Identifying Potential Problems and Risks in GQM+Strategies Models Using Metamodel and Design Principles

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Abstract

Although GQM+Strategies®[1] assures that business goals and strategies are aligned throughout an organization and at each organizational unit based on the rationales to achieve the overall business goals, whether the GQM+Strategies grid is created correctly cannot be determined because the current definition of GQM+Strategies allows multiple perspectives when aligning goals with strategies. Here we define modeling rules for GQM+Strategies with a metamodel specified with a UML class diagram. Additionally, we create design principles that consist of relationship constraints between GQM+Strategies elements, which configure GQM+Strategies grids. We demonstrate that the GQM+Strategies grids can be automatically determined with the help of design principles described in OCL. In fact, an experiment is implemented using these approaches in order to show that this method helps identify and improve potential problems and risks. The results confirm that our approaches help create a consistent GQM+Strategies grid.

1. Introduction

Companies are increasingly recognizing the importance of software and IT in their current and future business strategies [1]. Therefore, many companies align various business goals with IT strategies to improve the effectiveness of their business process. However, success can remain elusive because the relationship between a goal and a strategy is unclear.

GQM+Strategies [2] is a method to solve this problem. It is an integrated approach capable of creating a hierarchical model that ensures alignment between goals and strategies at different levels, ranging from the highest strategic level of the business to individual development projects.

However, the usage directions and design principles for GQM+Strategies are not defined clearly, which tends to cause issues for users of GQM+Strategies grids. After that, we call GQM+Strategies grid "grid". Issues include "Not being able to check whether grids drawn are correct because how to draw a grid is not described in detail" and "Not being able to confirm potential problems and risks in a grid". Therefore, we propose expressing a GQM+Strategies metamodel by UML [3] to define GQM+Strategies in detail. Additionally, we determine possible grids by defining design principles that constrain all relationships among elements. We describe the design principles by Object Constraint Language (OCL) [4] to automatically determine the grids using an existing tool.

Grids may have structural and/or content problems. The former are caused by incorrect connections between elements, such as connections contrary to the organizational structure. The latter are caused by the content of goals and strategy, such as inconsistency in the content of several strategies in the grid [5]. We examine only the former in this paper.

In this paper, we examine the following research questions about the problems and risks of a grid. A problem means that some points violating design principles exist in a grid, while a risk is a strategic danger caused by this problem.

- RQ1: Do GQM+Strategies grids contrary to the design principles actually exist?
- RQ2: Can the GQM+Strategies metamodel and design principles help identify potential problems and risks?
- RQ3: Can GQM+Strategies metamodel and design principles help improve GQM+Strategies grids with problems or risks?

This paper has two contributions. First, the metamodel specified with UML serves as the basis for inspection and enforcement of strict modeling rules. Second, applying the design principles to a grid can

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

URI: http://hdl.handle.net/10125/41752
ISBN: 978-0-9981331-0-2
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identify whether a grid is correct. These contributions prevent users of GQM+Strategies from creating and using grids that have problems and risks of incorrect structures. Also, our research contributes to business-IT alignment in terms of ensuring the integrity of business strategies for the introduction of IT into the company. Also, in Enterprise architecture, our approach helps the organization to maintain consistency of the goals and the strategies related to the components of it.

Below we describe the basic foundations, approaches and experimental results of our research.

2. Background

2.1 GQM+Strategies

GQM+Strategies [1][2][6] is a registered trademark of the Fraunhofer Institute for Experimental Software Engineering [7]. GQM+Strategies is a Goal-Oriented Requirements approach to align the goals and strategies of an organization across different units via the GQM approach [8] for goal-oriented measurements. Figure 1 shows the entire model of GQM+Strategies. GQM+Strategies Element represents mutual relations among a Goal, a Strategy, and the rationales (Context/Assumption) in an organization. A Goal is defined as a measurable and achievable objective within an organization. Strategies are defined to achieve the Goal. Additionally, Context and Assumptions influence the definitions of these Goals and Strategies by providing rationales that link them together in corporate environment. Based on the initial set of goals and strategies, lower-level goals are defined hierarchically. Applying this approach delivers a hierarchical model of goals and strategies, which often resembles the structure of the organization [9].

To evaluate the achievement of goals and the results of strategies, the goals of an organization correspond to a GQM graph, which is configured by a tree structure consisting of Goal/Question/Metrics (GQM). The GQM approach decomposes an organizational Goal into a Question that tries to characterize the object of the measurement to confirm whether the Goal is achieved, while Metrics provide the most appropriate information to answer the Question [2][8].

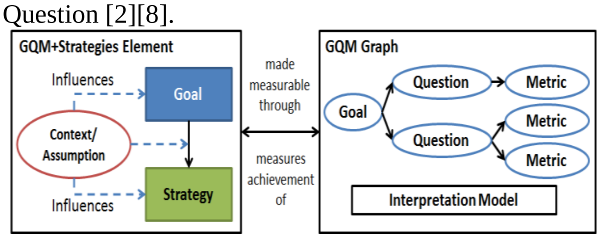


Fig.1 GQM+Strategies Model [1]

2.2 Object Constraint Language (OCL)

The Object Constraint Language (OCL) [4][10] is a formal language that can express constraints and queries that cannot be represented graphically in a model or a metamodel. Adapted to UML class diagrams, OCL helps clarify ambiguities in a UML class diagram by defining constraints of relevant attributes and multiplicities among classes. If constraints can be defined by OCL, then whether the model was constructed in accordance with the constraints can be determined, allowing mistakes in the design to be detected very early and easily corrected [10].

2.3 Motivating Example

GQM+Strategies method has many ambiguous parts that cannot be constrained by rules. Because the understanding of GQM+Strategies method varies by person, evaluating the correctness and deriving improvements are difficult. Figure 2 shows a grid adapted to GQM+Strategies as an example of common problems.

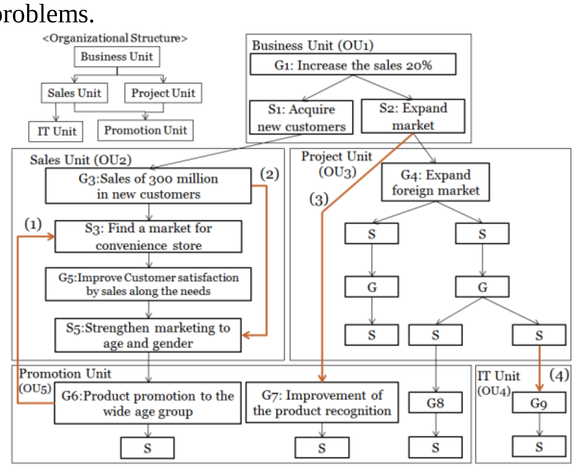


Fig.2 Motivating Example

2.3.1 Cyclic Dependencies In Figure 2, (1) shows a cyclic connection due to the relationship between Goal and Strategy. In the Sales Unit, achieving the top level Goal G3 "Sales of 300 million in new customers" is inhibited by a cycle where the Goal G6 "Product promotion to a wide age group" managed by the Promotion Unit is associated with a higher-level organizational (Sales Unit) Strategy S3 "Find a market for convenience stores". Also, it is incorrect that the lower level organizational Goal is associated with a higher level organizational Strategy in the GQM+Strategies grid. Because the next goal to be achieved in this grid is unclear, how to realize the overall goal is ambiguous.

2.3.2 Unified Hierarchy Level In (2), the hierarchy level of the relation between the Goal and Strategy is not unified. In the Sales Unit, the top level Goal G3 "Sales of 300 million yen in new customers" depends on the Strategy S5 of sub-Goal G5 "Strengthen marketing to age and gender". Thus, the route to achieve the top level Goal is unclear. In addition, the quality of the strategy likely will decline due to the difference in the particle size because the hierarchical strategy is not unified.

2.3.3 Difference in the Structure Level In (3), a connection is created without considering the hierarchal level of the organizational structure. The Business Unit's Strategy S1 depends on the Project Unit's Goal G4 and the Promotion Unit' Goal G7 as sub-Goals. The Promotion Unit is a sub-unit of the Project Unit. In this case, the granularities of G4 and G7 may be different. It is possible that subgoals are not set comprehensively to implement a specific strategy. Therefore, this problem prevents that a higher-level goal to be achieved.

2.3.4 Difference in the Structure Figure 2 shows a grid whose structure differs from the organizational structure. For example in (4), the connection does not consider the relationship of the organizational structure, and the Project Unit and the IT Unit are not directly related. The grid structure should be similar to the organizational structure because the grid is based on the organizational structure. Because aligning the overall goals throughout an organization is difficult, the validity of the grid to achieve the goals must be verified.

3. Approach

We propose two approaches to unify the design method and validate the grid. Firstly, in section 3.1, we propose a GQM+Strategies metamodel by UML. This approach visualizes strict design rules by defining the relationships among the elements of GQM+Strategies by creating a metamodel by UML.Secondly, in section 3.2, we propose Design Principle & Constraints by OCL. We created a list consisting of Design Principles defined GQM+Strategies by UML metamodel and Constraints that the Design Principle cannot adapt. Whether a grid is feasible can be automatically checked by describing the rule in OCL. These approaches are understood by the discussion facilitators at institutions that specialize in studying GQM+Strategies, as well as by the team leaders who examine the approaches using GQM+Strategies.

3.1 GQM+Strategies Metamodel by UML

As the foundation of this approach, we used the relationship among the elements of GQM+Strategies as defined by Fraunhofer IESE [2]. Elements of the GQM+Strategies metamodel by UML are divided into two parts. The one is GQM+SModel, which shows the plans for the organization by Organizational Goal (Goal) and Strategy. The other is GQMGraph, which measures and manages the Organizational Goal and Strategy by the GQM approach. Figure 3 shows the entire model, while TABLE I briefly describes the elements. Abstract classes are defined as the parent class of each element. Relating them can easily grasp the overall relationships. Figure 4 shows an abstract example model of a grid created using a metamodel that represents a portion of Figure 2 that is motivating example in this paper. This model has a Sales Unit (OU2) and a Promotion Unit (OU5) in which their organizational Goals G5 and G6 are related with the GQM method.

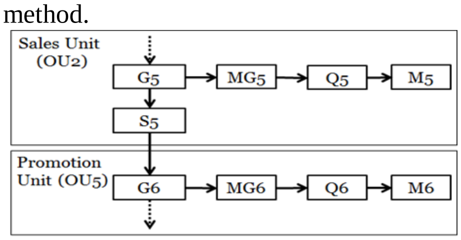


Fig.4 Abstract Example Model

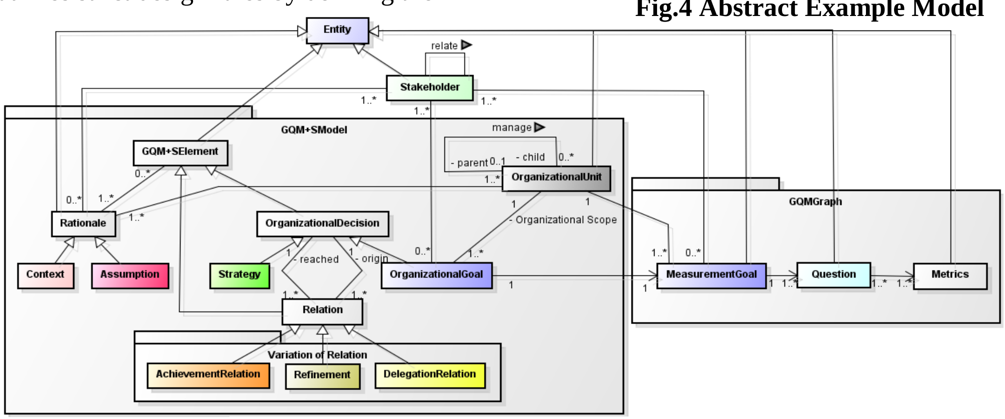


Fig.3 Entire Metamodel of GQM+Strategies

TABLE I Elements of the GQM+Strategies Metamodel

Class Name	Content
Entity	This is the parent class of all elements. It has an attribute called Number to identify the object of each class.
Stakeholder	This represents objects relevant to the grid.
GQM+S Element	This is the parent class of OrganizationalDecision and Relation. Relating this class and the Rationale class represents the association of the elements in the Rationale class to all of the child classes.
Organizational Decision	This class is the parent class for OrganizationalGoal and Strategy. This class allows a hierarchal structure between OrganizationalGoal and Strategy to be built.
Strategy	This achieves OrganizationalGoal. This class has an attribute “level” that shows the height from the top Strategy.
Organizational Goal	This is the goal to be achieved in the organization. This class has an attribute “level” that shows the height from the top OrganizationalGoal.
Organizational Unit	The organization with the responsibility to achieve OrganizationalGoal as OrganizationalScope. Also, this class can represent the hierarchical structure of the organization.
Relation	This is the parent class for AchievementRelation, DelegationRelation, and Refinement, which shows the relationships between OrganizationalGoal and Strategy.

Class Name	Content
Achievement Relation	This is used as a related class showing a path from OrganizationalGoal to Strategy.
Delegation Relation	This is used as a related class showing the path from Strategy to subOrganizationalGoal.
Refinement	This is used as a related class to embody OrganizationalGoal and Strategy.
Rationale	This is the parent class for the Context and Assumption class. These are rationales for the relationships between OrganizationalGoal and Strategy.
Context	This class shows objective facts about the environment.
Assumption	Uncertain characteristics and guesses about the environment. The attribute "confidence" shows its probability by a numerical value.
Measurement Goal	This class shows Goal to be confirmed by the achievement and indicates whether Goal achievement can be measured by a Metrics value.
Question	This class tries to characterize the object of a measurement to confirm whether the Goal is achieved.
Metrics	This class provides the most appropriate information value to answer the Question.

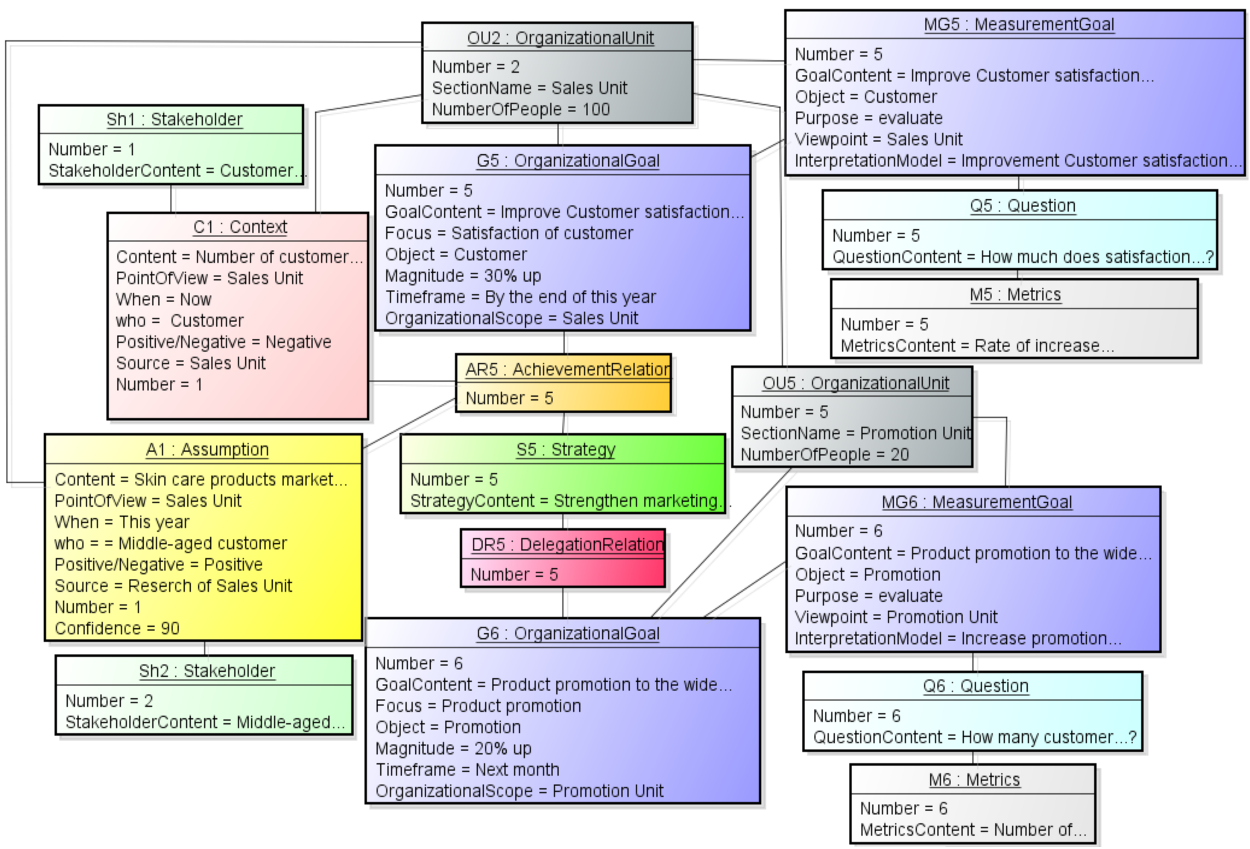


Fig.5 Model of Motivating Example by using Metamodel

Figure 5 is an example model. This grid shows part of the management strategy of a cosmetic company. The top goal (G5) managed by the Sales Unit “Improve Customer satisfaction by sales along the needs” and the strategy (S5) “Strengthen marketing to age and gender” are set. As a rationale of this relationship, the context (C1) “The number of younger generation customers is small” and assumption (A1) “Skin care products market for anti-aging represents about 4.6% growth compared to the previous year” are set. The strategy connects the subgoal (G6) “Product promotion to a wide age group”. All goals are managed by the GQM graph. In the case of the top goal, question (Q5) "How much does customer satisfaction rise in this year?" is measured by metric (M5) “Rate of increase of customer satisfaction in this year => 30%”, which are used to assess the achievement of the subgoal.

3.2 Design Principles & Constraints by OCL

3.2.1 Design Principles of GQM+Strategies We define the Design Principles, which determine the relationships among the elements of GQM+Strategies to create a grid correctly. We propose the three types of design principles as evaluation criteria of a grid created using the GQM+Strategies metamodel by UML. All the design principles are summarized in the Design Principle list.

TABLE II shows a list of the basic design principles. Other variations derived from these principles are described in our study group website[2]. This list includes the reason and an example solution for grids with an unsatisfied Design Principle. Therefore, the grid can be improved by referring to this list, which can prevent creating grids with design principle violations because the grids are prepared based on design principles. Additionally, we constrained these design principles by OCL. TABLE II shows some of the constraints described by the OCL for each Design Principle.

- **Fundamental design principles of a GQM+Strategies grid**

This defines the fundamental grammar used to create a GQM+Strategies grid in detail. This principle is necessary to determine unique connections among the elements of the GQM+Strategies metamodel by UML.

- **Possibility determination design principles**

These design principles enable the feasibility of the gird to be assessed by defining the constraints for parts that cannot be determined by the grammar.

- **Optional determination design principles**

These design principles are used to determine whether the grid is optional for a given constraint. Some relationships cannot be constrained uniquely because the management policies vary by company.

[2] Goal-oriented Quantitative Management Research Group (GQM-RG) https://gqmstrategies.wordpress.com/

TABLE II Main Design Principles and OCL

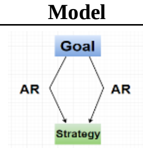
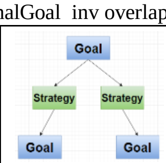
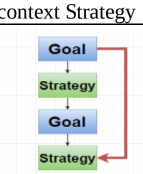
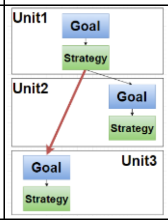
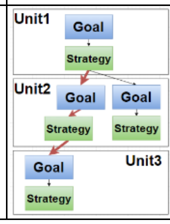
Type	Design Principle	Unsatisfied Model	Satisfied Model	Explanation and Reason
Fundamental design principles	**Grammar**			The fundamental grammar used to create GQM+Strategies. ・ The goal should always connect to the strategy with a single line. AR stands for AchievementRelation and indicates the relationship between Goal and Strategy.
Description by OCL		context OrganizationalGoal inv overlap: self.achievementRelation.strategy -> isUnique(s|s.Number)		
Possibility determining	**ADP :Acyclic Dependency Principle**			Acyclic Dependencies Principle: Relationship between Goal and Strategy must not be circular. (A Goal cannot take a higher level Strategy.) This grid makes the next Goal to be achieved unclear. Because the way to achieve the top goal is unclear, the grid needs to be recreated to remove fundamental conflicts.
Description by OCL		context OrganizationalGoal inv compareLevel:self.achievementRelation.strategy.delegationRelation.organizationalGoal -> forAll(g1|self.Level < g1.Level) context Strategy inv Level: self.delegationRelation.organizationalGoal -> forAll(og|og.Level > self.Level)		
Possibility determining	**HAP : Hierarchical Abstraction Principle**			Hierarchical Abstraction Principle: A Strategy under a Goal must be at the same level. This connection makes it difficult to understand how to achieve the top level Goal. In addition, the quality of the strategy likely declines due to the difference in particle size because the hierarchy of the strategy is not unified. To improve the grid, the particle size should match.
Description by OCL		context OrganizationalGoal inv sameStrategyLevel: self.delegationRelation.strategy -> forAll(s2, s3|s2.Level = s3.Level) context Strategy inv sameGoalLevel: self.achievementRelation.organizationalGoal -> forAll(g1, g2|g1.Level = g2.Level)		

TABLE II Main Design Principles and OCL

Type	Design Principle	Unsatisfied Model	Satisfied Model	Explanation and Reason
Possibility determining	**RUP : Responsible Unit Principle**			The hierarchical relationships between Units should be considered to clarify the responsibility of the Goal and Strategy. In this case, the granularities of the subgoals connecting Strategy differ. Therefore, achieving a subgoal may not exhaustively implement Strategy. This likely interferes with the achievement of the higher-level goal. To resolve this, a new direct subgoal and strategy are created to indirectly connect the subgoal and the final goal.
Description by OCL	context OrganizationalGoal inv sameUnit:self.delegationRelation.strategy.achievementRelation.organizationalGoal. organizationalScope -> forAll(u1, u2|u1.Number = u2.Number) context Strategy inv sameUnit: self.achievementRelation.organizationalGoal.organizationalScope -> forAll(u1, u2|u1.Number = u2.Number)			
Optional determining	**SUP : Sharing Unit Principle**			・Different Organizational Units share a Strategy. In this case, the organization responsible for sharing the strategy is not clearly defined. Solution examples: “Determined by each company's policies or dividing into two Strategies”, “Delegate the responsibility to either one of the organization.” Its implementation is for only detection, and the author of the grid must decide the determination method.
Description by OCL	Context OrganizationalGoal inv sameUnit:self.delegationRelation.strategy.achievementRelation.organizationalGoal .organizationalScope-> forAll(u1, u2|u1.Number = u2.Number) context Strategy inv sameGoalLevel: self.achievementRelation.organizationalGoal -> forAll(g1, g2|g1.Level = g2.Level)			

This approach was created based on software design principles [11], empirical data such as that derived in our related research [5][12] and the application of GQM+Strategies to the strategy of the company and the relationships among the elements that can exist when applying a metamodel. Also, we aimed to use this approach to detect misalignments in the structure of the grid. Therefore, we do not mention inconsistencies in the contents of the IT business.

3.2.2 Possibility determination by USE We automatically implemented a possibility determination based on the design principles for GQM+Strategies grids using an existing tool called USE [13]. Possibility determination means that the design principles defined by OCL are applied to grids. This approach reveals part of the grid does not satisfy the design principle. Thus, the facilitators of discussion and team leader who examine the strategy by using the GQM+Strategies have the opportunity to quickly improve the grid. Also, this approach requires little effort from users since the models can be directly used as inputs for validation [10]. Figure 6 overviews of the possibility determination.

Figure 7 shows the determination process using an UML activity diagram. A data file written by OCL is created to describe all the elements of the GQM+Strategies metamodel by UML, relationships among the elements, and constraints based on design principles. This data file is always used when implement a possibility determination.

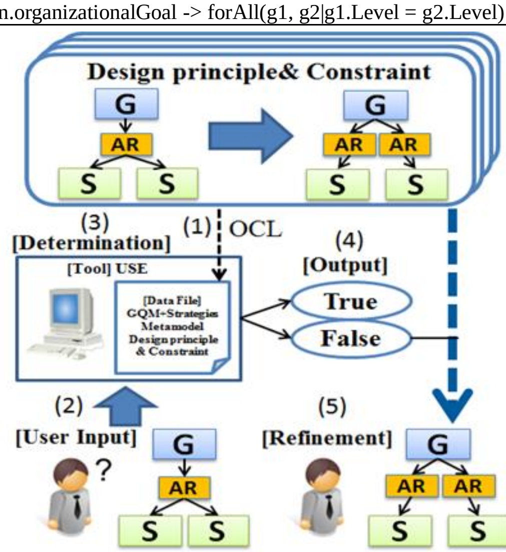


Fig.6 Overview of the possibility determination by USE

Our method has the following steps:

1. Install a metamodel and design principle & constraint data file to USE in advance.
2. Input objects into the grid, set attributes for each object and append the relationships among the objects manually. The hierarchical levels of OrganizationalGoal and Strategy are necessary to determine the possibility of GQM+Strategies grid by USE. Therefore, the distance from the top OrganizationalGoal or the top Strategy should be inputted into attribute “Level” when instances are created.

3. Implement a possibility determination about the inputted GQM+Strategies object grid.
4. Check the result of the possibility determination.
5. Improve the grid based on examples of solutions described in the design principle list if the grid does not satisfy all constraints.

Repeating steps 2-5 improves the grid until no design principle violations remain. By performing this cycle semi mechanically, it is possible to shorten the time than usual to improve the grid.

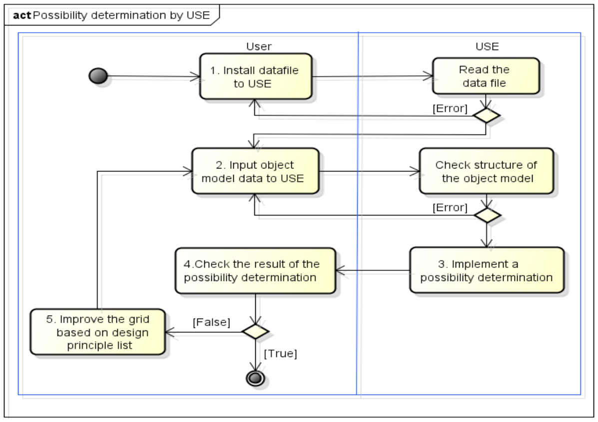


Fig.7 Process of determination

4. Evaluation

4.1 Validation of the design principles

The validity of the design principles must be confirmed. Thus, we asked five GQM+Strategies experts to verify the validity of the design principles based on their experience by sending out questionnaires about the design principles list. They are members of the translation team of a technical book of GQM+Strategies[2], and have the sufficient knowledge and the experience of practices about it. Respondents were asked "Does the Unsatisfied Model actually occur?", "Should the Unsatisfied Model be corrected?" and "Is the Satisfied Model correct?". Several experts responded that these models violated the design principles are occurred in fact. In particular, many experts answered that the RUP and SUP model shown in TABLE II is frequently occurred. But, on the other hands, some experts said that ADP and a part of HAP model are not occurred in reality. In addition, the majority of experts think that the modified methods of each of the design principles are correct. These results demonstrate that it is important validate that the design principles are incorporated. The models determined that they have a possibility to occur are confirmed roughly the validity as the design principles. The other models will be expected to be considered by many experts of the review in the future.

4.2 Case study

In this section, we implement a case study for possibility determination by USE using a simple grid described with OCL. The target of the determination is the Difference of Structure Level grid shown in the Motivating Example.

Figure 8 shows the Difference of Structure Level grid created by objects that violate part of the design principle. This grid is based on case planning of a new project strategy carried out across the hierarchy of the organization [1]. The result of the determination indicates that this model considers the following three constraints:

- subgoalLevel: Level of the Organizational Goal connecting the same Strategy as a sub-Goal is equal.
- subgoalUnit: OrganizationalUnit of the sub-Goal connection in the same Strategy is equal.
- subgoalUnitRelation: OrganizationalUnit of the Sub Goal should equal the above connecting Unit of Strategy or the Unit managed in the Unit of Sub Goal.

The elements indicated with blue arrows in Figure.8 cause problems, which can be solved by setting a new OrganizationalGoal G4 and Strategy S4 of the organization U2 between Strategy S1 and G3 OrganizationalGoal in order to unify the level of abstraction throughout the entire grid.

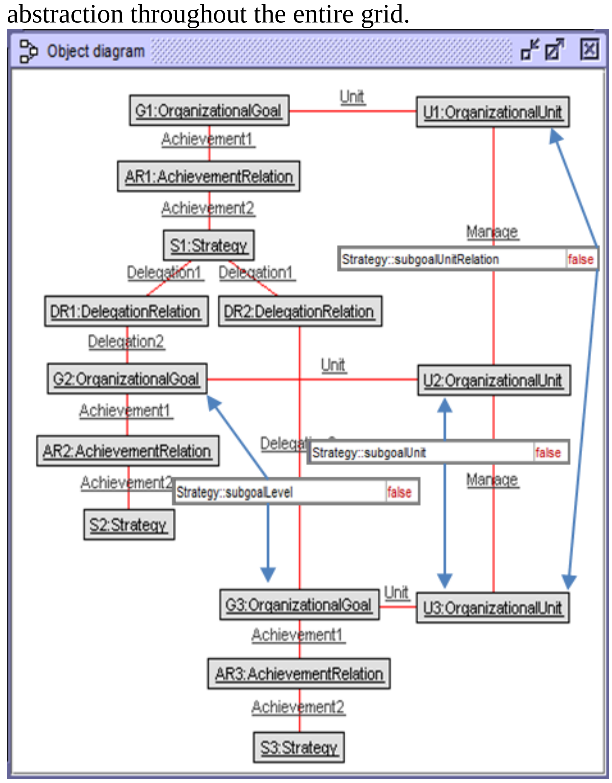


Fig.8 Difference of the Structure Level grid

4.3 Experiment

4.3.1 Experimental Overview We conducted experiments to determine whether it is possible to improve the grid by the proposed method. In this experiment, we prepared four GQM+Strategies grids that do not satisfy the design principle, and then asked seven subjects to fix each grid correctly. The subjects of the experiment were fourth-year undergraduate to second-year Master's students studying software engineering. Few of them had prior knowledge of or had professionally studied GQM+Strategies. They were divided into two groups; Group A modified the grids with the design principle list and Group B modified the grids without the design principle list. This experiment conducted after explaining GQM+Strategies to all subject all at once.

4.3.2 Results In this experiment, we verified whether the modified grids satisfy the design principles, and measured the time spent modifying the grids. TABLE III shows the experimental results.

Group A has an average correct answer rate of 83%, while Group B has an average correct answer rate of 63%, indicating that the design principle list identifies potential problems and risks. However, Group A did not have a correct answer rate of 100%, suggesting that the list may be insufficient to support modifying the grids. This may be because the subjects did not fully understand about the description of GQM+Strategies and the design principles.

With respect to the modifications, the average time of Group A is 11 minutes 28 seconds, but when the time to understand the design principle list is included, the average increases to 19 minutes. On the other hand, Group B has an average of 12 minutes 50 seconds. These results show Group A takes more time to modify the grids than Group B. However, using the design principle list allows grids to be effectively and correctly modified. Currently, the subjects require time to understand contents of the list because it is complicated, but after reading the list, the subjects in Group A modified these grids about 20 percent faster than those in Group B. Therefore, we need to clarify the design principle list in the future in order to the shorten time required to comprehend the list.

TABLE III Experimental results

	Correct answer rate	Modification time	Modification time (including reading time)
Group A (with design principles)	Avg 83%	Avg 11m 28s	Avg 19m 17s
Group B	Avg 63%	Avg 12m50s	

4.4 Discussion

We have verified the validity of the design principles on the basis of experts' reviews. The case study confirms that the grid can be determined automatically. In addition, the experiment demonstrates that our approaches help modify and improve the consistency of the grids.

Here we address the three research questions.

- RQ1: Do GQM+Strategies grids contrary to the design principles actually exist?

We have confirmed that grids contrary to RUP and SUP exist, based on validation of the design principles by GQM+Strategies experts. Additionally, grids contrary to other design principles such as ADP and HAP are expected to occur when grids are created. Experts reviewed models similar to these and confirmed that design principle violations may occur. It is likely that more examples like these will begin to appear due to the proliferation of GQM+Strategies. Therefore, in future works we will consider similar cases that may violate design principles.

- RQ2: Can the GQM+Strategies metamodel and design principles help identify potential problems and risks?

The case study confirms that the GQM+Strategies metamodel grid can determine the possibility by OCL based on design principles in detail. It is likely that the parts of grid detected by the possibility determination are problems or risk of the grid. Also, in the experiment, we demonstrate that subjects can identify potential problems and risk by using high quality design principles. Therefore, our approaches can help identify potential problems and risks of the GQM+Strategies metamodel grid and serve as a basis for inspections and modeling rules.

- RQ3: Can GQM+Strategies metamodel and design principles help improve GQM+Strategies grids with problems or risks?

Applying our approaches with USE clarifies the parts of the grid that do not satisfy the design principle mechanically. Therefore, these approaches provide a quick opportunity for grid improvement. Also, the design principle list describes examples of improved grids and explanations of the design principles. In fact, subjects who modified the grids according to the design principles in the experiment more accurately improved the grids than those without design principles even if the subjects are beginner. Consequently, our approaches can assist in improving grids for any person.

4.5 Threats to Validity

There are two threats to the internal validity. The first is the number of subjects. Group A using design principles in this experiment is composed of three people, while group B without design principle is composed of four people. The number of subjects who participated in this experiment likely affects the validity of the experimental results. In future experiments, the number of subjects will be increased to validate our results. The second is the difference in the ability and experience of the subjects. Subjects were grouped into people familiar with GQM+Strategies and beginners. These two groups have different experience levels, which may affect the rate of correct answers and the modification time. In the future, we plan on implementing an experiment involving many subjects with different experience levels to determine whether experience level is a factor.

One threat to external validity is the difference in understanding of the design principles. Although we can obtain positive results from this experiment because the subjects understood the design principles, negative results are also possible. In the future, we want to experimentally verify the validity of the correct answers rate and contributions of the design principle list using a combination of existing tools by the OCL.

5. Related work

Because recent studies have improved various aspects of GQM+Strategies, many methods have been proposed to create more efficient GQM+Strategies grids. Takanobu Kobori et al. proposed the Context-Assumption-Matrix (CAM) [12], which is a method to extract Context and Assumption comprehensively by analyzing the relationships among Stakeholders. This method strengthens the validity of the grids and the corresponding grids as well as changes in the business environment instantly.

Yohei Aoki et al., who aimed to improve the quality of GQM+Strategies grids, proposed a method called Interpretive Structural Modeling (ISM) [5], which detects positive and negative horizontal relationships between elements of GQM+Strategies grids decomposed by a top-down approach. This modeling method helps improve GQM+Strategies grids by clarifying relationships among elements. Although they did not consider the structure of the GQM + Strategies, they successfully improved the grid quality by different approaches using their respective techniques.

In the research field to confirm the consistency between business organizations and IT, Alain Wegmann et al. proposed SEAM [14] as a consistency confirming tool via the Enterprise Architecture model. In SEAM, the organization is considered as a hierarchy of systems that span from the business down to IT, and the alignment process corresponds to the hierarchy. This work may be useful to assure consistency between an organization and an IT Strategy in a GQM+Strategies grid.

Additionally, detailed definitions about models expressing business Strategies are researched widely [15]. Gil Regev et al. confirm the definitions of KAOS [16], GBRAM [17], and GRL [18] as Goal-Oriented Requirements Engineering (GORE) [19]. They mention that they can GORE methods under correct definitions by analyzing and comparing each method and its elements. This research motivation is close in our approaches in terms of clarifying relationships among elements. However, our research gives a new strict definition for a particular model, while their work implements an exact confirmation of definitions that exist from the original by comparison with some of the models.

Lina Nemuraite et al. proposed a tool that converts business vocabularies and business rules used in OMG SBVR standard [20] to UML class diagram supported by OCL constraints [21]. Similar to our study, their study can support creating correct models by clarifying an abstract rule using a metamodel by UML class diagram and OCL constraints. Depending on the situation of the organization, the results of the determination are often optional in our research.

6. Conclusion and Future work

Currently, some issues remain when creating GQM+Strategies grid due to unclear and disunity of the definitions. Also, the efficacy of the grid cannot be confirmed in advance because there is no standard for possibility determination of the grid. Thus, we propose the following approaches to solve these problems. First, we define a GQM+Strategies metamodel by a UML class diagram to decide and unify the definition of GQM+Strategies in detail. This approach elucidates the relationships among elements of GQM+Strategies, which then become the unifying modeling rule. Second, we defined the design principles that enable the possibility determination of the relationships that cannot be checked automatically by the OCL constraints in the metamodel to be evaluated. This approach can detect parts of the grid against design principles, allowing the grid to be improved. Additionally, we implemented an experiment to validate the design principles list. Therefore, our proposed approaches have two main contributions:

- To assist so that it is also easy to create and improve grids for beginners using the metamodel and design principles of the grid.
- Shortening of improvement time of grid by clarifying the problems of grid and solutions to prevent the risk is caused quickly based on possibility determination.

As a future work, we will implement reinforcements and validate the design principles. Currently we are considering finer variations of the five design principles proposed in this paper. For example, the logic of RUP does not only detect straddling relationships between organizations, but can also be used to detect inter-organizational relationships that are contrary to the organizational structure. However, we do not know whether these design principles cover all the relationships between GQM+StrategiesElements. Therefore, we plan to consult past examples of grids and incorporate details of actual business Strategy models to expand the design principles variation. Additionally, we must define and verify the contents of the design principles in greater detail based on many more GQM+Strategies experts' reviews. Finally, we will verify that all principle violations can be extracted by applying the design principles to real company strategy models in cooperation with specialists in our study group and Fraunhofer IESE.

7. Acknowledgement

We are grateful to members of the Goal-oriented Quantitative Management Research Group and Dr. Jens Heidrich for valuable comments.

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