problem is the one brought about by the fact that the scheme focuses on the patterns of flows between sections, but it does not address analysis of operations within a section. For example, a system containing multi-stage flows is not always inadequate. If values are added at an intermediary section that creates multi-stage flows, then it will not be appropriate to judge the flows as problematic. The same goes to inverse flow and diversion-confluence. Therefore, it is necessary in the future to enrich the framework of analysis by taking into consideration the contents of communicated information and the nature of operations at each section on top of the flow diagram and points to follow as enablers for the problem determination discussed in this paper.

The second problem is that we need more structured guidelines with which to develop an ideal level flow diagram and target level flow diagram. Among the three flow diagrams of current level, ideal level and target level proposed in this study, we recognize that the current development procedure for the ideal level and target level flow diagrams is so general that the resulted diagram varies depending on who did the analysis. As a further study it is necessary to create a procedure to develop those two flow diagrams in a more sophisticated and systematized manner as a general-purpose procedure. Also we presume that one of the big factors preventing the improvement of flows of information and goods from being carried out is the fact each section has its own idea of the ideal level and target level flow diagrams, which is perhaps not compatible with others. Therefore, one challenge is, while positively admitting perception gaps between sections, to devise ideas and operational conventions to facilitate consensus building between them on the necessary improvement through the use of ideal level and target level flow diagrams.

Footnotes

(1) In this study we define flows of information and goods between just two sections as ideal flows. However, this should not be interpreted that we deny the existence of in-house control department and distribution department. While a multi-layered organization and a distribution process based on division of labor are instrumental in the reduction of uncertainty, efficient distribution of resources, and distribution of risks, they are in turn also blamed for inefficiency and wasteful operations brought about by organizations that have little to do with flows of information and goods. Since we discuss problem identification and finding clues for solutions by putting flows of information and goods in focus, we regard flows of information and goods between just two sections as ideal flows.

(2) It is not appropriate to immediately mark multi-stage or inverse flows of information in a flow diagram as being inefficient and wasteful if their occurrence is indispensable for vital verification and other reasons. Therefore, the three points to follow as enablers of problem identification should be regarded as just serving the purpose of providing a reference. It is necessary, before identifying them as a problem, to examine whether or not they are truly inefficient and wasteful in actual operations.

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