A Framework for Measuring and Managing Value Achievement in Business Processes

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SUMMARY As business values pursued by today’s organizations are abstract concepts, measurement of these values and their achievement is not straightforward. This paper proposes a value achievement measuring and managing framework, which recursively decomposes business values to construct a value hierarchy and then links it with the business process hierarchy. The framework makes it possible to measure value achievement, trace values to processes, and take necessary actions in response to the measured progress in value achievement.

key words: business process, business process management, business value, value measurement, performance indicator

1. Introduction

Many of today’s organizations pursue business values as part of their business activities, from the organizational level to the individual’s task level. Business values can range widely from abstract and general ones that are not intended to be achieved in the near future, such as public happiness, to concrete and specific ones that are expected to be achieved as soon as possible, such as customer satisfaction. Regardless of the differences in pursued values, organizations can succeed only by having capabilities to measure the extent to which the values have been achieved and adapting their business processes in case the achievement does not proceed as expected. In addition, by reflecting the degree of value achievement in improving its business processes, an organization can carry out its activities more effectively. However, since business values are abstract and often vague concepts, their measurement, along with measurement of their achievement, is typically not straightforward.

It is widely recognized that in today’s competitive business world Business Process Management (BPM) is important for successful business [28]. However, even with organizations that have automated their business processes by adopting BPM systems and measured Performance Indicators using them, it is not easy to utilize BPM systems in such a way that their BPM processes are systematically linked with value achievement. This can be attributed to the following reasons: First, many concepts such as value, goal, objective, etc., that are related to value achievement are abstract and vague, and it is not clear how they are interrelated. In order to be able to measure and manage value achievement, the meanings and relationships of such concepts should be precisely and consistently defined. Second, there is no comprehensive framework that integrates these concepts and related methods and links value and processes so that measurement and management of value achievement can be systematically performed.

These issues were partially addressed in the past by a number of works [1], [4], [6], [9], [11], [14], [17], [18], [26]. However, they focused largely on either business process measurement [4], [9], [17], [18], [26] or on value measurement [6], [11], [14]. Works on business process measurement have dealt with metrics derivation, but the notion of value was not directly addressed and the targets of measurement and the business processes were not explicitly linked for management. Research works on value measurement have been either limited to software engineering [6], [14] or restricted to the notion of benefit as value [11].

To bridge this gap, we propose a framework for measuring and managing value achievement in business processes on the basis of the organization’s business values. To this end, this paper first lays a foundation by defining various concepts essential to measuring value achievement. Integrating these foundational concepts, we then develop a value achievement measuring and managing framework, which recursively decomposes business values to construct a value hierarchy and then links it with the business process hierarchy. This mechanism makes it possible to measure value achievement at appropriate places in the processes, trace values to business processes, and take necessary actions in response to the measured progress in value achievement. The usages and the efficacy of the framework are demonstrated with two application examples.

This paper is organized as follows: In Sect. 2 we explain the foundational concepts and assumptions for measuring and managing Value achievement. Section 3 presents a framework for measuring and managing value achievement. In Sect. 4, the framework is illustrated with application examples. In Sect. 5, related works are discussed. Finally, Sect. 6 concludes this paper by noting the contributions of the framework and future work directions.

2. Foundational Concepts and Assumptions

2.1 Value and Goal

In the business world, people say that companies pursue values [8] while the term value also can denote “the worth of a
thing” [10]. In the former case, value is a target of pursuit. In the latter case, it is the concrete value that a variable takes at a certain moment in time. In this paper, to clearly distinguish two different senses of the term value, we use ‘Value’ to mean the former and use ‘value’ to mean the latter.

Then Values that organizations pursue can be defined as follows:

Definition 1. A Value is a direction of an organization’s activities that is pursued to bring goodness to human society.

In this sense, a Value is more a target of pursuit than a target of achievement. That is, it is not something that we intend to achieve by a certain deadline but something that we try to approach continuously. There are Values that are pursued for ultimate goodness as well as Values pursued for survival, growth, profit making, etc. Organizations, in particular, actively strive to achieve the latter kind of Values and, moreover, want to know how close they are to realizing their ultimate pursuit. Such Values are called Business Values.

Definition 2. A Business Value is a Value that an organization considers important and publicly declares that it pursues.

The targets of measurement and management that this paper is interested in are such Business Values. In the remainder of the paper, we use the term ‘business Value’ and the term ‘Value’ interchangeably. Among business Values, strategically important business Values are called strategic business Values or simply strategic Values.

According to the American Heritage English Dictionary, a goal is “the state of affairs that a plan is intended to achieve and that (when achieved) terminates behavior intended to achieve it”. Also a ‘goal’ is defined to be a “purpose toward which an endeavor is directed.” The Capability Maturity Model Integration (CMMI) [21], which is a maturity assessment model for assessing the maturity level of an organization’s software development process, states, “The goals summarize the key practices of a key process area and can be used to determine whether an organization or project has effectively implemented the key process area. The goals signify the scope, boundaries, and intent of each key process area.” From these senses, we can say that for an organization that has not performed relevant core practices, a goal is a target of achievement that should be achieved within a certain period of time. On the other hand, for an organization that has performed core practices, they achieved goals. That is, if the deadline of achievement is ‘now’, often it is not explicitly specified but a goal is a target of achievement that is intended to be achieved ‘sometime in the future’. However, in the business world, merely saying ‘sometime in the future’ is viewed as lacking ‘will to achieve’. Therefore, from the organization’s point of view, a focal point of effort with no definite deadlines is an unnecessary thing with no practical meaning. Thus, whether it originates from Value or not, a focal point of effort for which the achievement deadline is declared is a goal and can be precisely defined as follows:

Definition 3. A goal is a focal point of effort with concrete contents to achieve and deadlines for achieving them.

Definition 4. An objective is a component of a goal and has concrete contents to do and a deadline to finish it.

Therefore, in order to specify a particular goal G, the ‘what’ and ‘when’ of the goal should be specified. Formally, a goal G can be specified as follows:

\[ G = \{(O_i, D_i)|1 <= i <= N_G\} \tag{1} \]

Here \((O_i, D_i)\) is an objective and \(O_i\) denotes the concrete contents (target value), \(D_i\) the deadline to finish \(O_i\), and \(N_G\) the number of objectives of G.

2.2 Measure, Metric, and Indicator

Measure, metric, and indicator are concepts that need be precisely defined in relation to measurement. According to [23], a measure provides “a quantitative indication of the extent, amount, dimension, capacity or size of some attribute of a product or a process.” IEEE software engineering standard[15] defines a metric as “a quantitative measure of the degree to which a system, component, or process possesses a given attribute.” In [25], Ragland says that an indicator is “a metric or a combination of metrics that provides insight into the software process, a software project or the product itself.” In this paper, among various indicators, we are interested in Performance Indicators (PIs). Performance Indicators that are managed as particularly important ones are called Key Performance Indicators (KPIs).

2.3 Assumptions for Measuring Achievement of Value and Goal

In this paper, for the measurement of Value achievement and to establish a management framework, we make the following assumptions on the relationship between Values and goals:

Assumption 1. Some Values become bases for setting goals.

Assumption 2. Some goals are not based on Values. That is, the set of Values and the set of goals have the relationship depicted in Fig. 1.

Rational organizations would pursue their Values as goals to achieve while performing their business activities. However, certain Values should be pursued for an indefinitely

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2. CMMI-DEV [7] defines generic goals and specific goals only, without defining the intrinsic meaning of goal.
long period of time, and thus are not suitable to be regarded as goals. Further, certain goals may be set without being connected to Values. Therefore, in this paper, ‘Values’ and ‘goals’ are viewed as independent concepts for which all the cases mentioned above can arise.

In relation to measurement, the following assumptions are made.

Assumption 3. Goals must be measured and managed with KPIs.

When goals cannot be directly measured, their achievement should be measured through metrics that can indicate the achievement of goals.

Assumption 4. KPIs must be measured.

Assumption 5. There are targets of measurements that are not KPIs. We refer to them as PIs.

Assumption 6. There are KPIs that are not goals now but are measured for future use.

From these assumptions, the relationship between Values and the various concepts that need be measured can be summarized as illustrated in Fig. 2.

That is, certain Values may be selected as targets of measurement while other Values may not be selected. As targets of measurement, there are goals, KPIs, and PIs. KPIs include goals and PIs include KPIs. Certain Values that are measured are managed through PIs or KPIs. Among Values that are managed through KPIs, there are Values for which we set target values and try to achieve them. We call Values set as goals Value Achievement Goals and the KPIs that have target values to be achieved are referred to as Key Performance Goals. All Value Achievement Goals are Key Performance Goals.

2.4 Targets of Measurement: Goals and KPIs

KPIs and PIs are measured and monitored but may or may not have goals and be managed with the target values that are associated with them. KPIs are more important indicators among PIs but they do not necessarily have associated goals. According to its judgment, an organization may or may not impose a goal on a particular KPI. However, if a KPI has an associated goal, it is necessary to keep track of its current value as well as its target value to be achieved and the related deadline. Therefore, a KPI or PI with a goal has a pair of variables, one un-primed and the other primed. An unprimed variable stores the current value and a primed variable stores the target value. The remainder of this paper follows this convention. If the deadline of a goal is ‘immediate’, then the goal immediately becomes effective while the goal is pursued.

2.5 Targets of Measurement: Goals and KPIs

In order to measure a Value, it should be linked to PIs. A Value may be so abstract that it is not easy to determine how to measure or evaluate it. Also, an organization may wish to take a bottom-up approach and measure it using other indicators. In such a case, the Value should be made more concrete in the form of subvalues for quantitative measurement or subjective evaluation.

Figure 3 shows how a higher Value is first decomposed into subvalues and PIs; a subvalue must be connected to PIs for measurement of Value achievement. In the case of the leftmost subvalue, as the subvalue is not sufficiently concrete to be measured directly, it is further decomposed and eventually connected to PIs. In the case of the two subvalues in the middle of Fig. 3, they are concrete enough to be measured and are directly connected to PIs. In the case of the rightmost subvalue, it was decided that subjective evaluation is more appropriate than quantitative measurement. When a Value is decomposed into subvalues, each subvalue should be decomposed such that achieving the value contributes to achievement of the original value. There may
be interdependence between the subvalues obtained as a result of decomposition. For example, while focusing on one subvalue, it may become difficult to work on the other subvalue(s). Subvalues that negatively affect the parent value are not suitable subvalues. However, when a Value is decomposed into subvalues and a set of subvalues is derived, metrics for measuring the achievement of the parent Value should be accompanied. That is, the current value of the Value should be a function of the values of its subvalues.

3. A Framework for Measuring and Managing Value Achievement

In Sect. 2, we defined various concepts that are essential for systematic Value measurement and management and investigated their relationships. This section presents a framework for measuring and managing Value achievement based on the concepts and assumptions introduced in the preceding section. We refer to it as the Value Achievement Measurement and Management Framework (VAMMF).

There are three major steps in the VAMMF, as shown in Fig. 4. In the first major step, Step A, metrics for Values are derived and responsibilities of Value achievement are cascaded to a business process. A business process is a set of activities conducted by an organization to produce products or provide services. There are two inputs for this step: a set of Values and a business process with a hierarchical structure, which is assumed to be Value agnostic. We call a business process Value agnostic if it does not have any associated mechanisms for realizing and tracking business Values. In the second major step, Step B, the Value achievement responsibilities are realized in the business process by redefining the business process. The output from Step B is thus a Value aware business process that has the capability of measuring and managing Values. In the final major step, Step C, the Value aware business process is executed and Value achievement is measured and managed.

3.1 Step A: Derive Metrics for Business Values and Cascading Value Achievement Responsibilities

In this section, we introduce a method to measure subvalues, KPIs, and PIs that are targets of Value measurement, as discussed in Sect. 2. The value measurement method consists of two phases: ‘Step A1. Apply the Recursive Value Decomposition Method (RVDM)’ and ‘Step A2: Assignment of Vi to subprocesses.’ Steps A1 and A2 are presented in Sects. 3.1.1 and 3.1.2, respectively. Section 3.1 first presents a method to measure subvalues, KPIs, and PIs as targets of Value measurement.

3.1.1 Step A1: Apply the Recursive Value Decomposition Method

In Step A1, subvalues and Performance Indicators are derived in the process of recursively decomposing business Values or subvalues into more concrete business Values and are eventually connected to the Performance Indicators. We call this step the RVDM method. The details of the RVDM are shown in Fig. 5. Step A1 consists of two substeps, Step A1a and Step A1b. In Step A1a, a variable V is declared to store the current value of a business Value and define all the metrics necessary to calculate the value of V. If the number of relevant metrics is p and all the relevant metrics are M1, . . . , Mp, declare variables V1, . . . , Vp to store the values of the metrics. Metrics and variables are in one-to-one correspondence and the calculated value of Mi is stored in Vi. Note that it is required that p ≥ 2; otherwise progress is not achieved by decomposing a Value. Step A1b defines a function CV that combines the values and converts them into a single measure. Some subvalues are managed as PIs and some subvalues are not.
3.1.2 Step A2: Cascade Value Achievement Responsibilities to Business Processes

Figure 6 shows a conceptual view of how the business Value hierarchy is mapped to an enterprise’s business process hierarchy via the application of RVDM. While business Values are being decomposed, they are assigned to the relevant subprocesses. The links thereby introduced between the business Value hierarchy and the process hierarchy can be used to trace the threats to business Value achievement. With such traceability links, feedback on problematic responsibilities can be provided to the relevant persons so that they can take appropriate actions. By tracking the traceability links, managers can identify which process elements help achieve the business Values. Whenever a business Value or subvalue is decomposed, the responsibilities of Value achievement need to be determined. To this end, the relations between the business value being decomposed and its subvalues are defined and the subvalues are mapped to the relevant processes in the process hierarchy. We call Value measuring and managing responsibilities Value achievement responsibilities.

For measuring a Value when a higher level process is decomposed into subprocesses, a measurement scheme should be set up concurrently. Figure 7 illustrates the steps of this procedure. Steps A1a and A1b correspond with those in Fig. 5. Figure 7 shows how measuring the current value of a Value depends on its subprocesses. However, at the lowest level of the process hierarchy, the current value of a Value should be determined by directly measuring PIs or by evaluating subvalues. Note that cascading Value achievement does not involve redefining the business process, which is performed in Step B.

In Step A2 of Fig. 7, subprocesses that are responsible for Vi’s are decided. One variable might be assigned to several subprocesses, and several variables might be assigned to one process. Vi, which is not assigned to any subprocess, should be measured or evaluated at the current process. After this has been completed, the value of Vi is decided in Step C1, and finally the value of V is determined by using the composition function CV. Figure 7 illustrates one step of decomposition and cascading of value achievement responsibilities. This step should be applied repeatedly until all the subvalues, KPIs, and PIs are assigned to the appropriate subprocesses.

Figure 7 shows a conceptual view of how the business Value hierarchy is mapped to an enterprise’s business process hierarchy via the application of RVDM. While business Values are being decomposed, Value achievement responsibilities need to be determined and assigned to the relevant subprocesses. The traceability links thereby introduced between the business Value hierarchy and the process hierarchy can be used to trace not only the more important factors but also the threats to business Value achievement so that appropriate actions can be taken as business processes are carried out.

Table 1 lists various value decomposition techniques that can be used as part of RVDM (Step A1) to make it more effective. There are three substeps where guiding techniques can be useful:

1. Determining subvalues, KPIs, and PIs
2. Defining composition functions
3. Aligning and detecting conflicts between the derived Values

3.2 Step B: Redefine Business Process for Measuring and Managing Capability

In Sect. 2 and Sect. 3.1 we discussed, respectively, the foundational concepts for measuring Values and the methods for measuring Values. This section discusses a procedure for enhancing a business process with Value measurement and management capabilities.

For measuring process performance we add measuring tasks to data collection points. Measuring tasks have the role of collecting the most basic data. Figure 8 shows that a process with measuring capability is transformed into a process with measuring and managing capability and also that the measuring results can be reflected in the existing process. The task of managing goal achievement should be dealt with separately, because it is much more complex than measurement.
<table>
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<tr>
<th>Technique</th>
<th>Description</th>
<th>2. Defining composition functions</th>
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<tr>
<td>Goal, Question and Metric (GQM) [1, 3, 4]</td>
<td>This metric measures the extent of goal achievement of an organization by analyzing data that is linked to the goal and the organization’s activities for achievement of the goal. It defines a measurement model on three levels, i.e. (1) Conceptual level (goal), (2) Operational level (a set of questions), (3) Quantitative level (a set of metrics)</td>
<td>This helps the decision makers make decisions that best suit their needs among alternative decisions. Users first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. Once the hierarchy is constructed, the decision makers evaluate its various elements by comparing them to one another two at a time. The AHP converts these evaluations to numerical values, which are processed and compared over the entire range of the problem. In the final step, numerical priorities are calculated for each alternative. The numbers represent the alternatives’ relative abilities to achieve the goal.</td>
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<td>Balanced Scorecard (BSC) [17]</td>
<td>This tool measures the performance of operational activities of a company. Its role is to view the vision and strategy of an organization in terms of financial, customer, internal business, and innovation and learning perspectives. There are four processes involved in its implementation: (1) Translating the vision into operational goals, (2) Communicating the vision and linking it to individual performance, (3) Business planning, and (4) Feedback and learning, and adjusting the strategy accordingly.</td>
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<td>Principal Component Analysis (PCA) [22]</td>
<td>This technique can be used to simplify a dataset. It is a useful statistical technique that has found application in fields such as face recognition and image compression, and is commonly used for finding patterns in data of high dimension. In contrast with common factor analyses, this factor analysis approach considers the total variance in the data. In a principal component analysis (PCA), the diagonal of the correlation matrix consists of unities and the full variance is brought into the factor matrix.</td>
<td>This is a more general form of the AHP. Compared to the AHP, the ANP structures a decision problem as a network. Both use pairwise comparisons to measure the weights of the components of the structure and finally rank the alternatives in the decision. The steps of the ANP are: (1) Determine the control criteria in the four control hierarchies; (2) Determine a complete set of network clusters (components) and their elements that are relevant to each control criterion; (3) For each control criterion, determine the appropriate subset of clusters of the comprehensive set; (4) Determine the approach to follow in the analysis of each cluster or element; (5) For each control criterion, construct a matrix by laying out the clusters; (6) Perform paired comparisons on the elements within the clusters; (7) Perform paired comparisons on the clusters. Compute the limit priorities of the stochastic matrix; (8) Synthesize the limiting priorities by weighting each idealized limit vector; (9) Determine strategic criteria and their priorities to rate the top ranked alternatives; and (10) Perform a sensitivity analysis.</td>
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<td>Ishikawa (Fishbone) [16]</td>
<td>When it is necessary to identify the sources that create Value, a Fishbone diagram can be used. It is also called an Ishikawa diagram or cause-and-effect diagram and represents the causes of a certain event. With this diagram, latent causes or major causes that produce defects in quality can be analyzed explicitly. The causes are frequently arranged into four major categories: manpower, methods, materials, and machinery.</td>
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<td>Six-Part Quality Attribute Scenario [2]</td>
<td>This technique was originally developed for systematically deriving verifiable architecture drivers for software systems. Instead of just specifying quality attribute names, by describing quality attribute scenarios in terms of the following six components we can obtain specific quality scenarios that can be used for testing the end product: (1) Stimulus – a condition that affects the system; (2) Source of stimulus – an entity that generates the stimulus; (3) Artifact stimulated – an artifact that is stimulated (e.g. process, processor, storage, communication); (4) Environment – the conditions under which the stimulus occurs; (5) Response – activity as a result of the stimulus; (6) Response measure – the measure by which the system’s response will be evaluated. Abstract system qualities can be viewed as the values sought for in the system and quality attribute scenarios obtained in this way expose various constituents contributing to the values of the system. Therefore, by applying this technique, measurable contributing factors can be determined.</td>
<td>This is a quantitative technique used to rank the multidimensional options of an option set. It is used to rank different options from various areas. A basic decision matrix consists of a set of criteria upon which the potential options can be decomposed, scored, and summed to gain a total score that can then be ranked. The criteria are not weighted so as to allow a quick selection process. One of the advantages of this technique is that subjective opinions can be made more objective. Another is that sensitivity studies can be performed.</td>
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<td>3. Aligning and detecting conflicts between the derived Values</td>
<td>Result Chain of BRA (Benefit Realization Approach) [30]</td>
<td>This can be used to validate whether the value derived from each step of a process can contribute to achieving the final value and link both super-value and sub-value. The result chain is a highly effective benefits realization technique. Not only has it been designed specifically to help realize benefits, but it is also an excellent visual technique for simplifying the presentation of complex components, initiatives, and risks associated with a program or project.</td>
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<td>Model Clash Spider Web/Master Net [5]</td>
<td>Developed by analyzing many failed-project examples, it reveals that potential model clashes occur frequently. Such clashes result from potential conflicts among the most frequent success models associated with the most common project stakeholders: users, acquirers, developers, and maintainers. It is an explicit representation of an inconsistency among the assumptions of the various process, product, property, and success models.</td>
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3.3 Step C: Measure and Manage Value Achievement

Section 3.3.1 shows a procedure for measuring the current value of a specific Value within the structure of business processes. Section 3.3.2 presents a Value achievement measuring method based on the procedure for measuring the current value of a Value in Sect. 3.3.1.

3.3.1 Step C1: Measure Value achievement

For measuring and managing Value achievement in Sect. 3.1, the current Values or PIs are measured and evaluated without specific goals to achieve. However, an organization commonly wants to know how close they have come to their goals or how much they have achieved toward the goals with their expected target values for Values. Measuring achievement as such can be calculated by introducing goals for improvement first and then by comparing the improvement results with the goals. The method for the latter involves expansion of the approach for measuring the current value of a Value in Sect. 3.2. So, if $V_1, \ldots, V_p$ are necessary variables for measuring the given Value, we declare new variables $V'_1, \ldots, V'_p$, define for each pair of variables $\delta(V_i) = V'_i - V_i$, and finally define the composition function $C_V(\delta(V_1), \ldots, \delta(V_p))$. $\delta(V_i)$ then represents how close the current values of PIs or subvalues are to the target values; by composing all these values, we can determine how close the current values of Values are to the target values.

Value achievement can be measured by extending the basic framework for measuring the current value of a Value presented in Sect. 3.2. Then, as a further extension, once improvement goals are introduced, achievement of improvement can be determined and measured by comparing value achievement against the goals.

3.3.2 Step C2: Manage Value achievement

A manager normally identifies goals to be accomplished and organizes the processes to accomplish those goals. In addition, a manager may measure the Value achievement of the processes to ensure that the processes meet their assigned goals [13]. This determines how much must be achieved by each element of the process hierarchy to accomplish the assigned goal by relying on the predefined composition functions, which is used to manage business Value achievement at each decomposition level. Before functions are defined, the responsibilities of each assigned element of the business process hierarchy are determined through a cascading process. This performance management connects business values with business process management, making it possible to assess the gap between the current performance and the desired performance [29]. On the basis of the assessment results, a manager can make a management plan that clearly indicates the responsibilities involved in executing the plan and, based on it, manages the tasks defined in Step B in accordance with the Value achievement.

4. VAMMF Framework Application Examples

In this section, we illustrate the VAMMF framework with two application examples. The first, presented in Sect. 4.1, illustrates the RVDM method and the second, presented in Sect. 4.2, illustrates the application of the whole framework.

4.1 The RVDM Application Example

Through this first example, we show how various concepts such as current value, value achievement, and process improvement can be measured based on the VAMMF framework, each of which is presented in Sects. 4.1.1 - 4.1.3. The following is an example Value that is to be a target of measurement:

Value T: Timeliness of processing change request from the project manager’s viewpoint

4.1.1 Measuring the Current Value of a Business Value

Basili et al. [4] considered that a PI can consist of several

\[ \delta(V_i) = V'_i - V_i \]

The advantage of top-down design is that, for the design results, it is easy to assign a Value that a high-level business process pursues, a Goal that they intend to achieve, and functions or responsibilities to subprocesses systematically. By integrating the results, we can then analyze the status and respond to it easily. Bottom-up design is applied when organizations’ processes interoperate or are integrated with each other, or when an organization’s business processes are designed to force the utilization of existing subprocesses or IT service
metrics. In our VAMMF framework, when several metrics are related to a PI, it is possible to evaluate the achievement via a single measure by defining a function that composes them. First, Value T is decomposed into a set of subvalues and PIs. For measurement, the decomposed subvalues should be eventually decomposed into a set of PIs. Figure 9 shows the results of decomposition. While a PI can be measured immediately by defining metrics, a subvalue can be evaluated by subjective judgment or can be measured after PIs are defined for it. The PI ‘Current change request processing speed’ can be transformed to one measure from the composition function after being measured by 3 metrics.

According to the RVDM, the variables Timeliness of change request (CRT), Average cycle time (ACT), Standard deviation (SD), FaultRate, and PMSatisfaction are declared (Step A1a) and the composition function $C_{CRT}$ is defined (Step A1b) as in Fig. 9. Then, SD, FaultRate, and their metrics, 1, 2, and 3, are assigned to the appropriate subprocesses (Step A2), and the values of these variables will be measured while the subprocesses are executed. In the case of PMSatisfaction, instead of being assigned to a subprocess, the project manager determines its value by a subjective evaluation. Finally, the measured value of Value T is determined by replacing these four values of the variables of the composition function $C_{CRT}$. In Fig. 9, $C_{CRT}$ is defined as

$$C_{CRT}(ACT, SD, \text{FaultRate, PMSatisfaction}) = \frac{\text{PMSatisfaction}}{(ACT \times SD \times \text{FaultRate})}.$$ 

4.1.2 Measuring achievement of a business Value

In the example in Fig. 9, the ‘Current change request processing speed’ KPI value and the Project Manager’s satisfaction about ‘Current change request processing speed’ are either quantitatively measured or evaluated by subjective judgment for Value measurement. If there are concrete goal values to be achieved associated with them, then, in order to measure the achievement of the goal values, for the variables ACT, SD, FaultRate, and PMSatisfaction in Fig. 9, goal values ACT', SD', FaultRate' and PMSatisfaction' are respectively declared. For the example of Fig. 9, variable CRTAchievement for Value achievement of CRT is declared and its value is defined as shown in Fig. 9. That is, by summing the proximity to the goal from each metric's viewpoint, achievement of CRT is measured as in Fig. 10.

4.1.3 Measuring process improvement

When measurement is conducted for Value-based process improvement, we can check whether or not there has been improvement (1) by defining KPIs representing improvement or (2) by using the rate of change during a fixed period of time. Figure 11 is an example of the former case. In this case, for measuring Value achievement improvement, we use the measurement method for the current value of a Value explained in Sect. 4.1.1 without modification. Figure 12 is an example of the latter case and shows that the target values are established after declaring the period and the variables for the target value. Also, we measure the degree of Value achievement improvement for the timeliness of processing a change request.

The Value achievement measured through these methods can be reflected manually for process improvement or, in the case where automated business processes are used, the following two methods can trigger the change of processes: (1) Processes are automatically redefined by a self-adaptive method. (2) Processes are the same but the actual workflow is changed by the new value of a variable that controls the

†This composition function is presented as an example like other composition functions shown in Sect. 4. In an organization, composition functions should be defined such that they are suitable to the characteristics and environment of the organization.
Fig. 12  Measuring improvement by using the change rate per unit period of time.

Fig. 13  The fulfillment process of A-Homeshopping.

4.2 Application of the VAMMF Framework

In this section, the whole VAMMF framework is applied to the Fulfillment Process of A-Homeshopping, a real online homeshopping company. Figure 13 describes simplified version of A-Homeshopping’s fulfillment process. It is drawn in a UML 2.0 [19] activity diagram, which has similar descriptive power to the business process modeling notation BPMN [20]. Different departments of A-Homeshopping perform different activities. The fulfillment process starts, for example, by making a supply plan for product B. The planned quantity is then ordered and sold to customers until there are no remaining items. While a customer order is fulfilled, the business processing continues to process the next customer order.

A-Homeshopping has chosen CustomerSatisfaction and CustomerBenefit as business Values to pursue. By applying the VAMMF framework, we wish to enhance A-Homeshopping’s existing fulfillment process such that it has Value measurement and management capabilities for achieving its business Values.

4.2.1 VAMM Process defined

Figure 14 describes the Value achievement measuring and managing process that is obtained by instantiating the VAMMF framework. We call this the VAMM Process.

The defined steps of the VAMM Process are as follows:

**Step A:** Derive metrics for business Values and cascade Value achievement responsibilities to process. As suggested by Step A of the VAMMF, in the VAMM Process, Step A is divided into Steps A1 and A2.

**Step A1:** Apply RVDM.

For this application of VAMMF, Step A1 of RVDM has been elaborated as follows:

- **Step A1':** To determine subvalues and PIs that are targets of measurement and to drive their metrics, apply RVDM with GQM.

**Step A2:** Cascade Value achievement responsibilities to the business process.

**Step B:** Redefine the business process for measuring and managing.

**Step C:** Measure and manage Value achievement.

The VAMM Process in Fig. 14 is designed to use GQM among the various techniques introduced at the end of Sect. 3.1.2. GQM is used to pose relevant questions for the purpose of decomposing Values. In GQM, the measurement target is called a goal, but a goal does not require a deadline. Therefore, this concept is similar to ‘Value’ in this paper. To measure the goal achievement of an organization, GQM can be used to link the goal to the data pertaining to the activities that the organization performs for the achievement of the goal. Thus, in order to measure the extent of goal achievement, which cannot be measured directly, GQM is used to link the goal to the activity data that can be measured directly and then the extent of goal achievement is measured from the measured values of the activity data. Note that, according to VAMMF, the decomposition of a Value results in either subvalues and/or PIs, as described in the example of Sect. 4.1.

4.2.2 Execution of VAMM Process

**Step A:** Derive metrics for business Values and cascade
Value achievement responsibilities.

Step A1': To determine subvalues and KPIs that are targets of measurement and to drive their metrics, RVDM is applied with GQM. Whenever a Value is decomposed into subvalues, a function for composing children business values with their parent business Value is defined. To derive PIs that are well aligned with a given business Value, we use GQM. In order to apply GQM, the questions asked included, ‘What do I need to do to achieve business Values?’ and ‘What attributes do I have to manage to achieve business Values?’, among others. From the answers to these questions, we derive subvalues that are well-aligned to the business Value.

We decomposed the Value CustomerSatisfaction into the subvalues OnTimeDelivery, which is delivery of the ordered item before or on the date specified by the customer, and OnTimeCommunication. The subvalue OnTimeDelivery was subsequently broken down into subvalues AccuracyOfDeliveryEstimate and GuaranteedQuickDelivery. The KPIs GuaranteedQuickDelivery and AccuracyOfDeliveryEstimate can be calculated as shown in Fig. 15. Then metrics for the KPIs are defined and the methods of collecting data are determined.

In confirming whether or not a goal has been achieved, A-Homeshopping’s existing method did not consider specification of responsibilities for accomplishing the business value; for this reason, it experienced difficulty in coping with obstacles to achieving the business Value.

Step A2: Cascade Value achievement responsibilities to business process.

After subvalues are derived, cascading of business Values to the business process is performed so that the business Values can be achieved through execution of the processes responsible for them. Figure 16 shows the results of cascading the business Value to processes for the purpose of measuring and managing them. The business process hierarchy is shown on the left-hand side and the Value hierarchy is shown on the right-hand side. The Value CustomerSatisfaction is assigned to the Fulfillment Process and its subvalue OnTimeDelivery is assigned to the Order Fulfillment Process. Assignment of the other subvalue OnTimeCommunication is not shown in Fig. 16. The traceability links between the Value hierarchy and the business process hierarchy are obtained through application of the VAMM process. When the actual Value achievement does not proceed as planned, the traceability links can be used to identify wherein the problems have occurred.

Step B: Redefine process for measuring and managing.

To better track achievement of the OnTimeDelivery Value, the management of A-Homeshopping decides to redefine its business process with the two measuring and evaluating activities, i.e. Evaluate ASN Adherence and Evaluate ATP Date Adherence, which measure GuaranteedQuickDelivery and AccuracyOfDeliveryEstimate, respectively, and they perform their evaluation as shown in Fig. 17. Since “Evaluate ASN Adherence” must be performed for each new product, it is inserted before the “Customer order processing”
activity and since “Evaluate ATP Date Adherence” needs to be performed once per each customer order, it is inserted in the customer order processing loop. Note that in order to detect progress or non-progress as rapidly as possible, “Evaluate ATP Date Adherence” is inserted immediately after the “Conduct an Arrival Scan” task.

**Step C: Measure and Manage Value achievement.**

The Value achievement results for OnTimeDelivery are shown together with the achievement results of the subvalues AccuracyOfDeliveryEstimate and GuaranteedQuickDelivery in Fig. 18. The composition function used was defined in Fig. 15 as C5.1. In January, the performance in OnTimeDelivery is low, achieving only 69% of the objective. So the manager of the OnTimeDelivery Value would like to check the status of the subvalues. Thus, the managers of the business Values GuaranteedQuickDelivery and AccuracyOfDeliveryEstimate are asked to report on their statuses and about the obstacles in achieving them.

A-Homeshopping’s existing method focused on deriving and achieving individual PIs but not on tracking how much each indicator contributes to the business Value and the whole performance of the organization. Moreover, it was difficult to decide which PIs are critical for accomplishing the Values of the organization. In contrast, the VAMMF framework explicitly deals with business Values and we can determine which processes or tasks are connected to the achievement of which business Values or PIs. Therefore, it is straightforward to take corrective steps to improve the business Value achievement in the processes pertaining to their responsibilities.

### 5. Related Work

The studies related to Value measurement in business processes can be classified largely into two groups: research on business processes measurement [1], [4], [9], [17], [18], [25] and research on Value measurement [6], [11], [14]. As representative techniques that can be used for measuring business process there are Goal Question Metric (GQM) [1], [3], [4] and Balanced ScoreCard (BSC) [17].

BSC suggests viewing the vision and strategy of an organization from four perspectives, i.e. a Financial Perspective, Customer Perspective, Internal Business Perspective, and Innovation and Learning Perspective. These four BSC perspectives help us decompose a business value more easily and accurately. To measure the achievement of the vision and strategy, the goals derived from these four viewpoints are measured. By suggesting four concrete viewpoints for measuring the extent of vision and strategy achievement, which are difficult to measure directly, BSC allows goals to be derived systematically and thoroughly, and therefore related measurement data can be accurate. For subsequent measuring of goal achievement, a method such as GQM can then be used.

The differences between GQM or BSC and the VAMMF framework proposed in this paper are: (1) this study aims at Values that businesses are seeking explicitly; (2) the Value measurement framework of this paper decomposes Values into subvalues recursively for measurement and management of the Value. This structure can be applied to business processes that have a complex hierarchical structure. This approach is superior to GQM, which derives a metric from questions about goals, and BSC, which derives a metric by dividing goals into the aforementioned four perspectives regarding vision and strategy; and (3) this study links necessary concepts such as Values, goals, and business process through PIs for measurement and management.

Business Activity Monitoring (BAM) [9], [18], [26] supports business decisions by measuring business processes and reporting the results in real-time to the manager. Since BAM itself does not provide a method of measuring an organization’s Values, goals, or vision and strategy, our VAMMF can be utilized by the BAM system for their measurement.

GQM and BSC are techniques that help measure goals and the vision and strategy of an organization. However, they do not address the Value measurement and management problem. Representative studies aimed at direct Value measurement include Value-Based Software Engineering (VBSE) of Boehm [6], Huang et al. [14] and Value Measuring Methodology (VMM) of Federal Chief Information Officer (CIO) Council [11].

Pointing out that existing software engineering is Value neutral as it does not take into account actual cost and earned Values in software development, VBSE attempts to give maximum benefit to stakeholders by properly calculating Values. In contrast, the VAMMF framework targets Values in general and business Values in particular. Value-based software engineering cannot be used as it is for measuring and managing Value achievement in business processes of an organization. In contrast with software processes, business processes are generally very complex and are modeled as a business process hierarchy in our framework.

VMM was devised as a methodology to measure Value for the e-Services of the United States government, which were brought about by Internet and software technology, and cannot be explained by the traditional Return On In-
vestment (ROI) concept. It was also designed to support the decision framework based on it. The decision framework draws its results from the benefits, costs, and risks that constitute Value. Although VMM does not target the general Value that an organization is pursuing, VMM is important in that it targets the notion of Value beyond ROI and considers cost and risk as vital elements. However, whereas our VAMMF targets various Values that are pursued through the activities of an organization, VMM focuses on rational calculation of benefit in a specific domain of the government e-Services. Therefore, in its current form, it cannot be directly used for measuring Value achievement of an organization’s business process.

6. Conclusion

According to B. Boehm [6], software development and software development methods have been carried out in the past in a Value-neutral way in the software engineering field, and software development will become more efficient when we consider Value. He also suggested that all the activities involved in software development should contribute to Value improvement.

This paper dealt with, in the context of business process and Value achievement, a similar problem of how to embed Value measurement and management capabilities in the business processes and how to reflect the results for business process improvement. A measurement and management framework that enables this should be simple and easy to understand. At the same time, it should include a sufficient set of relevant concepts and define these concepts systematically. To this end, the present paper proposed a framework incorporating these features.

The contributions of the paper are as follows: (1) it clarifies and defines foundational concepts and terms essential for Value measurement and management such as Value, goal, measure, metric, and Performance Indicator; (2) it proposes a VAMMF, the framework for measuring and managing Value achievement; in particular VAMMF employs RVDT, which recursively decomposes business Values to construct a Value hierarchy, and then links it with the business process hierarchy. Thus, VAMMF makes it possible to measure and manage Value achievement at appropriate places in the business processes and trace Values and take necessary actions in response to the measured progress; and (3) by applying the VAMMF framework to case study examples, we have shown the efficacy of the framework and illustrated its usages.

We believe that our framework helps define effective and measurable business Values and PIs, facilitates the formation of consensus on them, and helps manage business process performance. Moreover, the VAMMF framework also makes it possible to measure an organization’s processes at all levels, from the task performer level to the highest management level. It does so by defining the business Value hierarchy, the enterprise’s business process hierarchy, and by establishing traceability links between the two different hierarchies through a cascading and redefining process.

For future research, we plan to quantitatively evaluate the effects and impacts of the VAMMF framework with additional case studies. In the presented framework, redefining a process is an essential step, but this was only touched upon briefly as it is not the main subject of this research. We plan to study process redefinition methods and patterns in order to make the VAMMF framework a more effective tool for Value achievement measurement and management.

References

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