Identifying rationales of strategies by stakeholder relationship analysis to refine and maintain GQM+Strategies models

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Abstract. **To achieve overall business goals, GQM+Strategies®[1] is an approach that aligns the business goals at each level of an organization to strategies and assesses the achievement of goals. Strategies derived from business goals are based on rationales (context factors and assumptions). Because extracting all rationales is an important process in the GQM+Strategies approach, we propose Context-Assumption-Matrix (CAM)[2], which refines the GQM+Strategies model by extracting rationales based on the analysis of the relationships between stakeholders, and the Context Assumption (C/A) definition template to unify the expressive style of contexts and assumptions. To demonstrate the effectiveness of CAM, we conducted an experiment involving 43 students majoring in information sciences at Shimane University in Japan. GQM+Strategies with CAM can extract rationales more efficiently and exhaustively than GQM+Strategies alone. Moreover, when the management policy or the business environment changes, GQM+Strategies with CAM can analyze the rationales and the GQM+Strategies grid easily.**

Keywords: stakeholder relationship, rationales (context factors and assumptions), business goal, organizational change

1   Introduction

Because software is responsible for a lot business in corporate activities [1] and the complexity of software and IT systems in general has increased, linking business and system requirements is becoming increasingly difficult. Often it is unclear if IT/software related strategies and an organization's business goals are aligned. According to V. Mandi´c et al [2], the success of measurement initiatives in software

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1. GQM+Strategies® is registered trademark No. 302008021763 at the German Patent and Trade Mark Office; international registration number IR992843.
2. We have already submitted a short paper about idea of CAM to the APRES 2014 as a research previews [19]. This paper is added the result and evaluation of experiments to demonstrate the effectiveness of CAM.

companies depends on the quality of the links between metrics programs and organizational business goals. One approach to resolve this issue is GQM+Strategies [3, 4], which aligns and assesses the business goals of each level to the overall strategies and goals of the organization. Many companies worldwide (e.g., the Japan Aerospace Exploration Agency [5], the global oil and gas industry [6], and non-software development domains such as the military training domain [7]) have applied GQM+Strategies for measurement-based IT-business alignment. GQM+Strategies is used to establish management strategies and plans, determine the value of a contribution, ensure the integrity of a goal between a purchaser and a contractor, and evaluate management based on quantitative data.

GQM+Strategies extract strategies from goals based on rationales (context factors and assumptions). To extract valid strategies, rationales must be identified exhaustively, but it is unclear whether the identified rationales cover all existing ones. Moreover, business environments are constantly changing. In order to win business, the GQM+Strategies Grid must be adjusted, which may alter some context factors and assumptions. However, it is difficult to grasp exactly what has changed. Thus, GQM+Strategies needs a mechanism to identify exact changes and adapt the GQM+Strategies grid accordingly. Furthermore, rationales are often described ambiguously. It is important to unify them in an expressive style.

This paper proposes Context-Assumption-Matrix (CAM) to refine business goals and strategies iteratively. To unify the expressive style of context factors and assumptions, the relationships of stakeholders are analyzed as a complement to GQM+Strategies and the Context Assumption (C/A) definition template. Herein three research questions are examined.
RQ1: Can CAM and the C/A definition template efficiently extract new rationales?
RQ2: Can CAM exhaustively extract rationales?
RQ3: When the management policy or business environment changes, can the rationales and the GQM+Strategies Grid be easily analyzed via CAM?

The contributions of this paper are two-fold. First, the proposed method may provide an efficient and exhaustive method to extract context factors and assumptions. Second, when the management or business environment changes, GQM+Strategies, context factors and assumptions can be easily analyzed.

The rest of the paper is structured as follows: in Section 2, an overview of the GQM+Strategies approach and motivating examples of our approach is given. In Section 3, our approach is explained. Section 4 presents the evaluation of our approach. Section 5 introduces related works. Finally, section 6 concludes conclusion and suggests future work.

2   Background

2.1   GQM+Strategies

GQM+Strategies was developed by the Fraunhofer Institute for Experimental Software Engineering (IESE) [8]. The GQM+Strategies approach extends the goal/question/metric paradigm to measure the success or failure of goals and strategies,

while adding enterprise-wide support to determine actions on the basis of the measurement results [4, 9].

It is also difficult to understand the purpose of collecting such data if developers do not know that it is required [10]. GQM provides support for measurements by developing software-related goals and generating questions to refine goals and to specify measures that need to be considered in order to answer generated questions [6]. Although the GQM approach can measure whether a business goal is achieved in an organization, it lacks a mechanism to link higher- and lower-level business goals and cannot support and integrate goals at different levels of an organization.

On the other hand, GQM+Strategies creates maps between goal-related data at different levels, allowing insights gained relative to a goal at one level to satisfy goals at higher levels [11]. The major feature of GQM+Strategies is that business goal strategies are determined based on rationales as "contexts" and "assumptions". Contexts are environmental characteristics, and assumptions are aspects of uncertain environments, including estimated ones. Although many strategies are considered for a goal, the best strategy is then selected based on the rationales. Because all of the selected strategies are detailed into lower level goals, it is possible to determine strategies that reflect the actual business environment. Figure 1 overviews the concept of GQM+Strategies. The GQM+Strategies Grid visually confirms the link between a goal and a strategy, allowing the entire organization to communicate easily and work toward a common goal. Furthermore, through the GQM paradigm, it is possible to evaluate whether the goals at each level are achieved.
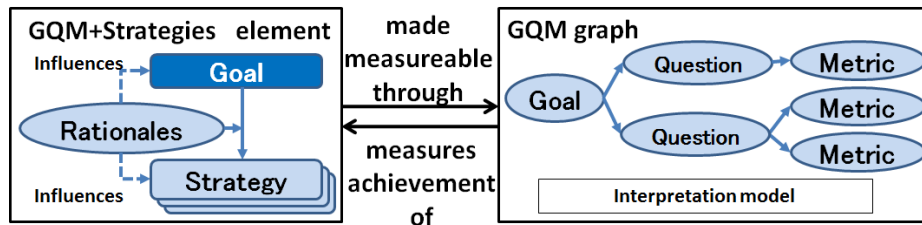

Fig. 1. GQM+Strategies components (based on Basili et al [4])

Our approach uses the following terminology (based on Basili et al. [6]):
- **Organizational goal:** Objective that the organization wants to accomplish within a given time frame that encompasses part of or the entire organization.
- **Strategies:** Possible approaches to achieve a goal within the environment of the organization. The number of strategies depends on the (internal) structure of an organization.
- **Rationales:** Relevant context factors and assumptions used to select goals and strategies.
- **Context Factors:** External and internal organizational environment.
- **Assumptions:** Estimated unknowns.
- **GQM Graphs:** Definition of how to measure whether a goal is accomplished and a strategy is successful. Following the classical GQM approach, GQM

goals are defined and broken down into concrete metrics. Interpretation models are used to objectively evaluate goals and strategies.

2.2   Motivating Examples

To successfully adapt GQM+Strategies, it is important to capture rationales. High-quality GQM+Strategies grids can guide an organization and help achieve business goals and strategies. However, this ability depends on the methods to "capture" relevant context (internal and external environment) [12].

As an example, we applied GQM+Strategies to the sales department of a stationary company, which sells stationary to corporations. The company receives orders from corporate customers and then ships based on the order form. Figure 2 overviews the corporate structure of the stationary company. The purpose of using GQM+Strategies is to improve the order acceptance process of the sales department and the shipping business. Figure 3 shows a level-3 business goal, strategy, and rationales.
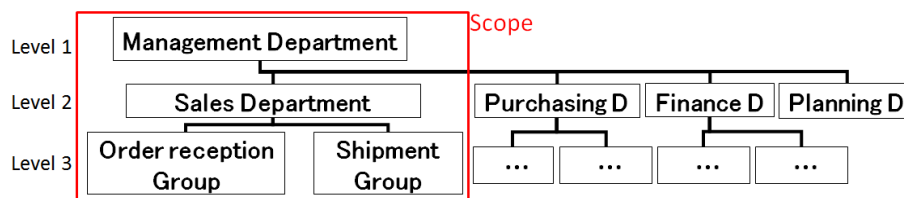

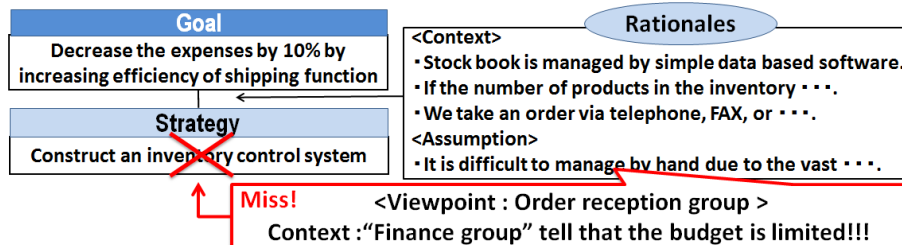**Fig. 2.** Corporate structure of a stationary company

Fig. 3. Business goal, strategy, and rationales (excerpt)

In Figure 3, the strategy, which constructs an inventory control system, is extracted from the goal to increases efficiency of the order reception business. Although the GQM+Strategies process derives business goals, strategies, and rationales, it is unclear whether the context factors and assumptions cover all existing goals and strategies. For example, there may be a context that limits the budget, which may make the strategy determined in Figure 3 impossible to execute. The lack of context factors and assumptions tends to be misleading, which can result in deriving incorrect strategies. Therefore, a mechanism must be able to extract context factors and assumptions efficiently and exhaustively.

Moreover, rationales are often described ambiguously. In Figure 3, the context is

"we take an order via telephone, FAX, or email". This context is unclear about "we", which may lead to a misunderstanding of the context or assumption even if it is extracted via CAM. Therefore, it is important to unify the expressive style of context factors and assumptions.

Business environments are constantly changing. For example, consider the management policy change when a company that began with individuals is sold to a corporation. The GQM+Strategies Grid must be adjusted, and some context factors and assumptions may change. Because the exact changes are difficult to understand, the mechanism must also be able to grasp exact changes and adapt GQM+Strategies.

3 Our Approach

In section 3.1, we propose the Context-Assumption-Matrix (CAM), which is a method to extract contexts and assumptions efficiently and exhaustively by analyzing the relationships between stakeholders. In section 3.2, we propose the Context Assumption definition template (C/A definition template), which is an expressive style of contexts and assumptions related to CAM. In section 3.3, the steps of our approach are given.

3.1 Context-Assumption-Matrix

CAM organizes common context factors and assumptions between stakeholders into a two-dimensional table. Our approach defines stakeholders as people, systems, or processes. This definition allows CAM to respond to the actual shape of corporations. Figure 4 provides an example of applying CAM to a stationary company and GQM+Strategies Grid.


Fig. 4. An example of applying Context-Assumption-Matrix to a stationary company

Each row element denotes a stakeholder who views the context or assumption. Each column element represents a stakeholder who is the subject of the context or assumption. For example, in Figure 4, C3 (Context 3) is "order reception group takes an order via telephone, FAX, or email." This means that the "Corporate Customer" (row) views that "Order reception group" (column) takes an order.

The dotted circle in Figure 4 shows that this row lacks contexts or assumptions related to the order reception group. It is possible to omit the context factors and assumptions from the viewpoint of the order reception group. In fact, there is a context, "finance group says that the budget is limited". Thus, CAM can extract context factors and assumptions.

Moreover, CAM has a column labeled TBD, which stands for To Be Determined. In CAM, TBD represents that a stakeholder who is undecided or does not currently exist. For example, in Figure 4, C4 (Context 4) is "no one to integrate complaints from customers in customer service" indicates that currently this role is not assigned. The rationales in TBD may create new strategies. For example, they introduce CRM.

Figure 5 shows the structure of CAM and a GQM+Strategies Grid for the stationary company. Similar to the GQM+Strategies grid, CAM has a hierarchy, which corresponds to the corporate structure.
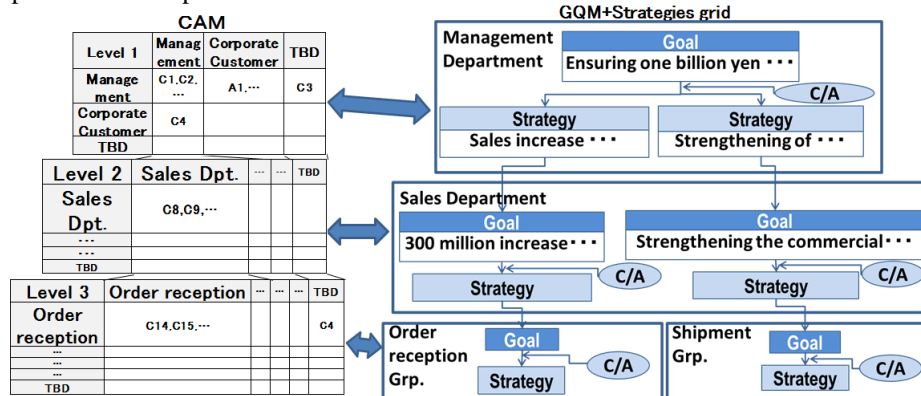
Fig. 5. Structure of CAM and the GQM+Strategies Grid of the stationary company (excerpt)

In this case, CAM has three levels because the example stationary company has three levels. The stakeholders of CAM have the same levels as the corporate structure. Initially, the stakeholders of CAM are determined based on the corporate structure (i.e., Management Department in level 1, Sales Department in level 2, and Order Reception Group and Shipment Group in level 3), but new stakeholders (e.g., for operations and maintenance) can be added if necessary.

The lower and upper levels are assumed to have the same rationales. In this case, rationales corresponding to their level are derived. Rationales at the higher level are defined abstractly, while ones at the lower level are defined concretely. Organizing the context factors, assumptions, and stakeholders two-dimensionally in CAM allows the context factors and assumptions to be visually reviewed.

3.2 Context Assumption (C/A) Definition Template

Context factors and assumptions are often described ambiguously. For example, consider the context, "We take an order via telephone, FAX, or email from a corporate company." This context does not clarify who "we" refers to, which may lead to a misunderstanding of the context or assumption even if it is extracted by CAM. Because it is important to unify the expressive style of the context factors and assumptions, we developed the Context Assumption (C/A) definition template. Table 1 shows the definitions and an example of a C/A definition template. This expressive style allows context factors and assumptions to be described exactly. Furthermore, the "viewpoint" in this template corresponds to the row elements, while "who" corresponds to the column elements in CAM.

Table 1. Definitions and an example C/A definition template

Item	Explanation	Example
Level	Level of corporate structure	Level 3
when	Period of Context and Assumption	until now
viewpoint	Stakeholder who views context or assumption (row element in CAM)	Corporate Customer
who	Stakeholder who are subject of Context or Assumption (column element in CAM)	Order Group
what	Contents of Context and Assumption	take an order via telephone, FAX or email
+/-	Context and Assumption are + or - for viewpoint. + is positive, - is negative, +- is positive and negative	+-
Source	Source of Context and Assumption	business outline

3.3 Steps of Our Approach

Figure 6 shows the relationship between our approach and GQM+Strategies. CAM finds context factors and assumptions exhaustively, while the CA definition template defines context factors and assumptions clearly. Our approach uses the following steps:

1. Collect context factors and assumptions using the C/A definition template.
2. Extract stakeholders of CAM from the organizational structure.
3. Apply the collected context factors and assumptions to CAM.
4. Use CAM to extract missing context factors and assumptions.
5. Create a GQM+Strategies Grid based on context factors and assumptions.
6. Update CAM and the C/A definition template by referring to the related stakeholders when the management policy or business environment changes.
7. Update the GQM+Strategies Grid based on context factors and assumptions.
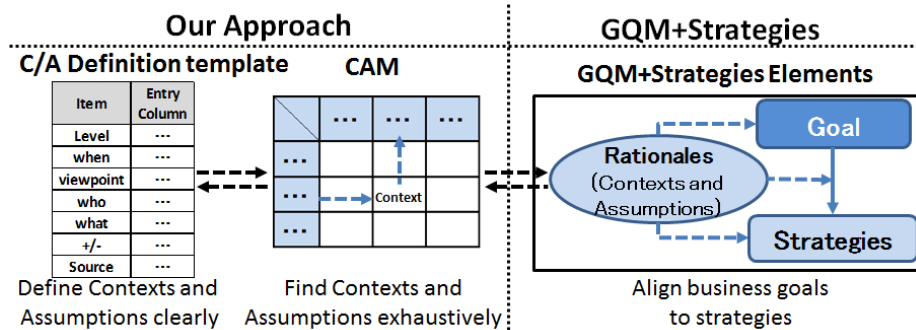8. Repeat steps 6 and 7.

Fig. 6. Relationship between our approach and GQM+Strategies

4 Evaluation

4.1 Experimental Overview

To demonstrate the effectiveness of CAM, we conducted experiments involving 43 students majoring in information sciences at Shimane University in Japan. The experiments were conducted on the last day of the 4 days software engineering class by dividing students into seven teams of five or six people. Teams were given a company profile and goals in a GQM+Strategies grid, and were instructed to derive contexts, assumptions, and strategies for the goals. Four teams were assigned to group A, and three were assigned to group B. Exercises 1 and 2 were cases of a stationary company and a cosmetic company, respectively (Figure 7). These cases were created from examples adapted from GQM+Strategies.
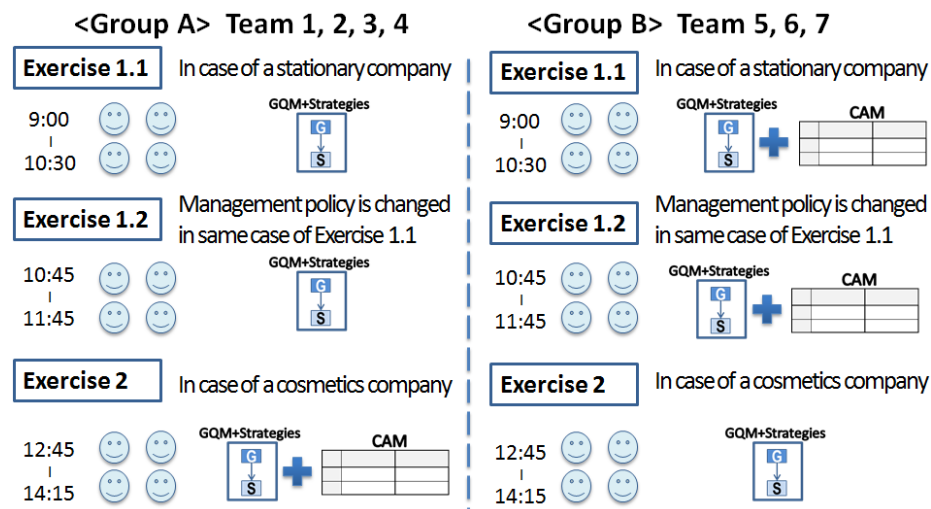

Fig. 7. Evaluation design

Exercise 1.1   In the case of a stationary company, group A performed the exercises with only GQM+Strategies, while group B performed the exercises with GQM+Strategies and CAM.

Exercise 1.2   Under the same conditions as Exercise 1.1, students performed the exercises when the management policy was changed.

Exercise 2   In the case of a cosmetics company, group A performed the exercises with GQM+Strategies and CAM, while group B performed the exercises with only GQM+Strategies.

4.2   Experimental Result

Table 2 shows the strategy evaluation that individual teams extracted based on three grades: Good, Normal, and Bad. Grades were determined using two criteria: (i) Is the strategy aligned with the goal? and (ii) Are the rationales of the strategy convincing? Good, normal, and bad satisfy both, one, and none of the criteria, respectively. To compare the case of using only GQM+Strategies to that using GQM+Strategies with CAM, we mapped the rationales, which students extracted using only GQM+Strategies, to CAM. Figure 8 shows the relationships between the number of views and the number of rationales. The number of views is the sum of the number of "viewpoints" and "who" in CAM, while the number of rationales is the sum of the number of context factors and assumptions in CAM. In Figure 8, X-axis represents number of view, and Y-axis represents number of rationales. The team on the top right of the figure is able to verify rationales from many viewpoints and extract many rationales. In Figure 8, an "o" mark represents the teams using GQM+ Strategies with CAM, while an "x" mark represents the teams using only GQM+ Strategies. Figure 9 shows the relationships between the number of views and the number of strategies, where "o" and "x" marks are the same as in Figure 8. In addition, we conducted a questionnaire after experiments with CAM. Figure 10 shows the results to the question: "When the management policy or business environment changes, are rationales and the GQM+Strategies Grid easily analyzed using CAM?" Table 3 shows an example of CAM which one team creates in exercise 1.1.

Table 2. Evaluation of the strategies

|		Only GQM+Strategies				GQM+Strategies with CAM		
		Team_1	Team_2	Team_3	Team_4	Team_5	Team_6	Team_7
Exercise 1.1	Good	1	1	2	2	4	1	2
	Normal	1	1	0	0	2	1	1
	Wrong	1	0	0	0	0	0	1
		Only GQM+Strategies				GQM+Strategies with CAM		
		Team_1	Team_2	Team_3	Team_4	Team_5	Team_6	Team_7
Exercise 1.2	Good	2	0	1	3	2	3	3
	Normal	1	2	2	0	2	1	1
	Wrong	0	0	0	1	0	0	2
		GQM+Strategies with CAM				Only GQM+Strategies		
		Team_1	Team_2	Team_3	Team_4	Team_5	Team_6	Team_7
Exercise 2	Good	1	3	5	2	2	1	3
	Normal	2	0	2	2	2	2	1
	Wrong	2	0	0	1	2	2	2
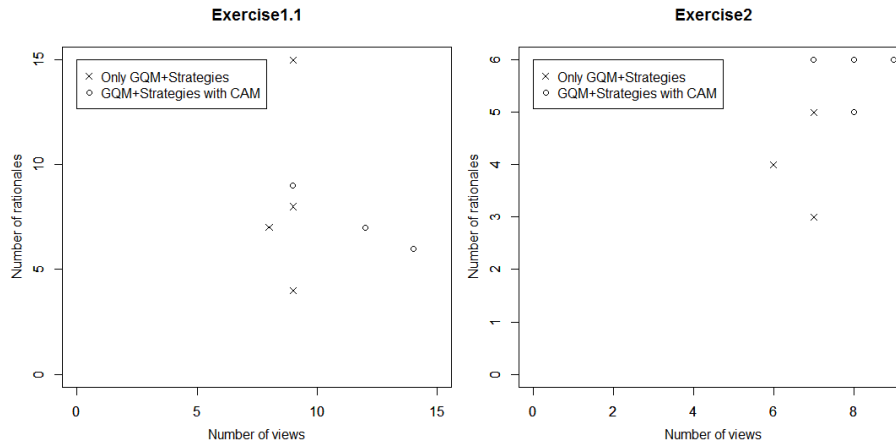
Fig. 8. Relationships between the number of views and the number of rationales
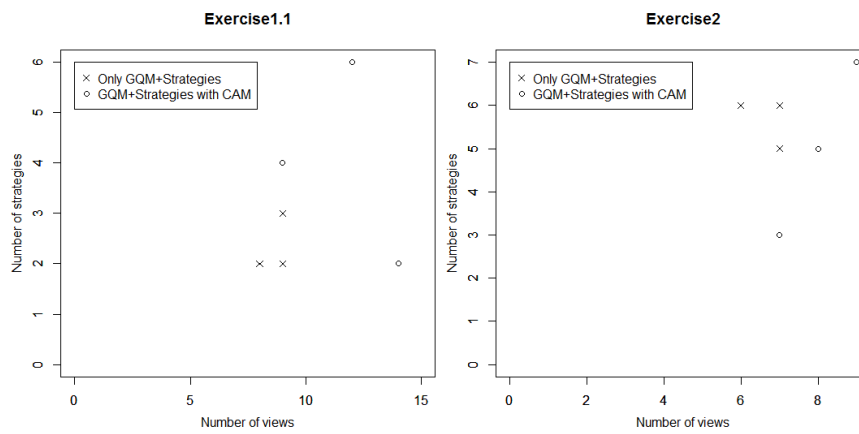
Fig. 9. Relationships between the number of views and the number of strategies

Q:When the management policy or business environment changes, are rationales and the GQM+Strategies Grid easily analyzed by using CAM?
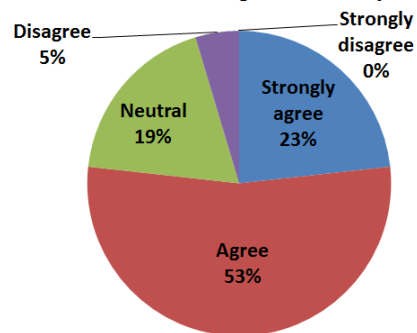
Fig. 10. Results of the questionnaire

Table 3. An example of CAM which one team creates in exercise 1.1

	Order reception Grp.	Shipment Grp.	Order Group	Control of goods in stock Group	Corporate Customer	TBD
Order reception Grp.	C:Order reception Grp manages catalog, customer ledger, stock ledger on simple database software. C:Because company have many goods, all products can not be posted in the catalog.				C: Claim information is not linked to customer information. C: There is a possibility that we can't recommend products tailored to customer preferences.	A:Company doesn't sell to individual customers.
Shipment Grp.	C:Collection personnel assorts goods based on the pickup list. C: It is considered that the products will increase in the future.			C:Goods are managed by people.		
Order Group						
Control of goods in stock Group				C:After withdrawal of the stock, we order the manufacturer product which is not enough.		
Corporate Customer			C:Company is not able to respond to the needs of the market.			
TBD						

● C represents context, A represents assumption.

4.3   Discussion

RQ1: Can CAM and the C/A definition template efficiently extract new rationales?

We conducted experiments to demonstrate the effectiveness of only CAM due to limited time in class. Teams using GQM+Strategies with CAM extracted average of 1.0 more rationales at exercise 1.1 (Team 4 is not included) and average of 1.75 more rationales at exercise 2 than the teams using only GQM+Strategies (Figure 8).

This is because CAM extracts new rationales based on "viewpoint" and "who". One team using only GQM+Strategies extracted 15 rationales in exercise 1.1. However, it appears that the team determined the rationales from the company profile, and although many rationales were extracted, the number of views is low.

RQ2: Can CAM exhaustively extract rationales?

GQM+Strategies with CAM resulted in more numbers of views and rationales (Figure 8). In fact, an example of CAM is considered from many views (Table 3). This team should reconsider rationales from the viewpoint of order group later, because there are no rationales on the order group's row. GQM+Strategies with CAM can more exhaustively extract rationales than using only GQM+Strategies because CAM extracts rationales based on the relationships of stakeholders. In case of exercise 1.1 (Figure 9), teams using GQM+Strategies with CAM extracted more strategies than teams using only GQM+Strategies, but in exercise 2 (Figure 9), both methods extracted about the same number of strategies. However, the strategies extracted using GQM+Strategies with CAM tend to be more highly evaluated than those extracted using only GQM+Strategies (Table 2). By extracting rationales exhaustively, CAM results in high-quality strategies.

RQ3: When the management policy or business environment changes, can the rationales and the GQM+Strategies Grid be easily analyzed via CAM?

The management policy changes from exercise 1.1 to exercise 1.2. In exercise 1.2 in Table 2, in addition to deriving more strategies, the teams using GQM+Strategies with CAM derived better strategies. In fact, one team added new stakeholders' views (e.g., individual customer, a character product company, etc.) to CAM. The teams of using only GQM+Strategies tended to extract strategies from the view of a few stakeholders, while the teams using GQM+Strategies with CAM tended to extract strategies from the view of many stakeholders. After the experiments, we asked students a question, "When the management policy or business environment changes, are rationales and the GQM+Strategies Grid easily analyzed using CAM?" Figure 10 shows that 76% people answered affirmatively. CAM can trace the changes easily, because its hierarchy corresponds to the same levels of the corporate structure.

We recognize that the final validation of CAM requires more empirical research. In this experiment, students derived contexts, assumptions, and strategies for goals in lower levels of an organizational structure (e.g., sales group, order reception group,

and shipment group). For this reason, the derived strategies are limited, which may be why CAM did not have a large impact on determining strategies.

4.4   Limitations

One threat to the internal validity is the difference between the ability of students by team. To remove this, the group assignments were reversed between Exercise 1 and 2. That is, Group A used only GQM+Strategies in exercise 1, but used GQM+Strategies with CAM in exercise 2, and vice versa. The same results were obtained in the both case.

We conducted experiments involving students enrolled in a class on requirements engineering. Thus, the students had limited business knowledge. Our approach may not have much effect on a business person with experience. This is a threat to external validity. However, the possibility of overlooking unexpected requests is considered high for even a business person with experience. In the future, we would like to conduct experiments involving not only students but also business persons. Another threat to external validity is that the experiment was limited to two domains (a stationary company and a cosmetic company). Because CAM has a hierarchy corresponding to the corporate structure, it is possible that CAM also corresponds to other domains. In the future, we would like to verify the effectiveness of CAM for other organizations.

5   Related Work

The GQM+Strategies approach extends the goal/question/metric paradigm [4, 5], which is a goal oriented approach. In the past, various approaches have been proposed to execute a goal-oriented approach.

E. Yu has proposed the i* framework [13, 14], which describes the dependency relationships among various actors in an organizational context. These relationships are used to describe stakeholder interests and concerns, and how they might be addressed by various configurations of systems and environments [15]. Moreover, an actor relationship matrix analysis method (ARM) extends the i*framework. ARM enables requirements engineers to better ensure completeness of the requirements in a repeatable and systematic manner that does not currently exist in the i* framework [16]. We use the point of analyzing requirements from the relationships between stakeholders as a reference for our approach.

Another approach that combines GQM+Strategies and other methods is Utilizing GQM+Strategies for Business Value Analysis [11]. This method integrates these two approaches, coupling cost-benefit and risk analysis (value goals) with operationally measurable business goals, which helps evaluate business goal success and the effectiveness of the chosen strategies. However, in this case, how to extract rationales efficiently and exhaustively is unclear.

V. Basili et al. have applied the GQM+Strategies approach to ECOPETROL, a global player in the oil and gas industry, for measurement-based IT-business align-

ment [7]. ECOPETROL has continued to extend the model, collecting and analyzing data based upon questionnaires. Moreover, J. Munch et al. have applied the GQM+Strategies method to examine and align the strategic, tactical, and operational goals in software-intensive integrated product development [17].

Our approach has been applied to an example company, but we did not consider operation and maintenance. In the future, we should verify whether GQM+Strategies models using CAM can be used for refinement and maintenance.

6 Conclusion and future work

Often, insufficient requirements management is on top of the list of factors contributing to project failures [18]. GQM+Strategies is an effective approach to align business goals with the systemization of strategies. However, rationales may be ambiguous or omitted. In our approach, ideal rationales are extracted by analyzing the relationships of stakeholders in an organization. Moreover, we propose a mechanism that can respond to changes in the management policy or business environment.

To demonstrate the effectiveness of CAM, we conducted an experiment involving 43 students at Shimane University in Japan. GQM+Strategies with CAM extracted rationales more efficiently and exhaustively than using only GQM+Strategies. Additionally, when the management policy or business environment changes, the rationales and the GQM+Strategies grid can be analyzed easily by GQM+Strategies with CAM.

In the future, we plan to conduct experiments to derive contexts, assumptions, and strategies for the goals at higher levels of the organizational structure or for multiple levels simultaneously. Moreover, we intend to develop a CAM tool to link to the GQM+Strategies grid and adapt CAM to other examples in order to validate the flexibility of CAM.

Acknowledgement

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