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Towards a Metrics Suite for Measuring Composite Service Granularity Level Appropriateness

A. Khoshkbarforoushha[a], R. Tabein[b], P.Jamshidi[a], F. Shams[a]

[a] Automated Software Engineering Research Group, Electrical and Computer Engineering Faculty

Shahid Beheshti University GC, Tehran, Iran

{a_khoshkbarforoushha, p_jamshidi, f_shams}@sbu.ac.ir

[b] Department of Computer and Systems Sciences, Royal Institute of Technology

Stockholm, Sweden, Tabein@dsv.su.se

Abstract

One of the prominent principles of designing services is the matter of how abstract services should be i.e. granularity. Since service-oriented analysis and design methods lack on providing a quantitative model for service granularity level evaluation, identification of optimally granular services is the key challenge in service-oriented solution development. This article through a systematic process proposes a model namely Weighted Granularity Level Appropriateness (WGLA) which leverages and consolidates four metrics to constitute quantitative basis for granularity appropriateness analysis. These metrics are, indeed, the four quantified attributes of service granularity including business value, reusability, context-independency, and complexity. Our preliminary controlled experiment confirms the correctness of the quantitative model. In fact, by adopting WGLA metric, service granularity appropriateness analysis could be conduct quantitatively that leads to realize an optimized service-oriented solution in terms of its granularity.

1. Introduction

One of the prominent principles of designing services is the matter of how abstract services should be i.e. granularity. The service granularity has numerous direct and indirect influences on service-oriented architecture (SOA) promises including the composability of loosely-coupled services, the degree of service complexity in consumers' view, and the reusability of individual services in various contexts. In the same manner, Kulkarni and Dwivedi (2008) [1] enumerate duplication, difficulty in maintenance and governance, misalignment of business and technology, and hardness of SLAs (Service level Agreements) and KPIs (Key Performance Indicators) assignment to the services as key issues arising out of improper service granularity. Indeed, incorrect granularity, which is one from top ten SOA pitfalls, could mean that a service covers too much functionality or too little functionality. Incorrect granularity of services in your SOA can lead to bad performance, low reuse possibilities, inappropriate abstraction levels and services without business value.

However, a trade-off needs to be made while taking into account likelihood of change, complexity of the service, and the desired level of cohesion and coupling [2]. In fact, it is important to appreciate that achieving an optimal level of service granularity requires a compromise between many elements, both technical and nontechnical [3]. Indeed, the key challenge that enterprise architects face is to determine the most appropriate level of service granularity depending upon the granularity attributes e.g. reusability, composability, complexity, business value, etc, since the extent of each aspect differs in accordance with the variations of service abstraction level. Therefore, architects identify services with different level of abstractions according to their experiences which cause the discovered services to be too coarse-grained or fine-grained.

Lack of quantitative and comprehensive model for service granularity analysis is the root of this difficulty. Based on the issue, a high motivation for developing a model for service granularity analysis is truly sensed.

This article through a systematic process, proposes a model namely WGLA, which leverages and consolidates four metrics to constitute quantitative basis for granularity appropriateness analysis. These metrics are, indeed, the four quantified attributes of service granularity including business value, reusability, context-independency, and complexity.

The definition of any measurement is formed of three basic elements: entity, attribute, and metric [4]. Entities concerned with our measurement are services. Attributes of our measurement definition are business value, reusability, context-independency, and complexity. The metric that we will investigate is the WGLA.

2. Basic Concepts

To provide a common understanding of the concepts, following sub-sections discuss the basic concepts of the paper.

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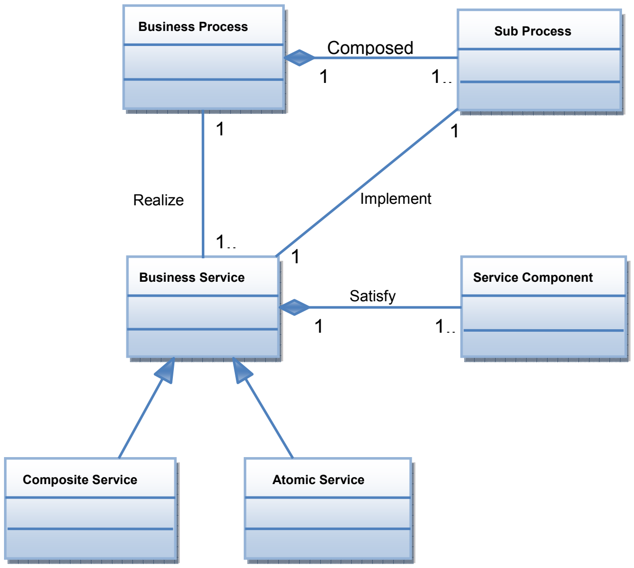

Fig 1 Service type meta-model

2.1. Service granularity

Service granularity is defined as how much functionality is exposed by a single service [5, 6].Although, the definition reveals the gist of granularity concept, but it provokes some ambiguities. To illustrate the point, consider two services doPrint() and patientVisitPreparation(). In the former the granularity concept refers to the number of service operations or their signatures which are related to service description that is interface granularity [7]. While in the latter it implies both service description and involved steps within a composite service in order to supply the expected functionality. To be more specific, granularity concept in atomic and composite services are not actually refer to the same thing. In atomic services granularity is the matter of service operations and their signatures, while in the composite one, it is the matter of both service description and the involved steps that are executed in terms of predefined control flow. Therefore, the optimal granularity of key services can be expected to vary at various layers with different service types [1] or service layers [6].

Till now, granularity concept has been under focus of researchers and practitioners with respect to the number of service operations [8, 9]. Such perspective cause foremost aim of SOA that is business-IT alignment to be neglected. However, this study contemplates both perspectives including service description and their involved services in case of composite service.

Since there are different service types at this level of abstraction, the relationship between them must be clarified precisely through a meta-model, Fig. 1.

Business processes, which are particularly under focus of this paper for granularity exploration, are composite web services. However, our metric can be applied to both atomic and composite services but based on the latest research which conducted in [10] thirty modern service analysis approaches showed that 76% of those approaches introduced two types of services (e.g. business service, software service or generic service).

The involved web services within a composite web service are mostly coordinated and orchestrated through Business Process Execution Language for Web Services (BPEL4WS). When we describe a BPEL process, we actually define a new web service with a WSDL to specify the interface of operations [11]. Therefore, the BPEL process is a technology for composition of various services to satisfy expected business logic. Besides, business services can be both composite and atomic web services.

2.2. Granularity attributes

2.2.1. Business value: Services are not equal from the viewpoint of their Return on Investment (ROI) and added value [12]. This means, every single service has different contributions on the value that a business creates. Capgemini, as a one of the market leaders in implementing SOA at customer site, emphasize that business value is one from seven basic principles that a service should have [13]. In fact, services should be defined at a level of abstraction that corresponds to the real world business activities and recognizable business functions in order to have better alignment of business needs and technical capabilities [14].

2.2.2. Reusability: Reusability is the degree to which a thing can be reused [15]. Service reusability is the key determinant factor for identification of optimally granular services since its proved role in saving cost of development, and maintenance.

2.2.3. Context-independency: Service context-independency is defined as the extent to which a service requires the knowledge of their surrounding environment. An environment, which a service needs to interact with and acquire or deliver the required information, consists of involved web services, clients, and resources.

2.2.4. Complexity: Service complexity is defined as the degree to which service is difficult to be understandable and usable by service consumers. Complexity concept has various dimensions such as data complexity, interface complexity, control-flow complexity.

3. The WGLA model: The design process

The process of designing WGLA metric is thoroughly systematic. We are almost following eight out of twelve commandments [16] to establish software metric.
Indeed, Westfall [16] introduces a practical process for establishing and tailoring a software metrics program that focuses on goals and information needs. The process provides a practical, systematic, start-to-finish method of selecting, designing and implementing software metrics.

3.1. Step 1: Find metrics customers

The first step of designing software metric is to find out who is going to be the customers of the metric. By saying customers, we mean everyone who make decision or take action based on information provided by the metric we are going to propose. If no one is using such a metric, any effort is waste of time and money. Customers who are directly or indirectly involved in our study are as follows:

- SOA architects
- Service developers
- Service designers
- Project managers

3.2. Step 2: Goal-Question-Metric

Step two in designing software metrics is to target goals by using the paradigm of Goal-Question-Metric [17]. The metric we are trying to design should be able to answer those questions which finally indicate how much we achieve our measurable goals. We have found following goals as service designer's goal in each designing process:

Main goal:

- Service granularity level appropriateness analysis.

Objectives:

- Business value contribution analysis.
- Reusability analysis.
- Context independency analysis.
- Complexity analysis.

In other words, services with appropriate level of granularity have four attributes that they have high business value contributions, high reusability, high context-independency, and less complexity.

One of the modelling techniques, which are applied in this step, is the Goal Model. We applied goal modelling in second step to select the high level goals. Goals are objectives the system should achieve. They can be formulated at different levels of abstraction. The final destination of designing such a model is designing a reliable metric which can be on consensus of different designers based on their expectations. In fact, our efforts in this step is addressing why a metric is needed, based on current or foreseen conditions. These conditions, as we will be discussed later in related sub-sections, would be internal concerns or external influencers. Since goal models are used in initial phases of business and system design, it would be an advantage of metric design process to be applied prior to process and service modelling.

3.3. Step 3: Ask questions

Step three is to find questions which should be answered in order to be confident that we have reached the goal and objectives.

Objective satisfaction:

- How can we measure business value of services and their contribution to the business?
- How can we measure service reusability?
- How can we measure context independency of services?
- How can we measure service complexity?

Goal satisfaction:

- How can we measure service granularity level appropriateness?

Therefore, in this step, designing a metric for service granularity appropriateness analysis, which is our first intention of this study is broken down to four other measurement problems, each of them is addressing a specific metric.

3.4. Step 4: Select Metrics

Step four is to design metrics that can answer the questions in step three. Each metric should contribute to at least one or even more questions in step three in order to get ensured if we can achieve the goals in step two. As specified earlier, we are going to measure service granularity level appropriateness through its attributes including business value, reusability, context-independency, and complexity. The quantification of these attributes will be discussed in step 7.

3.5. Step 5: Standardize definitions

Step five is to be agreed on definitions for the entity (service) and its attributes (granularity attributes) for which we are designing metrics. The definition of these concepts presented in 2.2. However, in this sub-section it is aimed to firstly discuss that whether or not the mentioned attributes are the correct ones and secondly their criticality in granularity appropriateness analysis.

Service granularity attributes are not fully agreed among researchers in terms of their importance and weight; hence their perceptions and attentions on these features are different. However, most of researchers in SOA literature are complied with the important roles of some service granularity attributes such as reusability, business value, complexity, and context-independency [18, 2, 19, 20, 21, 3], as portrayed in figure 2.

There are two important features about the attributes which should be elucidated. First, service granularity attributes have direct/indirect or inverse relationship with each other, so that it could be expected to calculate some aspects based on the others. For example, flexibility and context-independency are two sides of the same coin. That is, the more context-independent services are the more flexible ones. Thus, any possible metric for service context-independency measurement leads us to grasp the degree to which a service is flexible. Besides, some of these aspects are composed of the other parameters. For instance, flexibility is the function of reusability and context-independency.

Second, the weight of the attributes varies in accordance with the service design goals and in a broader scene SOA deployment direction. For instance, suppose order fulfillment and financial management processes in an automotive company. Vividly, the business value of the former is critical rather than the latter. Thus, in the process of granular service identification the business value factor for services within order fulfillment is adjusted to higher weight in comparison with services within financial management. In this regard, we utilize the AHP approach (Analytical Hierarchy Process) to calculate the attributes weights and criticality.

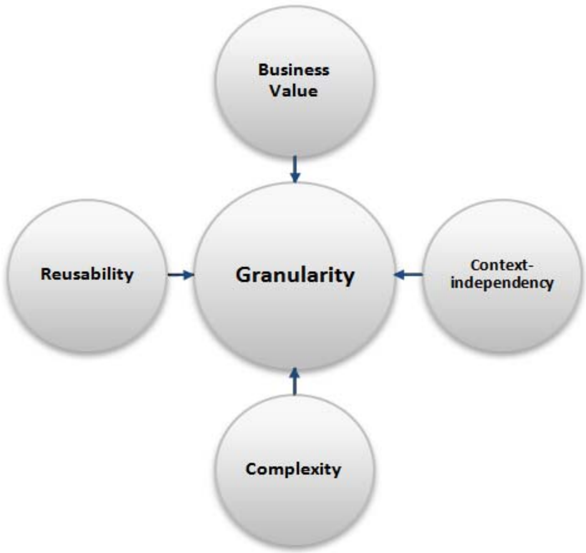

Figure 2. Service granularity attributes.

3.6. Step 6: Composite service granularity level appropriateness measurement

Choosing a measurement function is the sixth step of designing a metric. It defines how we are going to calculate the metric. In this step, we are going to utilize the most important granularity attributes which influence the metric and finally make a formula for the model, service granularity appropriateness analysis. We will then apply statistical techniques in order to validate our model and get feedbacks from software experts.

Regarding the fact that software metrics are not supposed to solve the problem, we need the metrics as indicators for professionals and domain expert, who can solve problems based on information resulted by metrics. In fact, metrics can play different roles in providing information about understanding, evaluating, controlling, and predicting the entity. In this study the final model help stakeholders to understand, evaluate, control, and predict service granularity appropriateness based on the model.

A model specifies relationships among metrics [15]. In order to measuring service granularity appropriateness, we need a model that specifies the metrics which are defined for four attributes; business value, reusability, context-independency, and complexity. In other words, granularity appropriateness analysis is the matter of taking various service granularity attributes into consideration all at once. Therefore, Weighted Granularity Level Appropriateness (WGLA), as a model for composite service granularity level analysis, is defined as follows:

Let:

- S_{BV}: refers to the business value of a service.
- S_R: refers to service reusability value.
- S_{CI}: refers to service context-independency value.
- S_{Co}: refers to service complexity.
- w_1, w_2, w_3, w_4: refers to the weight of each granularity attribute which are calculated via AHP (table 1 includes attributes weight).

$$\text{WGLA} = \left(\frac{(w_1 \times S_{BV}) \times (w_2 \times S_R) \times (w_3 \times S_{CI})}{(w_4 \times S_{Co})} \right) \quad (1)$$

Equation 1 denotes the granularity appropriateness of a given composite service in number. In fact, the equation works as an indicator that express whether or not the given version of a service is in more or less appropriate level of granularity. This means, the model provide a quantitative tool to compare a certain service in different level of abstraction. The higher WGLA indicates the more appropriate level of granularity and vice versa. Therefore an architect or service designer must attempt to maximize the WGLA. This can be achieved through minimizing service complexity (i.e. denominator) or maximizing its business value, reusability, or context-independency (that are numerator). Furthermore, WGLA should be an objective function for SOA architects and designers to provide granular services.

Now, we have to measure the attributes weights. Identifying proper measures vis-à-vis an objective has always been a challenge for software practitioners. We have adopted an analytical hierarchy process (AHP) model [22] as a framework for evaluating the criticality of the technical metrics. AHP is an effective quantitative tool that helps to prioritize problems, issues or variables based on relevant criteria and alternatives. We have chosen to adopt this tool for segregating the critical few metrics from the insignificant many ones.

A basic AHP model would consist of three layers, which is the goal, criteria and alternatives. From a metrics perspective, the purpose is to have a selection guideline with respect to identifying the critical metrics. Therefore, the goal is to formulate an objective function for separating the metrics as critical, essential and redundant. In view of the above discussions, the generic absolute AHP model for analyzing the criticality of technical metrics is portrayed as shown in Figure 3.

The data used in this work has been collected from a number of subject matter experts (quality management specialists, metrics analysts, software engineers etc.) belonging to software companies in Iran by distributing structured questionnaire. It is to be noted that the AHP approach is a subjective methodology that does not necessarily involve a large number of experts to take part in the process [22]. The respondents have been requested to make a pair-wise comparison of the identified criteria and the decision alternatives on the degree of their importance with respect to the goal and criteria respectively. Having built the hierarchical model according to Figure 3 with the Expert Choice, a popular software product for analyzing AHP models, the associated weights of the attributes demonstrated in Table 1 are synthesized for including in the WGLA objective function.

Table 1. Granularity attributes weights.

Attributes	Weight Index	Value
Business Value	w_1	0.306
Reusability	w_2	0.450
Context-Independency	w_3	0.125
Complexity	w_4	0.119

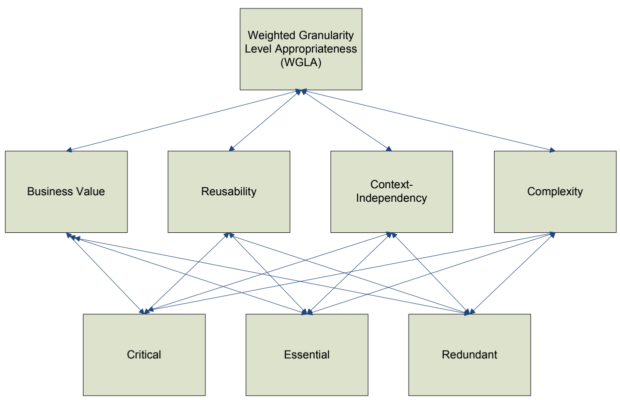

Figure 3. Absolute AHP Model for Analyzing the Critically of Metrics.

3.7. Step 7: Quantify attributes

Step seven is establishing a measurement method. In this step we will define counting criteria and the first level of data we need to gather in order to implement the metric. As specified earlier, WGLA is based on the four metrics corresponding to four granularity attributes and this step explores these metrics.

3.7.1. Service business value measurement:

The size of a service and its business value does not have a direct relationship. This means, services with much functionality which are close to the business may provide less business value relative to the ones with little functionality [23]. Thus, each service should be examined based on some criterion in order to determine its contributions to the business value. Business value can be quantified as ROI, whereas it cannot be used due to the fact that the granular service identification is in analysis and design phase of SOA development lifecycle, so these services are not implemented yet. As a result, it necessitates quantifying the value added of a certain service in order to provide quantitative basis for comparison between various versions of a service.

Business value contribution can be determined based on the application criticality in achieving business objectives and its ability to generate business returns both in terms of financial benefits and/or improved customer satisfaction [2]. In this regard, it can be analyzed and quantified through some touchstone questions. Our perspective is close to the approach of IBM SOMA methodology [24] in business-aligned granularity analysis, namely Service Litmus Test. These questions must address the influence of the service on goals, services/product, and business model components [25] including customer value, capabilities, revenue, and activities.

To quantify the business value, each service should be examined through benchmark questions which are specified in Table 2. Each question is ranked as high and low level. In this regard, these levels are further set to 1 and 0, respectively. For example, assume service scheduleBeds() that searches and allocates free beds to patients. Firstly, scheduleBeds() service is discovered from resource planning business process, which is associated with resource optimization business goal. Secondly, it hits utilization ratio [26], which is the Key Performance Indicator (KPI) of resource planning process. Moreover, as customer value can take the form of differentiated or lower-cost products/services [25], the provided service does not influence on customer value directly. However, the service get the high value for two last questions as it decreases the scheduling costs and increases business revenue through optimum free bed allocation. As four out of five questions are ranked to high value for the given service, the business value is set to the value of 0.8 (i.e. 4 divided by 5). Likewise, consider generatePrescription() service, which produces prescription for patients. Even though, it is related to customer relationship management goal but it is not concerned to any KPI. As the service produce prescription electronically it hits the customer value and following business revenue in terms of low cost service. However, it does not highly decrease business costs. As three out of five questions are ranked to high value for the given service, the business value is set to the value of 0.6.

Table 2. Service Business Value Analysis

Touchstone Questions	Rank (High/Low)
To what extent the service is directly concerned with the business goals?	H/L
To what extent the service is directly associated with the KPI of business process?	H/L
To what extent the service directly influences the customer value?	H/L
To what extent the service diminishes the business costs?	H/L
To what extent the service impacts the business revenue?	H/L

3.7.2. Service reusability measurement:

In order to quantitatively analyzing service reusability, we already proposed a metric for composite service reusability measurement in [27]. The approach for quantifying reusability is based on the analysis of logic and description mismatch. Description mismatch refers to the mismatch between the requirements and the description of the given composite service i.e. WSDL. Logic mismatch refers to mismatch between the requirements and the logic of given composite service. Composite service logic is utilized through the flow control of basic and structured activities within it. The authors then consolidated these measures to a metric formula for quantifying the probability of a service will be reused within potential service-oriented solutions.

3.7.3. Service context-independency measurement

In order to quantitatively analyzing service context-independency, we already proposed a metric for context-independency measurement in [28]. In our perspective, context-independency can be measured through coupling concept, as Vanderfeesten et al. (2007) [29] emphasize that the coupling measures the number of interconnections between the activities in a process model. On the other hand, a composite service is dependent on a context to the extent that it is coupled with its web services, resources, and clients. Hence, service coupling measurement paves the way for context-independency measurement.

3.7.4. Service complexity measurement

In order to quantitatively analyzing service complexity analysis, Cardoso proposed some metrics to measure data complexity, interface complexity [30], activity, and control-flow complexity [4]. In fact, service complexity can be measured through consolidating different aspects of its complexity including data, interface, activity, and control-flow complexity.

3.8. Step 8: Metrics evaluation and validation

In order to empirically validate the metrics that have been described, further experiments using experimental models need to be carried out. In this regard, to gain confidence in our theoretical works, we conducted a controlled experiment in which we take seven composite services from a project that is TJT Core-banking processes at international sector.

These processes were designed at different abstraction of functionality and design. These composite services were evaluated by use of WGLA and also examined qualitatively by the expert for business process. The two evaluations then were compared to demonstrate the validity of composite service granularity level appropriateness analysis. The table 3 states the results of our experiment.

Table 3 contains 17 versions of composite services and their corresponding WGLA values. The maximum of these values indicates the better granular variant, which is denoted by *Max(WGLA)* column. Regarding these versions are examined by the expert, table 3 also denotes the selected versions, which seem to be more granular comparing to the others.

As results indicate, there is a positive evaluation of our metric from the expert's view point. Indeed, the consensus provided by the participants when choosing the best process design is in favour of our metric.

4. Discussion and future works

Regarding that the proposed metric is expected to be used in service-oriented solution development lifecycle, firstly, we have validated it through a survey, which actually take place before implementation phase. However, for the purpose of validating the adopted technical metric and the method itself, certainly further experiments need to be carried out.

Secondly, the value that is produced by WGLA model is not equivalent to the granularity level. In fact, WGLA measures the appropriateness level of composite service granularity.

Thirdly, the value that is produced by WGLA model is not a definite value. This means, WGLA can be meaningful with comparison by other services. For instance, suppose there are two versions of a service have the WGLA 0.3 and 0.6 respectively. It means that the second service is twice as appropriate as the second one in terms of its granularity level appropriateness, while the second version may cover less functionality and following more fine-grained than the first one.

Work will be continued to implement a toolset as a metrics suite to automate computation, analysis, and optimization of the solution artifacts appropriateness based on the proposed metrics. A rigorous list of guidelines in accordance with our proposed model to design more appropriate services is considered to accomplish for the ongoing development of the suite.

5. Related work

To the best of our knowledge, the work on quantitative model for service granularity appropriateness analysis is non-existent in the literature. While much research from both industry and academia has been devoted to service granularity concept, publications in this area almost limit granular service identification to some prescriptive guidelines, which are mainly found on the architect's experiences.

Erradi et al. (2006) [18] suggest some clues including business-alignment, ease of composition, and reduce ripple-effects of applications changes, to decide on the optimal granularity level of services. That is, acceptable granular services are those which first, satisfy business value and requirements (business-alignment) second, can be reused in different contexts with minimal difficulties (ease of composition) and finally, their modifications handled in a way there are minimal effects on service consumers. Moreover, Erradi et al. (2007) [2] suggests that the service granularity can be quantified as a combination of the number of components/services composed through a given operation on a service interface as well as the number of resources' state changes like the number of database tables updated. However, the proposed approach neither covers important granularity attributes nor recommends any criteria to evaluate appropriateness of service granularity.

Table 3: The results of WGLA value and corresponding expert's judgment.

No	Composite Service Name	WGLA Values			Max(WGLA)	Expert View point	Success/ Failure
		Version 1	Version 2	Version 3			
1	*Issue Letter of Guarantee*	8.87×10^{-9}	3.07×10^{-6}	2.52×10^{-8}	Version 2	Version 2	✓
2	*Discard Letter of Guarantee*	4.32×10^{-4}	1.08×10^{-7}	5.07×10^{-4}	Version 3	Version 3	✓
3	*Prepare local branch Balance sheet*	1.39×10^{-6}	9.66×10^{-6}	-	Version 2	Version 2	✓
4	*Prepare total Balance sheet*	9.66×10^{-6}	4.62×10^{-5}	-	Version 2	Version 1	✗
5	*Centers performance measurement*	3.42×10^{-5}	2.50×10^{-4}	-	Version 2	Version 2	✓
6	*Prepare foreign branch Balance sheet*	6.62×10^{-6}	4.64×10^{-5}	-	Version 2	Version 2	✓
7	*Advance Payment Guarantee*	1.60×10^{-2}	2.06×10^{-2}	2.40×10^{-2}	Version 3	Version 3	✓

Steghuis (2006) [21] proposes granularity framework and four service granularity patterns include: flexibility, reusability, generality, and performance which are mapped to the framework. Each pattern accompanies some guidelines for choosing suitable level of service granularity. Even though, the work provides proper insight into service granularity trade-offs, but it limits to high-level guidelines which are both general and qualitative.

The focus of Feuerlicht's work (2006) [31] is on service interface design from the data engineering perspective and to decide on the service granularity level based on data normalization. It argues that the excessive use of coarse-grained services results in poor reusability and high-level of data coupling between services even though most practitioners believe that leveraging coarse-grained services minimizes the number of SOAP messages and eventually have lower communication overheads and less possibility of failure. The author applied data normalization approach in which functional dependencies and the Boyce-Codd normal form (BCNF) played an important role to select an appropriate level of service granularity.

Haesen et al. (2008) [23] propose the classification of service granularity types including functionality granularity, data granularity, and business value granularity. They also discuss the impact of granularity on a set of architectural concerns, such as performance, reusability and flexibility. In other words, the paper provides a worthy definition of granularity concept accompany with suitable examples. Moreover, it emphasizes that "granularity can hardly be measured in terms of absolute numbers, because of the subjectivity of the related concepts that may determine the granularity in question".

6. Conclusion

One of the common misconceptions in SOA is: "It is easy to develop services anybody can use" [32]. In fact, a key challenge for the designers of service-oriented applications is to determine the appropriate level of service granularity to ensure that services are reusable, context-independent, business-driven, and less complex. Therefore, it will be a common mistake to identify services at a wrong level of granularity which induce considerable architectural side effects.

To address this issue, WGLA model which constitutes quantitative basis for service granularity level appropriateness analysis was introduced. The model utilizes business value, reusability, context-independency, and complexity as service granularity attributes to compare a given service at different level of abstractions. The result of this comparison is to find the more granular version.

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