Defect Prevention Review by Process Relationship Matrix

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***Abstract*—To clarify business process completeness, we proposed a business process diagram that describes six aspects: input, output, accepting conditions, resource conditions, exception conditions, and judgement conditions. By separating exception conditions from the output, the proposed diagram has the advantage of making it possible to detect and respond to defects and extract exception handling knowledge. The procedure for reviewing the diagram has not been specified. In this paper, we define a process relationship matrix to demonstrate a step-by-step review procedure for preventing defects in business process diagrams. The main output of the paper is the business process review method using a process relationship matrix.**

Keywords-business process; knowledge management; defect prevention; review; process relationship matrix.

I. INTRODUCTION

Ji Koutei Kanketsu (JKK) [1] in Japanese is a word that translates to self (Ji), process (Koutei), and completion (Kanketsu). Self-process completion (JKK) is a method that optimizes the entire production process, not just a specific process.

To introduce JKK, it is necessary to define not only business procedures that define the flow of work, but also requirements organization sheets that define business requirements. The requirements organization sheet consists of fields for the necessary items/information, business inputs, and business outputs for each business process. The necessary item and information field clarifies the input, tools, methods, capabilities/authority, and reasons as conditions for the quality of product. The input field describes the receiving criteria, such as when, where, and what. The output field describes where to sink, by when, and what to produce. The judgment criteria field describes the criteria to judge that "output of the process is good."

JKK clarifies the completeness conditions for each business process element. The requirement organizing sheet is an essential characteristic of JKK.

Salvadorinhoa and Teixeira [2] pointed that Business Process Model can not only help organizations improve their Industry 4.0 environment, but also facilitate knowledge acquisition and distribution. As long as the digitalization of business is promoted, business process documentation become vital for business process continuity. The digitalization re-construct the traditional business process into a new digitalized business process [3]. For example, Digital Balanced Scorecard (DBSC) [4] consists of the digital business process.

Leonard and Swap [5] defined deep smarts as expertise that allows experts to instantly grasp complex situations and make fast and wise decisions to address real-world problems. In other words, deep smarts are "powerful expertise formed beliefs and social influences that can generate insights based on tacit knowledge derived from direct experience." For example, in production process design, a challenge is how to transfer defect investigation knowledge from an expert to a novice. An example of deep smarts is the knowledge of fault investigation held by an experienced engineer.

The business process completeness diagram proposed by Yamamoto and Fujimoto [6] is a diagram whose elements are hexagonal nodes with six vertices. The vertices have six sides: input, output, receiving conditions, resource conditions, exception conditions, and decision conditions. The receiving, input, resource, and decision sides represent the outside-in flow from external elements. The output and exception sides represent the inside-out flow to external elements. A distinctive feature of the defect prevention diagram is that exceptions and outputs are separated by separate arrows.

In this paper, we renamed the business completeness diagram as the defect prevention diagram, because business completeness is achieved by preventing defects in business processes.

In the following, we propose a procedure for creating a defect prevention diagram and a review method in Section II. Furthermore, we explain an example of application in Section III. We provide a discussion in Section IV, and conclude in Section V.

II. BUSINESS PROCESS DESIGN APPROACH

A defect prevention diagram consists of business processes and flow relationships between business processes. In a business process, input, output, receiving conditions, resource conditions, judgment conditions, and exception conditions are clarified. Flow relationships include flows from output to input and flows from exception conditions to input, resource conditions, and judgment conditions.

The Input describes the trigger and information for starting an action. The Output describes the response and information as a result of the action. Accepting conditions describe the conditions for executing an action. Resource conditions describe the people, equipment, information, and activities required to output the action results. Judgment conditions describe the criteria for outputting the action results. Exception conditions describe the conditions under which output cannot be generated because the receiving conditions, resource conditions, and judgment conditions are not met.

Figure 1 shows the defect prevention diagram process element.

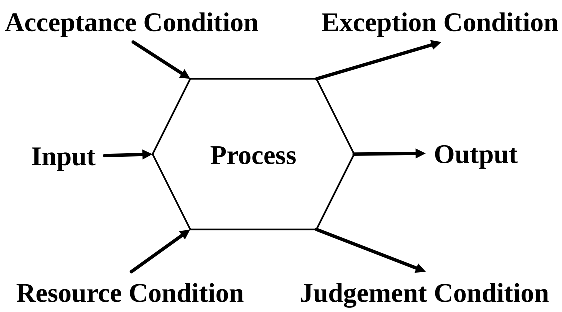

Figure 1. Defect prevention diagram process.

A. Defect Prevention Diagram Creation

The step-by-step procedure for creating a defect prevention diagram is shown below.

[Step 1] Identify the business process and name the business action.

[Step 2] For the business process, connect a flow relationship from the output of the preceding business to the input of the succeeding business. At this time, the input and output for the business process are named.

[Step 3] For the business process, identify the receiving conditions, resource conditions, and judgment conditions. For cases where these conditions are not met, extract the exception conditions.

[Step 4] Add an exception flow that connects the extracted exception conditions to the input conditions of the appropriate business process. At this time, if there is no business process to connect the exception flow to, add a new business process to the defect prevention diagram. Also, find the input that will be the output destination of the added business process, and add a flow relationship to the corresponding business process.

[Step 5] Check that the created defect prevention diagram is appropriate from the following perspectives.

- There are no missing business processes
- There are no missing inputs and outputs
- There are no missing conditions
- There are no missing exceptions
- There are no missing flow relationships

[Step 6] If there are any missing conditions in step 5, repeat the corresponding step. Otherwise, end.

(End of procedure)

B. Business relationship analysis

For the business process set P that constitutes the defect prevention diagram D, the business process relationship matrix M can be defined as follows.

TABLE I. BUSINESS PROCESS RELATIONSHIP MATRIX

	X	Y
X	Goal of X	X to S: Y Relationship
Y	Y to T: X Relationship	Goal of Y

In Table I, S and T are either the receiving condition A, the resource condition R, or the judgment condition J. If S and T are omitted, they are taken to be the relationship to the input of the target process.

The diagonal element M (X, X) describes the purpose of business process X. The off-diagonal element M (X, Y) describes the connection flow from business process X to either the input, receiving condition, resource condition, or judgment condition of Y.

The business process relationship matrix can be used to comprehensively check the connection flow between business processes that make up the defect prevention diagram. For example, the transitive closure of the business process relationship matrix can define a set of connection relationships for business processes. The set of connection relationships for X in Table I is $\Sigma_{k=1,\,n} (R_{xy} \cdot R_{yx})^{k}$. R_{xy} is the relationship from X to S: Y, and R_{yx} is the relationship from Y to T:X.

Similarly, the set of connection relationships for Y in Table I is $\Sigma_{k=1,\,n} (Ryx \cdot Rxy)^{k}$.

The process relationship matrix is used to identify defects caused by the flow relationship among processes.

The scalability of the matrix approach depends on the complexity of the number of relations between processes. The approach can be adaptable for any business process relationships by using matrix representation.

C. Process Checklist

The process review list is defined as issues of concern for six aspects, as follows.

[Process name]
[Input] issues on input labels
[Accepting condition] issues on accepting arrow labels
[Resource condition] issues on resource arrow labels
[Judgement condition] issues on judgement arrow labels
[Output] issues on output arrow labels
[Exception condition] issues on exception arrow labels

By using the checklist, defects on the process aspect can be derived.

III. CASE STUDY

The Shinkansen bogie crack trouble is said to be a problem of the entire system [7]. If we consider the Shinkansen bogie crack trouble as a system, the main components are (1) the cracked bogie, (2) the maintenance staff who confirmed the bogie abnormality, (3) the control person who ordered the bogie inspection, and (4) the supervisor who manages the overall train management process.

The Shinkansen express goes from Okayama to Tokyo, through Shin-Osaka, and Nagoya. The maintenance staff who boarded the train at Okayama Station confirmed the abnormal sound and suggested to the dispatcher by phone that the bogie be inspected at Shin-Osaka Station. At this time, the control person was receiving an inquiry from the supervisor and did not hear this suggestion from maintenance staff. As a result, the Shinkansen continued to run until JR Central decided to stop it at Nagoya Station.

This train operation management process includes the process in which the maintenance staff confirms the bogie abnormality, the process in which the maintenance staff proposes to inspect the bogie and asks the dispatcher for a decision, and the process in which the dispatcher responds to the inquiry from the dispatcher.

The inspection proposal from the maintenance staff conflicted with the inquiry from the dispatcher, resulting in a loss of information in that the dispatcher did not hear the inspection proposal. This train operation managing process includes supervision, command, problem detection, and train inspection processes, as shown in Figure 2.

As shown in the Table II, inputs for the control process include status inquiries, inspection requests, and inspection reports, and it is clear that there is a possibility that these may conflict. For this reason, it is necessary to prevent inputs from being lost when there is conflict by prioritizing the conditions for receiving these inputs.

In addition, outputs include status reports and inspection instructions, and it is clear that there is a possibility that these outputs may conflict. In this case, it is necessary to avoid output conflicts by specifying the judgment conditions.

TABLE II. PROCESS RELATIONSHIP MATRIX FOR TRAIN MANAGEMENT

	Supervise	Control	Detect	Inspect
Supervise	Governance	Status inquiry		
Control	Status report	Command and Control		Inspection instructions
Detect		Inspection request	Check for abnormalities	
Inspect		Inspection report		Inspection

This consideration is also clarified in the following checklist for the control process.

The Process Checklist for command process is as follows.

[Process name] Command process

[Input] Status inquiry, inspection request, inspection report

[Accepting conditions] Are there any conflicts between status inquiry, inspection request, and inspection report?

[Resource conditions] Commander, command procedure

[Judgment conditions] Are there any conflicts between reports and inspection instructions?

[Output] Status report, inspection instructions

[Exception conditions] Who should be notified of command exceptions?

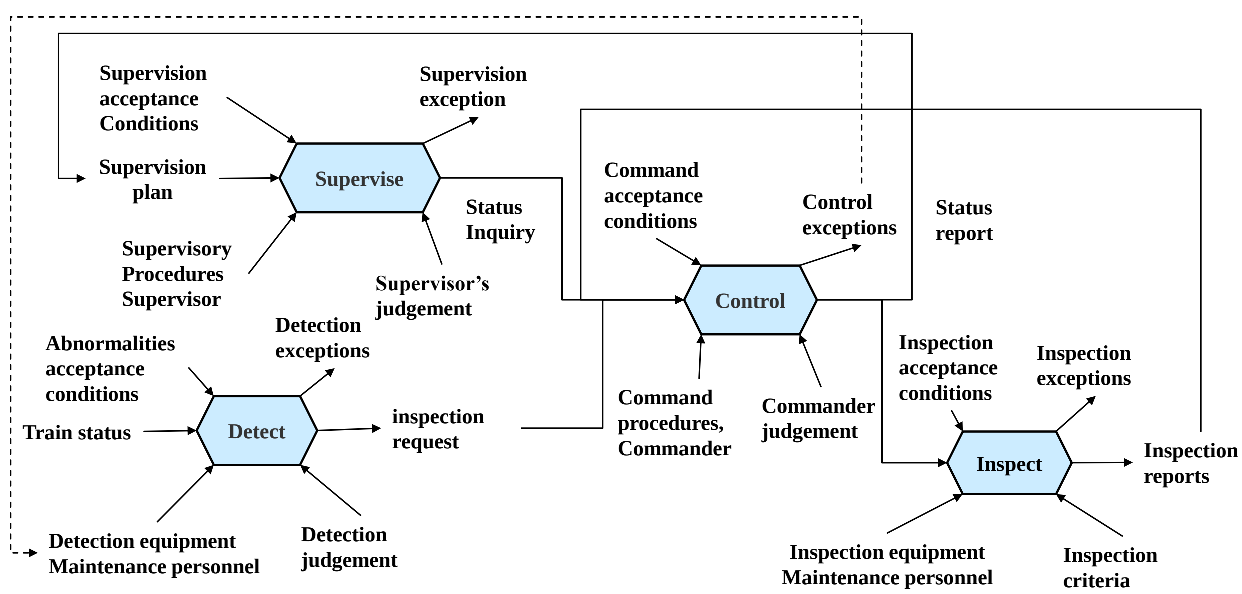

Figure 2. Train operation management process.

IV. DISCUSSION

A. Novelty

In this paper, we proposed a procedure for creating defect prevention diagrams and a review method.

In a defect prevention diagram, business process knowledge can be organized hierarchically using L1: business process knowledge, L2: business flow-related knowledge, L3: business process action condition knowledge, and L4: business action condition execution knowledge. Here, L1, L2, and L3 can be described in a defect prevention diagram. However, for L4, the described conditions must be evaluated when the actual business process is executed.

In the business process knowledge of a defect prevention diagram, L1 can grasp the overall picture of the business process by identifying the necessary actions that make up the business process. Business flow-related knowledge L2 can recognize the dependencies between business processes. Business process action condition knowledge L3 can recognize what conditions are necessary to execute the business. The difference between L3 and L4 is the difference between knowing the conditions and being able to appropriately confirm and evaluate those conditions. Condition evaluation knowledge L4 should be specified so that the evaluation results do not vary depending on the individual for the same conditions.

In the defect prevention diagram, this type of business process knowledge classification is used to organize business knowledge that has traditionally been thought to vary between individuals, making it possible to clarify where the variations in knowledge are occurring.

B. Applicability

In this paper, we confirmed the applicability of the proposed method by applying it to train operation monitoring operations. Because this case is an important business process in fields other than operation monitoring operations, the proposed method may be applicable to a wider range of applicable business processes.

C. Comparison with Root cause analysis

In Root Cause Analysis (RCA), when a defect is detected in a system, the cause of the defect is identified. Once the cause is identified, measures are devised to prevent the defect from occurring in the system.

In contrast, in defect prevention analysis, which is the premise of the defect prevention diagram, the success conditions and exceptions of the system are first defined. Next, measures to deal with exceptions are devised in the system. Defects that occur during the operation of the system are identified and the planned measures are implemented.

D. Limitation

In this paper, we proposed a method for reviewing defect prevention diagrams. However, we have only applied it to one case study. In the future, we need to quantitatively evaluate the effectiveness of the method by applying it to many cases.

V. CONCLUSION AND FUTURE WORK

In this paper, we proposed a procedure for creating a defect prevention diagram and a review method. The business process review checklist can validate the completeness of each of the six aspects of the process that constitute the defect prevention diagram. In particular, it can detect conflicts between multiple inputs and outputs. In addition, the process relationship matrix can analyze the comprehensive dependencies between the business processes that constitute the defect prevention diagram.

By defining transition relationships based on the elements of the business relationship matrix M, it is possible to iteratively track influence relations. In other words, it is possible to define a language expression L of the defect prevention diagram using M. Since it is believed that the equivalence of the defect prevention diagram can be formulated using this L, it is possible to minimize the defect prevention diagram.

Since the defect prevention diagram can complement the response to exceptions in the business process, it is possible to define a business process that can respond to defects as exceptions.

In this paper, the completeness of the defect prevention diagram is formulated by its ability to respond to exceptions. However, we have not yet discussed whether such an exception response is sufficient. Therefore, we plan to continue to consider the completeness of the defect prevention diagram. Moreover, more case studies and technical details shall be provided as future work.

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