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Modeling Measures for Service Interpretation in Discoverability of Service Oriented Architecture

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Abstract

Increase in number of web services, finding out the exact web service from service registry that fulfil the consumer requirements has become a greater challenge in recent days. Interpretation of appropriate service from the service registry needs a complete description of the service. Researchers have discussed basic forms of representing information about services through functional aspects that help in identifying the required web service. This information addressed does not fulfil the consumer requirements normally; hence an extended registry has to be provided with additional details of non-functional aspects in order to locate the exact service. The effect of these attributes on discovering a required service has to be measured. This paper focuses on formulating metrics for interpretation of services based on functional and non-functional aspects of a service. From the literature we have identified features for interpretation. These features have been considered as a focal point and a metric suite is proposed with the measures like described semantic elements, defined service operation, functional data value and so on. Based on these metrics, a measure for service interpretability is proposed. To verify the effectiveness of our proposed metrics, an experiment has been designed and carried out. The result of the proposed metrics shows the effectiveness and improvement of service discovery which leads to better service composition and execution.

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Keywords: Service Interpretation; Discovery measures; Service Interaction measures; Quality metrics and Service functional measures, Non-functional metrics.

1. Introduction

Service discovery is concerned with identifying the appropriate services for fulfilling consumer requirement [1, 2]. Effective service discovery is achieved through better interpretation. Interpretability deals with understanding of service with reference to functional and quality of service Meta data. Hence service Interpretation needs sufficient documentation and relevant Meta data which are used to interpret appropriate services. Functionalities rendered by a service are described through interface definition and details about syntax and semantics of services available in the service registry. Quality of service information is required to enhance discovery to suit the consumer requirements. The QoS information dwells with Availability, Compliance, Response Time, Throughput, Latency and Doc. Significance of service interpretability can be obtained from [3-6]. A need for measuring interpretability becomes vital.

Much of the research contribution is towards addressing the metrics for functional aspects which measures the interface and semantics of the web services. Other researchers have proposed measures for certain quality of service aspects like availability and response time. Hence the measures to corresponding interpretability are in primitive stage. In this paper we are focusing on identifying the features for both functional and non-functional aspects of services interpretation. We have proposed metrics for the aspects identified and finally we have defined a new metric for service interpretation based on the proposed metrics. In order to study the proposed metrics, an experiment was designed and conducted. The rest of the paper is

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organized, section 2 gives review of measures contributed for service interpretation, and section 3 elaborates the proposed work. The experiment design was illustrated in section in 4. The experimentation was carried out and results are reported in section 5. The conclusion is presented in section 6.

2. Related Works

One or more services provide related or common functionalities. It's hard to find out the exact service. There arises a need to define the information relevant to service which leads to easy identification of required services. Service interpretation supports in searching and identifying the required service and also the measures corresponding to this component plays major role in service discovery. Our study concentrates on measures towards service interpretation of discoverability. The Review presented in table 1 gives the existing measures proposed by various researchers that are more specific in finding out the appropriate services from the service registry.

Table 1. Existing Measures specific to interpretability

Researchers	Contributions	Aspect addressed and Metrics Proposed
Jyotishman et al., (2005)	Ontology based flexible discovery using semantics of web services.	semantic measure
Meng et al., (2009)	Introduced extensible ontology based approach for describing the QoS constraints in service registry. They proposed measures for certain QoS attributes used	Response time, Throughput, and Availability and capacity metrics
Ding Ding et al., (2010)	Contributed a discovery algorithm for service matchmaking which uses syntactic and semantic searches in service registry for getting accurate results	Syntax and semantics metrics
Hong-Linh Truong et al. (2010)	Proposed the quality of Service Data measures for filtering the web services	Proposed measures for completeness, Timeliness and interpretability
Ehsan Emadzadeh et al., (2010)	Proposed schema matchers techniques based on semantics and Quality attributes	Measures proposed for syntactic, semantic, (Correctness) and quality aspects (completeness)

The literature reveals that measures specific to functional aspects are addressed with semantic and syntax metrics. These metrics are focused much towards the technical data representation of services (deeper about the technical information about services i.e. validating the syntactic and semantic representation of functional data) and does not provide support to interpretability measures of services [7, 5, 6]. Similarly the existing QoS attributes measures are limited [3, 4]. Some of the author have proposed metrics for attributes like availability, response time, throughput and reliability (i.e. measures are proposed only for limited attributes). Hence there arises the need to measure other attributes also. From the study we have found that interpretability metrics of services are not addressed correctly. The measures corresponding to functional and quality of service attributes are in primitive or early stage needs more exploration.

3. Proposed Work

Discoverability is the process of searching the individual service based on the service description and to invoke or interpret those services based on the purpose and its capabilities [8]. Here the definition of discoverability indicates that the two components or items, discovery and interpretability are involved in the entire process of service discoverability [9, 4, 10, 11]. The discovery deals with the searching or finding the service and interpretability deals with usage or invocation of those services. So discoverability has to address these two components to offer better discovery. To address discovery and interpretability components we need to identify the features supporting these two items. In this paper our focus is to propose measures for interpretability component of discoverability.

Interpretability of services deals with clarity or communication which uses the functional and quality of service data for invocation. To invoke or use the services efficiently the functional and non- functional aspects i.e. quality of service data of each registered services has to be defined or represented clearly [12, 13]. From the study we have found out the factors or features which listed below are essential for the invoking the services.

3.1 Check for Functional Specification

Normally the functional data of service depicts the purpose and capabilities of the services in the service registry [14]. The two components which are used to represent functional data are [15, 16]:

- Check for Well Defined Semantic Elements – The semantic elements are used to represent the purpose of the service (i.e. which defines the scope of the services)
- Check for Well Defined Operation - The syntax or interface, which depicts the operation or capabilities of services (i.e. it clearly represents what functionalities are offered by services)

3.2 Check for Quality of Service Meta data

The Quality of Service data is used for finding the suitable service from the group of services which meet out consumer requirements. The Quality of Service data used by consumer for evaluating and filtering relevant service from group of services because it gives the behavioural characters, Operational thresholds and policies of the each service in the Service Registry [8]. We have identified the various quality data which are used by consumer for assessing or filtering their service are listed below [9, 12, 13, 11, 17, 18]:

- Availability
- Compliance
- Response Time
- Throughput
- Latency
- Doc
- Reliable messaging and best practices

3.3 Interpretation Metrics

3.3.1 Functional Data Measures

Check for Described Semantic Elements

Checking for Described Semantic Elements (DSE) is measured by assessing the ratio of matching similarity of semantic elements to total matching and mismatching semantic elements of Service. This metric check whether purpose or scope of the services are described properly or not.

$$\textbf{Ratio of Described Semantic Elements (DSE)} = \frac{Msemanticelements}{Msemanticlements + MMsemanticelements} \qquad (1)$$

Here the value range of DSE is 0...1. Higher the value of DSE metric indicates purposes of the service are clearly defined. The value of this metric is zero if no matches found

Check for well Defined Service Operations

Checking for defined Service operations (DSO) is measured by assessing the ratio of structural matching (Service operation matching) to total matching and mismatching Service operations of Service. The metric uses the additional factor called versioning of services. Here we have fixed values for each version of service. The versioning of service takes the maximum up to 3 versions. This metric checks whether capabilities of the services are described properly or not.

$$\textbf{Ratio of Defined Service Operations (DSO)} = \left(\frac{S1V1 + S2V2 + \ldots\ldots + SnVn}{NumofServop * (\sum_{i=1}^{n} Vn)} \right) \qquad (2)$$

The versioning of services are named as V1, V2 and V3 and the values of V1=1, V2=2 and V3=3.Here the value range of DSO is 0...1. Higher the value of DSO metric indicates operations of the service are well defined. The value of this metric is 0 if no matches found.

The functional data value measure is calculated by using the values of Eqn. 1 & 2. FDV is computed as

$$\textbf{Functional Data Value (FDV)} = W1 * DSE + W2 * DSO \quad (3)$$

Here W1 and W2 is the weight factor whose value is 0.5. We are giving the equal weights to both factors because the two factors are essential. Service operation is important component to expose the functionalities of service. Semantic elements are not a mandatory but it's used to increase the usability of services.

3.3.2 Quality of Service Measures

The QoS attribute measures for each quality are described below, here we have found out the expected minimum and maximum values for each quality attribute. The minimum value is calculated as ratio of min value of each QoS attribute to maximum value of each QoS attribute. The maximum value for each data is obtained from max of value of each quality attribute to max range of each quality attribute.

$$\textit{Ratio} \text{ of } \textit{Expected} \text{ Min } \textit{value} \text{ of QoS data} = \frac{\text{Min value of each QoS data}}{\text{Max value of each QoS data}} \quad (4)$$

$$\textit{Ratio} \text{ of } \textit{Expected Max value} \text{ of QoS data} = \frac{\text{Max value of each QoS data}}{\textit{Max Range}} \quad (5)$$

The value of numerator and denominator are taken from the service registry. Expected minimum metric (eqn. 4) values are used only when the particular quality of service data is not available in the service registry. The value range for these metrics falls from 0 to 1. In case of response time and latency ratios only we use expected max (eqn.5) value (response time and latency) remaining ratio's we have used expected minimum only.

1. **Ratio of Availability (Avail)**

Availability of services is measured by using this metric,
RA= Max (Measured Quality attribute Value, Expected Min Quality attribute Value)

$$RA = \max\left(1 - \left(\frac{Desired(_{Avail}) - Agreed(_{Avail})}{Max(_{Avail})}\right), Expected_{(MinvalueofAvail)}\right) \quad (6)$$

Where,

Desired (Avail) is expected availability of service,
Agreed (Avail) is the availability offered by the service
Max (Avail) is the maximum availability value for service

Here value range of Availability is from 0 to 1. Higher the value of this ratio indicates high availability of services.

2. **Ratio of Compliance (Comp)**

$$R_{(Comp)} = \max\left(\left(\frac{Agreed_{(Comp)}}{Max_{(Comp)}}\right), Expected_{(Minvalueofcomp)}\right) \quad (7)$$

Where,

Agreed (comp) is the compliance offered by the service
Max (comp) is the maximum compliance value for service
Here value range of Compliance is from 0 to 1. Higher the value of this ratio gives high compliance of services.

3. **Ratio of Response time (rt)**

$$R(rt) = 1 - \min\left(\left(\frac{Agreed(rt)}{Max(rt)}\right), Expected_{(Maxvalueofrt)}\right) \quad (8)$$

Where,

Agreed (rt) is the number of seconds taken by service to respond request
Max (rt) is the maximum number of seconds taken by service to respond request

Here value range of Response time is from 0 to 1. Lower the value of this ratio depicts better response from services. We are normalizing the value to 1 because all the ratios are in max value except two.

4. **Ratio of Throughput (tp)**

$$R_{(tp)} = \max\left(\left(\frac{\textit{Number} \text{ of Requests Processing by given Service}}{\textit{Expected Number} \text{ of Requests Processing by given Service}}\right), \textit{Expected}_{(Minvalueoftp)}\right) \quad (9)$$

Here value range of throughput is from 0 to 1. Higher the value of this ratio indicates the services can handle more number of user requests.

5. Ratio of Latency

$$R_{(latency)} = 1 - \min\left(\left(\frac{\textit{Agreed} \text{ Delay}}{\textit{Maximum} \text{ Delay}}\right), \textit{Expected}_{(Maxvalueoflatency)}\right) \quad (10)$$

Where,

Agreed Delay is the number of second's delay of service to respond request

Max. Delay is the maximum number of second's delay of service to respond request

Here value range of latency is from 0 to 1. Lower the value of this ratio indicates the services offer less delay in processing requests. We are normalizing the value of latency to 1

6. Ratio of Doc

$$R_{(Doc)} = \max\left(\left(\frac{\textit{Doc} \text{ supplied by Service}}{\textit{Expected} \text{ Doc for Service}}\right), \textit{Expected}_{(\min\ valueofdocfor\text{service})}\right) \quad (11)$$

Here value range of Doc is from 0 to 1. Higher the value of this ratio indicates the services offer more documents for better usage.

7. Ratio of Reliable Messaging (RM)

$$R_{(RM)} = \max\left(\left(\frac{NumberofErrorMessagehandlebyService}{ExpectedNumberofErrorMessagehandlebyService}\right), \textit{Expected}_{(\min\ RMvalue\ \text{for service})}\right) \quad (12)$$

Here value range of Reliable message is from 0 to 1. Higher the value of this ratio indicates the services can handle more Error messages.

8. Ratio of Best Practices (BP)

$$R(BP) = \max\left(\left(\frac{\textit{Actual} \text{ BP}}{\textit{Expected} \text{ BP}}\right), \textit{Expected}_{(\min\ BPvalueforservice)}\right) \quad (13)$$

Here value range of best practices is from 0 to 1. Higher the value of this ratio shows the services adopted good practices.

The overall quality of Service data Measure (QDM) is computed by using values of eqn. from 6 to 13

$$\text{QoS Data Measure } (QDM) = avg\left(\sum_{i=1}^{n} Qi\right) \quad (14)$$

Where, Qi gives ratio of each quality data. We have used eight qualities of Service data, the maximum value of i is 8.

3.3.3 Interpretation metrics

Finally, the interpretation of service (IoS) is computed by the values of Functional Data measure (eqn. 3) and quality of Service data measure (eqn.14) (i.e. FDV and QDM).

$$\textit{Intepretation} \text{ of Service (IoS)} = ((\text{FDV}+\text{QDM}))/2 \quad (15)$$

Here value range of IoS is from 0 to 1. Higher the value of this measure gives better invocation of Service.

4. Experiment Design

To demonstrate the usability of the proposed metrics, we have designed and implemented three different service registries. Each registry contains three different ranges of data (i.e. registry with 1000, 2000 and 3000 entries) based on references [19, 4, 14, 20, 21]. We derived complete list of attributes which describes functional and non-functional aspects of Services. The value ranges of each attribute (i.e. from minimum to maximum) chosen for the service registry based on Shanmugasundaram G et al. (2012) [22] .

The naming of the registry is based on attributes chosen for the registry i.e. minimum set of attributes, next level or medium set of attributes and full set of attributes [20, 21]. The attributes for each service registry have been chosen from our earlier work [22]. The registries are named as SR1, SR2 and SR3.

- SR1- Service Registry 1 is the basic registry which contains limited number of attributes
- SR2 – Service Registry 2 extended version which contains additional attributes when compared to SR1.
- SR3 – Service Registry 3, Optimum registry which contains complete attributes

Here we have considered the banking and financial services (B&F Services) as specific category for conducting the experiment towards interpretation.

4.1 Interpretation Metrics on Service Registry1 (SR1)

The Service Registry (SR1) contains limited attributes. It contains basic attributes like service name, category, service ID, service operation, availability and compliance. Here we formulated 12 queries for our experiment. i.e. Query1 contains Category, Query2 contains Category + Compliance, and likewise remaining queries contains the fields from previous queries in addition to its own field. Out of 12 queries, SR1 gives response for first three queries and for the remaining queries values of query 3 will be repeating as it is a primitive registry and contain basic fields. In SR1 versioning of Services and semantic descriptions are not available. So the metric DSE gives zero for all the services. The QDM is computed by using the two QoS attribute measures (i.e. availability and compliance). The remaining field measures values are computed by using the expected minimum and expected maximum metric. Here the expected minimum is not applied Latency and Response time because for these measures expected maximum is the worst case. For remaining quality data the worst case is expected minimum.

4.2 Interpretation Metrics on Service Registry2 (SR2)

The Service Registry 2 (SR2) is the extended version of SR1 with additional attributes like version, interface name, Response time and throughput. Out of 12 queries, SR2 gives response up to the sixth query and the remaining there is no response, the values of the query 6 will be repeating because it is an extended version which contains additional fields compared to SR1. In case of SR2 the DSO metric will be high when compared to SR1 because it has an additional attribute versioning of services. The versioning of services will have an impact on these defined service operation. Hence the FDV values of SR2 are high. Similarly in case of QoS data measures uses additional two values of QoS Data measures when compared to SR1.

4.3 Interpretation Metrics on Service Registry3 (SR3)

The Service Registry 3 (SR3) contains the all attributes listed in the table 1 because it is a complete registry and gives output for all the 12 queries. The FDV is computed based on two factors but in the case of SR1 & SR2 it uses only defined service operation (DSO). Similarly in the case of QoS data measure value is calculated by using the values of all quality of service data measures.

5. Findings & Discussions

The experiment was conducted against the three different registries that have been formed with B& F services, by using certain queries which supports interpretation. In analysis, we focus on each metric value that is applied in the experiment. The table 2 displays the result of FDM values of three different registries. High value FDM shows that the services contain more functional data i.e. the semantics and syntax of services are clearly defined. Consider the B&FI services 13 , the FDM value upon three different registries indicates there is a gradual increase because the clear representation of syntax and semantics of the service. So the complete/essential information about syntax and semantics has greater importance in FDM value as shown in figure 1. This indicates that high value of FDM gives better interpretation of Services.

Table 2. Functional data measure values of SR1, SR2 and SR3 for various Services

Services	Function data measure values (%)		
	SR1	SR2	SR3
B&F Services 13	25	30	40

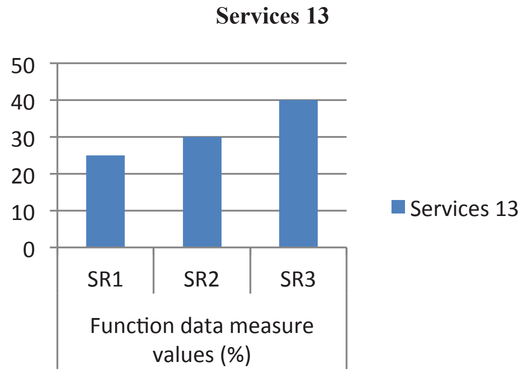

Figure 1. FDM values of SR1, SR2 and SR3 for various Services

Table 3 depicts the results of the QDM values of three registries for various Services. Here QoS data measures values shows an impact of presence of more quality attributes (i.e. service registry contains more quality attributes acts as the filter provide effective interpretation). Here the services 13 gives the gradual increase in the QDM value due presence of various additional QoS attributes in different service registries. QDM value for all services considered is high in case of service registry SR3 as shown in figure 2.

Table 3. Quality of Service Data Measure values of three registries for various Services

Services	Quality of Service data measure values (%)		
	SR1	SR2	SR3
B&F Services 13	39.7	53.5	87.2

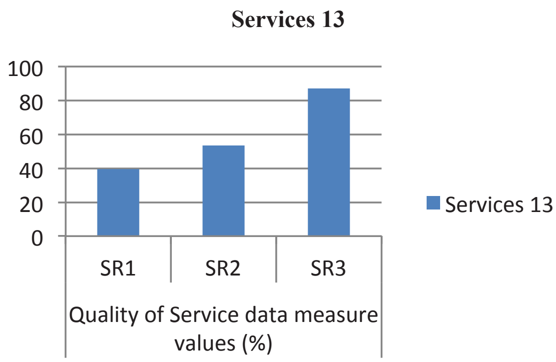

Figure 2 QDM values of three registries for various Services

Table 4. Interpretation of Service Measure values of three registries for various Services

Services	Interpretation of Service metric values (%)		
	SR1	SR2	SR3
B&F Services 13	32.3	42	63.8

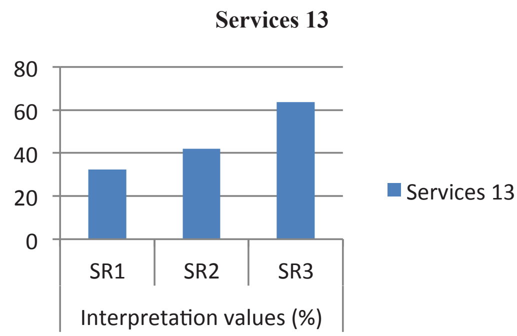

Figure 3 Interpretation of Service (IoS) values of three registries for various Services

The effect of FDV and QDM values for measuring service interpretation upon various registries is depicted in table 4. It indicates that SR3 gives more IoS values when compared with other two registries. Figure 3 shows that Service Registry 3 B&F service 13, the IoS value is high when compared with other two registries. From this experiment we have observed that interpretation of services (IoS) is effective when a service represents its functional and quality aspects clearly and completely. This in turn leads to better discovery of services.

6. Conclusion

Interpretation of Services (IoS) can be measured by metrics of functional and qualities of Service aspects of Services. We have proposed metrics to measure the functional and non-functional aspects. Experiment was designed and conducted to apply the proposed metrics. The results of the proposed metrics are used to find the IoS value of services. The IoS value for each case indicates that interpretation of services is effective for service registry which contains essential information about the services. This has been observed from the values of metrics obtained from the experiment and applied on different service registries (SR1, SR2 & SR3). The SR3 gives better response towards interpretation of services as proved by the values of the metrics. This metric will help us to enhance discoverability of Service Oriented Architecture systems.

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