Review of IoT Device and Service Discovery

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***Abstract*— Internet of thing is a unique domain that will work on various things that enables human to interact with web services as well as helps to attain the goal of creating a smart world. People lack unified way to discover software devices and services in the present existing infrastructure. There is no standard method to find IoT devices and services at one place. The process of finding the services and devices are carried out by entering a query in natural language and search is done in a search engine which displays a corresponding result to the user. Semantic search plays an important role in discovery of IoT devices and services in the present era. Semantic search is one of the techniques used in data searching, which determine the purpose and contextual meaning of the words which are used for the search. So, this review paper mainly focuses on different techniques and methods used in the semantic searching.**

Keywords—IoT; Keyword based Search; Semantic Search; Web Services;

I. INTRODUCTION

The term Internet of Things (IoT) has evolved over the time due to the combination of several concepts together such as embedded systems, wireless sensor networks, automations and many more [1]. IoT is also a field where people interact with the things, web services to create a smart world. The internet consists of a number of IoT services catering to variety of requester's demand. Generally the process of finding the services are carried out by entering a query in natural language and search is done in a search engine which displays a list of services with corresponding uniform resource locators (URL's). The problem faced by a service requestor here could be when he enters a query, all the available service URL's will be presented to the service requester and it will be the responsibility of the service requester to search for his needy service.

The main purpose of search engine is to provide required web documents to the user, which is requested by the user with the proper search query [2]. The entered query undergoes several processes to produces the requested web document based on the search engine's technology. There are different varieties of search techniques are used in search engines like keyword based search [3], semantic search and many more.

The traditional search engine technology is completely depends on the relationship between the user's query and the occurrence of words in billions of web documents which is named as keyword search [4]. Search engines like Google initially relied on these techniques in their search algorithms. This keyword based search is helpful in finding information on the internet, but there is a drawback, it does not identify the meaning of query entered by the user. They only limited to identify the keywords in the query and identify the web documents matching to those keywords in the query. So, the user finds difficulties in getting the expected results for his query.

Semantic search is another kind of searching technology which intelligently understands the context of the query, intention of the user and the relationships between the words present in the query [5]. Semantic search engine uses ontology so that meaningful and accurate results should be returned to the user query. It provides more relevant results to the query depending upon the meaning and relations of the words present in the query.

Semantic search comes out from the topic semantic web [6]. The semantic web is based on ontologies. In the field of information computers and science, ontology is basically a framework for facts and information that constitute a cluster of knowledge. The semantic search considers several factors to perform the search. For example, when you enter a query such as "Best android phones with 5 inch display" on a semantic search engine, you get a very different result than the traditional search engines. Rather than showing results based on keywords present in the query, semantic search considers context and user's intention of the query and provides the result using some set of attributes.

The remaining portion of the paper is organized as follows: Section II lists literature survey and Section III contains comparison between the different technologies used for semantic search. Then, Section IV describes about conclusion.

II. LITERATURE SURVEY

A. A smart web query method for semantic retrieval of web data

Chiang et al. proposed a smart web query (SWQ) concept for semantic extraction of web data [7]. The SWQ uses domain semantics as context ontologies to specify and formulate suitable web queries to search. This method comes under semantic search and this search method filters to recognize and it will provide rank to relevant resultant web pages semi automatically. SWQ method carry out semantic web search by using context ontologies and semantic search filters. This SWQ engine does not support for automatic learning capability to refine its context ontologies based on web queries that it has processed.

B. An Ontology Search Engine Based on Semantic Analysis

Gao et al. proposed a method, which uses semantic analysis to improve the search precision by using concepts--weights vectors matching algorithm (CWVMA) [8]. The CWVMA algorithm firstly analyses input messages and preparatory keywords based results into concepts sets. Later it decides

matching rule according to impact of concept set on Ontology semantic and generates weight vector by matching rule. At the end it provides result vector as foundation of measure similarity between input messages and preparatory results. Along with this search, this paper designed and developed an Ontology search engine based on the algorithm----WI OntoSearch prototype system. The system can search from 4 billion web pages by Google Web Service. The algorithm provides good effect on improving accuracy of Ontology search. The algorithm with different matching rules can satisfy different requirements.

C. Search Engine: Intelligent Web Service Search

Rajkumar et al. developed Semantic search engines and are used to recognize content on the web pages and do logical reasoning on content to achieve complicated search queries and to provide accurate results [9]. This paper proposed an intelligent web service search by using the RDF technology to retrieve the correct results for user queries. Intelligent Search Engine is used to overcome the disadvantage of the Search Engine that relies on keyword search and it's powerless to produce precise results for user queries. This search engine retrieves the RDF files based mostly on the keyword and then retrieve the connected links by comparing the keywords with RDF file's tags.

D. Intelligent search engine for xml based on index and domain ontology

Li et al. proposed a new semantic scheme for search by using XML data [10]. The semantics of XML documents and the query are enhanced by domain ontology annotation. Also, the extra information given by the structure of XML documents is taken by adding node path index, semantic keyword index and element tag index to indices. A searching algorithm is considered to understand clearly a semantic search for XML documents. By calculating the semantic correlation coefficient between two nodes and between a keyword and a node and by inferring from ontology base, the search algorithm understands clearly about searching. The top node R-value is put forward to rank the results. This semantic search scheme applies domain ontology to improve the semantics of query and XML documents.

E. Semantic Search Engine Using Natural Language Processing

Pandiarajan et al. proposed a novel algorithm for bringing suitable documents using semantic web based on the concept of Natural Language processing (NLP) [11]. Proposed system uses NLP to examine the user query concerning Parts of Speech. The extracted terms are tallied to the domain dictionary to recognize the appropriate domain of the user interest. And also, the retrieved documents of the user query are scrutinized with the help of Natural language processing to recognize the suitable domain. The documents are graded as per the suitability of the contents against user query. But one drawback of this work is that, the time taken to classify a document is slightly higher compared to other existing search engines.

F. Semantic Web Search and Inductive Reasoning

d'Amato et al. proposed a plan to enhance the approach of Semantic Web search by using inductive reasoning techniques for the offline ontology compilation [12]. This appends an ability to handle inconsistencies, noise, and incompleteness, which are all very likely to occur in distributed and heterogeneous environments, like the Web. By combining the concepts of Semantic Web and inductive bias increases the accuracy and the recall of querying databases and of information retrieval. They have described on a prototype implementation and very positive experimental results on the accuracy and the recall of the new inductive approach to Semantic Web search. The search expressions expressed as plain natural language sentences cannot be translated into ontological conjunctive queries.

G. A Hybrid Approach for Searching in the Semantic Web

Rocha et al. proposed a search that merges classical search engine techniques with ontology based spread spectrum technology [13]. The search will make it possible to link concepts hidden in the keyword description of these textually rich attributes, with semantic meaningful ontology instances that are present in the knowledge base. Given ontology, weights are allocated to links by considering definite properties of the ontology, to measure the strength of the relation. Spread activation techniques are considered to discover associated concepts in the ontology given an initial set of concepts and corresponding initial activation values. The initial values considered are acquired from the results of classical search. This classical search applied to the data associated with the concepts in the ontology. Two test cases were executed, with positive results. Also noticed that the proposed hybrid spread activation, combining the symbolic and the sub-symbolic approaches, achieved better results are provided when compared with each of the approaches independently. The problem with this proposed spread activation algorithm is that there is no semantic interpretation of the activation value flowing through the network.

H. Web Service Discovery Research and Implementation Based On Semantic Search Engine

Ma et al. proposed a plan that combines traditional web service discovery strategy with search engine technology and semantic web technology [14]. Search engine technology gives a search capability by considering lexical analysis and grammar analysis. Semantic Web technology gives a matching and scoring capability based on semantic information. It makes syntax level keyword matching more precisely and adds semantic information to services additionally. Search result lists arrive to users will sort from higher score to lower score. This Web Service discovery strategy will improve service's recall ratio and accuracy.

I. Efficient Proposed Framework for Semantic Search Engine using New Semantic Ranking Algorithm

El-gayar et al. proposed semantic framework includes four different phases crawling, indexing, ranking and retrieval phase [15]. This semantic framework works over a sorting RDF by considering proposed ranking algorithm and enhanced crawling algorithm. The enhanced crawling algorithm crawls suitable forum content from the web with minimum overhead. The proposed ranking algorithm is implemented to order and evaluate similar meaningful data to make the retrieval process becomes faster, easier and more accurate.

J. *Transport Service Ontology and Its Application in the Field of Semantic Search*

Dong et al. used semantic web technologies to build a conceptual model of transport services and present a proper structure of the transport service hierarchy [16]. They proposed a semantic search engine by applying transport service ontology, to give an efficient tool for users to query transport service providers. This design is also being seen as a potential alternative approach for solving the problem of transport service inefficiency. Mainly there are two drawbacks in this scheme. The data source of transport service metadata is only from the Australian yellow pages, which has limited query scope. The semantic search engine is only in experimental phase, which has not been implemented on the internet.

III. COMPARISON OF DIFFERENT TECHNOLOGIES USED IN SEMANTIC SEARCH

Semantic based search engine are able to provide more relevant information because they understand the meaning of the term and relationship between the term and web pages. Several semantic search methods in terms of different technologies are available. For comparison work I considered different technologies used for semantic search.

TABLE I. COMPARISON TABLE FOR DIFFERENT TECHNOLOGIES USED IN SEMANTIC SEARCH

Sl. No.	Authors and Ref.	Methodology	Advantage	Disadvantage
1	Chiang et al. [7]	Semantic Web Query (SWQ)	Semantic retrieval of web data	SWQ engine cannot refine its context ontologies automatically by considering web queries
2	Gao et al. [8]	Concepts--weights vectors matching algorithm (CWVMA)	algorithm has very good effect on improving precision of Ontology search	It won't support for complex mapping rules
3	Rajkumar et al. [9]	Intelligent web service search by using the RDF technology	This search engine helps to answer the complicated queries	This search engine does not support based on logical reasoning
4	Li et al. [10]	Intelligent search engine for xml based on index and domain ontology	This helps to improve the semantics of both query and XML document	-
5	Pandiarajan et al. [11]	Natural Language processing (NLP)	Accuracy of the retrieved document is good	The time taken to classify a document is slightly higher compared to other existing search engines
6	d'Amato et al. [12]	Inductive reasoning techniques	Method handles inconsistencies, noise, and incompleteness	It won't support probabilistic ontology
7	Rocha et al. [13]	Classical search engine techniques with ontology based spread spectrum technology	Better results are provided when compared with each of the approaches independently	There is no semantic interpretation of the activation value flowing through the network
8	Ma et al. [14]	Traditional web service discovery strategy with search engine technology and semantic web technology	Improved service's recall ratio and precision	-
9	El-gayar et al. [15]	Semantic ranking algorithm and crawling algorithm	Good performance in minimum time and less error rate	It will not detect accurate semantic information from social networks in a short time.
10	Dong et al. [16]	Semantic web technologies	It will resolve issue of transport service inefficiency	The semantic search engine is only in experimental phase, which has not been implemented on the internet.

IV. CONCLUSION

This paper will give insights on review of different techniques and methods used for semantic search, which are used in IoT device and service discovery. Upon a person seeking either a suitable device or a service rendered, or both, makes his query with specific terms, the system will fetch the appropriate and suitable device or service through the semantic search. The semantic search is not identical to keyword search; it finds context and purpose of the user query and gives the result to the user. This comparison work compares between different techniques and methods used for semantic search. There are lots of technique available in the current market while the market is progressing in further research to find out new method and technique.

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