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A Knowledge Representation Technique for Intelligent Storage and Efficient Retrieval using Knowledge based Markup Language

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Abstract

Background: Knowledge Engineering is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise. Knowledge Engineering is the technique applied by knowledge engineers to build intelligent systems: Expert Systems, Knowledge Based Systems, Knowledge based Decision Support Systems, Expert Database Systems etc. **Methods:** This work builds a Knowledge Base using Knowledge Base Markup Language (KBML) which is derived from XML architecture. All the Meta information is stored in a KBML file whereas the actual data may be available in any data source. **Findings:** This system also provides facilities to search/add the contents to and from the Knowledge Base dynamically. The experimental results show that the system provides a high precision, recall and f-measure values which proves the high relevance of the retrieved values. **Applications:** Builds an intelligent system for Edaphology domain which concerns with plants and its related soil features. It provides the edaphologists and agriculturists by retrieving relevant and useful information about the plants. This is of huge importance as plant growth and yield are directly dependent on the soil features.

Keywords: Data Source, Edaphology, Knowledge Base Markup Language, Meta Information

1. Introduction

Living in a fast moving world, it is natural to expect things faster. Similarly, in our quest for data search we need fast and efficient retrieving methodologies[1]. With the evolution of new technology and new products in various domains, researchers are focusing more on exploring new techniques of storage, managing and retrieval of data and knowledge from a repository which has been acquired from various sources[2]. Only having a repository of data or efficiently organizing the data cannot guide decision makers or management to make accurate decisions as humans do[3]. The best approach is to integrate and manage the data in the form of knowledge. Retrieving of exact knowledge through online is increasing and it requires more amount of time to retrieve from different data sources and creating knowledge from information available[4]. Knowledge searching through mobile phones does not exist through SMS. To defeat these anomalies, we have built a Knowledge Base using Knowledge Base Markup Language (KBML) which is derived from XML architecture[5]. This system also provides facilities to

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search/add the contents to and from the Knowledge Base though mobile phones and Windows Mobile phones without using GPRS.

The aim of this work is to build a secured intelligent storage mechanism, which can store the information in the form of knowledge using the knowledge based representation technique with the help of KBML tags, also the retrieval process is also simplified as it can just refer the KBML file which contains the Meta information about the Knowledge which is going to be stored in distributed data sources.

1.1 Knowledge System to Soil Database

Edaphology is a domain that is bothered with the influence of soils on living things, notably plants. The term is additionally applied to the study of soil influences[6]. An agricultural soil science explores soil's physical and chemical properties to search out the plants acceptable for cultivation[7,8]. The most common pitfall information is the lack of standardization of the nomenclature and of the data acquisition procedures[9]. The user is not required to know fully the model to interact with the system. The retrieval of a large amount of the same type of data is very efficient, even though the user need not know completely the database schema to formulate the queries[10]. Here the decision support systems are used in arriving at decisions on what kind of plants can be that grown in soil, based on the domain information given by the user[11,12].

The dataset comprises of various plant names and soil attributes obtained from various Edaphologists and agriculturists and these are made used in evaluating the processed system. The database considered for the consists of 49 different types of plant species and for each plant species the geological taxonomy properties were represented in this database. The 49 different types of plant species represented in this database were Prosophis juliflora, Cyprus sp, Hariyali, Indigo plant, Palmyra, Eucalyptus, Neem, Tamarind, Acacia, Ipomoea, Thespesia populanea, Vagai, Eucalyptus, Vetiver, Banyan, Calotropis, Lantana camera, Ammania baccafera, Astracantha long folia, Cyanodon, Thespesia, Cassia, Acacia Arabica, Grasses, Wetland weeds, Croton sparciflorus, Gomphrena spp, Pongamia glabra, Tricalli, Jatropha, Bonassus, Agave, Ferns, Rich evergreen shrubs and bushes, Cactus, Tephrosia purpurea, Pungai, Manjanathi, Cassia auriculata, Cyprus rotantus, Dates, Prosophis, Delonix regia, Karuvalam , Argimone, Calotropis , Lantana , Pungam, Sandal. The geological properties suitable for 49 different plant species were represented in the database. They were clay, Granite, Laternite, sand, Western Ghats, Eastern Ghats. Typically, the taxonomy properties of each plant species were represented here such as Fine, montmorillonitic, isohyperthermic, noncalcareous, Chromic Haplusterts, Typic Rhodustalfs, Mixed, Typic Haplustepts, Clayey, Lithic Haplustepts, Clayey-skeletal, Loamy, Lithic Ustorthents, Typic Ustipsamments, Vertic Haplustepts and montmorillonitic. The various colors of the soils were represented here in this database such as grayish brown, Red, very dark grayish brown, Yellowish brown, Brownish yellow, Dark yellowish brown, Dark

Id	Name	Geology	Taxonomy
0001	Prosophis juliflora, Cyprus sp., Hariyali,	Clay	Fine, montmorillonitic, isohyperthermic, noncalcareous, Chromic Haplusterts
0003	Palmyrah	Granite	Fine, mixed, isohyperthermic, noncalcareous, Typic Rhodustalfs
0017	Eucalyptus, Palmyrah, Neem, Tamarind	Laterite	Fine, mixed, isohyperthermic, noncalcareous, Typic Haplustepts
0019	Palmyrah, Neem	Granite	Clayey, mixed, isohyperthermic, noncalcareous, Lithic Haplustepts
0021	Palmyrah, Prosophis juliflora	Granite	Fine, mixed, isohyperthermic, noncalcareous, Typic Haplustalfs
0023	Neem, Palmyrah, Prosophis juliflora, Ta	Sand	Loamy-over-sandy, mixed, isohyperthermic, noncalcareous, Typic Ustifluvents
0034	Neem, Prosophis, Tamarind	Granite	Sandy, mixed, isohyperthermic, calcareous, Typic Ustorthents
0032	Palmyrah	Sand	Sandy, mixed, isohyperthermic, noncalcareous, Aquic Ustipsamments
0035	Neem, Palmyrah	Granite	Fine, mixed, isohyperthermic, calcareous, Calcic Haplustepts
0037	Neem, Prosophis juliflora	Western Ghats	Fine, mixed, isohyperthermic, noncalcareous, Typic Haplustepts
0039	Neem, Palmyrah, Tamarind	Granite	Fine, mixed, isohyperthermic, noncalcareous, Typic Haplustepts
0041	Palmyrah, Neem, Accacia	Granite	Clayey-skeletal, mixed, isohyperthermic, noncalcareous, Typic Haplustepts
0042	Ipomea, Thespesia populanea, Vagai	Clay	Fine, mixed, isohyperthermic, noncalcareous, Typic Rhodustalfs
0045	Palmyrah, Neem, Prosophis juliflora	Granite	Loamy, mixed, isohyperthermic, noncalcareous, Lithic Ustorthents
0047	Eucalyptus, Vagai	Laterite	Fine, mixed, isohyperthermic, noncalcareous, Fluventic Haplustepts
0050	Prosophis juliflora, Neem, Vetiver	Granite	Clayey-skeletal, mixed, isohyperthermic, noncalcareous, Lithic Ustorthents
0051	Prosophis juliflora, Palmyrah	Granite	Fine-loamy, mixed, isohyperthermic, noncalcareous, Fluventic Haplustepts
0055	Prosophis juliflora, Palmyrah, Tamarind	Granite	Fine-loamy, mixed, isohyperthermic, noncalcareous, Typic Haplustepts

Figure 1. The Plant table.

Id	Depth	Desc1	Clay	Silt	Sand	PH	EC	Ca	Mg	Na	K	P2O5	K2O
0001	0-13	Dark brown (10 YR 4/3); sandy clay; m	38.46	15.84	45.70	8.30	1.30	11.80	4.10	3.59	0.40	10.00	120.00
0001	13-65	Dark grayish brown (10 YR 4/2); sandy	41.92	18.07	40.01	8.90	1.50	13.87	4.30	4.07	0.46	10.00	80.00
0001	65-184	Very dark grayish brown (10 YR 3/2); c	40.84	21.90	37.36	8.90	1.40	14.35	3.90	4.09	1.02	0	0
0003	0-18	Red (2.5 YR 4/6); sandy clay loam; mo	24.80	15.2	60.2	7.36	0.04	8.0	1.5	0.68	0.32	29.45	228.00
0003	18-42	Red (2.5 YR 4/6); sandy clay loam; mo	25.60	16.8	57.60	7.11	0.04	10.0	2.0	0.75	0.35	27.17	376.00
0003	42-80	Dark yellowish brown (10 YR 4/6); cla	38.14	24.2	37.66	6.85	0.09	15.5	1.5	2.59	6.70	29.41	415.00
0003	80-140	Dark yellowish brown (10 YR 4/6); cla	44.60	25.4	29.80	6.81	0.08	18.5	1.5	4.25	4.62	13.60	425.00
0017	0-10	Dark yellowish brown (10 YR 4/4); sar	38.24	13.64	48.12	6.81	0.03	5.50	8.50	0.46	0.33	16.58	89.00
0017	10-29	Brownish yellow (10 YR 6/6); sandy cl	36.92	14.06	49.02	7.02	0.03	3.50	3.00	0.51	0.25	9.30	42.00
0017	29-57	Brownish yellow (10 YR 6/6); clay; mo	43.82	20.90	35.28	7.12	0.02	6.00	4.00	0.48	0.25	10.68	46.00
0017	57-87	Yellowish brown (10 YR 5/4); clay; mo	46.18	19.56	34.28	7.18	0.03	6.50	4.00	0.47	0.25	12.67	51.00
0017	87-1000	Weathered parent	0	0	0	0	0	0	0	0	0	0	0
0019	0-12	Very dark grayish brown (10 YR 3/2);	44.60	20.24	35.16	8.19	0.07	11.00	6.50	0.36	0.28	20.78	172.00
0019	12-25	Very dark grayish brown (10 YR 3/2);	48.40	21.26	30.34	8.33	0.05	32.00	8.00	0.38	0.08	19.82	141.00
0019	25-39	Dark brown (10 YR 4/3); gravelly clay;	50.00	24.24	25.76	7.76	0.07	10.50	8.00	0.48	0.05	22.53	69.00
0019	39-1000	Weathered Granitic	0	0	0	0	0	0	0	0	0	0	0
0021	0-18	Reddish brown (5 YR 4/4); sandy clay	18.60	13.00	68.40	7.12	0.06	5.50	2.50	4.27	1.12	3.73	103.00
0021	18-37	Reddish brown (5 YR 4/4); clay; mode	31.24	18.80	50.06	6.77	0.02	10.00	8.00	4.25	1.09	6.77	200.00
0021	37-78	Dark reddish brown (5 YR 3/4); clay; r	34.60	15.25	48.15	6.72	0.02	16.50	12.00	3.75	1.17	4.67	108.00
0023	0-17	Brown (10 YR 5/3) clay loam; weak, fi	15.00	22.50	42.50	8.00	0.85	14.50	3.26	1.56	0.58	2.80	174.00
0023	17-39	Pale brown (10 YR 6/3) clay loam; wea	18.00	19.50	42.50	8.30	0.86	15.81	3.51	1.52	0.82	3.30	158.00
0023	39-42	Yellowish brown (10 YR 5/4) sand; we	4.85	7.60	87.50	8.50	0.10	2.15	0.86	0.45	0.54	4.00	36.00
0023	42-96	Yellowish brown (10 YR 5/4) sand; we	13.70	5.00	81.30	7.00	0.05	4.39	1.53	0.33	0.20	2.00	15.00

Figure 2. The Description table.

Brown, Reddish brown, Dark Reddish brown, Brown, Pale Brown, Light Brownish Grey, Light gray to gray, Grayish brown, Very pale brown, White, Light brownish gray, Dark red, Yellowish red, Light red, Dark grayish brown, Brown to dark brown, Reddish yellow, Brown, very dark brown, strong brown. In this database, the size of the particles that make up the soil such as clay, silt and sand are listed for each color of soil separately. For each color, the depth and the mineral content of soil such as PH, EC, Ca, Mg, Na, K, P2O5, and K2O are represented in this database which will provide nutrients to plants. The database is structured into parent plant database and child description database as mentioned in Figure 1 and Figure 2.

1.2 Existing System and Its Limitations

In any knowledge based system, the first step is to model the domain knowledge collected from experts, so as to enable effective retrieval of knowledge[13,14]. Some of the existing knowledge based systems have employed the data structure termed as *K*-graphs, tree data structure for representing the expert knowledge in their domain of interest[15,16]. The *K*-graphs was able to represent the expert knowledge about domains in problem-solving, minimizing the semantic loss that would occur if production rules were used instead[17,18]. A tree data structure very much resembles a graph, and it can also be defined as an acyclic connected graph where each node has a set of zero or more children nodes, and at most one parent node[19,20].

Existing Data Structure suffers from the following limitations:

- Ambiguous design in storage of data.
- Slower performance.
- Insecure data storage.
- Complexity in retrieving the appropriate data.
- Increased Space and Time Complexity.

The aim of our proposed system is to design a new knowledge representation technique for Edaphology which eliminates the drawbacks of existing storage techniques and to build an efficient system with high relevant retrieval and with minimum space and time complexity.

2. Proposed System

2.1 Conversion of Meta Information in KBML

This work performs the searching of knowledge across several data sources. The searching facilitates the user to select particular data sources from a list and to get the search result.

During the search process, the existence of the search string is first looked up into a KBML file. This KBML file has the Meta information about all the knowledge in a particular data source, the KBML file which is a feature, enabled with derived XML architecture so that our goal of efficient retrieval of exact data is achieved. Information is stored in form of knowledge (KBML Tags).

Security is a factor of major concern in any mode of data storage, so we take immense care of this stored information. Here, each knowledgebase is provided with a unique ID, which is stored in an encrypted format. When a search is made, the title is first picked and the corresponding IDs are used to navigate for retrieving the description. If the search keyword is not found in the KBML file, the control is passed to search the knowledge in the database for retrieval.

End-users may wish to create knowledge when the particular search is not present. In such cases, users should create an account and enter the knowledge along with the title and description. At this stage, a KBML file is created for this newly created knowledge with all its constraints.

2.2 Enhanced Knowledge Base Representation

Our vision of efficient retrieval comes true by the fast fetching of information stored in the form of knowledge. This system builds a Knowledge Base using Knowledge Base Markup Language (KBML) which is derived from XML architecture. All the Meta information is stored in a KBML file whereas the actual data may be available in any data source. Knowledge sharing is achieved, as this system can retrieve information from heterogeneous data source through this KBML file. This system also provides facilities to search/add the contents to and from the Knowledge Base though mobile phones and Windows Mobile phones without using GPRS.

2.3 Derivation of KBML using XML

Extensible Markup Language (XML) is a fast emerging technical tool. It has several advantages to its name. The limelight feature of "user defined tags" makes this technology worth its salt.

The sample structure of KBML is represented in Figure 3. We use the structure of XML and derive our KBML file which is purely knowledge based. XML has a predefined structure whereas KBML has exclusively user defined structure; this is the major reason why we prefer KBML to XML. Apart from this KBML has a hierarchical structure which superimposes the characteristics of its predecessor XML. The exciting feature that KBML possesses is user can add his own information and by giving it with a unique id, which serves as a Meta information. This forms a part of the knowledge store that can be modified accordingly. Search of information which is our ultimate aim is also made easy.

2.4 KBML in Edaphology

The KBML file is used to store the Meta information about the soil corresponding to each plant. The edaphology deals with the plant and its classification, here edaphology is a best suited case where we can impart the Knowledge base to represent the details of plants and its description as knowledge and this process is enhanced by the use of KBML file which contains the Meta information of the respective data stored in it. In order to avoid the complexities in using the tree structure we go for KBML. The sample KBML file created by our system is as shown in Figure 3.

```
- <KBML>
  - <Description>
      <ID>0001</ID>
      <DEPTH_MIN>0</DEPTH_MIN>
      <DEPTH_MAX>13</DEPTH_MAX>
      <DESCRIPTION>Dark brown,sandy
        clay,hard,slightly firm,sticky and
        plastic,fine and very fine roots,clear
        smooth boundary</DESCRIPTION>
      <CLAY>38.46</CLAY>
      <SILT>15.84</SILT>
      <SAND>45.70</SAND>
      <PH>8.30</PH>
      <EC>1.30</EC>
      <CA>11.80</CA>
      <MG>4.10</MG>
      <NA>3.59</NA>
      <K>0.40</K>
      <P2O5>10.00</P2O5>
      <K2O>120.00</K2O>
    </Description>
  </KBML>
```

Figure 3. The KBML file.

2.5 Dynamic storage: Adding the Knowledge

It is a key feature of the project that makes our database a dynamic one. Knowledge can be represented in any form such as text, documents etc. When a particular search is out of reach of the data sources, users may create their own knowledge to the data source. To facilitate the users, a wizard (as shown in Figure 4) is designed which contains the simple steps to add the knowledge to the specified Knowledge base and the corresponding data source, provided the users are already registered. The system is also extended to add the user's knowledge to the knowledge base through Mobile phones. Through the use of this feature our project seems to be "user-friendly".

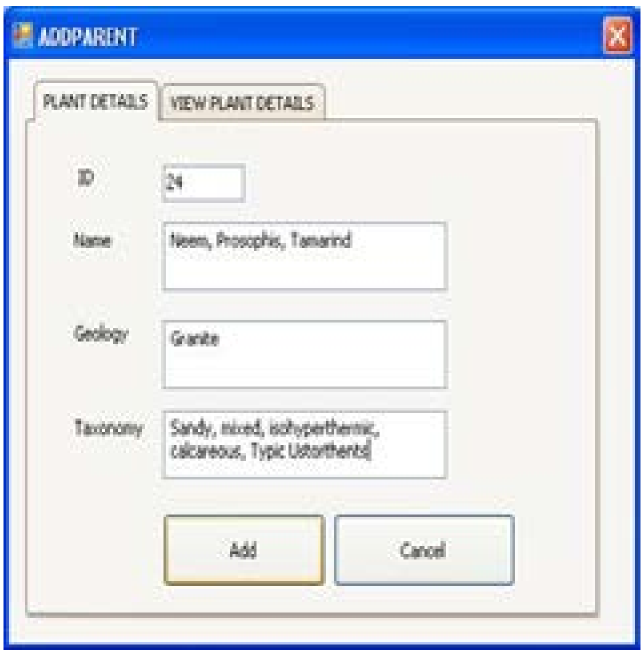

Figure 4. Adding a parent plant record.

2.5.1 Updating the Knowledge

Day in and day out we have new information. Any knowledge created is not constant, changes are mandatory so as to maintain the efficiency. Changes or updating are done when new techniques are introduced. To carry out these updates, users are allowed to update the existing knowledge that helps other searchers to gain knowledge. Also we can comment/ question on the particular knowledge of the user.

2.5.2 Retrieval: Searching The Knowledge

It is the main part of the project, by which the data that a user needs is retrieved unto him. It is easier for us to search the relevant information which is available from the selected knowledge base through windows/ mobile applications. When the user searches a particular knowledge, they are allowed to select knowledge base and data sources from which they need to search the knowledge from a varied variety of options. All the relevant results are displayed as a list (as shown in Figure 5) and the knowledge is obtained by navigating to the specified data source.

Figure 5. Plant output based on the input values.

3. Experimental Results

Users have the option of adding data in the already existing data base. While adding data about a plant the fields like name of the plant, taxonomy, geology should be filled in the appropriate text boxes is as given in the form of Figure 6.

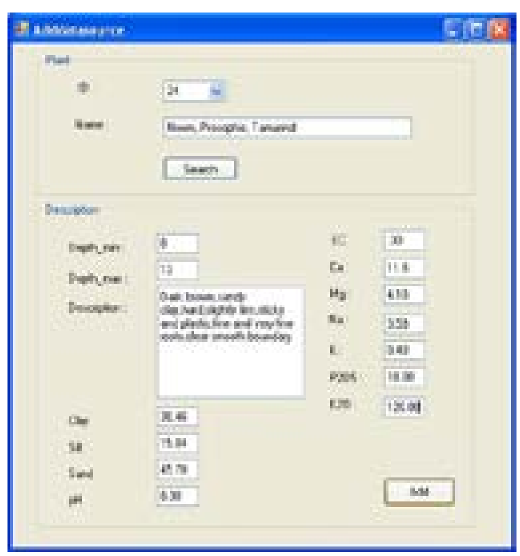

Figure 6. Add data source.

Table 1. Input queries

Query1 (Q1)	Query2(Q2)	Query3(Q3)
Depth = 26-52	Depth =50-91	Depth =13-33
Color = light grey to grey	Color = brownish yellow	Color = reddish brown
Sand = sandy clay	Sand = clay	Sand = sandy clay
Strength = medium	Strength = medium moderate sub angular	Strength = medium weak sub
moderate	blocky Moist = sticky	angular blocky
sub angular blocky	Pores = few pores	Moist = sticky
Moist = sticky	Clay =38.89	Pores = few pores
Pores = pores	Silt =20.25	Clay =47.00
Clay =36.31	Sand=50.18	Silt =22.00
Silt =13.51	PH=8.65	Sand=8.00
Sand=50.18	EC=0.09	PH=8.00
PH=6.28	CA=15.34	EC=1.50
EC=9.40	Mg=7.82	CA=14.00
CA=9.40	Na=3.01	Mg=10.00
Mg=1.80	K=0.12	Na=1.10
Na=0.50	P2O5=14.00	K=0.60
K=0.12	K2O=302.00	P2O5=7.00
P2O5=11.26		K2O=208.00
K2O=108.00		
Query4(Q4)	**Query5(Q5)**	**Query6(Q6)**
Depth =41-51	Depth =23-37	Depth =60-65
Color =very pale brown	Color = dark red	Color =dark red
Sand =sandy	Sand =sandy clay	Sand =sandy clay
Strength =medium sub	Strength =moderate medium	Strength =moderate medium sub
angular blocky	sub angular blocky	angular blocky
Moist =	Moist =slightly sticky	Moist =slightly sticky
Pores =	Pores =few fine pores	Pores =few fine pores
Clay =3.40	Clay =40.00	Clay =40.00
Silt =4.00	Silt =24.00	Silt =24.00
Sand=92.60	Sand=36.00	Sand=36.00
PH=8.00	PH=7.17	PH=7.17
EC=0.06	EC=0.16	EC=0.16
CA=3.57	CA=10.00	CA=10.00
Mg=0.51	Mg=4.50	Mg=4.50
Na=0.25	Na=1.28	Na=1.28
K=0.10	K=0.93	K=0.93
P2O5=4.00	P2O5=25.65	P2O5=25.65
K2O=49.00	K2O=195.00	K2O=195.00

3.1 Result Analysis

For analyzing the performance of the implemented systems, six input queries (shown in Table 1) are used. The results obtained in each system for the six input queries are listed. The results are then analyzed using evaluation metrics[21].

The number of plants retrieved for query 1 to query 6 is mentioned in the Table 2.

Table 2. Number of plants retrieved

	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6
No. of Plants Retrieved	11	15	10	13	12	10

The work is evaluated with the aid of various metrics.

The evaluation metrics used are precision, recall, F-measure, ranking efficiency, number of plants retrieved, memory usage and response time.

- Table 3 shows the evaluation metric values of precision, recall and F-measure.
- The system yields good performance values with respect to precision, recall and F-measure.
- The maximum values of precision, recall and F-measure reaches one which shows the effectiveness of the proposed system.
- Good precision, recall and F-measure values validate the effectiveness of the system.
- Table 4 shows the ranking efficiency obtained for the system.
- The ranking is found out for two conditions. One is when top 5 results are taken and second, when top 10 results are taken.
- In both conditions, system yields good results by achieving good efficiency values.
- The maximum values in both cases come about one.
- Average value in case 1 is about 0.46 and in case 2, it is about 0.41. Total average is about 0.435.
- The values indicate the validity of the system.
- Table 5 gives memory usage and response time achieved by the system.
- The system consumed an average of 261 Kb per query with a minimum of 111 Kb for the 2nd query.
- Average response time came about 1060 ms with a minimum response time of 1015 ms for the 1st query.
- High number of plants retrieved, low memory usage and low response time further demonstrates the effectiveness of the system.

Table 3. Precision, Recall and F-measure values of the tree based system

	Precision	Recall	F-Measure
Q_1	0.4	0.4	0.40
Q_2	1.0	0.2	0.33
Q_3	1.0	0.2	0.33
Q_4	1.0	0.2	0.33
Q_5	1.0	1.0	1.00
Q_6	0.83	1.0	0.907

Table 4. Ranking efficiency values of the tree based system

	Ranking (top 5)	Ranking (top 10)
Q_1	0.4	0.5
Q_2	0.2	0.1
Q_3	0.2	0.1
Q_4	0.2	0.2
Q_5	1	1
Q_6	1	0.9

Table 5. Memory utilized and response time values

	Memory utilized (kb)	Response time (ms)
Q_1	480	1015
Q_2	111	1041
Q_3	233	1072
Q_4	287	1065
Q_5	215	1063
Q_6	210	1075

4. Conclusion and Future work

Development of the Knowledge Base Markup Language (KBML) is used to improve the performance of the search process for Edaphology domain by selecting data sources. Each data source contains a set of knowledge descriptions to serve the requests. Using this, the search was made efficient. With world moving too fast all that a user expects is an efficient time constraint and we have strived to impose the same and have achieved a reasonable success. The precision, recall and f-measure values shows the high relevancy of retrieved values.

Also, in future the computation complexity can be further reduced with the help of effective searching and retrieval methods, leading to decrease in the time delay and improving search accuracy. Decreasing the time delay and improving search accuracy also would improve the system. Better knowledge management can be brought in by incorporating latest smart concepts into data structures. Also, better information retrieval employing latest techniques can also improve the system performance.

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