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# A Semantic Web Services Query Optimization Method Based on Social Tagging

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***Abstract—****How to find web services quickly and accurately has become an urgent need. This paper presents a semantic web services query optimization method based on social tagging, under the guidance of the user behavior model for general service semantic of social tagging, a multidimensional-based social tagging method is proposed, it allows the user to tag the services from the perspectives of function attributes, non-functional attributes and contextual attributes of the services, recognizing the semantic annotation types of services, reducing the search scope and improving service query efficiency; Also FOAF(Friend of A Friend)-based social-semantic web community and social tagging ontology(STO) are established, Through the analysis of user attributes, tag attributes and service attributes and the relationship among them, the system will use the rule of ontology reasoning to find the web services to meet user demand, enhancing services searching of precision and completion. Finally, experimental analysis shows the feasibility and effectiveness of this method.*

***Keywords-social tagging; service query; FOAF;STO***

## I. INTRODUCTION

Web services as the unit of system integration so as to quickly construct the application system has become an irresistible trend in the software industry [1].Be different of traditional software design, development, use and maintenance of the development method of four in one way, web services providers and users are played by different companies and different individuals. Therefore, traditional software engineering methodology will be challenged. whether expected use context and that of the actual context of use is consistent; whether the design of web services can be found and used by potential users, all that will be a new problem. How to accurately find the existing web services to meet user needs has become a research hotpoint. As the search engine for users from mass of information in the network to find the required information, this paper provides the key methods and technologies which can assist service consumers from the web services sea to locate the required services.

In addition, with the development of SOA, the changing of system development patterns and the upgrading of user experience of services, enabling services not only to meet the user needs in the functional, but also in the non-functional on a timely satisfy the user's changing needs. The software development of the future will be user-centric, service-oriented to quickly build applications, requiring the user to quickly and accurately discover web services, however, traditional web services discovery method by only keywords query can not meet immediate needs, need to dynamically discover web services by utilizing semantic information [4]. Meanwhile, the development of social networks can promote independent users to build certain links on a basis of social attributes between each other, through the auxiliary recommendation way to meet the needs of each other. FOAF (Friend of a friend) is a social network vocabulary based on RDF [5], by creating multiple FOAF files and sharing URL, so the software can use the information in the document, while the easy extension of FOAF for the new service discovery method provides a good opportunity.

The paper firstly gives the dimension framework of service semantic social annotation, annotating the services from the functional properties, non-functional attributes, and situational attributes of services; at the same time STO will be built, considering the user as the core, constructing users, tags, services, and the relationship between their properties and establishing the user's dynamic properties (seeAlso, knows, etc) and static properties (name, preference, etc), so that user can find services according to social networks relationship between users to improve the precision and completion for service query. A service query optimization algorithm is proposed in the paper, through the integration of FOAF-based social networks and social tagging-based semantic web, it will make service resources found more accurately.

## II. USER BEHAVIORING MODEL BASED ON SOCIAL TAGGING

This paper gives a general service annotation system's internal flowcharts to guide service discovery. Firstly, the system will record the user's registration information, then join the information collected into posterior information, then acquire the parameters of the information by post pushed valuation and make statistical inference, finally user's social behavior can be predicted to facilitate more accurately services discovery, look at Figure 1.

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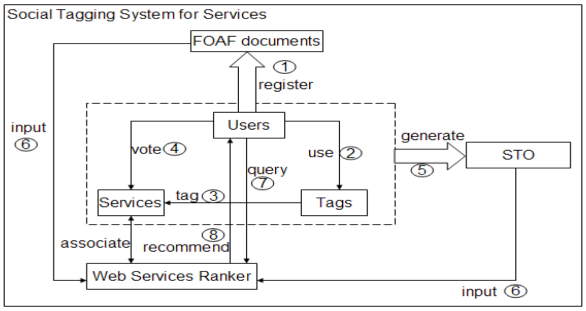


Figure 1. General user behavioring model for social tagging of services

## III. SOCIAL TAGGING FOR WEB SERVICES

### A. *Social Tagging Dimension for Web Services*

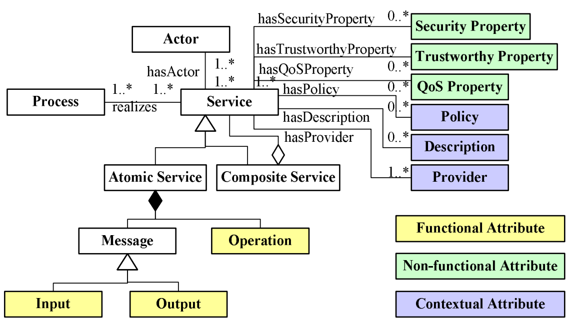


Figure 2. Social tagging dimensions for service semantic.

This model is on a basis of the service meta-model[6] created by the research group in State Key Laboratory of Software Engineering, Wuhan University where the author works in, which will focus on service properties, see Figure 2, using WSDL to describe services, primarily through the extraction of WSDL document Operation, < input, output> message to mark service function attributes; Non-functional attributes of the service, considering the following factors: WS-Security, describes web services security features; WS-Quality, describes web service response time; WS-Trustworthy, describes the commercial web services trust. Also need to describe the service from the context attributes, such as WS-Policy, describes the requirements of web services calls, service capacity and preference; WS-Description, general description of the services text; Provider, description information of service providers.

### B. *Social Tagging Ontology*

STO = (User, Tag, Service, Vote, Relation). Social tagging ontology as the core of service semantic social tagging, connecting users and services, through the tags recording the correspondence relationship between them to facilitate post-comprehensive analysis of the data and provide a solution for later optimizing the service query.

- User = (Uid, Uname, mailbox, homepage, role, position, preference | knows, seeAlso), describes the user's personal information (static information / attributes), and similar users(dynamic information / attributes). User is considered as the sponsors for service marking, through the association of its properties, type of relationship, establishing the association between similar users, and identifying the marked services by similar users making use of this element, providing assist for precisely searching services.
- Tag={Tname,Ttype}， Ttype={functional, non-functional, contextual}。Functional={operation, <input, output>}, non-functional={QoS, security, trustworthy}, contextual={policy, description, provider}。Tag is a connection bridge between the user and the service, in which tag type attributes is correspondence with service attributes.
- Service={<input, output>, operation, QoS, security, trustworthy, policy, description, provider}. Service is an object for user annotating, through the provision of description, function, input and output, strategy, vendor information of service, user can annotate the service from multiple perspectives.
- Relation={hasTag, hasVote, hasService}， Vote elements can be measured the value of the user's network, to establish the link between users and services, showing what services are popular for which users. Relation describes the relationship among them, and by recording the number corresponding to each relationship to determine their relationship weight.

## IV. SEMANTIC WEB SERVICE QUERY OPTIMIZATION BASED ON SOCIAL TAGGING

In order to meet personized needs of users, we propose a web service query optimization method based on social tagging. The paper uses the WordNet ontology vocabulary to preliminary query the services meeting the user's needs, generating the initial service requirement set, through FOAF-based analysis of the social semantic web, filtering function equivalent web services, and enhancing precision.

### A. *FOAF-based Social Network Analysis*

User attributes, tag attributes , service attributes and the associated relationships among them are shown in Figure 3.

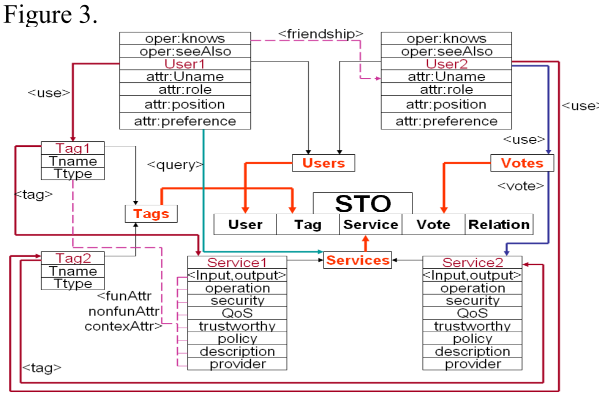


Figure.3. The associated relationship among user attributes, tag attributes, service attributes

We start with the simplest case to consider two users User1 and User2, two service Service1 and Service2, two tags Tag1 and Tag2. User1 uses Tag1 to mark Service1, User2 uses Tag2 to mark Service2. User2, after a trial of Service2 likely evaluates or votes the service, so social tagging ontology records user, service, tag and their relations from a macro point of view; At the same time from the microscopic point of view recording the properties of these elements, user owns role, position, preference and other static properties, and knows, seeAlso dynamic properties, the service has function property of input, output, operation, non-functional attributes of security, trustworthy, Qos, and context attributes of policy, description and provider, tag has the attributes of Tname and Ttype, tag type attribute values are corresponding to service attribute values. User1 searches User2 who is associated with User1 with some social relationship by dynamic property knows, mainly using the FOAF document to search, finding Tag2 used and Service2 annotated by User2, and then will recommend Service2 to User1, User1 decides whether use Service2 in accordance with his needs.

Thus extending the above situation, assume that the user sets User_S = (ur1, ur2, ... ..., urm), User1, User2 ∈ User_S, m is a positive integer; service set Serv_S = (sv1, sv2, ... ..., svn), Service1, Service2 ∈ Serv_S, n is a positive integer; Social Annotation ServA_S = (sa1, sa2, ... ..., saj), the n-th service of social tagging set ServnA_S = (sna1, sna2, ... ..., snak), Tag1, Tag2 ∈ ServA_S ∧ Tag1 ∈ Serv1A_S ∧ Tag2 ∈ Serv2A_S, j, k non-negative integers. Voting is the user feedback after the trial service, can be expressed as hasVote: urm → svn. See the specific algorithm of section 4.2.

## B. Service Query Optimization Algorithm

**Algorithm idea:** using ontology similarity calculation formula, calculating the semantic similarity between keywords description for target requirement and social tags of service, return the initial service set meeting the user needs, then through tracking the user information and analysizing social tagging Ontology, to filter out the best matched service to meet user's needs.

First, we give a requirement inquiry set ReqQ = (rq1, rq2, ... ..., rqi), i is a positive integer.

**Algorithm description 1:** by keyword matching and semantic similarity calculation, search the initial service set to meet user needs. (See my previous research papers [7,8], keyword matching and semantic similarity computing research has been very mature, so this study will focus on how to use the user's social attributes and social tagging to filter out the best matching service meeting the user needs, see algorithm description 2).

**Algorithm Description 2:**

Step 1: user inputs keywords describing the requirement, while the system will track the user, and detect whether the user has been registered and generate FOAF documents and the corresponding STO after annotations on the services; If so, step 2 ; Otherwise, return algorithm description 1;

Step 2: recall out the user's FOAF document and the corresponding STO:

(a) for ∀uri∈User_S, extracting his associated user sets UserA_S = (url, ur2, ... ..., url) (UserA_S⊂User_S, l is non-negative integer, and i ≠ l), place into similar user list (SimUrList),

For{p = 1; p <= l; p + +

hasService: url → svn; / / loop through each of the services similar to the user marked

return (svn); / / UserA_S-Serv = (uas1, uas2, ... ..., uasq), q is non-negative integer, will return to (svn) stored in the corresponding set of services associated with the user list UserA_S-Serv;

}

(b) for ∀saj∈ServA_S, search the service set (svn) annotated by the user using the same tag, storing into the tag corresponding to the list of services ServA_S-Serv = (sas1, sas2, ... ..., sasn);

(c) for the evaluation for service based on user feedback / vote, calculate the value of Vote, search the service set evaluated by the user(svn), and stored in the voting corresponding to list of services Vote-Serv = (vs1, vs2, ... ..., vsn);

Step 3 filter out the best matched service meeting user needs set SuitForReq-Serv = UserA_S-Serv ∩ ServA_S-Serv ∩ Vote-Serv;

Step 4 user selects the best suitable service meeting user needs according to their preference, service set (svn), {svn}⊂SuitForReq-Serv，n>=0, and n is an integer;

Step 5 the algorithm stops.

# V. EXPERIMENTAL RESULT AND ANALYSIS

This experimental data are crawled from service search engine seekda, acquisition time is 2010-05-01.For example, the requirement “query weather”, by entering the keyword "weather", the system will search out the corresponding 122 services, 10 services of which are shown in the table 1.

TABLE I. MATCHED SERVICES RELATED TO "WEATHER" AND THE TAGS CORRESPONDING TO THE SERVICES.

| Services | Tags |
|---|---|
| MeteorologyWS | weather, waether |
| GlobalWeather | weather, global, company, city, current, MyWeather, condition, aviation, mywebservice, worldwide, free |
| DOTSFastWeather | current, weather, condition, tourism, weather information, unkown, company, commercial, meteorologic intelligence, onsale, weather, forecast, alert service, travel information |
| Weather | forecast, unkown, :weather |
| USWeather | company, report, weather, ZIP code, USA |
| GlobalWeather | free, current, city, worldwide, company, weather, condition, global |
| WeatherForecast | weather, location, USA, company, |

| | |
|---|---|
| | free, forecast, name, ZIP code |
| GlobalWeatherService | Commercial, signup, weather |
| ndfdXML | organization, wind direction, temperature, weather, tropical cyclone wind, amount, wave height, wind speed, snow fall, cloud cover, precipitation, dewpoint, direction |
| ……… | ………… |
| FlightRouteAggregatorService | aviation, company, development, unkown, commercial |

From the analysis of above table, we can see the queried services are lack of prioritizing, and service tags also appear haphazard. By introducing the proposed method in this paper, we can enable the service of social tagging to correct guidance, to filter out incorrect, redundant and non-meaningful tags. At the same time by recording correspondence relationship among the user's social information, tags, and the services, can provide the basis for lately services query optimization.

As the huge resources in the network, this method only is proposed from the perspective of research, small and focused, and then extended to the entire network service resources. To facilitate the study, this paper will consider 5 users and 10 service resources in Table 1 as experimental carrier.

Here assume that five Internet users were Abama (A), Blaz (B), Corne (C), Dady (D), Elaine (E), marking the services from functional properties (dark blue), non-functional attributes (dark red) and the contextual properties (black) and classify the tags in the table 2:

TABLE II. CLASSIFICATION OF SERVICES AND TAGS CORRESPONDING TO SERVICES

| Services | Tags |
|---|---|
| MeteorologyWS | weather, GetActualInfo(A), GetBiometeorology, GetPredictionInfoCR |
| GlobalWeather | weather, global, company, city, current, condition, aviation, mywebservice, worldwide, free(C), GetCitiesByCountry(B), GetWeather, reliable(A) |
| DOTSFastWeather | current, weather, condition, tourism, weather information, company, commercial, meteorologic intelligence, onsale, forecast, alert service, travel information(B), GetWMOIDByCity(D) |
| Weather | forecast, :weather, GetRemainingHits, GetWeatherForZipCode(E) |
| USWeather | company, report, weather, ZIP code, USA, GetWeatherReport(B), updately(C), trustworthy(A) |
| GlobalWeather | free, current, city, worldwide, company, weather, condition, global, GetCitiesByCountry(E), GetWeather(B) |
| WeatherForecast | weather, location, USA, company, free, forecast, name, ZIP code, GetWeatherByPlaceName(A), GetWeatherByZipCode(C) |
| GlobalWeatherService | Commercial, signup, weather, GetLatestWeather(B), GetWeatherStationList(E), timely(C) |
| ndfdXML | organization, wind direction, temperature, weather, tropical cyclone wind, amount, wave height, wind speed, snow fall, cloud cover, precipitation, dewpoint, direction, CornerPoints, GmlLatLonList |
| ……… | ………… |
| FlightRouteAggregatorService | aviation, company, development, commercial, accurately(B), FlightRouteAggregatorGetFlightsOperation |

At the same time, social tagging ontology is generated, in which the value in parentheses behind the service is that evaluation/voting of users to service, the value domain is (2,1,0, -1, -2), 2 – very good, 1 – good, 0 - General, -1 - badly, -2 – very badly.

- User A： Services→Tags={ MeteorologyWS→GetActualInfo, GlobalWeather(2) → reliable, USWeather(2)→trustworthy, WeatherForecast(2)→GetWeatherByPlaceName}；
- User B： Services→Tags={ GlobalWeather(1)→GetCitiesByCountry, DOTSFastWeather→travel information, USWeather → GetWeatherReport, GlobalWeather → GetWeather, GlobalWeatherService(1) → GetLatestWeather, FlightRouteAggregatorService(2)→accurately}；
- User C： Services→Tags={ GlobalWeather(1)→free, USWeather(2)→updately, WeatherForecast → GetWeatherByZipCode, GlobalWeatherService(2)→timely}；
- User D： Services→Tags={ DOTSFastWeather→GetWMOIDByCity}；
- User E： Services→Tags={ GlobalWeather(1)→GetWeatherForZipCode, GlobalWeather → GetCitiesByCountry, GlobalWeatherService → GetWeatherStationList}；

The interaction between five users in Figure 4, where two-way arrows between the two users with each other knows, one-way arrow denotes the arrow end knows the arrow head.

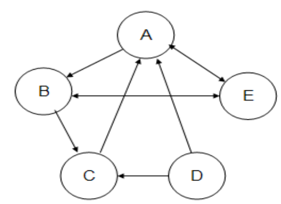


Figure 4. The interaction graph between users based on FOAF

For the above method, we can have an experiment as follows. Assume that user A input the requirement “GetWeatherByCity”, through the analysis of the interaction relationship between users，firstly, user A query the services annotated by him previous，Services→Tags={MeteorologyWS → GetActualInfo, GlobalWeather(2)→reliable, USWeather(2)→trustworthy, WeatherForecast → GetWeatherByPlaceName} whether meeting the demand，then query the services annotated by the similar users，for similar user B，there are Services → Tags={ GlobalWeather(1) → GetCitiesByCountry, DOTSFastWeather → travel information, USWeather → GetWeatherReport, GlobalWeather → GetWeather, GlobalWeatherService(1) → GetLatestWeather, FlightRouteAggregatorService(2) → accurately} ; for user E , Services → Tags={ GlobalWeather(1) → GetWeatherForZipCode, GlobalWeather → GetCitiesByCountry, GlobalWeatherService → GetWeatherStationList} ; thereby, a service set meeting user's demand is showed, that is {WeatherForecast → GetWeatherByPlaceName , GlobalWeather(1) → GetWeatherForZipCode}, according to user's evaluation/voting to service used, we will get the service "WeatherForecast" as the most suitable result meeting user's demand.

## VI. RELATED WORK

Under the guidance of service-oriented computing pattern, some demand-driven service discovery methods have emerged. For example, Andreas presents target-driven alignment mathod between services and business demands[2], on a basis of Tropos, by comparing with goal model to find the service to meet specific business needs, but how to automatically generate the corresponding target model from web services description is the bottleneck of the method. Hausmann proposes a model-based service discovery method[3], extracting the service semantic through ontology and graph transformation rules, and using graph transformation rules to formally describe requirements, finally by rule-based matching to complete service discovery.

In the domestic, Chinese Academy of Sciences Computing Institute Shi Zhong-Zhi researcher proposes a semantic web service description and service matching method based on the dynamic description logic, using dynamic description logic in actions to describe the target service of service request party and the atomic service of service delivery side, and using dynamic description logic reasoning capabilities of the action, discovering the atomic services composition with target service matching [9]; Wuhan University HE Keqing proposes a web service descovery method based on context and reasoning rules, which is on a basis of semantic web service discovery results, using the reasoning relationship between the user context and web service context, obtaining the contextual states of user by perception, automatically finding the appropriate services sulting for user context[10].

## VII. CONCLUSION

This paper presents a semantic web services query optimization method based on social tagging, under the guidance of the user behavior model for general service semantic social tagging, a multi-dimensional social tagging method is proposed, allowing the user to annotate the service from the perspectives of function properties, non- functional attributes and contextual attributes, recognizing semantic annotation type, reducing the search scope to improve the efficiency of service inquiries; while establishing FOAF-based social network and social tagging ontology STO, through the analysis of the relationship between the user attributes, tag attributes and service attributes, using the rules of ontology reasoning to discover web services to meet customer needs, improve service precision and recall rate.


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## REFERENCES


[1] *Luciano Baresi, Neil Maiden, Peter Sawyer, Service-Centric Systems and Requirements Engineering, 16th IEEE International Requirements Engineering Conference, pp:305, 2008*

[2] *Andreas Gehlert, Nadine Bramsiepe, Klaus Pohl, Goal-Driven Alignment of Services and Business Requirements, 2008 International Workshop on Service-Oriented Computing Consequences for Engineering Requirements (SOCCER'08), pp:1-7, 2008*

[3] *J. H. Hausmann, R. Heckel, and M. Lohmann, Model-Based Discovery of Web Services, in IEEE International Conference on Web Services (ICWS 2004) San Diego, CA, USA, pp:324-331, 2004.*

[4] *Kyriakos Kritikos, Dimitris Plexousakis, Requirements for QoS-Based Web Service Description and Discovery, IEEE TRANSACTIONS ON SERVICES COMPUTING, VOL. 2, NO. 4, pp:320-337, 2009*

[5] *http://www.foaf-project.org*

[6] *Jian Wang, Keqing He, Ping Gong, etc., RGPS: A Unified Requirements Meta-Modeling Frame for Networked Software. Proceedings of Third International Workshop on Advances and Applications of Problem Frames (IWAAPF 2008) at 30th International Conference on Software Engineering (ICSE 2008), pp: 29-35, 2008*

[7] *Da Ning, Rong Peng, A Requirements Recommendation Method Based on Service Description, CloudCom 2009, LNCS 5931, pp. 656~661, 2009.*

[8] *NING Da , PENG Rong, An On-Demand Model Selection Method Based on O-RGPS Domain Modeling Framework, J. Wuhan Univ. (Nat. Sci. Ed. ), Vol.55 No.6: 689～695,2009.12*

[9] *Peng Hui, Chen Limin, Chang Liang, Shi Zhongzhi, Semantic Web Service Matching Based on Dynamic Description Logic, Journal of Computer Research and Development, 45(12): 2102- 2109, 2008*

[10] *FENG Zai-Wen, HE Ke-Qing, LI Bing, et al. A Method for Semantic Web Service Discovery Based on Context Inference, CHINESE JOURNAL OF COMPU TERS, Vol. 31 No. 8, pp: 1354-1363, 2008*