Putting Business Goals in Context for Measurement

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Abstract—Effective software measurement in a business organization requires a deep understanding of the business context, i.e., the business world in which the organization operates. Thus, there is a need for describing the business world and placing business goals into their context, so sensible measurement plans can be defined and enacted. In this paper, based on Jackson's ideas on domain representation and using concepts from the GQM+Strategies technique, we propose a method to precisely describe the business domain and its characteristics, the business goals, the strategies, their relationships with the software activities carried out to support the strategies, and how strategies are selected. Specifically, we propose a way to describe the business world first, including business and software processes, and then specify the required measurements.

Keywords–Software development process; Software process measurement; GQM (Goal/Question/Metric); Domain representation

I. INTRODUCTION

Business organizations need measures, to evaluate the performance of their processes, identify improvements, evaluate the effectiveness of changes, etc. Since business is largely supported by software, both business and IT people are interested in measuring how effective and efficient software is in supporting business.

The *business world* (BW) is the part of the real world relevant for the business, e.g., the market, users, stakeholders, competition, etc.. In the BW, *business goals* are conceived and *strategies* are deployed to achieve such goals. Goals and strategies are hierarchical in nature: implementing a strategy usually involves achieving a lower level goal, which, in turn, could require a strategy. A clear understanding of the business domain, the rules and constraints affecting the business, the final goals of the stakeholders, and the cause-effect relationships that govern the business is of fundamental importance to devise effective strategies. Those who need to support such strategies by means of software and then measure the effectiveness of the software solutions and the implemented strategies need to have access to explicit and clear descriptions of the BW. They have to distinguish between what is given (the context), what is currently not true and must be achieved (the business goal), and what is the set of actions (the strategy) that have been planned to achieve the business goal. In general, the context accounts for several elements (e.g., laws, standards, the market, etc.) that cannot be changed, at least within the considered project or activity; nonetheless, some parts of the context can be modified as needed (e.g., we can instruct an employee to perform some action that was not carried out previously).

The *measurement world* (MW) is where measurement plans are specified, measures are defined, and indicators (e.g., key process indicators) are computed. The MW is much more controllable than the BW, so, techniques and tools—like the Goal/Question/Metric (GQM) [1]–[3] and related tools and methodologies—have been defined to support the work to be carried out in the MW. Measurement should be used to assess strategies and goals at different hierarchical levels in the given business context, i.e., in the BW. Thus, there needs to be a two-way set of relationships between the BW and the MW. The BW contains the relevant objects of study, so the data used in the MW come from observations on the BW. Conversely, the MW needs to feed back to the BW the results of measurement and modeling activities. Thus, people from the two worlds need to at least agree on the measure definitions, how measurement is carried out, the meaning and expressiveness of indicators, etc.

GQM+Strategies [4] [5] highlights the relations existing between business goals and software development (or acquisition) within the BW and supports identifying and documenting the relationships between goals in the BW and measurement plans in the MW, as shown in Figure 1.

We here propose an approach to precisely describing the BW, in terms of the business domain characteristics, the business goals, the strategies and their relationships with the software activities that support the strategies. We argue that the elements used to select a strategy in a set of alternatives need to be explicit. Specifically, we recommend that the specific figure of merit and preference criterion among alternative strategies be made explicit and recorded, to evaluate the usefulness of the selection process, so it can be used in future strategy selections. Our proposal is based on ideas from Jackson's work [6]–[8] on requirements and domain representation, and uses concepts that have been formalized in GQM+Strategies.

The paper is organized as follows. Section II introduces a case study to explain our ideas throughout the paper. Section III concisely discusses the need for better (measurable) business models. Section IV proposes a (meta)model to represent the hierarchy of requirements in the BW; Section V discusses the selection of the best strategy; Section VI links business elements to measurement plans. Section VII accounts

for related work. We conclude and we draw some directions of investigation in Section VIII.

II. A CASE STUDY

We use an example (taken from [9]) to illustrate our approach. A company operates in a market that is becoming highly competitive, so there is a need to safeguard the company's place in the market, i.e., to keep existing customers. To this end, generating customer loyalty is necessary. This can be achieved by improving customer satisfaction with the next product, so business goal "increase customer satisfaction by 10%" is defined.

An analysis revealed that many customer complaints are due to product reliability problems. After considering several possible strategies, it was decided that the most promising way to increase customers' satisfaction is to "test reliability in." Thus, the software test processes are examined and potential lower-level goals are identified. The company has found a new system test process that seems appropriate for the context and can decrease the total number of customer complaints by 10% by reducing customer-reported software field defects (i.e., those that slip by system test) by 20%. So, a second-level goal, "improve system test effectiveness by 20%," can be defined. Because there is a new suitable system test process, the only strategy available is to introduce the new system test process.

Based on historical defect slippage data, the company assumes that reducing slippage by 20% reduces reported defects by 20%. So, the lower level goal is to apply the new system test method to see if it actually reduces defect slippage by at least 20% and eventually generates the necessary improvement to customer complaints.

III. ON THE NEED FOR BETTER MODELS OF BW

Consistent with GQM+Strategies, in our approach we specify *Business goals* in a *Context* (some of whose characteristics are known with certainty, while others are represented by *Assumptions*) and devising *Strategies* to reach the *Business goals*.

First, the boundaries of the BW model should be explicitly defined. Similarly, it should be clarified why some elements of the BW are in the model, while others have been excluded. Given a business goal, it is always possible to wonder from where it originates, what business needs led to the definition of such goal, etc. However, the specific problem to which top level context and assumptions (namely: the market is competitive; customer satisfaction increases customer loyalty) are related is not mentioned, so we do not know if there is an even higher-level goal that can be reached by pursuing the example's top-level goal. One might infer that the (unknown) higher-level business goal is to increase customers' loyalty, or just to preserve the current market share, since in a competitive market, improving customers' satisfaction could be necessary to just preserve company's market share. In general, there may be an upward chain of several goals, so the top-level goal should be given as an "axiom," and no further context or assumptions should be provided to justify it.

At the opposite end, a goal that is at the ground level in a model can always call for a strategy. In fact, any goal that can be pursued in two or more different ways can be associated with a "strategy" that indicates which of the several possible implementation ways has been chosen.

Let us now consider the fact that several different strategies can possibly satisfy a given business goal. For instance, customers' satisfaction can be increased in several different manners: increasing the reliability of products is surely a way, but it could be possible to decrease prices, add functions, improve efficiency, etc. Explicitly recording the decision criteria that lead to selecting a strategy would be beneficial, since decision criteria could play a very important role in the evaluation of strategies. Over time, by recording the decisions made, their rationales, and the results obtained, we can reach a reliable evaluation of the strategy selection criterion that can be recorded (e.g., in an Experience Factory [10]) as an asset of the organization for future use.

IV. DESCRIBING REQUIREMENTS HIERARCHIES

Given a context and a goal, the strategy is the "solution" that—in the given context and under the given assumptions—satisfies the goal. Using Jackson's concepts and notation [6], the statement above can be written as follows

$$Context, Strategy \vdash Goal \qquad (1)$$

where *Context* is the description of the business domain, including all knowledge relevant to the goals currently considered in the form of known facts or assumptions, *Goal* is the description of what is desired by the business actors, and *Strategy* is the solution devised to achieve the *Goal*.

The logical entailment $A \vdash B$ states that from assuming A we can prove B. The level of formality of Formula (1) depends on the formality of *Context*, *Strategy* and *Goal*: if they are described formally, it is possible to prove that the achievement of *Goal* descends from the statements in *Context* and *Strategy* being true. Instead, informal descriptions allow only for argumentations, which are however deemed sufficient in most cases.

In Jackson's terminology, the context is given, thus it is "indicative." However, part of the context can sometimes be controlled or changed: this part of the context is therefore not indicative. Actually, changing it could be part of a strategy.

The Goal is "optative," i.e., it represents something that is not currently true, but needs to be made true by applying the Strategy in the Context.

The Strategy is clearly optative, since in general the Goal can be achieved via several different strategies. Once a Strategy has been described, i.e., we have decided *what* has to be achieved, it is necessary to specify *how* it should be achieved. Thus, goals and strategies form hierarchies [11]: implementing a strategy in general requires the achievement of some lower-level goal, which calls for a lower-level strategy, which could require the achievement of an even lower-level goal, etc. This
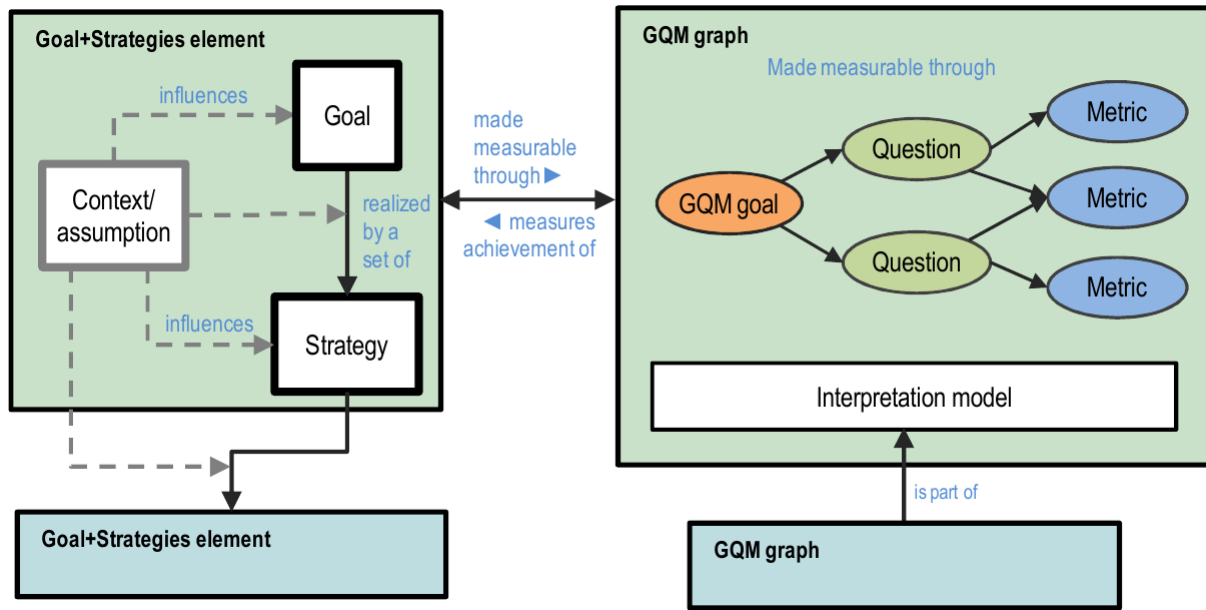
Fig. 1. GQM+strategies.

type of hierarchies can be described using Jackson's notation as follows:

$$Context, Strategy \vdash BusinessGoal$$
$$Context, LowerLevelGoal \vdash Strategy$$
$$Context, LowerLevelStrategy \vdash LowerLevelGoal$$

The LowerLevelGoal specifies *what* we can do to realize the Strategy. Reaching LowerLevelGoal in the Context is a sufficient condition for the realization of the Strategy. However, LowerLevelGoal is a goal, so it is again necessary to specify how LowerLevelGoal itself should be achieved. To this end, we need to devise a LowerLevelStrategy to reach LowerLevelGoal as shown in the last logical entailment above.

Note that in formula $Context, Strategy \vdash BusinessGoal$ the Strategy is optative, while in formula $Context, LowerLevelGoal \vdash Strategy$, the Strategy has become indicative, while the LowerLevelGoal is optative. These observations are coherent with the fact that proceeding from the business goal level to the lowest-level operational goals involves a sequence of decisions. Our description method is suitable for representing the progress of the decisional process, as well as the cause-effect relationships linking goals and strategies at the different levels.

V. SELECTING A STRATEGY

Different strategies are characterized by different costs, effectiveness, risks, and benefits, so that choosing a strategy (i.e., exercising the option) implies that multiple characteristics of multiple strategies may need to be assessed. Therefore, in addition to the Goal, a Figure of Merit (FM) exists, whose value depends on the Context and the Strategy. The FM can be used in two ways. First, a constraint can be set on the FM. For instance, if cost is the FM, we can consider acceptable only strategies whose cost is below a specified cost threshold. Second, the FM can be used to comparatively assess different strategies, based on a Preference Criterion (PC) that ranks alternatives based on their corresponding values of FM. The PC may be a straightforward one when the FM is a single-objective one. However, FMs are often multiple-objective: for instance, a double-objective FM may address effort and development time. The application of the PC results in general in a partially ordered set of strategies, as some strategies may be deemed equivalent as for their FMs.

Making the FM and PC explicit shows that the selection of a strategy is not based only on the Goal; instead, it involves the optimization of characteristics that do not necessarily appear in the Goal. For instance, take the business Goal in the example, which should be interpreted as "Increase customer satisfaction by at least 20%." This Goal sets a constraint on the set of possible strategies used to reach it, but by no means does it explicitly indicate how to choose among competing strategies that satisfy it. In principle, one could choose any Strategy that satisfies the Business Level Goal in the given Context, regardless of the cost. However, in practice, the Strategy that minimizes the cost is likely to be preferred over the others.

Also, making the FM and the PC explicit provides guidance in the building of effective strategies, when no previously used strategies are available, or in the tailoring of existing ones or when there is a significant level of uncertainty, which is always present when making decisions. If so, we may not be able to identify the optimal Strategy with certainty, but the FM and the PC will help us at least reduce the set of strategies.

Summarizing, the FM and the PC need to be made explicit so that all ambiguities are removed as to why a specific Strategy is selected. Also, the analysis of the results obtained in the field will allow us to refine our decision processes.
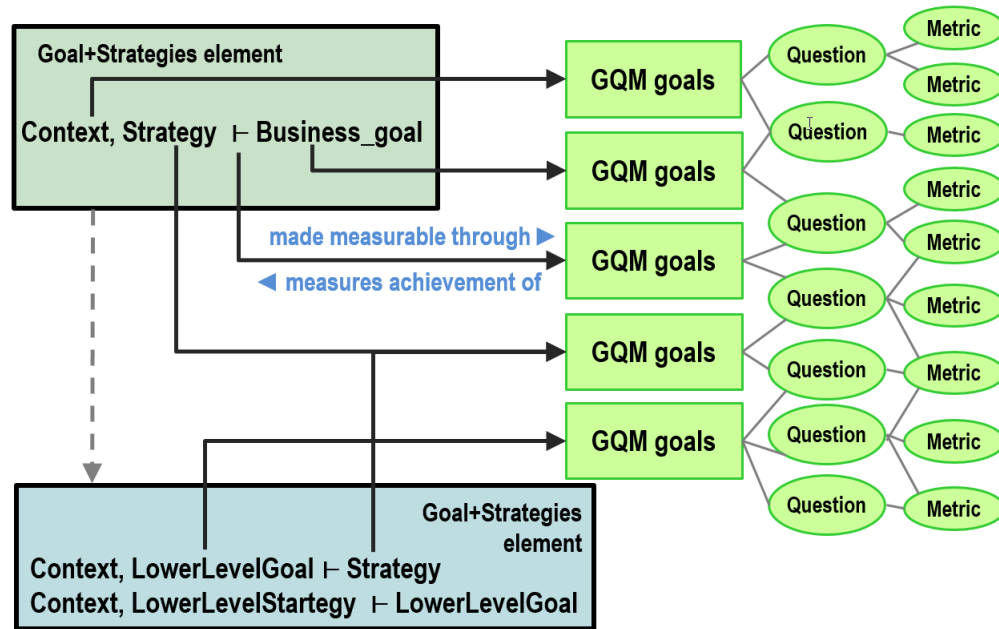
Fig. 2. Our proposal.

VI. WHAT SHOULD BE MEASURED (AND HOW)

Basili et al. provide the following indications for measurement [5]:

Associated with each GQM + Strategies element is a measurement plan that uses the GQM measurement and evaluation framework to specify how to evaluate the goal, what data to collect, and how to interpret that data. The nodes of each GQM graph consist of a measurement goal, which describes what knowledge needs to be gained from the measurement activity; a set of questions to be answered; the metrics and data items required to answer the questions; and an interpretation model that specifies how the data items are to be combined and what the criteria are for determining the goal's success.

With respect to GQM + Strategies, Formula (1) provides clearer indications on what should be measured. While a single GQM plan is connected to a Goal+Strategy element [5], it is more natural and effective to associate specific measurement plans to each part of the entailment:

– Context: if the context description contains assumptions, it is generally a good practice to measure to what extent the assumptions are true.
– Goal: of course, we want to know to what extent the goal has been achieved. To this end, a GQM plan is typically attached to the business goal.
– Strategy: like the goal, we want to know to what extent the strategy has been applied. So, a specific GQM plan is typically defined for the strategy.

For sure, we want to measure the FM associated to a given entailment. In some cases, we could even have several FMs, each one representing a specific point of view. For instance, we could have a FM for top management and another one for the project manager. Measuring the FM usually requires measuring the elements the Context and the Strategy to which a FM refers. However, it must be noted that very often a FM concerns properties (e.g., the amount of resources used to implement a Strategy, or the time taken to complete the activities involved in a given Strategy) that belong to a sort of meta-level, and are possibly not considered in the "basic" measurement of Strategy. The quantification of Strategy selection criteria usually does not call for additional measures; instead, it is just a function of the computed FM.

As an example, let us consider the entailment *Plans based on reliable estimates of resource needs lead to more effective usage of resources, Resource allocation planning is improved ⊢ Available resources used more effectively*. Evaluating the FM involves measuring properties like the cost of planning, the increase of competence needed to perform better planning, the cost and the learning curve of tools used for planning, etc.

The entailment is usually assumed to be true. In other words, it is believed that the devised Strategy, correctly applied in the given Context, causes the full achievement of the Goal. However, it may happen that the Goal does not follow from the Context and Strategy. Measuring (i.e., looking for quantitative evidence of) this fact is therefore advisable. This usually involves verifying the connection between properties of the processes and products addressed by the Strategy and processes and products considered in the Goal. For instance, in the example's top level Goal and Strategy, one of the conditions that make the entailment true is that the cost of development depends on the usage of resources: this is usually true but not always so (e.g., when free resources are used). The interpretation model mentioned in [5] is clearly of great

importance, since the whole interpretation of the collected data depends on it. Nevertheless, in [5] it is not specified how the interpretation model should be defined; instead, it is delegated as part of the GQM plan. This is not advisable, in that the GQM itself is generally more oriented to refining goals into metrics than in prescribing how the collected data would be interpreted.

With our approach, the interpretations are generally made apparent by the formulae. Moreover, we do not have multiple GQM plans and graphs, as in GQM+Strategies; instead we have a single plan, with clearly interconnected elements, as shown in Figure 2 (which schematically represents a portion of the requirements hierarchy).

The connections between a strategy and its lower level goals are not emphasized by Basili et al., while they are clearly represented and measured in Figure 2.

VII. RELATED WORK

The weakness of GQM in describing the software product or process that is the object of measurement were overcome by coupling GQM-compliant measurement tools with tools for modeling the product and process [12]. The work described here can be seen as a continuation of that work, in that here we provide the basis for coupling reasoning on business goals, user requirements, software development and –finally– measurement.

The need for linking business processes and Goal/Question/Metric paradigms has been felt since 2004 [13]. In [13], the authors define a measurement framework to support process analysts in assessing business processes by means of the GQM paradigm, to find useful indications about process performance, critical elements, change impact, and expected improvement. In our approach, the focus moves from a way to assess the quantitative and qualitative aspects of a business process to a way to precisely (possibly formally) describe business processes in a manner that is compliant with the GQM paradigm. The precise description of the business world and of company goals eases both the measurement of process aspects and the evaluation—both quantitative and qualitative—of the business and technical aspects of the process.

GQM+Strategies has been introduced for the first time in [4] to extend the GQM approach with the capability to create measurement programs that ensure a link between business goals and strategies, software goals, and measurement goals. The approach has been supported by the SAS tool to improve the definition of the context, assumption, and strategies [14]. In our paper, we adopt the extensions proposed in [4] to go further in the direction of representing the BW processes that are to be connected with GQM+Strategies. Our approach makes the representation of relevant relationships explicit, independently from the GQM.

In [15], the GQM+Strategies approach is adopted to perform business value analysis and to identify success/critical business goals. The paper clearly states that the various aspects of business value expressed and defined by goals require the knowledge and experience of the stakeholders to identify what elements (context, assumptions, strategies, goals) are valuable and appropriate for the company's success. In our paper, we aim at improving the process of describing the BW, in terms of the business domain, characteristics, goals, strategies and relationships with the software activities.

In [16], the author notes that the business level should be mapped into a Conceptual/Strategic level to clearly define the scope of the Business level in a generic way (i.e., outside the boundary of the software domain): the conceptual level is actually the highest organizational abstraction where an organization determines how to succeed in those activities that are strategic for the existence of the organization itself. This kind of mapping is quite easy with our approach.

VIII. CONCLUSIONS AND FUTURE WORK

In this paper, we introduce a proposal to help organizations better represent their business goals and how to achieve them (mostly via software), and to link the business-oriented descriptions with measurement goals and plans. Our proposal is based on using Jackson's ideas on domain representation and uses concepts from GQM+Strategies, and allows for the precise description of the business domain, the business goals, the strategies, and their relationships with the software activities carried out supporting the strategies, and how strategies are selected. Thus, the most promising approach does not appear to consist in inventing a brand new technique or notation, but in leveraging on two existing techniques to make their joint use applicable in practice. The proposal also makes it possible to clearly and explicitly describe and therefore record the rationale behind the selection of strategies. A Figure of Merit of practical interest needs to exist, in addition to a Goal, for the evaluation of strategies in a given Context. A Preference Criterion must be defined so the different strategies can be ranked according to the values of their Figure of Merit.

A significant amount of future work remains to be done, including:

– Applying the approach to a set of real life business cases;
– Defining a fully coherent approach that enriches the GQM+Strategies methodology;
– Developing supporting tools to be integrated with existing GQM tools.

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