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Horizontal Relation Identification Method to Handle Misalignment of Goals and Strategies Across Organizational Units

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ABSTRACT GQM+Strategies aligns business goals and strategies to help organizations achieve business objectives. Using the initial set of goals and strategies, GQM+Strategies creates a grid, through which the goals and strategies are linked throughout an organization by iteratively determining the lower-level goals and strategies. The GQM+Strategies creates consistency within a vertical refinement tree but cannot handle horizontal relationships from different branches. Hence, horizontal relationships lead to problems, such as redundant investments, inefficient resource utilization, and failure. Horizontal relation identification method (HoRIM) is proposed to handle horizontal relationships. The HoRIM is a grid modification approach that identifies differences between the initial GQM+Strategies grid and a model by interpretive structural modeling (ISM). Herein, we experimentally demonstrate that HoRIM finds about 1.5 times more horizontal relationships than an *ad hoc* review. Additionally, we show its practicality via a case study involving a real-world application.

INDEX TERMS GQM+Strategies, integration of technology and business strategies, interpretive structural modeling (ISM), horizontal relationship, alignment of strategies.

I. INTRODUCTION

Organizations in the Business Process Management (BPM) community are more likely to be successful if their organizational goals and strategies align [1] because alignment is directly related to performance [2]. One way to realize such alignment is GQM+Strategies®[1] [3], [4]. It provides a hierarchical structure called a GQM+Strategies grid based on the organizational structure and a measurement model called the GQM (Goal Question Metrics) model [5].

Using the initial set of goals and strategies, including IT strategies, GQM+Strategies creates a grid through which goals and strategies are linked throughout an organization by iteratively determining lower-level goals and strategies.

Figure 1 shows an example of a GQM+Strategies grid. Vertical relationships connect a child and its parent strategy. GQM+Strategies creates consistency within a vertical refinement tree as it clearly links vertical strategies. However, it cannot handle horizontal relationships from different branches (red lines in Fig. 1) such as S4 and S7, which employ the same approach.

Horizontal relationships in a GQM+Strategies grid cause issues, including implementing contradictory strategies and inefficient use of resources. Hence, addressing horizontal relationships help an organization maximize its resources. [6]. In GQM+Strategies, horizontal relationships are subjectively determined, which often results in overlooked horizontal relationships, especially for complex GQM+Strategies grids.

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[1]GQM+Strategies® is a registered trademark No. 302008021763 at the German Patent and Trade Mark Office and international registration number IR992843.

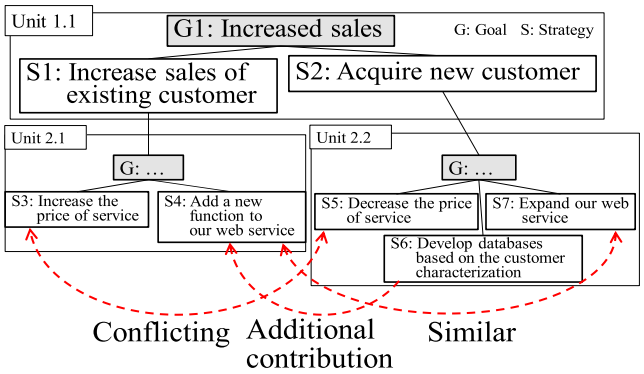

FIGURE 1. Example of a GQM+Strategies grid.

Horizontal Relation Identification Method (HoRIM) identifies and handles horizontal relationships.[2] HoRIM is a grid modification approach that finds differences between the initial GQM+Strategies grid and a model by Interpretive Structural Modeling (ISM) [7]. The hierarchical structure generated in ISM makes the relationships between elements easier to understand.

Our experiment addresses the following research questions (RQs):

- RQ1: Which (HoRIM or an ad hoc review) is more effective at identifying horizontal relationships in GQM+Strategies grids?
- RQ2: Which (HoRIM or an ad hoc review) is more efficient at identifying horizontal relationships in GQM+Strategies grids?
- RQ3: Does HoRIM have practical applications for real-world GQM+Strategies grids?

This paper proposes HoRIM to identify horizontal relationships, demonstrates its effectiveness, and applies it to a real example to confirm its practicality.

The rest of this paper is structured as follows. GQM+Strategies and the motivating examples are overviewed in Section II. HoRIM is explained in section III. Sections IV and V evaluate and conduct a case study of HoRIM, respectively. Section VI introduces related works. Finally, section VII concludes this paper.

II. BACKGROUND

A. GQM+STRATEGIES

The GQM approach creates measurement programs [5] and is an extension that provides a hierarchical structure called a GQM+Strategies grid to align organizational goals and strategies throughout an organization. A grid consists of GQM graphs [8] and GQM+Strategies elements (Fig. 2).

By assessing the goals across all organization levels, a GQM graph assesses whether a goal is achieved using goals, questions, and metrics. The goal indicates the objective. Questions are designed to quantify how to measure goal

[2]This paper is an extension of a paper presented at the 49th Hawaii International Conference on System Sciences (HICSS-49) [24] and several parts taken from another paper titled "Experimental Evaluation of HoRIM to Improve Business Strategy Models" presented at ICIS 2017.

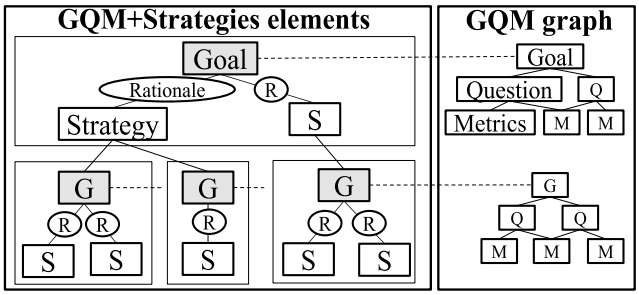

FIGURE 2. GQM+Strategies grid [10].

achievement. Finally, metrics are defined to quantitatively answer the questions [9]. In this scheme, metrics are collected for specific questions designed to evaluate a goal.

GQM+Strategies elements are designed to align goals and strategies throughout an organization. These elements specify organizational goals, strategies, rationales, and their mutual relationships. The goal is the objective to achieve. A strategy is the means to achieve a goal, while a rationale refers to the necessity of the goal and strategy.

The initial goal is used to create a GQM+Strategies grid. The grid is then iteratively decomposed to create a concrete goal using four steps:

1. Define the initial goal.
2. Specify strategies and rationales to achieve the goal.
3. If the strategies can be refined, go to 4. If not, stop as the GQM+Strategies grid is complete. Use qualitative analysis to determine whether further refinement is needed.
4. Define goals of the lower level units and return to step 2.

B. PROBLEM AND MOTIVATING EXAMPLE

Our research aims to improve strategy execution using GQM+Strategies grids. Strategies can have vertical and horizontal relationships. Vertical relationships are those such as a parent-child relation between strategies, while horizontal relationships occur between different branches. Although both types may be present, GQM+Strategies grids only support vertical relationships. The presence of horizontal relationships often leads to misalignment across organizational units [11].

Here, three kinds of horizontal relationships are considered: conflicting strategies, additional contributions, and similar strategies. Below, each kind is described using a simple example of a GQM+Strategies grid in Fig. 1. For the goal of increase sales (G1), two units (1 and 2) each adopt its own strategy to achieve G1. S1 is to increase existing customer sales and S2 is to increase sales to new customers. S1 and S2 likely have horizontal relationships.

1) CONFLICTING STRATEGIES

To achieve S1, unit 1 proposes increasing the service price (S3). On the other hand, unit 2 proposes reducing the service price (S5) to achieve S2. These strategies will undermine each

other if both are executed simultaneously. Thus, units 1 and 2 need to work together to determine the service price and ensure uniform operations.

2) ADDITIONAL CONTRIBUTIONS

This situation arises when the implications of a strategy are not fully considered. As shown in Fig. 1, unit 1 proposes adding a function to our service (S4) and unit 2 proposes developing a database using customer characteristics (S6). If S4 and S6 are pursued independently, resource utilization is not maximized because the results of S6 could determine which service should be added to achieve S4. Because S6 has an additional contribution to S4, fully understanding the impact of S6 on S4 increases the likelihood that S4 will be successful and enhance the overall product quality.

3) SIMILAR STRATEGIES

In development, similar strategies lead to challenges such as redundancies and inefficient use of resources. Integrating similar strategies into one improves efficiencies. Using the example in Fig. 1, add a new function to a web service (S4) and expand our web service (S7) both aim to enhance the web service. However, executing both strategies is a waste of limited resources.

Identifying and addressing horizontal relationships will mitigate the above problems. Figure 1 depicts a simplistic example. Because actual GQM+Strategies grids are more complex, horizontal relationships are often overlooked. To address this shortcoming, HoRIM is proposed to elucidate horizontal relationships.

III. APPROACH

HoRIM is a grid modification approach that identifies differences between the initial GQM+Strategies grid and a model using Interpretive Structural Modeling (ISM). Typically, ISM analyzes the relationships between elements such as knowledge management barriers and educational factors. However, ISM determines the relationship between two elements via a relation matrix. The relation matrix subsequently generates the hierarchical structure between elements. Typically, a GQM+Strategies grid is reviewed by the person who constructed the grid and a supervisor (or promoter). Similarly, these parties can use HoRIM.

HoRIM has the many benefits. First, using a relation matrix, it analyzes all relationships between strategies. Second, it not only finds horizontal relationships between strategies, but also categorizes the types of relations. Third, it can be used to classify three or more strategies. Finally, its hierarchical structure allows the GQM+Strategies grid to be modified.

HoRIM identifies and handles the horizontal relationships in a GQM+Strategies grid (Fig. 3). Once a GQM+Strategies grid is generated, then HoRIM is applied via a review. HoRIM consists of the following steps:

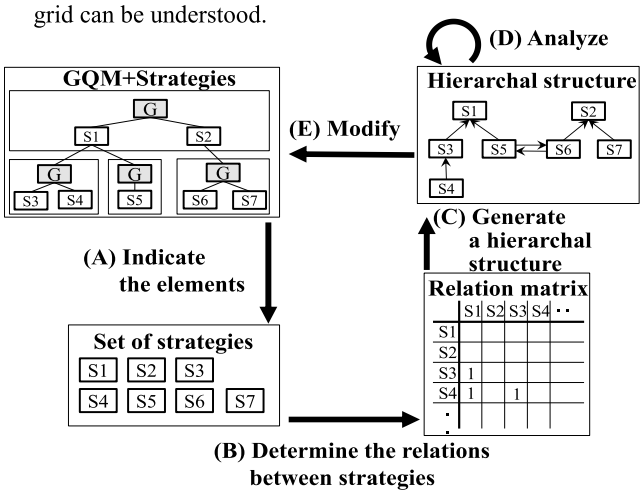

FIGURE 3. Overview of HoRIM.

A) Identify elements.
B) Determine relationships between strategies.
C) Generate a hierarchical structure.
D) Analyze.
E) Modify.

Steps (B), (D), and (E) are manual. Step (A) is semi-automatic, whereas step (C) is automatic.

Reviewing the entire GQM+Strategies grid (ad hoc) to find horizontal relationships is daunting, especially for complex grids. On the other hand, comparing strategy pairs is straightforward. Step (B) simply evaluates strategy pairs. The hierarchal structure is generated automatically in step (C). Hence, the overall relationships in the GQM+Strategies grid can be understood.

A. IDENTIFY ELEMENTS

The first step in HoRIM is to list the elements in the hierarchical structure. Because not all strategies in the GQM+Strategies grid are defined as elements, the applicability of HoRIM may be limited. As an example, Fig. 1 shows all the strategies defined as elements in order to apply HoRIM to the entire GQM+Strategies grid.

B. DETERMINE RELATIONSHIPS BETWEEN STRATEGIES

Next, the relationships between strategies are carefully ascertained since they affect the grid modification result. All direct binary relationships are expressed in relation matrix $A = \{a_{ij} \mid i, j = 1, 2, \cdots, n\}$ [12], where "n" is the number of the strategies, which are the rows and columns of the relation matrix. In the matrix, related row and column elements are scored as 1 and unrelated ones are scored as 0. Diagonal elements are not evaluated.

The relationships between the rows and columns can be classified into three types: affect/affected, support/supported, and overlapping. The ISM approach often contains unidirectional relationships. On the other hand, mutual overlapping relationships, which express similar and conflicting strategies, are unique to our approach.

TABLE 1. Element levels.

Element	Reachability set	Antecedent set	Intersection set	Level
S1	S1	S1, S3, S4, S5, S6, S7	S1	I
S2	S2	S2, S3, S4, S5, S6, S7	S2	I
S3	S1, S2, S3, S5	S3, S5	S3, S5	II
S4	S1, S2, S4, S7	S4, S6, S7	S4, S7	II
S5	S1, S2, S4, S5	S3, S5	S3, S5	II
S6	S1, S2, S4, S6, S7	S6	S6	III
S7	S1, S2, S4, S7	S4, S6, S7	S4, S7	II

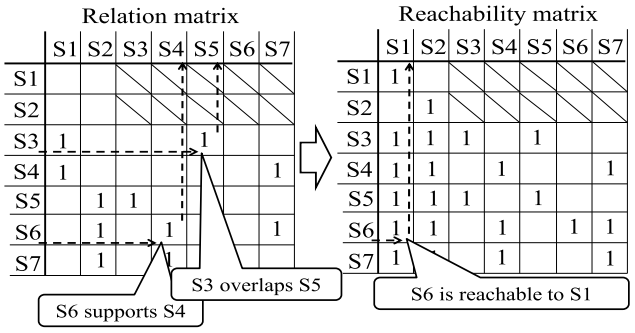

FIGURE 4. Relation matrix and reachability matrix.

Overlapping approaches and targets represent similar or conflicting strategies. Affect/affected and support/supported relationships denote additional contributions as well as the type of conflicting strategy (e.g., negative influence).

To demonstrate how a direct relationship between two elements is identified, Fig. 4 shows an example relation matrix based on the grid in Fig. 1. Because S6 supports S4, a_{64} has a value of 1. Because S3 overlaps with S5, a_{35} and a_{53} both have values of 1.

In HoRIM, some cells are filled automatically. Elements with vertical relationships are assigned a value of 1. As HoRIM is intended to identify horizontal relationships, it does not inspect vertical relationships. A higher-level strategy should overlap with a lower-level one and its relationship is known. An element where the row and column indicate a higher-level and lower-level strategy, respectively, denotes a hierarchical structure with circulation. A higher-level strategy should be at the top compared to the initial GQM+Strategies grid in step (D).

C. GENERATE THE HIERARCHICAL STRUCTURE

The hierarchical structure is generated via the same algorithm as ISM automatically. Initially, reachability matrix M is calculated. This denotes the element and the column elements that can be reached by a row element [12]. As an example, Fig. 4 shows a reachability matrix where S6 reaches S1 because S4 is related to S6 and S4 is related to S1.

Equations (1) and (2) show how the reachability matrix M is calculated. "I" is the unit matrix. If $(A+I)^{(k+1)} = (A+I)^k$, then $(A+I)^k$ is the reachability matrix.

$$(A+I) \neq (A+I)^2 \neq \cdots \neq (A+I)^k = (A+I)^{k+1} \quad (1)$$

$$M = (A+I)^k \quad (2)$$

Next, the reachability matrix is used to determine the reachability set and the antecedent set. The reachability set simply represents the element and other elements that it may reach. The antecedent set consists of the element itself and the other elements that may reach it [13]. Using S3 in Fig. 4 as an example, the reachability set is S1, 2, 3, and 5, whereas the antecedent set is S3 and 5.

Third, the intersection of the reachability set and the antecedent set separates the elements into different levels. The element with identical reachability and intersection sets is the top-level element of the hierarchical structure. The top elements do not reach elements above their level. Hence, after a top-level element is identified, it is separated from the remaining elements. Next-level elements are determined by iteratively repeating this process [13]. Table 1 shows the reachability, antecedent, intersection sets, and levels from the example in Fig. 4.

D. ANALYZE

Here the hierarchical structure is used to find horizontal relationships. The hierarchical structure of the grid considers all relationships except vertical ones (Fig. 5). Similar and conflicting strategies are determined by confirming mutual relationships. Strategies using the same approach or targets are likely similar relationships, whereas those that negatively impact each other are likely conflicting. In Fig. 5, the relationship between S4 and S7 and that between S3 and S5 depict similar and conflict relationships, respectively.

Verifying unidirectional relationships such as S6 to S4 and S7, can elucidate additional contributions to a strategy and determine horizontal relationships within the hierarchical structure.

E. MODIFY

The last step is to modify the GQM+Strategies grid from the viewpoint of horizontal relationships. There are four types of modifications: detail, select, integrate, and breakthrough. Detail concretely prevents overlap. Select chooses one option from two or more similar strategies. Integrate combines similar strategies. Breakthrough creates new strategies to address conflicting ones. However, the applicable modification approach depends on the type of horizontal relationship (Table 2). Detail, select, integrate, and breakthrough can modify conflicting strategies, while all but breakthrough can modify similar strategies. Multiple approaches (such as detail and integrate) may be applied to resolve the same horizontal relationship. On the other hand, only detail and relate can modify additional contributions.

TABLE 2. Correspondence of the kinds of horizon relationships and potential approaches.

Horizontal relationship	Approach				
	Detail	Select	Integrate	Breakthrough	Relate
Conflicting	✓	✓	✓	✓	
Similar	✓	✓	✓		
Additional contribution	✓				✓

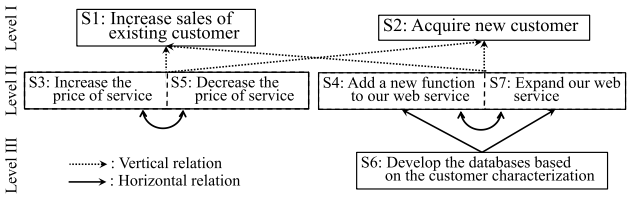

FIGURE 5. Hierarchical structure.

Many techniques have been proposed to address conflicting strategies. One is a conflict resolution diagram, which verifies that a lower strategy contributes to a higher strategy (or goal) [14]. If the contribution is unclear, then it should be clarified by adding a rationale and revising the strategic description. Using Fig. 5 as an example, the contribution of S6 to S4 must be added to the GQM+Strategies grid.

On the other hand, the five-solution approach considers three viewpoints. One is the influence of the strategy on the parent goal. A larger influence indicates that a strategy contributes more to the goal. Deleting strategies with a high influence may have a negative impact on achieving the goal. However, if the influence is low and the strategy can be modified or deleted, detail or select is appropriate.

The second is the strength of a horizontal relationship. A strong relationship indicates a large influence on each other. For example, conflicting strategies with a high influence counteract each other and it will be difficult to realize a new strategy using breakthrough than those with a smaller influence. In contrast, similar strategies with a large influence mean that they are actually the same. Consequently, integrate is an effective approach.

The third is the complexity of the GQM+Strategies grid, which denotes the number of strategies, goals, and their relationships. Implementing select and integrate reduce the complexity as they decrease the number of strategies. In contrast, breakthrough and relate increase the complexity and create more strategies. If a less complicated grid is preferable, the select and integrate should be employed.

Figure 6 shows an example of a modified GQM+Strategies grid of Fig. 1. It should be noted that the ideal modification depends on the organizational principle and situation.

IV. EVALUATION

The effectiveness (RQ1) and efficiency (RQ2) of HoRIM and an ad hoc review are evaluated experimentally. In an ad hoc review, horizontal relationships are subjectively determined. The experiments are designed to answer RQ1 and

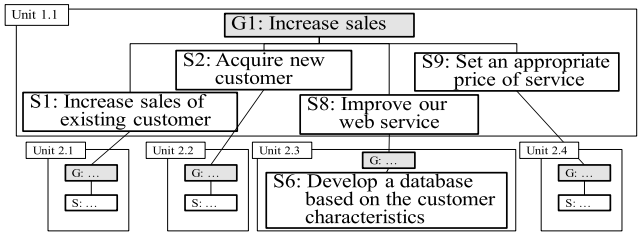

FIGURE 6. Refined GQM+Strategies grid.

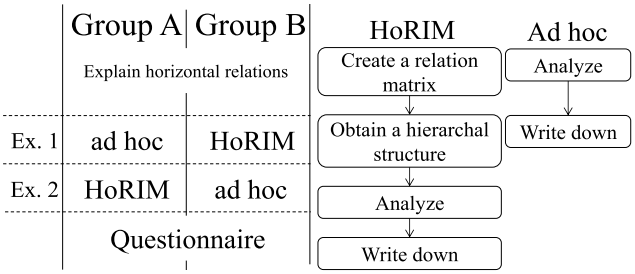

FIGURE 7. Experimental overview.

RQ2. In addition, a case study evaluates the practical application of HoRIM (RQ3). In the case study, HoRIM is applied to the GQM+Strategies grid of a company that provides housing-related services and products (Recruit Sumai).

A. EXPERIMENTS

The subjects were university students majoring in computer sciences who belong to our laboratory. They ranged from 4th year undergraduates to second year master's students. As shown in Fig. 7, the students were divided into two groups of three students (Groups A and B). All subjects were familiar with modeling a GQM+Strategies grid. Prior to the experiments, we explained the concept of a horizontal relationship.

The experiment involved analyzing horizontal relationships in a GQM+Strategies grid. In an experiment, each group received the same grid. The grids were 3-level layers with about 23 strategies. All groups were asked to judge all the horizontal relationships and to explain their rationale for their judgment. One group used HoRIM, while the other used an ad hoc review. The experiment was finished when the subject thought that all horizontal relationships were identified (i.e., unrestricted time limit). The number of identified horizontal relationships and the time required to complete the exercise were measured.

This experiment employed materials for GQM+Strategies introduced in other seminars. Experiment 1 and 2 had domains of a cosmetic company and a stationery company, respectively. For experiment 1, Group A used HoRIM and Group B used an ad hoc review. In experiment 2, the methods were switched.

After completing both experiments, the subjects completed a questionnaire on the ease of identifying horizontal relationships using each method and the utility of HoRIM. Questions were answered on a six-point scale.

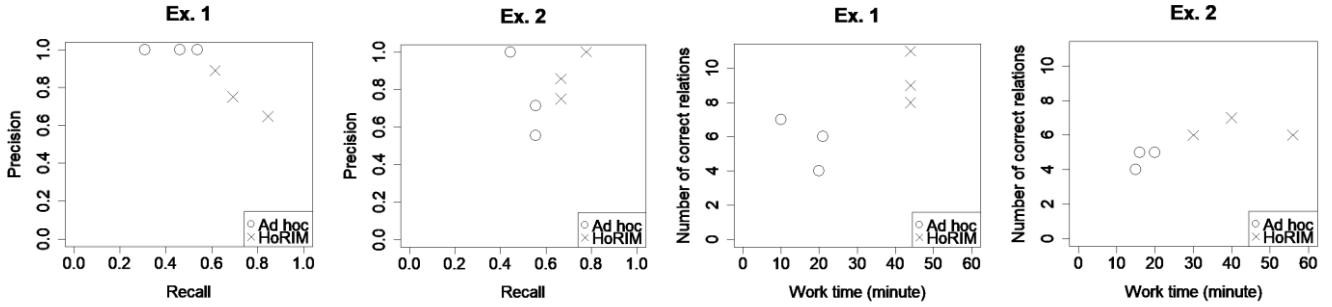

FIGURE 8. Experimental results.

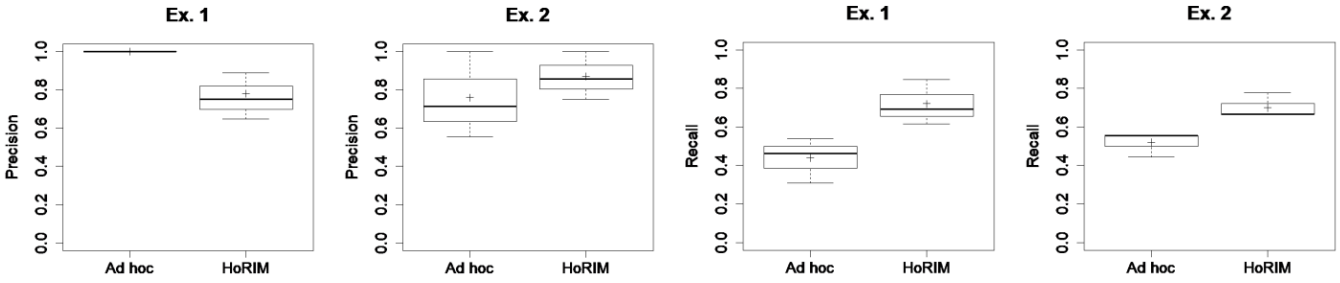

FIGURE 9. Boxplot results on the precision and recall.

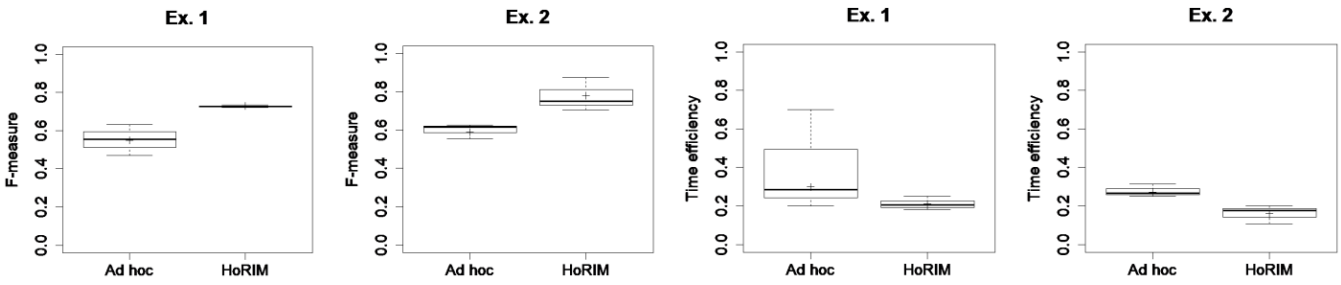

FIGURE 10. Boxplot results of the F-measure and time efficiency.

College Analysis Ver5.1 [15] can be used to analyze the hierarchical structure from a relation matrix by ISM. In the experiment, the group using HoRIM used College Analysis to create a relation matrix of the strategies, generate the hierarchical structure, and analyze the structure.

B. RESULTS

As shown in Fig. 8, the two graphs on the left plot the precision against recall and the two on the right plot the number of identical relationships against work time. An "o" and "x" denote using an ad hoc review and HoRIM, respectively. Figure 9 depicts the boxplots of the precision and recall, while Fig. 10 is the boxplots of the F-measure and time efficiency.

Table 3 shows the questionnaire results of the questionnaire. Q1 (Q2) are about how easily horizontal relationships can be determined by an ad hoc review (HoRIM). Q3 asked about the functionality of HoRIM and whether HoRIM is worth the effort. All responses used a six-point scale where 1 indicates strongly disagree and 6 indicates strongly agree.

TABLE 3. Questionnaire results.

	1	2	3	4	5	6	Average score
Q. 1	0	0.17	0.67	0.17	0	0	2.8
Q. 2	0	0.17	0.22	0.38	0.22	0	4.7
Q. 3	0	0	0.17	0.50	0.33	0	4.1

C. DISCUSSION

1) RQ1

Figure 9 shows that HoRIM has about 1.5 times higher recall than that of an ad hoc review. This shows that HoRIM is more effective. Not only did subjects using HoRIM identify more relationships, they also found more complex relationships involving three or more strategies. Because more complex strategies can be visualized, HoRIM assists in analyzing complex GQM+Strategies grids.

In exercise 1, the ad hoc review is more precise. Moreover, the group using the ad hoc review in exercise 1 made more mistakes in exercise 2 using HoRIM.

2) RQ2

Figure 10 shows that HoRIM is more time consuming than an ad hoc review. This is because a relation matrix, which involves checking n∗n (n is the number of strategies) cells, must be created for HoRIM. Although checking each cell is straightforward, creating the relation matrix is cumbersome due to the sheer volume. In the future, a method to easily create a relation matrix should be devised.

HoRIM has three benefits. It identifies horizontal relationships in GQM+Strategies. Thus, the generated structure by HoRIM yields a logical argument that the GQM+Strategies grid is free of horizontal relationships. Second, it provides knowledge for future iterations of the GQM+Strategies grid because deploying HoRIM elucidates why the grid needs to be refined. Although more time consuming, using HoRIM is deemed to be a valuable asset. Table 3 shows that 83% of the subjects indicated in a survey that HoRIM is worth the effort.

An ad hoc review is more efficient than HoRIM, but HoRIM identifies more horizontal relationships. Moreover, it is unclear if all the horizontal relationships can be found in an ad hoc review. Although an ad hoc review may be suitable for a simple GQM+Strategies grid, HoRIM visualizes horizontal relationships in a large and complex grid more effectively.

3) THREATS TO VALIDITY

The subjects had differing abilities and experiences. This is a threat to the internal validity. To remove this bias, we divided the subjects into two groups. For exercise 1, Group A employed HoRIM, while group B used an ad hoc review. The conditions are the opposite in exercise 2. In both exercises, HoRIM is more effective than an ad hoc review. The precision and effectiveness of HoRIM cannot be verified due to the small sample size. In the future, an experiment involving more subjects should be conducted.

The study involved students with limited knowledge of the strategies in GQM+Strategies grids. Additionally, only two GQM+Strategies grids (a cosmetic company and a stationery company) are examined. Moreover, this study used simple GQM+Strategies grids, which are easily analyzed, and this may skew the actual effectiveness of HoRIM. These are threats to external validity.

V. CASE STUDY

A. BACKKGROUND

To demonstrate the practicality of HoRIM, Recruit Sumai is used as an industrial case. Recruit Sumai provides housing-related publications and services such as a retrieval service of apartments in Japan. The planning section of Recruit Sumai uses GQM+Strategies to develop new services, products, and businesses.

The workshop involved four employees from the planning section and three of the authors. The workshop consisted of two three-hour sessions. First, the authors taught the employees how to use GQM+Strategies. Next, the members of the planning session constructed a grid on their own. The grid was developed in the first session. The second session proposed new businesses and inspected their lifecycles quantitatively.

The overarching organizational goal was to increase the number of excellent business proposals. This led to two strategies. The first was to increase the number of participants in a competition (S1). The second was to improve the quality of the proposals (S2). Figure 11 shows the GQM+Strategies grid.

We reviewed the GQM+Strategies grid to verify consistency between the closest strategy and goal with the rationales. Because the consistency between the different branches (i.e., horizontal relationships) could not be identified, HoRIM was used to examine whether the GQM+Strategies grid contained horizontal relationships.

B. RECONSTRUCTION & ANALYSIS

By creating a relation matrix based on the strategies of the constructed GQM+Strategies grid, the combinatorial relationships between the strategies with the relation matrix and specified relationships not expressed in the GQM+Strategies grid are verified. A hierarchical structure was generated based on the specified relation matrix.

The initial GQM+Strategies grid (Fig. 11) and the generated hierarchical structure (Fig. 12) have three differences (the relationship of S6 to S1, mutual relationship between S5 and S7, and the relationship of S8 to S9). Consequently, we examined these in detail.

Develop more interesting themes (S6) is considered to contribute to increase participation in the competition (S1) because S6 should influence S1. An interesting theme should help realize S1, while a dull theme should not. To address this, either this relationship should be clarified or S6 should be omitted.

Design feedback for participants (S5) and support participants during the competition (S7) are considered to be similar strategies. S7 includes procedures for the competition and proposal review, while S5 includes proposal review. Thus, one strategy should be selected or these should be integrated to maximize resource utilization. However, if ''support'' in S7 has a different meaning than above, it should be specified to remove ambiguity.

Participants take charge of new business (S8) is considered to be a contribution to give participants initiative (S9). For example, the prize for S9 could be the launch of a new business. Hence, S9 is a refined strategy from S8, but S9 also helps achieve G3. This relationship is simplistic because the intermediate rationale to appoint new business as a motivation to participants, is missed. S8 should be moved to a higher level than S9 to maximize resource utilization and to improve the analysis accuracy.

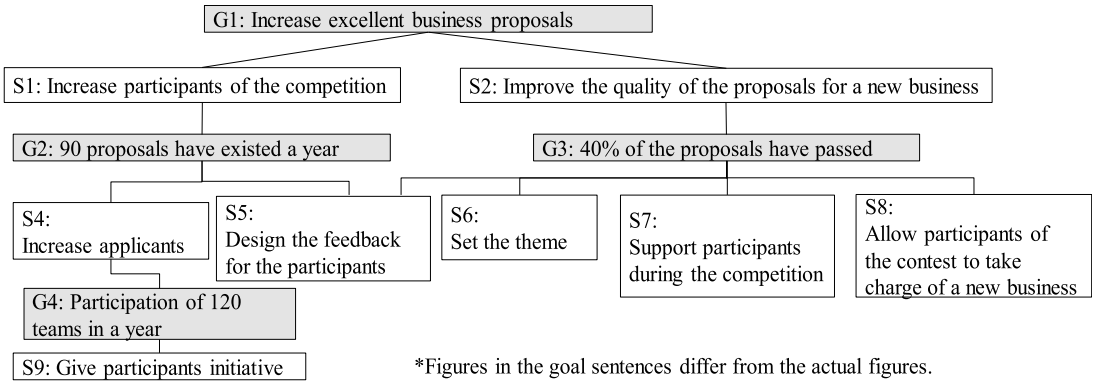

FIGURE 11. Part of the initial GQM+Strategies of Recruit Sumai.

C. MODIFICATION

To modify the contribution, details of the strategies, their relationships, or both must be clarified. As an example, consider set the theme (S6) and increase participation in the competition (S1) in Fig. 11. In this case, S1 should not be revised as it affects many lower strategies. S6 should be refined to specify the relationship of S6 to S1. Revising S6 to set an interesting theme clarifies the importance of identifying an interesting theme as a means to achieve S1.

S5 and S7 are integrated because support in S5 means feedback on the proposal. The only difference is the periodicity of providing feedback. Refining S5 to indicate that this occurs prior to the competition removes the horizontal relationship. S7 implies the adviser in the planning section cannot provide feedback to the participants due to time constraints. Because all feedback should be part of S5, it is revised to provide feedback to the participants at any time. The revision is clearer, and the revised S5 prioritizes efficiency of feedback over quantity.

The additional contribution from S8 to S9 can be modeled in two ways. Either strategies can be detailed or relationships can be added. As ensuring that S8 and S9 are separate and distinct is challenging, relationships are added. S8 is a refined strategy of S9, but the rationale from S8 to G3 is that participants are motivated by a new business, indicating that motivation will result in higher quality proposals. As this implication is the rationale from S8 to G3, the relationship of S8 to G3 should be added. In this revision, S9 becomes more important as it contributes to G2 and G3. Hence, both S8 and S9 are related to G3 and the relationship of S8 to S9 is omitted. The revised GQM+Strategies grid shows that S8 contributes to G3 through S9.

Figure 12 shows the modified GQM+Strategies grid where the horizontal relationships are resolved. S1 does not affect S6, S5 and S7 are not similar, and S9 does not contribute to S8.

D. DISCUSSION

HoRIM identified three horizontal relationships in the GQM+Strategies grid of an industry case (RQ3). One member of the planning section stated that removing the horizontal relationships improved the grid. An ad hoc review during the development of a GQM+Strategies grid rarely identifies horizontal relationships. In contrast, horizontal relationships are easily identified in HoRIM because the relation matrix checks strategy pairs.

Handling horizontal relationships improves the GQM+Strategies grid by clarifying the points to be discussed, execution efficiency of the strategies, and accuracy of the analysis of the results.

An ad hoc review can derive incorrect horizontal relationships because the lack of formal methods and processes may result in a misinterpreted meaning. Although this results in incorrect analysis of horizontal relationships, the crux of the problem is that a vague strategic description is open to misinterpretation. Each strategy should have one interpretation. S7 in the case study had multiple meanings.

This case study did not fully utilize the hierarchical structure by ISM. ISM is more effective when the strategies have complex relationships. As our future work, we plan to analyze a grid with more than three horizontal relationships in order to validate the effectiveness of HoRIM in more complex GQM+Strategies grids and to clarify how the precision of the initially identified relationships between strategies affects further modifications and the effectiveness of HoRIM.

VI. RELATED WORK

A. GQM+STRATEGIES EXTENSION

GQM+Strategies has been expanded in various ways. One study reported that the GQM+Strategies approach can improve business value analysis (BVA) [16]. They employed a cost-benefit evaluation to select the organizational strategies. They have also integrated the GQM+Strategies and the Earned Value Analysis [26]. Another developed the Context-Assumption-Matrix (CAM) [17]. CAM extracts rationales by analyzing the relationships between stakeholders to refine the GQM+Strategies model. One study proposed GQM+S-EI to determine information needed by GQM+Strategies [18]. GQM+S-EI provides questions to comprehensively identify GQM+Strategies elements from stakeholders.

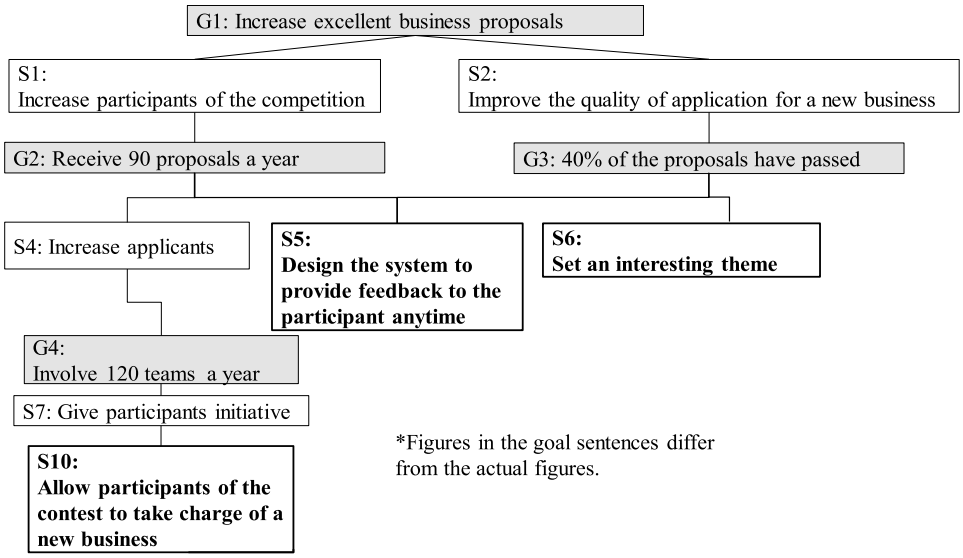

FIGURE 12. Modified GQM+Strategies grid of Recruit Sumai.

GO-MUC (Goal-oriented Measurement for Usability and Conflict) expands GQM+Strategies [19]. Business goals and the user's purpose are analyzed to reveal conflicts between the business and user to create a GQM+Strategies grid and a GQM+P (GQM+Persona) graph. Unlike their study, our study uses a single graph to identify relationships.

A formal notation of the GQM+Strategies concepts and a method to create the GQM+Strategies grids have been proposed by introducing causality theory based on the notation [25]. This method can quantify experts' knowledge and beliefs regarding the effectiveness of organizational strategies. GQM+Strategies plus causal analysis was used to support strategies identification [29].

However, these studies do not address horizontal relationships over different branches in the grids. One study proposed a project alignment matrix to support the assessment of strategic project alignment [27]. Although the matrix can link strategies over different branches in the grids, it does not explicitly consider horizontal relationships.

GQM+Strategies was applied in a systems product development organization. The importance of cross-team dependency identification to refine the GQM+Strategies grids and accurate execution of plans were revealed [28]. Such cross-team dependencies may exist over different branches in the initial grids prior to refinement. However, they did not employ any concrete techniques for the identification except for workshops with no clear systematic procedure.

B. BUISINESS AND PROJECT ALIGNMENT

Under the software process improvement contexts, some research have strived to align organizational and business goals with strategic projects. One proposed a framework named M^3P as an extension of GQM in a three-tier hierarchy by linking business measures, processes, and projects [30].

Another proposed a related framework to align strategic and project management systems by integrating GQM and the Balanced Scorecard (BSC) [31].

Although these studies can be used to align business and organizational goals with specific projects, they do not explicitly consider horizontal relationships over different organizational goals.

C. REQUIREMENTS CONFLICTS RESOLUTION AND REFINEMENT

Some studies have strived to identify conflicts between requirements. One used a specific grammar (e.g., EBNF) to formally describe requirements. They identified potential inconsistencies and/or conflicts through semantic analysis of the information in textual requirement descriptions [20]. Unlike their study, our research includes the causal relationship but manual analysis is necessary.

Another study proposed an effective approach to detect and solve inconsistencies and conflicts in web software requirements using both the web requirements model and semantic analysis [21]. They employed an algebraic comparison of models to identify potential structural and navigational conflicts.

One study proposed combining the output of GORE and Analytic Hierarchy Process (AHP) to find the best alternative among candidates [22]. Similar to their study, we emphasize the hierarchical structures of GORE models. However, we strive to derive the best model, while they aimed to identify the best alternative.

A previous study aimed to refine goal models by proposing an elaborate process to refine the goal model to determine the changes necessary in subsequent development processes [23]. To avoid unnecessary couplings, similar goals are integrated. Like this study, our research refines goal models, but we strive to determine relationships between elements before refining the goal model.

VII. CONCLUSION AND FUTURE WORK

GQM+Strategies grids often have horizontal relationships (similar strategies, additional contributions, and conflicting strategies) between strategies in different branches. As horizontal relationships lead to misalignment within an organization, they must be exhaustively identified and resolved. To address this, we propose HoRIM. Although HoRIM is more time consuming than an ad hoc review, it more effectively identifies horizontal relationships.

In the future, we plan to develop a method to create a relation matrix in HoRIM quickly. For example, we aim to incorporate a method to suggest noteworthy relationships based on the similarity and dependence by natural language processing. Moreover, to improve hierarchical structure analysis, we will expand HoRIM so that it can distinguish the impact of a relationship (e.g., a positive, negative, and overlap) and perform a coherency analysis. In addition, we plan to extend the scope of related works, including the theory of system organization.

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