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Modeling Metrics for Measuring Service Discovery

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Abstract *Services* are discoverable based on the functional description published in the accessible registries. Service Discovery or identification is one key factor of discoverability in Service Oriented Architecture (SOA) systems. Locating or positioning the service exactly in the registry gives better discovery leading to easy identification of service. The success of service discovery lies in how appropriately a service is identified. This has been talked about qualitatively in the recent works of service discovery. This paper focuses on giving the related and recent works on the measures of service discovery indicating how far they have been addressed and brings out from the findings that there exist no proper measures for service identification /discovery. From the literature we have identified essential features. These features have been considered as a focal point and a metric suite is proposed with essential measures like service contract, relevance of metadata and exact positioning of service. Based on these measures, a measure for service discovery is proposed. In order to verify these measures, an experiment has been designed and conducted with three types of service registries namely Service Registry1, Service Registry2, and Service Registry3. From the experiment results it is evident that maximum of 18 percentage increase in service discovery in Service Registry 3 when compared to other two registries. So these measured results will help the service provider and service broker in fine tuning the service registry and the consumer for a better design the service queries. The results prove that the proposed measures enables effective service discovery.

Keywords Service Discovery Model, Service Discovery Measures, Discovery Features, SOA Quality Metrics , Discoverability Measures

1. Introduction

Distributed systems have their functionalities spread across various applications in heterogeneous environment. These systems demand a flexible architecture as that of SOA. SOA finds itself suitable because of its adaptive nature and ability to discover and adopt services and expresses the needed functionalities through service composition. Hence service discovery has a major role to play. Service Discovery enables composing or assembling together distributed functionalities or services to build new services.

Discoverability is one of the quality attribute of SOA which promote reuse of services by increasing the consumption of services as many time a particular user requires them[3]. Discoverability is comprises of two components which are service discovery and service Interpretation. This paper focuses on service discovery.

Service Discovery consists of various players like service consumer, service provider and service broker. The Service Discovery is based on sufficient information provided by the service providers which are published in theregistry[6][8][26], suitable queries used to find the required service and process to discover the service from the registry which is maintained by service broker. In order to enable effective service discovery, it has to be measured and finetuned. The measures involved are effect of service information representation in the registry, the similarity match of user query with the Meta data of service registry and also underlying algorithm in the discovery process. Based on these measurements appropriate steps can be taken by service producer, service consumer and the service broker to achieve effective service discovery.

Hence a mechanism to check the appropriateness of the service discovery is highly needed. The objective of this paper is to propose the measures to estimate the effectiveness of service discovery process and information representation quantitatively. An experiment has been done to validate the measures.

The rest of the paper is organized as follows, section 2 continues with a discussion of related work. Section 3 describes our proposed measures for service discovery. The experiment design was illustrated in section in 4. The experimentation was carried out and results are reported in section 5. Finally concludes in section 6.

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2. Related Works

Discoverability is the quality attribute of SOA which

discovers the exact web service that the service consumer requires[1]. It is essential to find the aspects or constituents for achieving complete discoverability. From, the research contribution of different researchers it has been known that discoverability contains the two constituents or aspects in it. The two parts of discoverability are discovery/ identifiability and interpretability[2][17][21][29]. Many researchers have confusion with the use of these two terminologies (i.e. discoverability and discovery)[4][10][12][40]. The research works are more specific towards the discovering of web services and they are not addressing discoverability of services. From the literature it is obvious that discovery is a part of discoverability which finds or searches the web services. Here we have done a survey which focuses on both discoverability and discovery of services.

The table 1 presents the list of works that focuses towards discoverability. The table indicates that most of works have concentrated more on the functional and non- functional aspects of web services. These aspects are generally used to describe the capabilities and to invoke or interpret the web services. The literature concludes that the constituents of discoverability have not been addressed exactly.

In this paper our focus is on discovery component of discoverability. Here, we have narrow down our review to concentrate on works specific to discovery of services.

From table 2, it reveals that most of research works focuses on the functional aspects, few researchers on categorization or location and some of them have focused on semantics and interface definition as factors for discovering the appropriate web services. Here the existing measures proposed for service discovery by various contributors are in a qualitative manner[16][23][41][44]. The above factors that are stated in the review do not cover the discovery part of discoverability completely, that had been visible through the study done to find out the factors that supports discovery alone[27][28][40][42]. This research gap motivates us carry out the research towards proposing the measures of discovery.

Table 1. Contributions towards Discoverability of SOA

Researchers	Contributions	Aspects Addressed
Zain Balfagih and Mohd Fadzil Hassan[4]	Proposed quality model for web services and they addressed discoverability as key factor in provider qualities	Concentrated on functional specification
Si Won Choi, Jin Sun Her, and Soo Dong Kim[9]	Proposed a set of QoS metrics for service providers especially considering the consumer's concern. They defined metrics for availability, dynamic discoverability, adaptability and compos ability.	Discoverability measured in terms of Syntax and Semantics
C Si Won Choi and Soo Dong Kim[10]	Proposed metrics for discoverability to measure Reusability of Services	Centered on Syntax and Semantics and in addition addressed interface definition
Si Won Choi, Jin Sun Her, and Soo Dong Kim[11]	Proposed metrics for discoverability to measure discovery at runtime	Focused on interface definition
Kozlenkov et al.,[13]	Presented a framework for supporting architecture driven service discovery.	Discovery addressed at design phase (considered functional and other constraints of services)
Chen Zhou, Liang-Tien Chia, and Bu-Sung Lee[12]	Proposed semantic based mechanism to improve the discovery.	Addressed functional and non- functional aspects

Table 2. Contributions towards Service Discovery

Researchers	Contributions	Aspects Addressed
Andreas Wombacher[14]	Evaluating the usability of Service discovery. Proposed similarity based measures for ordering list of services.	Used relevance of services as aspect for ordering list of services obtained during discovery.
Rube´n Lara et al.,[15]	Contributed a model for discovering the web services	Used categorization as factor for discovery.
Benjamin and Agnes[16]	Similarity measure are used to ranking the list of web services during discovery of services	WSDL tag used as token because it describes the service.
R. Deepa, S. Swamynathan[17]	Developed Protocol for discovery of services	Used quality of service data
Eyhab Al-Masri and Qusay H. Mahmoud[18]	Proposed framework for Discovering the web services using artificial neural networks	Ingredients used for discovery is Quality of Service data.
Bensheng Yun[19]	Framework based approach for web service discovery	Concentrated on Behaviour of services
Yu-Huai TSAI et al.,[20]	Contributed a hybrid approach to automatic web services discovery	Used textual and semantics as aspects for discovering web services

3. Proposed Work

The definition for discoverability from various studies stating that it 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. Here the definition of service discoverability indicates that the two components or items, discovery and interpretability are involved in the entire process of service discoverability[17][21][29]. The discovery deals with the searching or finding the service and interpretability deals with usage or invocation of those services. We have defined three factors which is essential for discovering the services from the service registry. We have proposed measures to validate those factors for its appropriateness in service registry. To demonstrate the proposal an experiment was designed with three different service registries. Each registry contains the entries of services range from 1000 to 3000.

To validate the discovery process in service registry, it is essential to measure the following factors which enable the better searching of services in service registry.

- **Check for Service Contract of required service in the Service Registry[40]**

The service provider has to register their services with the service contract.

- **Find the Appropriateness of Meta Data Associated with Service Contract of required service[28]**

Service contract of the registered services has associated with the corresponding Meta data which are describing the service functionalities.

- **Check the exact position or location of the required service in the Service Registry[27][42]**

In registry, the services has to be positioned or fall under the categories to make search easier

Based on the above discussed factors, we have designed a service registry which contains complete list of attributes. The attributes relevant to discovery of services are listed in the table 1. We have defined the value range and corresponding units for each attributes are explained in section 4.

In this paper we concentrate on proposing measures for service discovery. Three measures are proposed to check or validate the factors of service discovery of discoverability.

Metrics for Discovery

1. Metric for Checking for Service Contract

Checking for Service Contract (CSC) is measured by assessing the ratio of total number of hits to get the Service Contract of required Service **n** to Maximum number of hits possible to check Service contract on the available services **N** on the Service Registry.

Ratio of Checking Service Contract for Required Service (CSC) = $\frac{n}{N}$

Where, the max of n >=N

Here the value range of CSC is 0...1. The lower value of Service Contract metric indicates higher existence of the Service Contract. The maximum value of n is greater than or equal to N. The optimal value for large volume of N the ratio should be low. The value of this metric is zero in case of failure (i.e. Non-existence of Service Contract in the Service Registry).

2. Metric to Check the Relevance of Meta Data in Service contract

Relevance of Meta Data in Service Contract (RMD) measures the degree to which service contract contains relevance in its Meta data for required service in the service Registry. It means whether the supplied Meta data items are giving relevance with their corresponding service contract.

Ration of checking the Relevance of Meta Data in Service Contract (RMD) = $1-\left(\frac{A-a}{A}\right)$

Where, the value of a>=1 && a<=A

Here **A** is the number of attributes giving Meta information and **a** gives the attributes which are having relevance Meta information of the required service in the Service Registry. The constraint chosen for **a** must be at least 1. The value of **a** increases and the part of the metric **(A-a)** nearing to zero seems a good relevance because **a** is directly proportional to number of attributes **(a ∞ A)**. The RMD Metric value range is 0...1. The value nearer to one indicates the better relevance of the Meta information.

3. Check for Exact Positioning or categorization of Service in the Registry (EPS)

There is no metric for measuring the Exact or appropriate positioning of Service (EPS) in the Service Registry. We used the constant value for this factor. The value falls either zero or 1 i.e. if it is exactly positioned in the specified location the value is 1 otherwise the value is zero.

$$EPS = K$$
$$(where, k = 0 : noExactPosition$$
$$\& k = 1 : ExactPosition)$$

The discovery value for services is computed as follows,

$$D = 1 - (W1(CSC / RMD) + W2 * EPS)$$

Here, W1 & W2 is the weight factor whose value is 0.5. Since RMD and CSC are associated terms a single weight factor W1 has been used. The value for discovery is ranging from 0 to 1. Higher the value of Discovery metrics enables better discovery.

4. Experiment Design

To demonstrate the usability of the proposed metrics, we have designed and implemented three different service registries. The service registry and the corresponding information are designed based on the inspiration from[9][10][18][23][24][25][28][34][33][35]. For our experimental purpose we have registries with three different ranges of data (i.e. registry with 1000, 2000 and 3000 entries). We derived complete list of attributes and the value ranges (i.e. from minimum to maximum for each attribute) for the service registry as shown in table 3.

Table 3. Service Registry Attributes

Types of Data in Registry					
Functional Data					
S. No.	Attribute Name	Type		Value Range (Min to Max)	
1.	Service ID (UUID)[32]	Numeric		Use 8 digit	16 digit
2.	Service Name[33]	String		10 char	50 char
3.	Category[15][25][32][40]	String		10 char	20 char
4.	Version[25][40]	Number		1	3
5.	Interface Name[12]	String		10 char	30 char
6.	Consumer Type[25]	String		10 char	20 char
7.	End point Address[28]	String (url)		15 char	30 char
8.	Semantic Elements[43]	Number		3	5
9.	Service Operation[43]	Number		3	6
Quality of Service Data[31][32]					
S. No.	Attribute Name	Type	Units	Value Range (Min to Max)	
1.	Compliance to Std.[18]	Numeric	Percentage	10	100
2.	Response Time[31]	Numeric	Millisecond	10	30
3.	Latency[24]	Numeric	Seconds	20	50
4.	Doc[24]	Numeric	Percentage	10	100
5.	Availability[18][31]	Numeric	Days	1	7
6.	Throughput[24]	Numeric	Hits/sec	10	20
7.	Reliable messaging[23]	Numeric	Percentage	5	10
8.	Best Practices[23]	Numeric	Percentage	10	100

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. The attributes for each service registry have been chosen from table 3. The registries are named as SR1, SR2 and SR3.

- SR1- Service Registry1 is the basic registry which contains limited number of attributes
- SR2 – Service Registry2 extended version which contains additional attributes when compared to SR1.
- SR3 – Service Registry3, Optimum registry which contains complete attributes

Service Registry Attributes

The attributes chosen are based on the review of various works and the values for each attributes are defined with help of the references[9][10][18][23][24][25][33][40][43] . The information given below gives description about each attributes and corresponding values for them.

- Registry attributes listed in table 3 describes the complete information of each registered service. Here the attributes are differentiated based on functional and quality of service data. The primitive attribute is service name usually represented using the string type. Service category provides the support for better organization of services and to avoid the misplace of services falls under string type, service version is a number type attribute allowing for simultaneous deployment of multiple versions of the same service and allowing the consumer to choose the version he wants to use. An interface is a fully qualified name of the service, ensuring that a consumer refers to the interface what the services actually expose.

The Consumer Type parameter allows us to assign different service endpoints/bindings to different types of consumers for example platinum/golden/etc. The other fields or attributes like semantic elements and service operation falls under type number and are used to represent the purpose and capabilities. The Semantic elements give the described semantic elements matching to consumer demands or requirements. The attribute value is set to max of 5 and min of 3 for our experimental purpose. We have checked the optimality for these values. Service Operation gives the number of operation defined for the service. The attribute value is set to max of 6 and min of 3 for our experimental purpose.

- The quality of Service data are described using list attributes and their values for the services in the registry to filter and use appropriate services that matches the service consumer demands. The values for each attributes and units are chosen based on the references[18][23][24][31][32].

The Service registry SR1 is designed with minimum or basic fields and SR2 with additional fields other than SR1 and SR3 is the complete set which consists of the all fields defined in the table which is explained separately in section 4.1, 4.2 and 4.3.

4.1. Experiment Conducted with Service Registry1 (SR1)

The Service Registry the attributes are limited when compared to other registry. 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 plus its own field.

Out of 12 queries, SR1 gives response for first three

queries and the remaining there is no response the values of the query 3 will be repeating because it is a primitive registry doesn't contain the additional fields. Three proposed measures are validated with the experiment which is represented as factor1, factor 2 and factor3.

a) Measuring CSC metric from service registry 1

Similarly, we have computed the metrics on 2000 and 3000 data sets and the results are shown in table 8 & 9.

b) Measuring RMD metric from service registry 1

Table 4. CSC metric value of SR1 of various services

Service Registry1 (SR1)						
Field used for Query	Queries	Services	Size	n	N	n/N
		Service13	100	17	100	0.17
(category)	Query 1	Service32	100	15	100	0.15
		Service91	100	99	100	0.99
		Service13	100	15	100	0.15
Category +compliance	Query2	Service32	100	13	100	0.13
		Service91	100	51	100	0.51
		Service13	100	14	100	0.14
Category + compliance + availability	Query3	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Version	Query 4	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Response	Query 5	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Throughput	Query 6	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
consumer type	Query7	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Latency	Query 8	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Doc	Query 9	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Reliable Messaging	Query 10	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Best Practices	Query 11	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Semantics and order by syntax	Query 12	Service32	100	12	100	0.12
		Service91	100	45	100	0.45

In SR1, the attributes supporting the Meta data are six in which more 4 attributes are giving the relevance to Meta data. It is common for three different data ranges of SR1

Here A= 6, a=4

Ration of checking the Relevance of Meta Data in Service Contract (RMD) = $1-\left(\frac{6-4}{6}\right)$

The Value of RMD metric is 0.66

c) Measuring EPS metric from service registry 1

The value of exact positioning is 1 for the three services chosen in service registry SR1. The value is same for the SR1 with different data ranges (1000, 2000, and 3000).

EPS= 1

4.2. Experiment conducted with 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.

a) Measuring CSC metric from service registry 2

Similarly, we have computed the metrics on 2000 and 3000 data sets and the results are depicted in table 8 & 9.

b) Measuring RMD metric from service registry 2

In SR2, the attributes supporting the Meta data are nine in which 7 attributes are giving more relevance to Meta data. It is common for three different data ranges of SR2

Here A= 9, a=7

Ratio of checking the Relevance of Meta Data in Service Contract (RMD) = $1-\left(\frac{9-7}{9}\right)$

The Value of RMD metric is 0.77

c) Measuring EPS metric from service registry 2

The value of exact positioning of services (EPS) is 1 for the three services chosen in service registry SR2. The value is same for the SR2 with different data ranges (1000, 2000, and 3000).

EPS = 1

Table 5. CSC metric value of SR2 of various services

Service Registry2 (SR2)						
Field used for Query	Queries	Services	Size	n	N	n/N
		Service13	100	17	100	0.17
(category)	Query 1	Service32	100	15	100	0.15
		Service91	100	99	100	0.99
		Service13	100	15	100	0.15
Category + compliance	Query2	Service32	100	13	100	0.13
		Service91	100	51	100	0.51
		Service13	100	14	100	0.14
Category + compliance + availability	Query3	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Version	Query 4	Service32	100	12	100	0.12
		Service91	100	38	100	0.38
		Service13	100	12	100	0.12
Response	Query 5	Service32	100	10	100	0.1
		Service91	100	35	100	0.35
		Service13	100	11	100	0.11
Throughput	Query 6	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
consumer type	Query7	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
Latency	Query 8	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
Doc	Query 9	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
Reliable Messaging	Query 10	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
Best Practices	Query 11	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	11	100	0.11
Semantics and order by syntax	Query 12	Service32	100	9	100	0.09
		Service91	100	29	100	0.29

Table 6. CSC metric value of SR3 of various services

Service Registry3 (SR3)						
Field used for Query	Queries	Services	Size	n	N	n/N
		Service13	100	17	100	0.17
(category)	Query 1	Service32	100	15	100	0.15
		Service91	100	99	100	0.99
		Service13	100	15	100	0.15
Category + compliance	Query2	Service32	100	13	100	0.13
		Service91	100	51	100	0.51
		Service13	100	14	100	0.14
Category + compliance + availability	Query3	Service32	100	12	100	0.12
		Service91	100	45	100	0.45
		Service13	100	14	100	0.14
Version	Query 4	Service32	100	12	100	0.12
		Service91	100	38	100	0.38
		Service13	100	12	100	0.12
Response	Query 5	Service32	100	10	100	0.1
		Service91	100	35	100	0.35
		Service13	100	11	100	0.11
Throughput	Query 6	Service32	100	9	100	0.09
		Service91	100	29	100	0.29
		Service13	100	10	100	0.1
consumer type	Query7	Service32	100	8	100	0.08
		Service91	100	25	100	0.25
		Service13	100	9	100	0.09
Latency	Query 8	Service32	100	7	100	0.07
		Service91	100	21	100	0.21
		Service13	100	7	100	0.07
Doc	Query 9	Service32	100	5	100	0.05
		Service91	100	19	100	0.19
		Service13	100	6	100	0.06
Reliable Messaging	Query 10	Service32	100	4	100	0.04
		Service91	100	15	100	0.15
		Service13	100	2	100	0.02
Best Practices	Query 11	Service32	100	1	100	0.01
		Service91	100	1	100	0.01
		Service13	100	3	100	0.03
Semantics and order by syntax	Query 12	Service32	100	2	100	0.02
		Service91	100	1	100	0.01

4.3. Experiment conducted with Service Registry3 (SR3)

The Service Registry 3 (SR3) contains the all attributes listed in the table 3 because it is a complete registry and gives output for all the 12 queries.

a) Measuring CSC metric from service registry 3

Similarly, we have computed the metrics on 2000 and 3000 data sets and the results are shown in table 8 & 9.

b) Measuring RMD metric from service registry 3

In SR2, the attributes supporting the Meta data are 17 in which 14 attributes are giving more relevance to Meta data. It is common for three different data sets of SR2

Here A= 17, a=14

Ration of checking the Relevance of Meta Data in Service Contract = $1-\left(\frac{17-14}{17}\right)$

The Value of RMD metric is 0.82

c) Measuring EPS metric from service registry 3

The value of exact positioning of services (EPS) is 1 for the three services chosen in service registry SR3. The value is same for the SR3 with different data ranges (1000, 2000, and 3000).

EPS= 1

5. Discussion

Our proposed work is distinct when compared to[9][11][13][15][16][19][20] based on number of attributes used in measuring the service discovery. Due to this fact, it will be inappropriate if we carry out the comparison either qualitatively or quantitatively with other related works. So, we carried out the study based on the three different type of service registries with different data sets.

The output of each case gives proposed metrics values for three different registries with different data sets as shown in table 7, 8 & 9. Let us consider the CSC metric value for three registries used. In case 1 the CSC metric value is high when compared to case 2. Similarly the case 2 CSC metric value is high when compared to case 3. It is clearly evident from this that Case 3 CSC metric value is low which indicates the higher existence of Service Contract. The graph below

figure 1, 2&3 shows that CSC metric value comparison with three registries on various data sets.

The RMD metric gives the common value for service registry 1(SR1) of different data sets, similarly for other service registries (SR2 & SR3) also. The RMD Metric Value comparison shows that SR1 is low when compared to SR2, similarly SR2 RMD Metric value is low compared with SR3. So SR3 having high RMD Metric value indicates the better relevance of the Meta information when compared with other registries. The graph below figure 3 shows the comparison of RMD metric value of three registries with three different data sets.

Finally, exact positioning factor gives a constant value 1 for all Service Registries with different sets of data because all the searched services are exactly categorized.

Table 7. CSC, RMD and EPS Metrics values of various services with three Registries for 1000 records

Services ID	Metric Values for 1000 data range								
	CSC (in average)			RMD			EPS		
	SR1	SR2	SR3	SR1	SR2	SR3	SR1	SR2	SR3
Service 13	0.143333	0.124167	0.1	0.66	0.77	0.82	1	1	1
Service 32	0.123333	0.104167	0.081667	0.66	0.77	0.82	1	1	1
Service 91	0.5	0.3925	0.315833	0.66	0.77	0.82	1	1	1

Table 8. CSC, RMD and EPS Metrics values of various services with three Registries for 2000 records

Services ID	Metric Values for 2000 data range								
	CSC in average			RMD			EP		
	SR1	SR2	SR3	SR1	SR2	SR3	SR1	SR2	SR3
Service 13	0.397917	0.324167	0.239583	0.66	0.77	0.82	1	1	1
Service 32	0.102917	0.0825	0.070833	0.66	0.77	0.82	1	1	1
Service 91	0.420216	0.361882	0.298132	0.66	0.77	0.82	1	1	1

Table 9. CSC, RMD and EPS Metrics values of various services with three Registries for 3000 records

Services ID	Metric Values for 3000 data range								
	CSC in average			RMD			EP		
	SR1	SR2	SR3	SR1	SR2	SR3	SR1	SR2	SR3
Service 13	0.270278	0.248889	0.170278	0.66	0.77	0.82	1	1	1
Service 32	0.112778	0.093333	0.077222	0.66	0.77	0.82	1	1	1
Service 91	0.436667	0.336389	0.256111	0.66	0.77	0.82	1	1	1

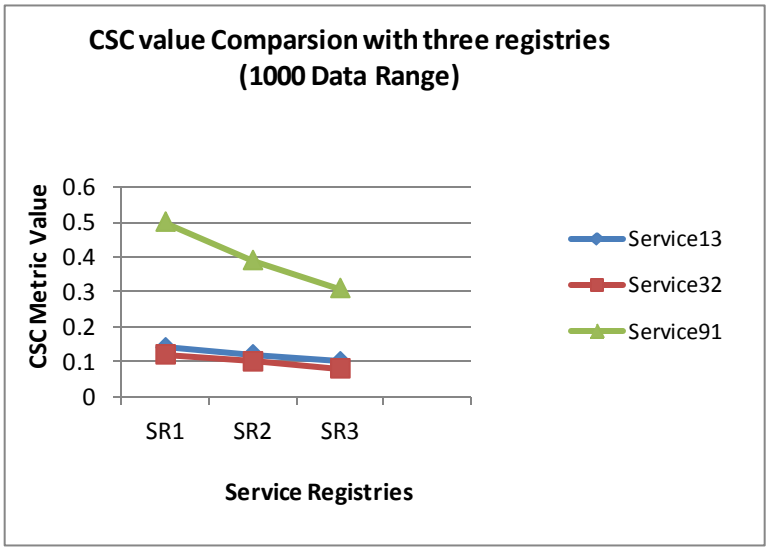

Figure 1. CSC Metric Value of various services compared with SR1, SR2 and SR3 for 1000 data range

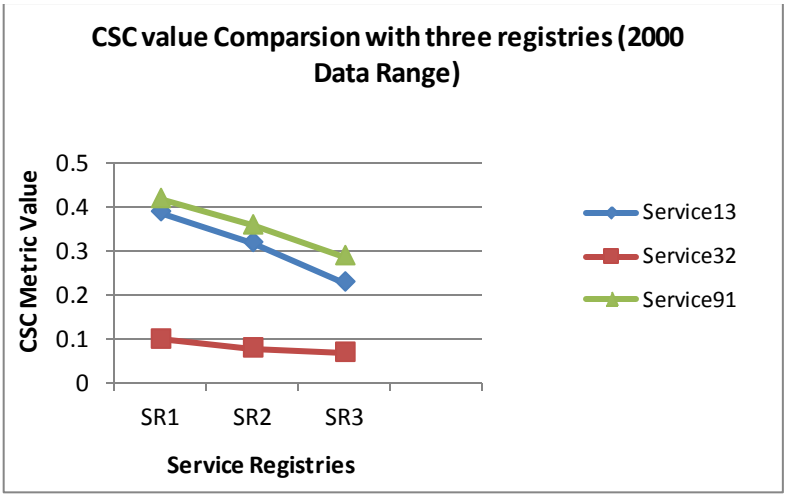

Figure 2. CSC Metric Value of various services compared with SR1,SR2 and SR3 for 2000 data range

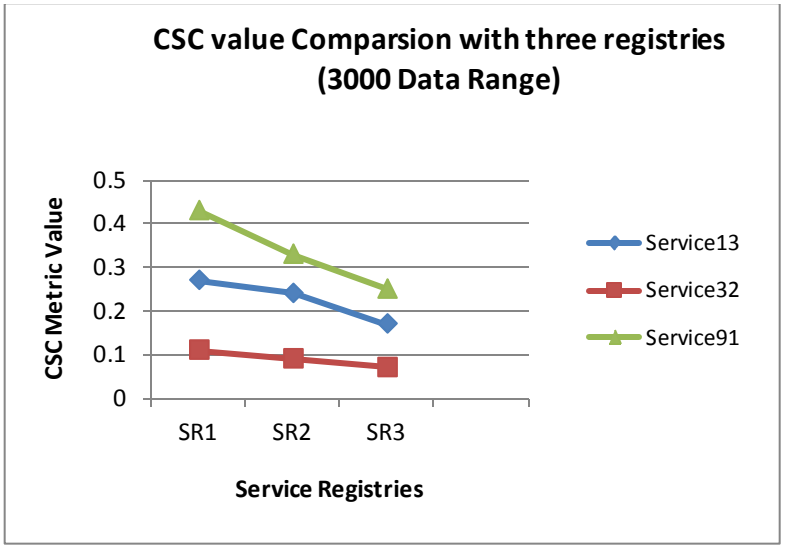

Figure 3. CSC Metric Value of various services compared with SR1, SR2 and SR3 for 3000 data range

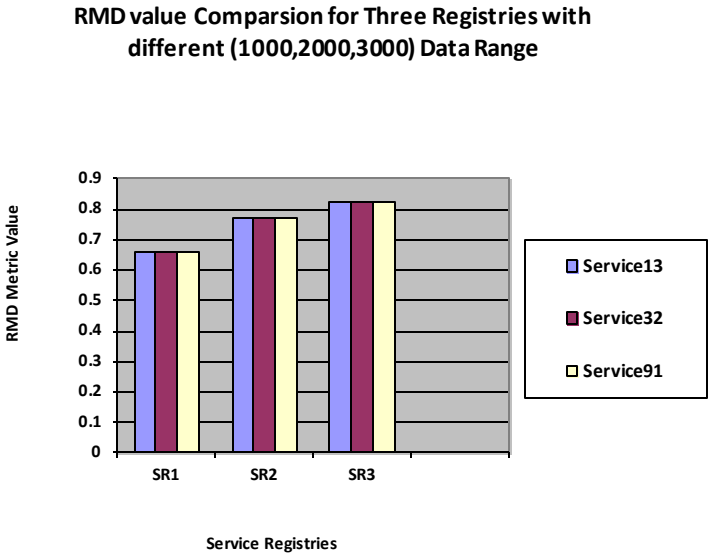

Figure 4. RMD Metric Value of different services compared with SR1, SR2 and SR3 for 1000, 2000 and 3000 Records

Table 10. Discovery Metrics values for 1000,2000 and 3000 Data Entries

Service Registry	Services	Discovery Metric Values		
		For 1000 Entries (%)	For 2000 Entries (%)	For 3000 Entries (%)
SR1	Services 13	39.1	19.8	29.5
	Services 32	40.6	42.2	41.4
	Services 91	12.1	18.1	16.9
SR2	Services 13	41.9	28.9	33.8
	Services 32	43.2	44.6	43.9
	Services 91	24.5	26.5	28.1
SR3	Services 13	43.9	35.3	39.6
	Services 32	45	45.6	45.2
	Services 91	30.7	31.8	34.3

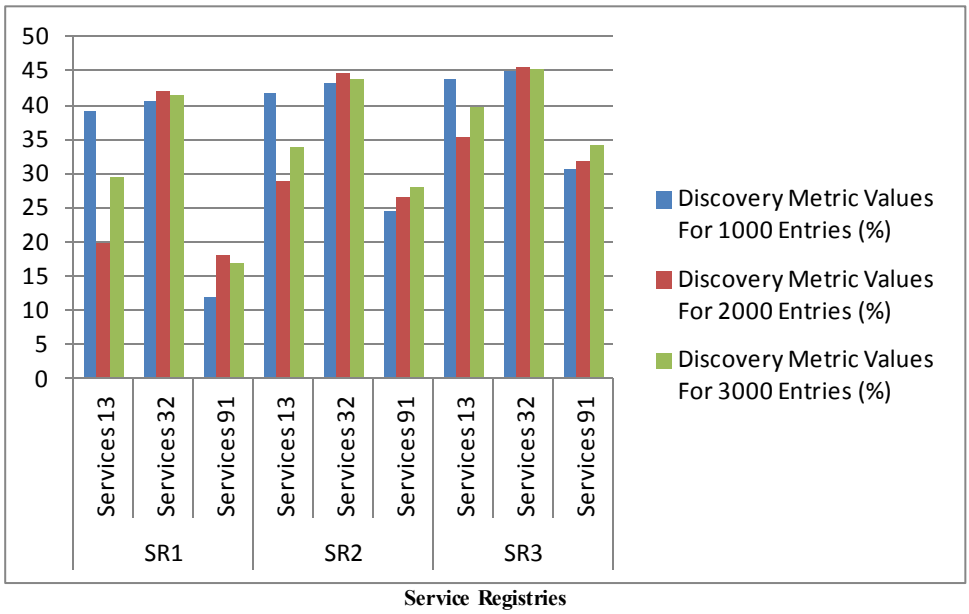

Figure 5. Discovery Metrics values for 1000, 2000 and 3000 Data Entries in percentage

The table 10 shows the Discovery metric values of registries with different data range. From the values, we can see that the service discovery values of each service are varying, i.e. SR2 the increase in the value to maximum of 11 % when compared with SR1. Similarly SR3 gives maximum of 18 % increase in service discovery when compared with SR2. The graphical representation in figure 5,6, and 7 shows that SR3 gives better discovery values for Services that have been taken to demonstrate our proposed measures. There is a clear indication that Service Registry3 (SR3) is more effective which gives better discovery environment for finding exact services.

The discovery metric value of different registries indicates that how service provider can improve the discovery of their services which are published in service registry. In addition, it can also provide the essential features of discovery, which the service providers taken into account for registering their services in service registry. These proposed measures are giving support to satisfying the requirements of service consumer by measuring the service discovery with various queries.

6. Conclusions

Service Discovery is a component of Discoverability, which increases the better discovery of services that are registered in the registry. In this paper we have identified the factors constituting the discovery component. We have proposed three metrics which can be used to evaluate those identified factors and in turn measures the service discovery. The proposed metrics are validated with our experiment using three different service registries. The results of each metric show how the discovery of services was improved from SR1 to SR2 and SR3 and also paves way to improve discovery faster and effectively by giving more attributes of services. This metric can offer the essential attributes of

service that the service provider has been considered while publishing their services in service registry thereby consumer requirements are fulfilled in discovering the relevant services.

Our future work is to carry out the same experiment with real time service registries. Also, we have planned to devise the method to compare our work with other existing approaches.

In addition to the above we have planned to define metric suite for service discoverability. This can be carried out by defining metric suite for discovery and we have to propose measures for the interpretability. Future work focuses on proposing the features and measures for interpretability component of Discoverability.

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