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A Simultaneous Business Design Method Utilizing G-RD

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ABSTRACT: *This paper proposes a new Simultaneous Design Method that is called Global Relations Diagram of function and demarcation (G-RD). When enterprises aim to perform BPR, not only the breakdown of business functions but also the design of the relations between businesses is required. Generally, BPR projects focus on the breakdown of business functions, but the relations between businesses are not fully designed by the conventional design method, Sequential Design Method, in many cases. In order to solve these problems, the modeling approach which details not only the business functions but also the relations simultaneously is required. This paper introduces some case studies which applies this Simultaneous Design Method to the BPR projects, and confirms the effectiveness of this Method utilizing G-RD.*

KEYWORDS: *Global Relations Diagram of Function and Demarcation (G-RD), Business Process Reengineering (BPR) Activity Sequence, Interaction, Goal-oriented, Modeling Approach, Function Point Practices.*

1. Introduction

Enterprises renovate management strategy and business structure in order to correspond to change of business environment. In recent years, an organizational renovation involving other enterprises is increasing due to Mergers and Acquisitions (M&A). A Business Structure Renovation is executed toward their own organizational renovation. In the meantime, the needs for these renovations are increasing, and to achieve business objectives, enterprises continuously execute a Process/Operation Renovation. Generally such a Process/Operation Renovation is accompanied by an IT System Renovation. Thus, enterprises must execute continuously three kinds of renovation, Businesses Structure Renovation, Process/Operation Renovation and IT System Renovation.

To design business structure, business process/operation, and IT system, it is necessary to define and break down business functions in detail. It is also necessary to design various relations, such as information or data, between business functions.

The knowledge, skill and technology necessary to execute three layers of renovation are different. Moreover the required talent of leaders and members who promote the renovation are also different between layers. When the layer changes, the knowledge, skill or technology transfer will usually lack or change, therefore the objective or designed contents of renovation tend to alter. Also, in the designing and definition phase of renovations, breakdown tends to focus on business functions, and there are many cases that relations are not broken down enough compared to business functions. In order to solve these problems, it is needed that the definition method of business functions which can be applied to three kinds of renovations, and it is needed that the design method to break down in detail but functions and relations.

In this paper, a new business design method which breaks down functions and relations simultaneously is proposed using modeling approach called Global Relations Diagram of Function and Demarcation (G-RD) (Mitsukuni & Shibata, 2000; Mitsukuni, Tamaki & Saito, 2010; Saito & Mitsukuni, 2011; Saito, Udagawa & Mitsukuni, 2011; Shozui & Mitsukuni, 2002; Tamaki, Sasaki & Komatsuhara, 1995). At the same time, the evaluation criteria is defined to measure what kind of effect is expectable, when this simultaneous design method is applied to several types of Business Process Reengineering (BPR) (Hammer & Champy, 2001). To confirm the effectiveness of this simultaneous design method, this study presents some case studies which were actually applied this method.

2. The problems of design method utilizing conventional modeling approach

2.1 Three modeling approaches utilized for BPR

There are various modeling approaches which are utilized for BPR. Firstly, Activity Sequence defines activities, then improves and evaluates the sequence of activities. This modeling approach is applied to improve routine a work in one section. As an example for this modeling approach, there is Data Flow Diagram (DFD). This modeling method enables to describe activities and sequence of activities in detail, so usually utilized to analyze business processes. Secondly, interaction considers operation as an interaction between the requester and conductor. This modeling approach is applied to improve operation between several sections. As an example for this modeling approach, there is Use Case. This modeling method is effective to grasp the roles of human and the events of operation, so usually utilized to analyze IT system. At last, goal-oriented defines the business goals to various processes and improve processes. This modeling approach is applied to improve business processes drastically in cooperate level. As an example for this modeling approach, there is Balanced Scored Card (BSC). This modeling approach is effective to reveal the improvement initiatives in cooperate level. These representative modeling approaches can be classified in three groups according to the objectives and the applied scopes as shown in Table 1 (Kobayashi, 2005).

Activity Sequence modeling approach is effective to analyze and improve process/operation and IT system by breaking down the objects. However, it is difficult to describe the relationships between activities, since this modeling approach mainly focuses on the activities and sequence.

On the other hand, interaction modeling approach is effective to analyze and improve process/peration and IT system by breaking down the relationship between requestor and

Table 1 The Feature of Three Modeling Approaches

Modeling approach	Activity Sequence	Interaction	Goal-oriented
Objective	Improve and evaluate the sequence of each activity under the obvious goal and constraints.	Improve the interaction between the requestor and conductor of the operation, and improve the customer satisfaction.	To achieve business goals, define goals to various processes and improve processes.
Applied scope	To improve a routine work in one section.	To improve value provided to customer through renovating cross-functional operations.	To improve business processes drastically in cooperate levels.
Key data of Modeling	Input/outputs, activity sequences	Roles and Operational events additionally to left item.	Goals additionally to left item.
Evaluation criteria	Speed, cost, quality	Customer Satisfaction	Various business goals
The perspective of business process	Workflow interpretation. Perspective of the industrial engineering and software engineering.	Co-ordinational interpretation, Perspective of the cognitive science, and systems theory.	Developed style of Co-ordinational interpretation. Perspective of the business administration and organizational theory.
Conventional modeling methods	Integrated DEFinistion methods (IDEF), Data Flow Diagram (DFD), Activity Diagram	Use case, CN model	BSC (Balanced School Card) Model, Unified Modeling Language (UML), Goal Model

conductor. However, it is difficult to aggregate the activities as Activity Sequences, since this modeling approach mainly focuses on the relationship of activities, and thus each activity is described in various places.

As mentioned above, Activity Sequence has a disadvantage in describing the overview of relationships. On the other hand, interaction has a disadvantage in describing the overview of activities. When designing the business operation, it is necessary to break down both business functions and business relationships. The business functions are broken down utilizing Activity Sequence modeling approach. As the breakdown proceeds, the layer gets deeper and the number of charts increases. This makes it more difficult to grasp the linkage with original business described in upper layer. Meanwhile, the business relationships are broken down utilizing Interaction modeling approach. As the breakdown proceeds, the process flow gets longer and becomes impossible to describe in one sheet. This makes it more difficult to trace the whole processes. Therefore, it is difficult to describe the overview of both business functions and business relationships simultaneously by one modeling approach.

Generally, multiple modeling approaches are combined for business design, the conversion among multiple modeling approaches must be done by hand. As the scope of modeling gets bigger, communication between members (i.e., stakeholders such as project leader, project members, engineers, architects and users) gets insufficient, causing a lack or duplication of information during the conversion.

2.2 The flow of business design and modeling approach

Business design usually is accompanied by IT system development as a following step. Assuming to advance to IT system development, business design is executed in sequence of eight steps utilizing optimal modeling approach in each step as Figure 1 (Forsberg & Mooz, 2000).

The first step of business design, "Theme Definition" is executed to achieve business goals based on business strategy. In this step, goal-oriented modeling approach is utilized. The following step is "Business Requirement Definition." "Business Requirement Definition" focuses on functions and relations between functions. Thus in this step, interaction modeling approach is utilized. Then, this step is followed by "System Requirement Definition" which breaks down the business functions. Thus, Activity Sequence modeling approach is utilized in this step. "System Design" and "Program Development" succeed the step of "System Requirement Definition." Activity Sequence modeling approach is also utilized in these steps. "Integration Test" is executed for both broken down functions and interfaces between different functions to verify both of them. In this step Activity Sequence and interaction modeling approaches are utilized. "System Test" succeeds "Integration Test" which verifies interfaces. In this step, interaction

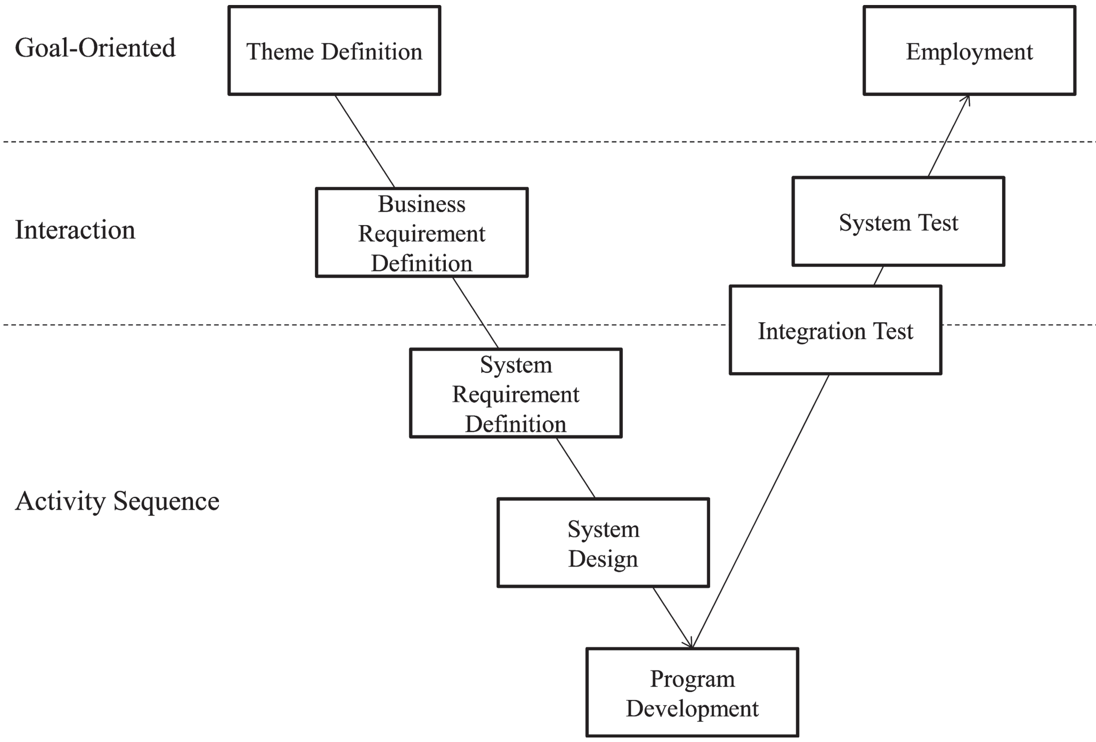

Figure 1 The Flow of Business Design

modeling approach is utilized. At the last in "Employment", newly designed Process/ Operation and IT system are utilized to achieve the business goals defined in the first step, "Theme definition." Hence, the goal-oriented modeling approach is utilized in this step.

2.3 The problems of conventional modeling approach

Business and IT requirement definitions are usually performed in sequence as the following, after the business design theme definition. (1) Design main interactions of business processes, (2) Aggregate main activity sequences of business functions, then (3) Break down the aggregated activity sequences as a design unit. At each design step, the most suitable design modeling approach is selected and designed in sequence. As the design step proceeds, the utilized modeling approach changes. For example, to design the sales order processing/delivery process, conventional design is performed as Figure 2. Business processes are designed by Data Flow Diagram (DFD) which is one of the Interactions modeling approach. Business functions are designed by Structured Data Flow (SDF) which is one of the Activity Sequence modeling approach (Svoboda, 2000).

In this design method, the linkages between business processes outside of SDF, are disconnected during the breakdown of function. The newly designed linkage inside one SDF is not reflected toward outside of that SDF. As the result, broken down linkage is not

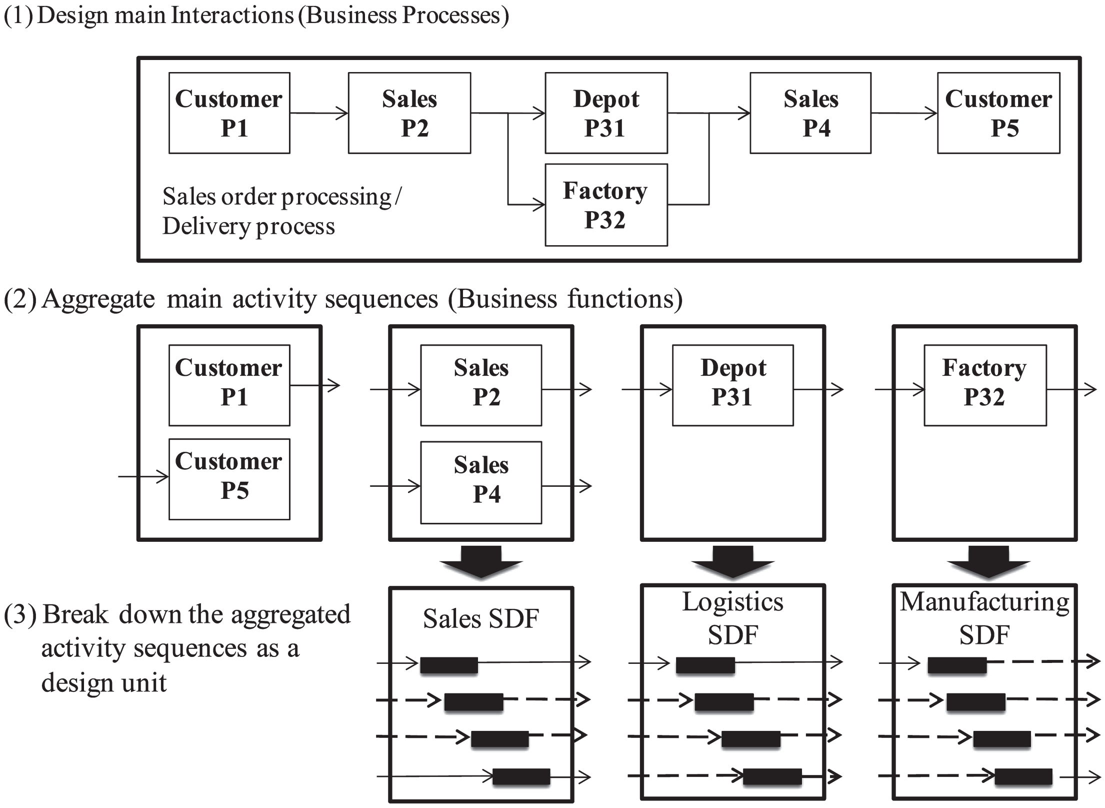

Figure 2 The Procedure of Business and IT Requirement Definition

designed as an interaction. It will be never broken down without going back to business process design. By this, the newly designed linkages are left without being reflected into business processes. In this Sequential Design Method, even the most suitable modeling approach is selected for each design step, when the design step proceeds and the modeling approach changes, the broken down contents of current step are not reflected in the outcomes of previous step. A step back to re-design of business process occurs after breakdown is already executed.

3. The perspective of the new business design method

3.1 The perspective of the design method utilizing G-RD

The new business design method executes “Business Requirement Definition” and “System Requirement Definition” simultaneously after “Theme Definition” as shown in Figure 3. The feature of G-RD is breaking down functions and relations simultaneously using levels. This design method allows the detailed design contents to be described in

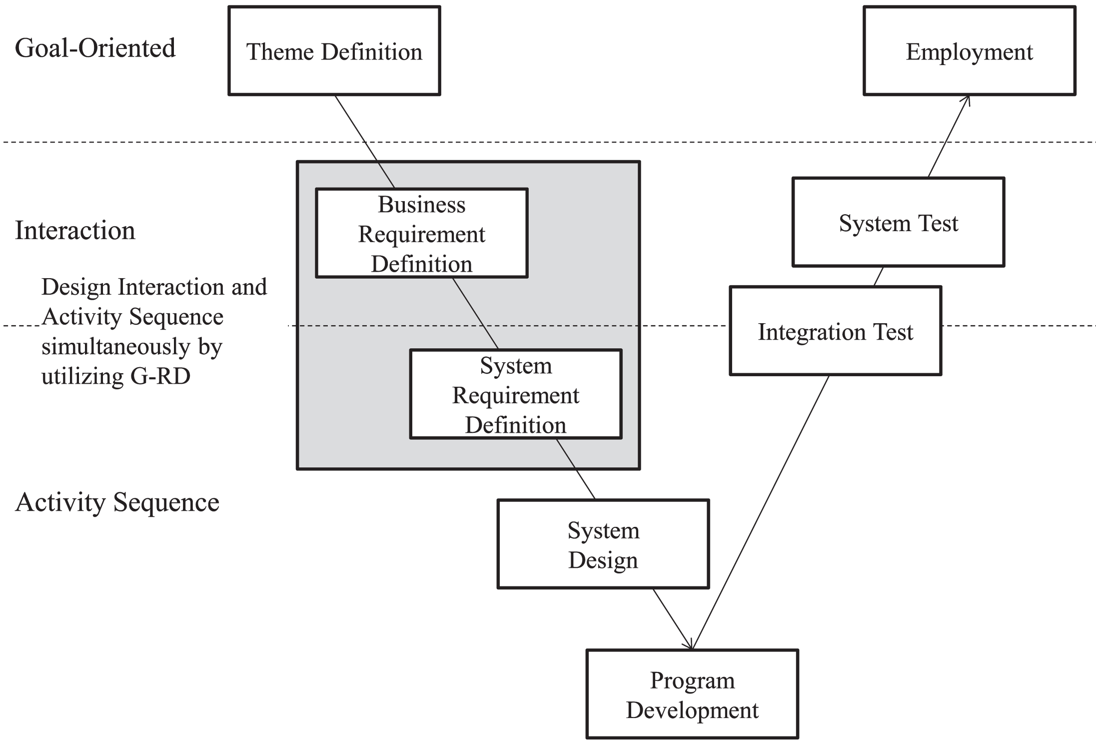

Figure 3 The New Flow of Business Design Utilizing G-RD

one chart. In this way, the problem of the conventional design method is solved (i.e., the information on the chart which is broken down at one step, is not reflected into the chart of the preceding step). Consequently, the problems of lack or duplication of the design contents can be solved. These problems were caused by insufficient communication when the design steps as proceeds. And the problem of deterioration of design contents can be prevented with this design method.

3.2 Validity evaluation of the Simultaneous Design Method

The validity of the design method which breaks down Activity Sequences and interactions simultaneously utilizing G-RD is evaluated by comparing the estimation in the development scale of an information system, by using the Sequential Design Method and by using Simultaneous Design Method proposed in this paper.

Generally, the development scale of an information system is estimated by accumulating the development scale required for each activity in the viewpoint of an Activity Sequences. In Sequential Design Method, designing a business process/operation is performed by focusing on Activity Sequences. In this case, it is thought that activity is performed by input from external activity and cooperates to another external activity. This is the design method generally called Input Process Output (IPO).

An activity is exchanged into the system processing unit called Function Point (FP). An activity is broken down into three processes as shown in Figure 4. Three processes are the entrance process which receives the input from the outside, main processing of the activity containing an algorithm, and exit process which sends the output to the outside. In the Function Point method (FP method) which Albrecht advocated, function points are estimated using three transaction functions, an input, output and enquiry, and two data functions, an external interface file and an internal logic file (Garmus & Herron, 2001).

In general, since the FP method is used in the stage which detailed functions is determined, such as a screen of an information system and a database; these five items are used for measurement. On the other hand, the development scale of the information system estimated at business design phase is performed when none of detail function, such as a screen of an information system and a database, is determined. Therefore, in this stage, it won't be enough assure as original FP method, but it is utilized as an estimation to compare the efficiency of simultaneous design method.

Here, an external interface file is included in an external input or an external output, and external enquiry is included in an external input. Therefore, FP is used to three items, an external input, an external output, and an internal logic file.

The number of relations will be 6 times of the number of activities as Figure 4, if relations to the exterior, relation to the entrance processing and relation to the exit processing are included. In the estimation by an activity sequences, since the track record of the number of relations is not clear, the number of relations is assumed to be 6 times of the number of activities. This figure is used as a standard unit of the estimation of the sequential design method.

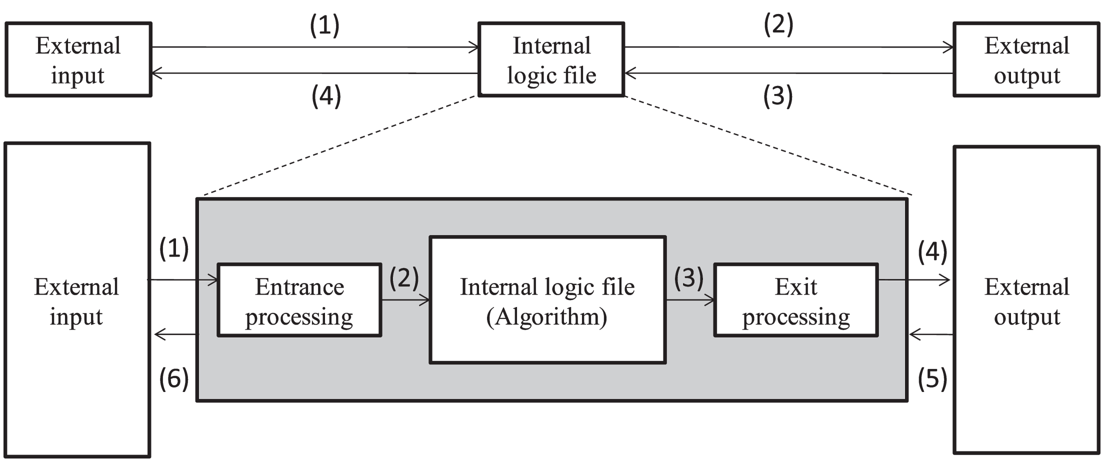

Figure 4 The Exchange Method of FP Practices

The Simultaneous Design Method carries out the design which breaks down functions as well as the Sequential Design Method. Hence the number of activities is same, which is the standard unit of FP related to the development scale of information system.

Instead, if the number of relations is estimated by the design method using G-RD, the number of relations is clearly acknowledged and it will become the designed number of relations itself. Comparing to this, in Sequential Design Method, the number of relations is estimated to 6 times of the number of activities. This number of relations designed by utilizing G-RD and the number of assumption designed by an Activity Sequence are compared and evaluated.

The validity of the Simultaneous Design Method which utilized G-RD is evaluated by considering the number of activities and relations by difference of the design method.

4. Business Design Method utilizing G-RD

4.1 The concept of description method of Data Flow Diagram (DFD)

Generally, DFD is represented by some ovals which express functions, and arrows which express information flow from one oval to another oval as shown in Figure 5.

There are three rules in this description method.

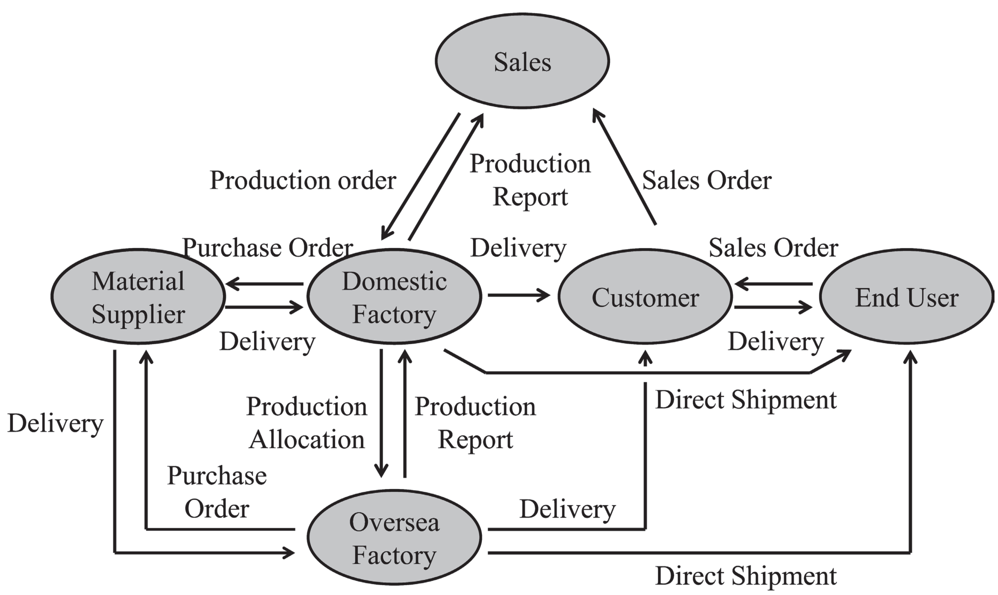

Figure 5 Example of Plant Relations DFD

(1) The oval in which a function is shown inputs (receives) information from other ovals.

(2) The oval in which a function is shown outputs (sends) information to other ovals.

(3) The information inputs and outputs by using address of receiver oval and sender oval.

If this description method is generalized, as shown in Figure 6, it can be expressed by using two new rules.

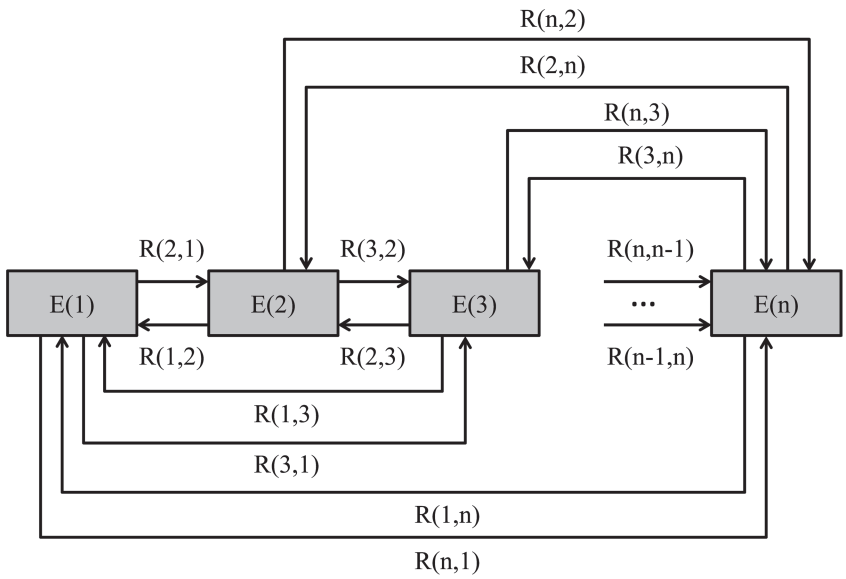

Figure 6 General Description Rule of DFD

(1) An oval which expresses function in DFD is considered as the element E (Element) and described as a box. The numbers of 1 to n are attached to all the elements in a figure.

(2) The information received and sent is considered as the relation R. The element number, which shows the direction (vector) of the relation to a certain element from another element, is attached to all the relations in the figure. Specifically, the element number (y, x) of vector, which is defined as one-dimensional y, is the element number of receiver and two-dimensional x is the element number of sender as shown in Figure 7. For example, R(3,2) shows the relation between out-element E(2) and in-element E(3). R(2,3) shows the relation between out-element E(3) and in-element E(2).

Focusing on a certain element E(x) in generalized DFD, element E(x) is sending the relation R (y, x) to another element E (y). Meanwhile focusing on a certain element E(y), element E(y) receives the relation R(y, x) from another element E(x).

R(y, x) : y = the element number of receiver,
x = the element number of sender

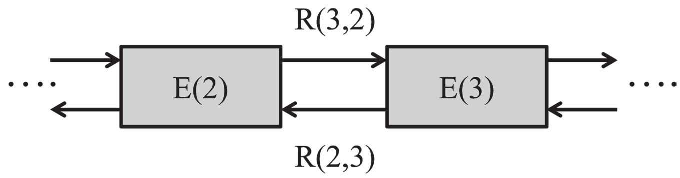

Figure 7 General Description Rule of Relations

Then, in-element E (y) and out-element E(x) are separated from the relation R (y, x). The number of relation R(y, x) which a certain element E(y) receives (the number of allows which E(y) receives), and the number of relation R (y, x) which a certain element E(x) sends (the number of allows which E(x) sends) are counted.

If the number of relations which in-element E (y) receives is set to Ri(y), the number of Ri(y) can be defined as Equation (1).

From this formula, it turns out that the maximum number of relations which in-element E (y) receives is n, equal to the number of elements.

$$\begin{aligned} R_i(y) &= R(y, 1) + R(y, 2) + \dots + R(y, n) \\ &= \textstyle\sum_{x=1}^{n} R(y, x) \end{aligned} \tag{1}$$

In the same way, if the number of relations which out-element E(x) sends is set to Ro(x), the number of Ro(x) can be defined as Equation (2).

From this formula, it turns out that the maximum number of relations which out-element E(x) sends is n, equal to the number of elements.

$$\begin{aligned} Ro(x) &= R(1, x) + R(2, x) + \dots + R(n, x) \\ &= \textstyle\sum_{y=1}^{n} R(y, x) \end{aligned} \tag{2}$$

Furthermore, since the relation R (y, x) shows a direction from out-element E(x) to in-element E (y), the direction can be divided into the sending vector x and the receiving vector y.

Therefore, the product of the number of relations R(y), which in-element E(y) receives in Equation (1) , and the number of relations Ro(x), which out-element E(x) sends in Equation (2), becomes the maximum number of relations which exist in DFD.

Thus, when the relation R(y, x) (x = 1 ~ n), which in-element E(y) receives, is defined as a row vector, and the relation R(y, x) (y = 1 ~ n), which out-element E(x) sends, is defined as a column vector, the maximum number of relation N in DFD can be expressed by Equation (3).

$$
\begin{aligned}
\mathrm{N} &= Ri\,(y) \times Ro\,(x) = \textstyle\sum_{y=1}^{n} \sum_{x=1}^{n} R\,(y, x) \\
&= |R\,(y, 1) \ldots R\,(y, n)| \times \begin{vmatrix} R\,(1, x) \\ \vdots \\ R\,(n, x) \end{vmatrix} \\
&= \begin{vmatrix} R\,(1, x) \cdots R\,(1, n) \\ \vdots \qquad\qquad \vdots \\ R\,(n, 1) \cdots R\,(n, n) \end{vmatrix}
\end{aligned}
\tag{3}
$$

This determinant shows that relations R(1,1) ~ R(n, n) exist in each column of the two-dimensional square matrix (n, n) of n elements.

This means that the two-dimensional square matrix (n, n) covers all the relations that are described on DFD which has n elements.

And the relation on diagonal line means the relation from one element to same element; hence the relation from one element to another element does not exist.

Thus the relation on diagonal line is always 0, for example R(k, k) = 0.

Therefore the maximum number of relations (number of arrows) on DFD of n elements can be expressed as $(n^2 - n)$.

Thus, if the name of relation (information), R is expressed in the vector position (y, x) where the relation exists, it is possible that DFD is expressed using the square matrix of n elements.

Since all relations can be expressed on the square matrix, the arrows which usually become complicated can be eliminated.

Furthermore, it is easy to check if all relations can be covered without duplication or omission.

4.2 The concept of description method of G-RD

G-RD is a modeling approach that defines element as the roles or functions of business operation/process and IT system. The linkages among elements are defined as relation, any structure such as structure of businesses, structure of organizations or structure of information systems can be dealt as a same object. When elements are plotted in the diagonal of square matrix, Relations are described at the intersections of the column and the row of two Elements. As a result, the position of intersection expresses the in-element and out-element at the same time.

Focusing on Elements, outbound from one Element will be expressed in vertical direction and inbound will be in horizontal direction as Figure 8, thus the direction of Relation is determined. In other words, the column number of Relation expresses in-Element and the row number of Relation expresses out-Element. This means that Relations are expressed in a counterclockwise direction and an arrow or line which expresses information flow is not necessary. (Arrows are added in some figures in this paper for explanation purpose only. In actual application of G-RD, arrows are not written.) Moreover, it is possible to breakdown Elements and Relations utilizing Levels in same modeling approach. Based on this concept, G-RD utilizes Square matrix, Elements, Relations and Levels.

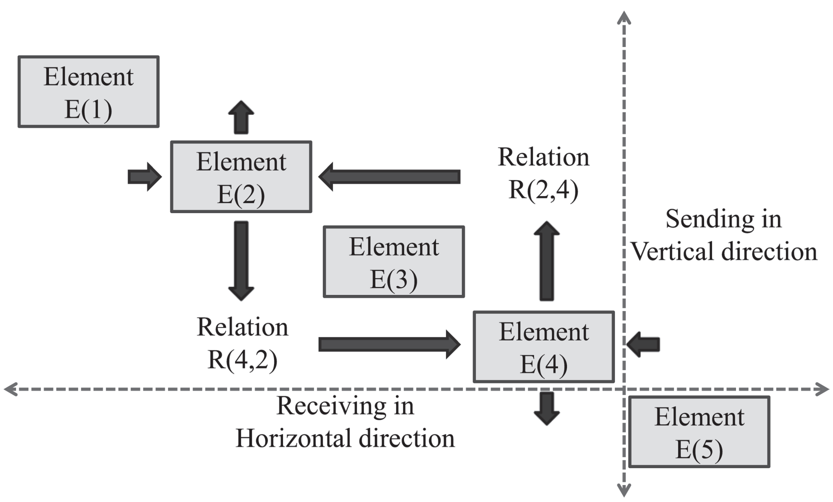

Figure 8 The Rule of Expressing Relation in G-RD

5. The description method of G-RD

5.1 The design step of G-RD

G-RD is generated by the following design step shown in Figure 9. As mentioned before, Square matrix, Elements, and Relations are utilized to form G-RD to describe the structure of business and linkage efficiently. First of all, prepare Square matrix as Step 1. Then, Step 2, define and set Elements as identical row and column labels of Square matrix. In Step 3, Elements are represented along the diagonal by the shaded Elements.

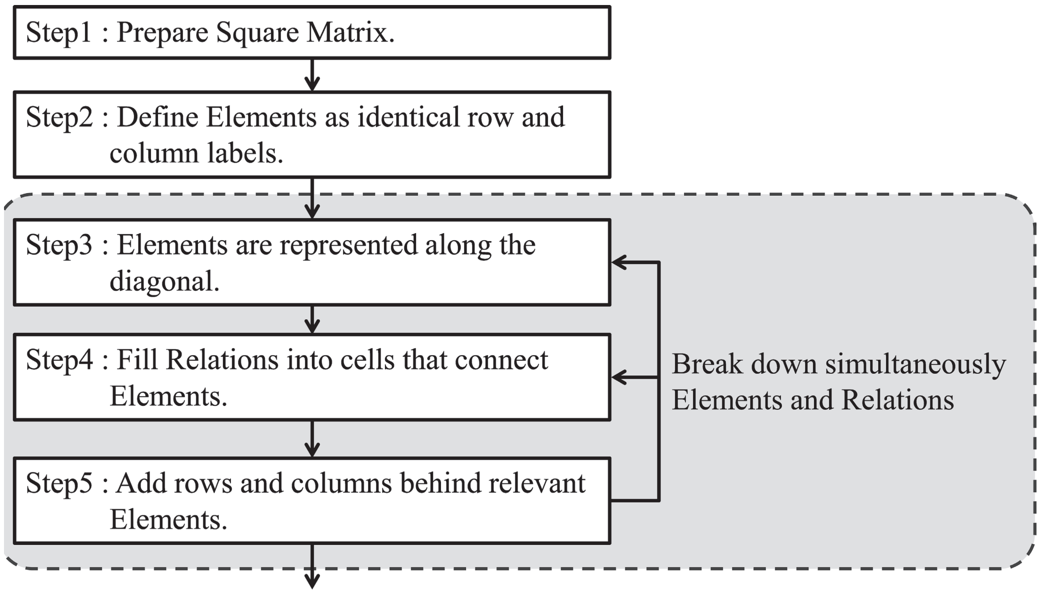

Figure 9 Design Step of G-RD

In Step 4, fill Relations into cells that connect Elements. At last, in Step 5, add rows and columns behind relevant Elements to break down. After these steps, confirm that there is no lack or duplication in the Square matrix. By continuing Step 3, Step 4 and Step 5, it enables to break down simultaneously Elements and Relations.

5.2 Square Matrix

Square matrix: M(y, x) is a base work-sheet to create G-RD. M(y, x) is a square matrix of y = x. y and x are equal to maximum values n of the number of Elements. G-RD can be shown with M(y, x) as Figure 10. The column of the matrix is called y-axis and the

x-axis →

y-axis ↓

0,0	0,1	0,2	0,3	0,4	…	0,n
1,0	1,1					1,n
2,0		2,2				2,n
3,0			3,3			3,n
4,0				4,4		4,n
…					…	…
n,0	n,1	n,2	n,3	n,4	…	n,n

Figure 10 Sample of Matrix M(y, x)

row is called x-axis. Each arbitrary intersection on the matrix is called cell C. The cell can be described by its position with two axes such as C(y = 1, x = 1), C(y = 2, x = 2) … C(y = n, x = n). As first, this Square matrix is prepared (Step 1).

5.3 Elements

The Element expresses the allotment of the role. The Element can express organization, functions or resources. The user defines and utilizes the kind of the Element arbitrarily.

Elements: E (e), e = 1, 2, …, n

Element number "e" only expresses the position of the Element, and it does not express the meaning of the Element. The number "n" describes the maximum number of elements and the user determines its definition arbitrarily. Elements are arranged as label of y-axis and x-axis (Step 2). For instance, matrix M(26, 26) is shown in Figure 11, when the user allocates the function(A to Z) to the Elements E(e): e = 1 to 26. First, the Elements are arranged from left to right of x-axis, such as C(y = 0, x = 1) = E(1), C(y = 0, x = 2) = E(2), C(y = 0, x = 3) = E(3), and C(y = 0, x = 26) = E(26). Next, the same Elements are arranged from the top to the bottom of y-axis as well as x-axis such as C(y = 1, x = 0) = E(1), C(y = 2, x = 0) = E(2), C(y = 3, x = 0) = E(3), and C(y = 26, x = 0) = E(26).

Finally, the user stores the Elements in each cell along the diagonal line of M(26,26) such as C(y = 1, x = 1) = E(1), C(y = 2, x = 2) = E(2), C(y = 3, x = 3) = E(3), and C(y = 26, x = 26) = E(26). As a result, these shaded cells represent the Elements as the label. A sample layout of Elements is showed as Figure 11 (Step 3).

5.4 Relations

Relations connect and explain the relationships between Elements. Relations can

x-axis →

y-axis ↓

M(26,26)	A	B	C	D	…	Z
A	A					
B		B				
C			C			
D				D		
…					…	…
Z					…	Z

Figure 11 Sample Layout of Elements

express follow items, knowledge, information, direction, instruction, report, response, approval, authorization, license, permission, publication, physical existence (for example, materials, products, goods), etc. The user defines and utilizes Relations according to the purpose of the linkages.

Relations: R(y, x), x=1, 2, …, n, y = 1,2, ..., n.

The Relation has an in-Element and out-Element. The description rule of Relations is defined that the direction of y-axis (vertical direction) is an in-Element of the Relation. Moreover, it is assumed that the direction of x-axis (horizontal direction) is an out-Element of the Relation.

Therefore, the Relation can be expressed by one-way as counterclockwise.

A Relation can be plotted in the cell where an in-Element's column and out-Element's row intersect. When the Relations between Elements are expressed, Relation R(y, x) from Element E(x) to Element E(y) is described in cell C(y, x). Relation from a certain Element to another Element utilizes the y-axis cell (vertical direction).

According to this rule, when the user takes out all the Relations written in the same row of y-axis (vertical direction), all Relations of the Elements written in the row label can be expressed as a list. These Relations (vertical direction) show the Relations that should be accumulated in the data base such as ledgers, vouchers, invoices and reports.

As well as above, Relation from a certain Element uses the x-axis cell (horizontal direction). By this rule, when the user selects all the Relations written in the same column of x-axis (horizontal direction), it is possible to express a list of all the Relations that this Element sends to others. These Relations (horizontal direction) express the transaction such as noticing, sending and receiving, which occurs to each Element.

This rule is illustrated in Figure 12, Relation R(4, 2) from B to D is described in cell C(y = 4, x = 2). Similarly, Relation R(2, 4) from D to B is described in cell C(y = 2, x = 4) (Step 4).

Multiple Relations of a different meaning can be plotted in cell C(y, x). For instance, as shown in Figure 13, two Relations, R1 and R2 are from Element B to Element D in cell C(4, 2). Moreover, it is possible to have same relation in different cells when there are same contents cooperate with multiple Elements. For instance, R3 of the same content is related from Element D to Element A and Element B.

5.5 Breakdown method utilizing level

Elements and Relations are able to break down in multiple levels. The sorts of level both exist for Elements and Relations.

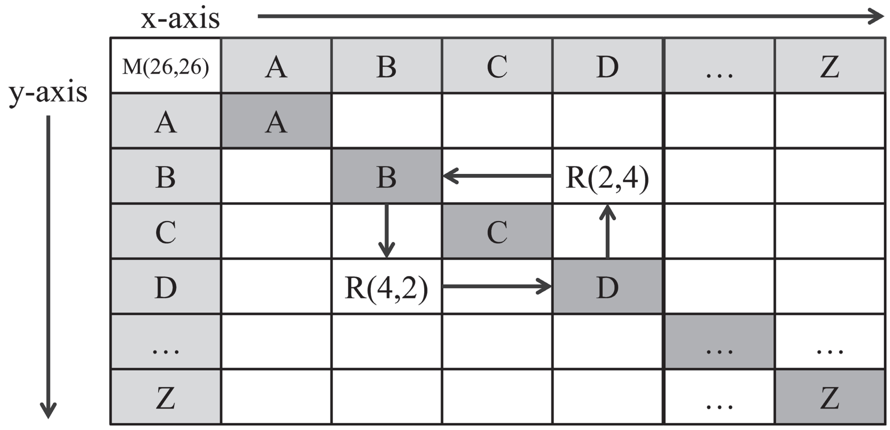

Figure 12 Sample of Relations (1)

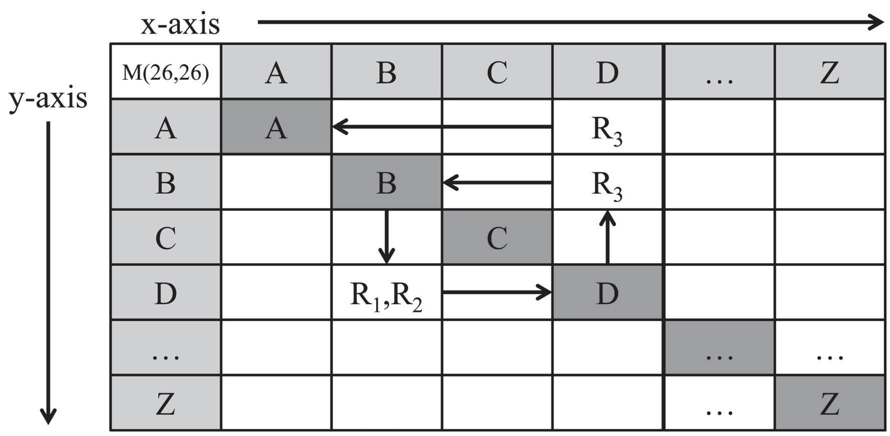

Figure 13 Sample of Relations (2)

Elements at each level : E(e, le)

Relations at each level : R(r, lr)

The level of Elements : (le), le =1, 2…, j

The level of Relations : (lr), lr = 1, 2…, k

Level numbers (le) and (lr) do not express the absolute level but expresses the relative level. The level of Elements and Relations can be defined individually. Even if the number of level is same, it does not mean that Element and Relation are in the same level. The user defines and utilizes Level of Elements and Relations, according to the maximum depth of level to analyze. However, the level utilized for Elements or Relations should be defined as same degree of depth. For example, Elements, E(1, 1) and E(2, 1), should be broken down in the same level. In this section, an example of breaking down E(e, le) into one lower Level is shown.

Figure 14 illustrates the procedure to breakdown level of Element D. First add rows and columns as the number of broken down Elements D_1, D_2 behind Element D. In Figure 14, two rows and columns are added (Step 5).

Then next, add Element D_1 and D_2 along diagonal line. Fill in Relations that Element D receives in each row in expanded matrix, in Figure 14, R_1 and R_2 are added. As well as this, fill in Relations that Element D sends toward expanded Matrix. For this example, R_3 is added in D_1 and D_2 column. Repeat this procedure in order to break down Element, E(n). Through this procedure, breakdown can be conducted by capturing whole Relations.

When any new Relation was found through breaking down Elements, add the new Relation, at the same time of expanding the Matrix. In Figure 15, the R_4 that Element A

x-axis →; y-axis ↓

M(26,26)	A	B	C	D	D_1	D_2	…	Z
A	A			R_3		R_3		
B		B		R_3	R_3			
C			C					
D		R_1,R_2		D				
D_1		R_1			D_1			
D_2		R_2				D_2		
…							…	
Z								Z

Figure 14 Sample of Breakdown Utilizing G-RD (1)

x-axis →; y-axis ↓

M(26,26)	A	B	C	D	D_1	D_2	…	Z
A	A			R_3		R_3		
B		B		R_3	R_3			
C			C	R_5		R_5		
D	R_4	R_1,R_2		D				
D_1	R_4	R_1			D_1			
D_2		R_2				D_2		
…							…	
Z								Z

Figure 15 Sample of Breakdown Utilizing G-RD (2)

is sending to Element D_1 is added, and this R_4 is also copied to column of Element D. R_5 that Element D_2 is sending to Element C is copied to row of Element D as well. Adding Relations into row or column of original Element means that moving back to breaking down Interaction from breaking down Activity Sequence, that was rarely hard to conduct in conventional method, Sequential Designing Method. By this feature, it is possible to reduce the risk that missing Elements or Relations as designing phase. Additionally, it enables adding new Elements and breaking down Relations by confirming the in-Element and out-Element. As mentioned above, the breakdown method utilizing G-RD with level enables breaking down Interaction and Activity Sequence in simultaneous, which was difficult in Sequential Designing Method.

6. An example of utilizing G-RD

6.1 Comparison of DFD and G-RD

An example of DFD utilized to describe one enterprise system with ERP is shown as Figure16. In this figure, each operation or system and their relation are designed. On the other hand, same enterprise system is described by utilizing G-RD as shown in Figure17.

6.2 An example of breakdown utilizing in multiple levels

Both Elements and Relations are able to breakdown utilizing Levels. In Figure18,

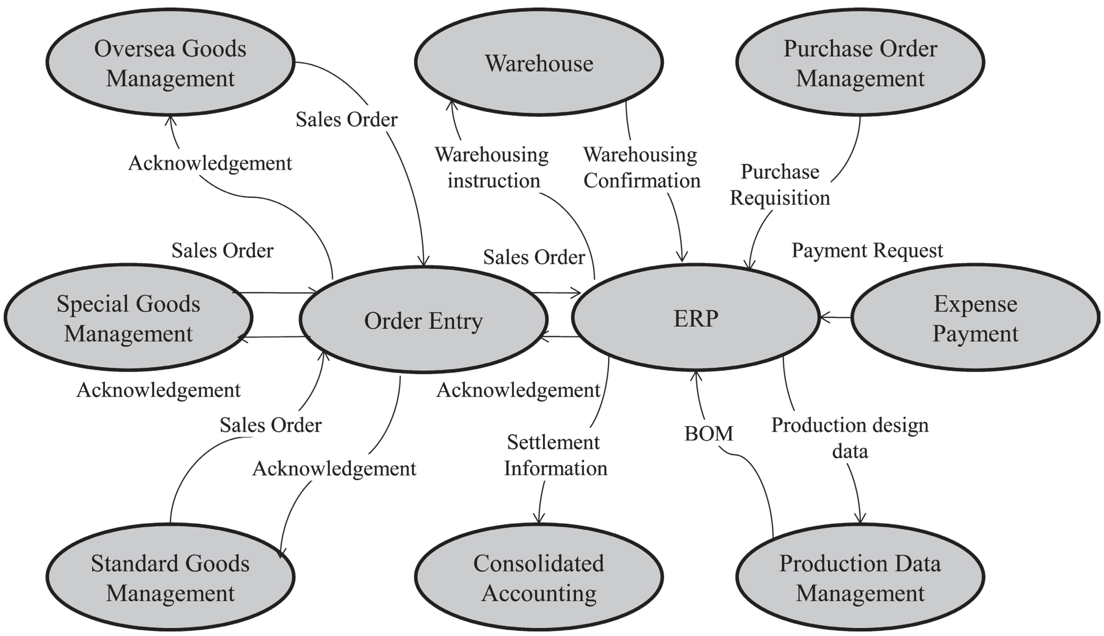

Figure16 An Example of DFD

	Oversea sales mgmt	Special goods mgmt	Standard goods mgmt	Order Entry	Warehouse mgmt	Purchasing order mgmt	Production data mgmt	Expense payment	Consolidated accounting	ERP
Oversea sales mgmt	Oversea sales mgmt			Acknowledge ment						
Special goods mgmt		Special goods mgmt		Acknowledge ment						
Standard goods mgmt			Standard goods mgmt	Acknowledge ment						
Order Entry	Sales order	Sales order	Sales order	Order Entry						Acknowledgm ent
Warehouse mgmt					Warehouse mgmt					Warehousing instruction
Purchasing order mgmt						Purchasing order mgmt				
Production data mgmt							Production data mgmt			BOM
Expense payment								Expense payment		
Consolidated accounting									Consolidated accounting	
ERP				Sales order	Warehousing confirmation	Purchase requisition	Product design data	Payment request	Settlement data	ERP

Figure 17 An Example of G-RD

	Oversea sales mgmt	Special goods mgmt	Standard goods mgmt	Order Entry	Order Entry (Oversea)	Order Entry (Domestic)	Warehouse mgmt	Purchasing order mgmt	Production data mgmt	Expense payment	Consolidated accounting	ERP
Oversea sales mgmt	Oversea sales mgmt			Acknowledgement	Acknowledgement							
Special goods mgmt		Special goods mgmt		Acknowledgement		Acknowledgement						
Standard goods mgmt			Standard goods mgmt	Acknowledgement		Acknowledgement						
Order Entry	Sales order	Sales order	Sales order	Order Entry								Acknowledgment
Order Entry (Oversea)	Sales order				Order Entry (Oversea)							Acknowledgment
Order Entry (Domestic)		Sales order	Sales order			Order Entry (Domestic)						Acknowledgment
Warehouse mgmt							Warehouse mgmt					Warehousing instruction
Purchasing order mgmt								Purchasing order mgmt				
Production data mgmt									Production data mgmt			BOM
Expense payment										Expense payment		
Consolidated accounting											Consolidated accounting	
ERP				Sales order	Sales order	Sales order	Warehousing confirmation	Purchase requisition	Product design data	Payment request	Settlement data	ERP

Figure 18 An Example of Breakdown of Elements

Element “Order Entry” is broken down in one lower level. First of all, the same number of row and column is added behind relevant Element. In this example, two rows and two columns are added behind Element “Order Entry.”

Next, plot these two Elements, “Order Entry (Oversea)” and “Order Entry (Domestic)” on the diagonal line. And Relations for broken down Elements are copied in the cells of relevant locations. This expresses that Relations are added to two new broken down Elements, “Order Entry (Oversea)” and “Order Entry (Domestic).”

Through this break down, new Relations that were not described yet are found. In this case, those Relations are added into relevant cells. And at the same time, Relations are added into original row or column. In this example, Relation “Ship notice” was found. From this finding, it was realized that Element “Oversea Sales management” is needed to break down into lower level Elements, “Oversea Order management” and “Oversea Logistic management.” A new Relation “Ship notice” is added intersection cell which describes from Elements “Order Entry (Oversea)” to Element “Oversea Logistic management.” This Relation is also copied into intersection cell of each higher level Element, “Order Entry” and “Oversea Sales management.”

As well as this, another new Relation “Shipment Required date” was found and added to each relevant cells. The result after new Relations are added is shown in Figure 19.

By utilizing this feature of G-RD, it is possible to reduce the risk that missing Elements or Relations in designing phase. Also it enables adding new Elements and breakdown Relations by confirming the in-Element and out-Element in one figure. This method using multiple Levels in G-RD makes it possible to break down Interaction and Activity Sequence in simultaneous. It is difficult in conventional design method as mentioned in Section 2 in this study.

7. Case studies and effectiveness of new design method

7.1. Case studies

This section shows three case studies which utilized G-RD in the promotion step of each business structural renovation.

7.1.1 Food-service Company A

Food-service Company A applied G-RD to improve business efficiency (Process/ Operation Renovation). The businesses of Company A were broken down by structurizing the business operation in the business design step. First, whole business operation/

	Oversea sales mgmt	Oversea (Order mgmt)	Oversea (Logi mgmt)	Special goods mgmt	Standard goods mgmt	Order Entry	Order Entry (Oversea)	Order Entry (Domestic)	Warehouse mgmt	Purchasing order mgmt	Production data mgmt	Expense payment	Consolidated accounting	ERP
Oversea sales mgmt	Oversea sales mgmt					Ack, **Ship Notice**	Acknowledgement							
Oversea (Order mgmt)		Oversea (Order mgmt)					Acknowledgement							
Oversea (Logi mgmt)			Oversea (Logi mgmt)				Ship Notice							
Special goods mgmt				Special goods mgmt		Acknowledgement		Acknowledgement						
Standard goods mgmt					Standard goods mgmt	Acknowledgement		Acknowledgement						
Order Entry	Sales order, **Req. Date**			Sales order	Sales order	Order Entry								Acknowledgment
Order Entry (Oversea)	Sales order		Shipment Req date.				Order Entry (Oversea)							Acknowledgment
Order Entry (Domestic)				Sales order	Sales order			Order Entry (Domestic)						Acknowledgment
Warehouse mgmt									Warehouse mgmt					Warehousing instruction
Purchasing order mgmt										Purchasing order mgmt				
Production data mgmt											Production data mgmt			BOM
Expense payment												Expense payment		
Consolidated accounting													Consolidated accounting	
ERP						Sales order	Sales order	Sales order	Warehousing confirmation	Purchase requisition	Product design data	Payment request	Settlement data	ERP

Figure 19 The Result after Adding New Relations and Elements

process were classified into two groups. One was Management and Staff business operation, such as head office business. Another was Line business operation such as store operation. Next, each group process was broken down to the practical level. For example, Management operation was broken down to store budget control and so on. Staff business operation was done to store location analysis and so on. Line business operation was done to foods and materials purchasing at stores and so on as well. The relations of business based on this level were designed by G-RD. The new business operation of Company A was launched as planned. The number of Elements of G-RD was 61 and the number of Relations was 415.

7.1.2 Do-It-Yourself store Company B

Do-It-Yourself (DIY) store Company B applied G-RD to clarify the role and business assignment of each company after integrating its businesses by M&A (Business Structure Renovation). Company B is a holding company established by M&A. Company B was consist of three retail companies and one cooperation purchasing company. To rationalize their businesses of the whole group companies and increase the efficiency of management, it was necessary for Company B to integrate the functions and unify the business processes of three retail companies. First, Company B arranged and detailed the roles and allotments of each organization. Next, in order to perform detailed business without inconsistency, it was confirmed by utilizing G-RD what kinds of information linkages between businesses were needed for every main business process. The number of Elements of G-RD was 97 and the number of Relations was 773.

7.1.3 Tool manufacturer Company C

Tool manufacturer Company C applied G-RD for large scale ERP implementation (IT System Renovation). Company C launched a restructuring project to downsize its mainframe systems which has been utilized for more than ten years. At the same time, this Company C aimed to perform BPR.

In this project, the allotment of the function which was to be achieved by ERP and other systems was designed as how it was done by mainframe and other systems. Therefore, the problem, that the number of linkages of information was tremendous and complicated, remained as it was. G-RD was utilized in order to arrange information linkages of ERP and other systems. The number of Elements of G-RD was 40 and the number of Relations was 300.

7.2 Application effectiveness of new design method and consideration

The development estimation can be summarized as shown in Table 2, if the estimation method of the development scale shown in Section 3.2 is applied to this case study of food-service company A. The number of Elements is 61, the number of Relations

Table 2 The Evaluation of Effectiveness of G-RD

Items	Company A	Company B	Company C
Objective	Business efficiency improvement	Business integration after M&A	Large scale ERP implementation
Result of Simultaneous Design Method			
The number of Elements (1)	61	97	40
The number of Elements (2)	415	773	300
The number of Elements (3) = (2)/(1)	6.80	7.97	7.50
Estimated by Sequential Design Method			
The number of Elements (4) = (1)	61	97	40
The number of Relationship (5) = (4)*6	366	582	240
The Ratio of standard unit (6) = (5)/(4)	6	6	6
Evaluation			
Deviation of Relations (7) = (2)-(6)	49	191	60
Comparison of standard unit (8) = (3)/(6)	1.13	1.33	1.25

is 415 designed utilizing G-RD as mentioned Section 5.1, and the number of Relations was 6.80 times the number of Elements.

If the numbers of Elements and Relations are estimated by modified FP method shown in Section 3.2, the number of Elements will be 61 and the number of Relations will be 366, 6 times as much as the number of Elements.

There are more 49 relations designed using G-RD than estimated by modified FP method. The ratio of the number of Relations is 415/366 = 1.13. This has suggested that there is possibility of the omission in a design in the early stage of the information system design, when breaking down the businesses by the conventional Sequential Design Method focusing on Activity Sequence.

Moreover, if it were estimated and developed by the Sequential Design Method, 13% of shortage of workload would have occurred. A case study of company A is application of G-RD to improve the business efficiency. As well as company A, a case study of company B is application of business integration after M&A, and a case study of company C is application of G-RD to large scale ERP implementation. The result of these cases is also summarized in Table 2. For any case, there was more Relations designed utilizing G-RD than those estimated by modified FP method.

The ratio of the number of Relations was 1.33 at company B and 1.25 at company C. It is suggested that Table 2 shows the effect of the Simultaneous Design Method which utilized G-RD in the promotion step of each business structural renovation. (Business

Structure Renovation, Process/Operation Renovation and IT System Renovation)

Next, case studies of applying G-RD to ten companies are considered. These case studies are divided into two groups by five each, one is the Business Requirement Definition and the other is System Requirement Definition. The track record of five companies which applied the Simultaneous Design Method to Business Requirement Definition phase is shown in Table 3. For all cases, it is shown that the ratio of the number of Relation has exceeded 1 and the Simultaneous Design Method is effective. The track record of five companies which applied the Simultaneous Design Method to the System Requirement Definition phase is shown in Table 4. For four of five cases, it is shown the ratio of the number of Relation has exceeded 1 and the average ratio of five cases of Relation is 1.05, so it can be suggested that the Simultaneous Design Method is effective.

Moreover, the average ratio of the number of Relations is 1.26 for Business Requirement Definition and it is larger than that of System Requirement Definition. It can be suggested that Simultaneous Design Method is more effective to apply to early stage of designing phase by utilizing Simultaneous Design Method.

For renovation projects utilizing the conventional Sequential Design Method, there are many cases that must move backward, as the breakdown proceeds and the lack of designing found. As a result of this, workload shortage or delay in delivery has occurred, it prevents lack of design and the accuracy of estimation will be higher, it can be suggested that it is effective method for designing Business operation/process.

Table 3 The Evaluation of Effectiveness for Business Requirement Definition

Items	Company A	Company B	Company D	Company E	Company F	Average
Result of Simultaneous Design Method						
The number of Elements (1)	61	97	20	47	30	
The number of Elements (2)	415	773	187	287	226	
The Ratio of standard unit (3) = (2)/(1)	6.80	7.97	9.35	6.11	7.53	
Estimated by Sequential Design Method						
The number of Elements (4) = (1)	61	97	20	47	30	
The number of Relationship (5) = (4)*6	366	582	120	282	180	
The Ratio of standard unit (6) = (5)/(4)	6	6	6	6	6	
Evaluation						
Deviation of Relations (7) = (2)-(5)	49	191	67	5	46	
Comparison of standard unit (8) = (3)/(6)	1.13	1.33	1.56	1.02	1.26	1.26

Table 4 The Evaluation of Effectiveness for System Requirement Definition

Items	Company C	Company G	Company H	Company I	Company J	Average
Result of Simultaneous Design Method						
The number of Elements (1)	40	44	64	55	57	
The number of Elements (2)	300	266	386	331	330	
The Ratio of standard unit (3) = (2)/(1)	7.50	6.05	6.03	6.02	5.79	
Estimated by Sequential Design Method						
The number of Elements (4) = (1)	40	44	64	55	57	
The number of Relationship (5) = (4)*6	240	264	384	330	342	
The Ratio of standard unit (6) = (5)/(4)	6	6	6	6	6	
Evaluation						
Deviation of Relations (7) = (2)-(6)	60	2	2	1	-12	
Comparison of standard unit (8) = (3)/(6)	1.25	1.01	1.01	1.00	0.96	1.05

8. Conclusion

It is possible to break down Interaction and Activity Sequence in simultaneous by utilizing G-RD. In this proposed Simultaneous Design Method, it is possible to grasp the number of functions and clarify the number of relationships simultaneously from the early stage of designing phase. Hence it is possible to prevent or decrease the risk of lacking design at the Business Requirement Definition step which positioned at the early stage of System Requirement Definition step. Through several case studies, it is suggested the G-RD is effective method to each designing phase of Business Structure Renovation, Process/Operation Renovation and IT System Renovation. The functions and relationships that must be designed in these three phases are equal with the whole role that cooperation possesses and the width between internal and external of operation/process. Therefore, G-RD is expected to expand its capability and application area, as one of the effective modeling approaches to promote business designing.

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