Ontology-Based Diet Recommendation System

S Shridevi , K Archana

Abstract: Recommender systems are needed to find food items of one's interest. We propose a food personalization framework that assists the user with the actual diet selection process. The Ontology-based process, recommend an appropriate diet for the user. The system analyses the user's queries based on their requirements and recommends diet, based on their diseases and deficiencies. The system is tested for its efficiency in terms of query processing for users nutrient requirements.

Keywords : Semantic framework, Ontology, RDF dataset, SWRL, SPARQL query.

I. INTRODUCTION

The semantic web is an add-on of the live web in which the data shows precise result and superior enabling of system and people to work jointly, where a set of related concepts is designed based on hierarchical structures. We can define ontology as the heart of our semantic framework. Food, nutrition, disease are some domains of the ontology. In this work, a simple food ontology is designed to help in providing food recommendations and suggestions at different points of users needs. Here the whole system is been developed semantically which is a significant feature of our system.

Section 2 discusses the related works and section 3 with the details of system architecture. The Section 4 deals with the Customization of the ontology and the implementation works that explains the generalized and the question answer system modules. The result analysis is discussed in Section 5 which describes the application outputs. In Section 6 the analysis of the system is tested for its performance. The conclusion is discussed finally in Section 7.

II. LITERATURE SURVEY

Shreya B.Ahire etal [12] has proposed a Healthcare recommendation framework where user based nutrition and food are provided semantically. Here the framework is fully automated which gives relevant information to users with fewer interventions from domain experts.The analysis of this ontology has solved various food and nutrition inquiries successfully. Implementing decision tree algorithm to classify the healthcare system is achieved in this healthcare recommendation system.

Dewi Ika Sari etal [9] have proposed Ontology model in pediatric nutrition domain where it is mainly focused on pediatric nutrition domain and suggested for the users.The results of this ontology have resulted in good results where it can be used as the knowledge in a knowledge-based application. The basics of semantic technology, developing and visualizing ontology model, enriching the classes and properties to the ontology, making instances, working with SPARQL etc were inferred from here.

Napat Suksom etal [1] have designed a knowledge-based framework for the development of personalized Food recommender System which focuses on ontology and rule-based knowledge development.They suggested the system to hospital patients as a meal suggestion system or can also be used in any healthcare systems. The main ideas like making rules set for the recommendation system in a semantic way and personalizing it was inferred from here. Ahmed Al-Nazer etal [11] have made a User's Profile Ontology-Based semantic framework for personalized food and nutrition Recommendation system which focus on Personalization technique for the health and food information. They proposed an agent-based framework for semantic query processing and have personalized results with disease-centric, food-centric, nutrition-centric, recipe-centric and body parts plus functions-centric. Their empirical evaluations of the process show accurate results with promising outputs. We identified the different categories where the food can be combined and queries can be designed.

Maged N.Kamel Boulos etal [10] contributed towards an "Internet of food": Food Ontologies for the Internet of things where in this article consist of different food ontologies which are been available and this coverage of foods with advantages and disadvantages were provided. Apart from that, a menu recommendation system for diabetic patients is been suggested here. This paper gave us a background idea of developing food ontology in this semantic field.

Nick Bassiliades [] have proposed SWRL2SPIN: A tool for transforming SWRL rule bases in OWL ontologies to object-oriented SPIN rules. The paper combines the ontology and rules by building it in SPARQL. They have tested it in protégé and successfully imported in TopBraid composer which shows the expected inference results. From this, we inferred the idea of choosing the SWRL, its need and its effectiveness in designing the system.

III. SYSTEM ARCHITECTURE

The system consists of the ontology data in OWL format with the datasets mapping the ontology in RDF graphs with many records in it. The rules are the knowledge gained from the ontology which is applied to the RDF datasets and results in gaining new knowledge's which help in designing the system. The system follows fig-1 which shows the semantic process.

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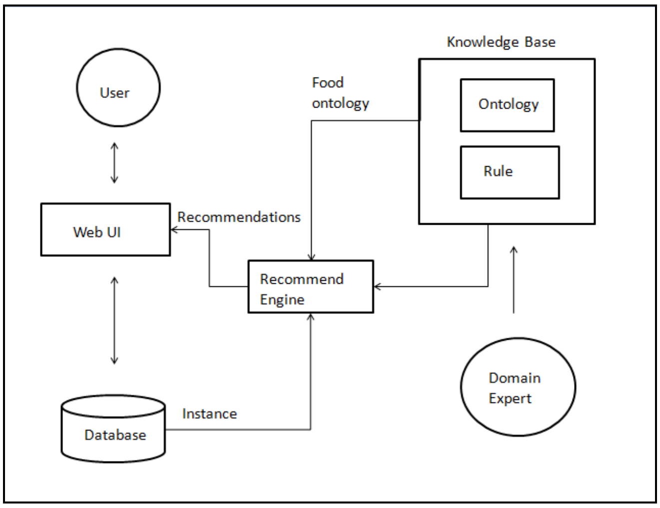

Fig 1-Semantic framework of the system

Jena Library is been used to manipulate the knowledge base for getting the results. Many experts and guides design the knowledge and represent the relations between the knowledge. Here we customize the dataset as per our needs in the system.

IV. DESIGNS AND IMPLEMENTATION

This section discusses the implementation details.

4.1 Customizing the existing ontology

The datasets were taken from the data hub repository where it is then customized with our new instances during the design process. The process involves defining classes, properties and providing instances to them. There are about 25 classes and 17 properties in the dataset. Steps considered are:

- Determine the area and range of the ontology
- The ontology is an open source here
- They can be used as a knowledge base and new knowledge can also be inferred because of it.
- Consider reusing strategies
- List the new classes and properties and their related hierarchies.
- Define the facets of the properties which have different value types, and features in it.
- Create new instances

The ontology is in the form of OWL file linked to the RDF graphs. It consists of classes like food, vegetables, fruits, herbs etc in eatable domains and diseases, nutrition, vitamin and minerals in the health domain. Apart from that several classes and their respective properties are been linked to it. Protege tool helps in constructing the ontology and visualizing it. The classes of the system are shown in Fig-2 below.

Properties like hasRecommended, hasNutrient, is good for, isOfType etc are the key things used in the system. We have customized the RDF dataset to our needs and expectations by adding new instances to the source for getting a new knowledge. The dataset has been enriched with many properties related to classes, properties, individuals and to the data instances.

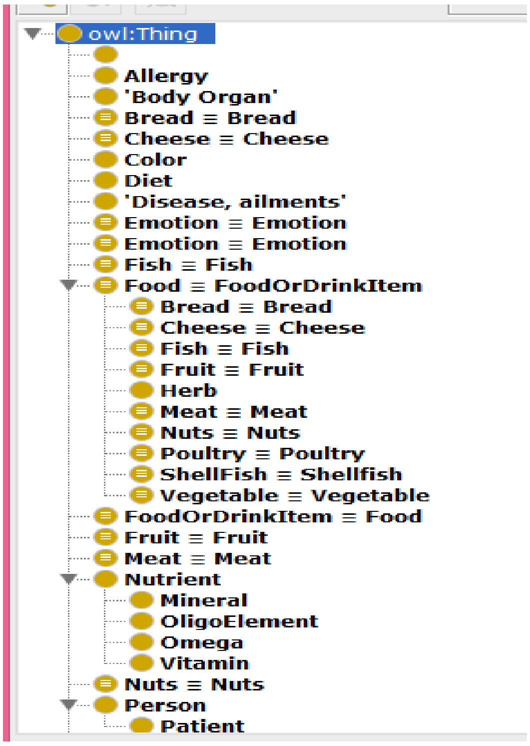

Fig-2 Dataset Classes

We have considered around 40 diseases, 13 body organs, more than 140 foods including herbs, fruits, vegetables, nuts and around 20 nutrition's including minerals, vitamins, oligo and omega Elements in the datasets. The main concept of this process is Food, Nutrition and disease which are mainly used.

Food concept:

The food class consists of all food items which involves different properties at various levels. They include:

- "Food Type" which classifies them as vegetarian and non-vegetarian.
- "Based on seasons" where each food is been suggested for their respective seasons like summer, winter, autumn and spring.
- "Food has color" tells the colour of each food item represented in the datasets (i.e., yellow, white, orange, blue, etc.)
- "Food good for" represents each food items which can be taken for the good of our body organs (i.e., heart, liver, hair, eyes, nails, etc.)

Each food is been labelled and its respective resources are linked to them along with their instances. The food concepts are linked with various domains like disease and nutrition domains as mentioned below (see Table 1).

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Table 1- List of ontology properties

Property	Type	Domain	Range
Has_Nutrient	Object property	Nutrition	Nutrient function
Is_recommended	Object property	Disease	Disease sources
Is_good_for	Object property	Body organs	Health function
To_avoid	Object property	Disease	Disease sources
Has_bmi	Data property	person	float
Has_height	Data property	Person	float
Has_weight	Data property	Person	float
Is_of_type	Object property	food	Food source
Has_season	Object property	food	Food source
Has_color	Object property	food	Food color
Likes	Object property	Person	Food source
Hates	Object Property	Person	Food source
Has_allergy	Object property	Food	Symptoms source
Has_emotions	Object property	Emotion	Emotion source

Disease concept:

- "Food recommended" consist of food items which are recommended for various diseases, symptoms and for other illness (i.e., cold, cancer, headache, overweight, flu, kidney stone, bad breath, etc.)
- "Foods to avoid" classifies all the food items that should be avoided at various stage of diseases and symptoms.

Nutrition concept:

- "Food having nutrition" represents all the food items which consist of the nutrition content in it. This includes vitamins, minerals, and other omega elements contained in the food items here (i.e., fibre, calcium, omega3, vitamin A, Carbohydrate, fat, etc.)

4.2 Semantic querying

SPARQL is an RDF query language used to retrieve and manipulate data stored in it. The data model of RDF is a statement of triplets having subject, predicate and object. We use SPARQL as the query language to access the semantic web.Below is the sample SPARQL:

```
PREFIX rdf:
<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX naturopathy:
<http://olddatahub.com/Organization/food/naturopathy#>
PREFIX fo: <http://olddatahub.com/Organization/food/fo#>
SELECT  ?s  ?o
WHERE {
        ?s naturopathy:isGoodFor ?o
  }
```

4.2.1 Generalized system

The user can view their needed diet recommended food items based on the concepts and properties of the dataset when they search in fields like a disease, nutrition, body organs and seasons needs. This search is made as a generalized search to the users in various fields to get the recommended food for what they need by choosing the options provided.

4.2.2 Question answering system

A query searching technique is been set out where the queries are semantically searched and we get output for that questions. Here special rules are made to the process (SWRL rules) to give the results. The search has boundary limitations within the dataset, where we can search for only the stuff we added to the rules. In our work, we have taken 12 questions and added rules for that so that searching those queries give semantic results.

The process of creating SWRL to the source gives us additional expressive power for the knowledge base. It helps us to add rules based on the recommendations needed from the users. They are logically defined and many inferences are made out of these rules. The output of the newly defined rules will result in new knowledge gain at the end of the process. The knowledge is been shared very effectively and accurately to the users because of these defined rules.

Each scenario is been provided with the respective rule set so that it can answer the user's queries very effectively. The scenarios are based on food, nutrition, disease queries of peoples from various aspects. The rules have been limited within the boundaries and defined based on our datasets (see Table 2). Here we get an accurate result which is been suggested to the user. Basic Natural Language Processing technique is been enabled for the user to search the queries and to get the results.

Table 2- Sample Rules

scenarios	SWRL rules
Does apple a day keeps a doctor away?	?apple rdf:type n:fruit-> apple n:doctor away "provided for many disease"
How can I reduce my belly fat?	?tea ?lemon ?honey rdf:type n:food-> "reduces belly fat"
I don't sleep in night what is the problem?	?insomnia rdf:type n:disease-> "sleepless disease"

Here we take the basic NLP parser by using the word net dataset where it is in a form of bin file (Parser chunking) that helps us to make a semantic search for the questions and answers the user's queries. The most common library openNLP is used here in the process.

Steps involved:

- Load the input Stream file for parsing and the data model
- Parse the sentence with the parsing object
- Take the noun, Adjective, and Verb to check the keywords of the queries and the questions are answered.

V. RESULTS

The general recommendations of food are been listed out for various categories like disease, symptoms, nutrition deficiency, on different seasons and for different body organs Example- When the user selects their respective disease and check for the food all the food recommended for the particular food will be listed out (see Fig-4).

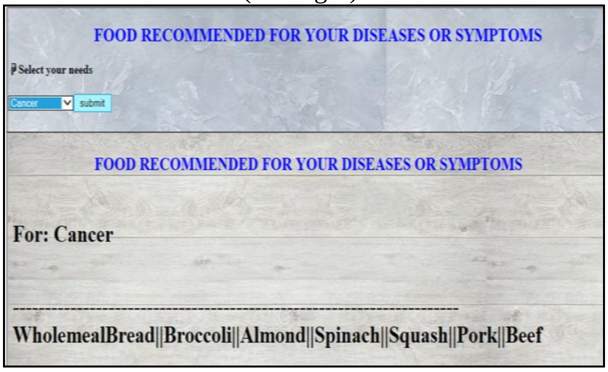

Fig-4 Food recommended based on a disease you select

Similarly, if they choose any nutrition deficiency and search for the food corresponding to that its respective foods are suggested to the users (see Fig-5). We have designed such that the user can ever search foods for two diseases at a time (example- cough and cold). Apart from that checking the BMI of the users using their height and weight is been added up to tell their BMI status and foods are recommended based on their evaluation results (i.e. underweight, normal, overweight or obese).

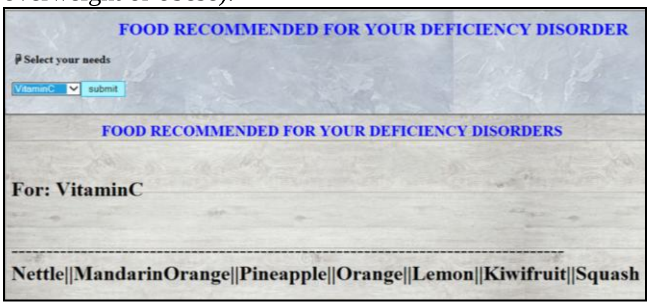

Fig-5 Food recommended based on nutrient you select

The next part consist of defining the SWRL rules to the RDF datasets and getting new knowledge base is the result of that process which is designed with limitations (see Fig-6).

The sample scenarios which are been considered for making rules are as followed:

- ✓ Does eating an apple every day keep a doctor away?
- ✓ What is the nutrition's content in milk?
- ✓ How nutrition's can make my bones strong?
- ✓ What food consists of Sulforaphane provided for cancer?
- ✓ I have memory loss often, what is my problem?
- ✓ How can I reduce my belly fat?
- ✓ What types of Nutrition's can I intake for blood coagulation?
- ✓ What nutrients can I have for high caloric value?
- ✓ What is the nutrient which is not easily digested, but needed for human life?
- ✓ What type of food can I eat for the healthy Immune system?
- ✓ List out the minerals helping for muscle contraction?
- ✓ I have a sleepless night most of the time, why?

The system was found to be difficult to generalize the process and the questions should be domain specific and a high time-computation process is needed since the system is not fully flexible.

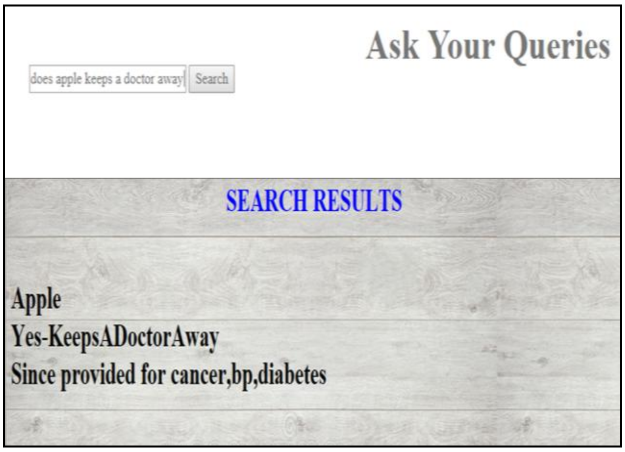

Fig-6 Question and Answer system

A new Knowledgebase is been obtained from the rules constructed and the answers are been accessed through NLP techniques for the users to use the recommendations. Reasoner is used for fetching the results from the SPARQL queries successfully.

VI. EXPERIMENTAL ANALYSIS

Our semantic framework system is been tested for users effective communication with 76 queries in the system including all related domains and 15 rule sets for the diet framework and taken for evaluation. The Precision and Recall is calculated based on the different categories of the data.

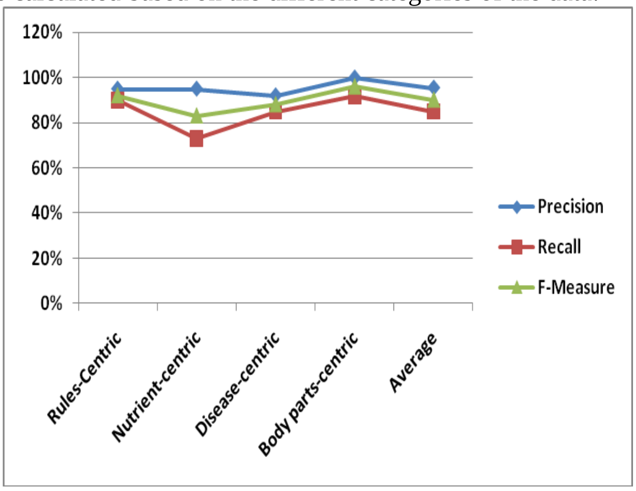

Fig-7 Precision and Recall analysis

The analysis process in Fig-7 consists of categories like Rules-centric, Nutrient - centric, Disease- centric, Body-centric analysis where their Precision and Recall are taken to know the F-Measure of the application. The F-Measure of them is been found out by using the formula:

F Measure= 2(Precision*Recall/Precision +Recall)*

From the above method, we have found out that the F measure is 90% for our process framework.

Results can be enhanced using NLP with the questions and the rules so that we get a perfect semantic result which will increase the recall value in future. Apart from that our ontology is been created where only a few elements are considered during the work, so using experts and enhancing the ontology and the rules will also give more effective results.

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Performance evaluation of the ontology:

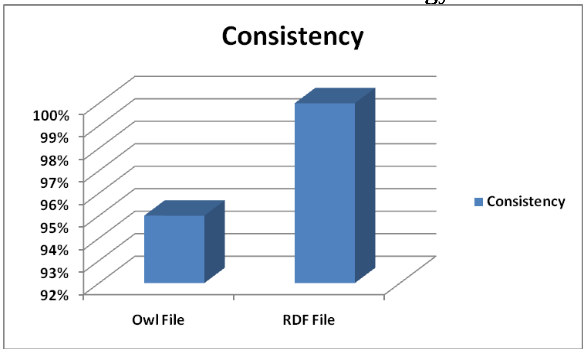

Fig-8 Consistency check

The Ontology is been tested for its consistency (see Fig-8), completeness (see Fig-9) and for its pitfalls (see Fig-10 with its OWL and RDF files) and the following graphs are plotted, Where it shows successful result in its consistency and completeness.

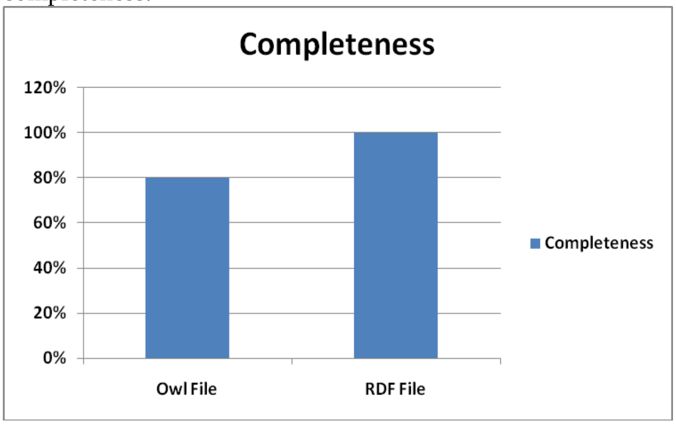

Fig-9 Completeness check

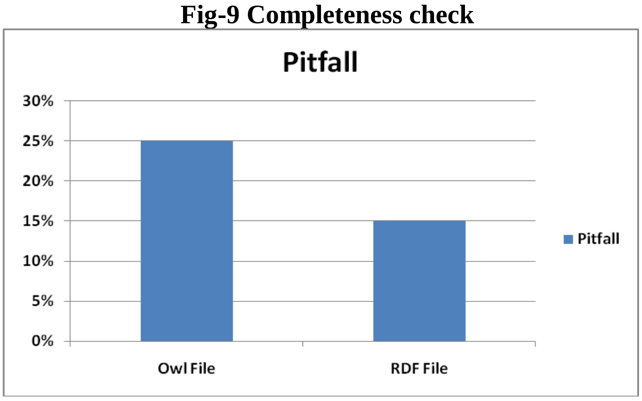

Fig-10 Pitfall check

Some minor cases of pitfalls are listed as below:

- creating unconnected ontology elements
- Merging different concepts in the same classes
- Missing annotations
- Inverse relationship not explicitly declared
- Misusing ontology annotations
- Untyped classes
- Missing Disjointness

VII. CONCLUSION

The paper discusses about the diet recommendation system using the knowledge provided thru Ontology and RDF datasets in a semantic framework. A logical rule-based knowledge development is been designed to support the process. User's queries for Food recommendations based on their diseases, nutrition deficiencies and based on human organs are being considered. Also personalized diet recommendation based on users BMI is also done. The system is tested for its efficiency and proved to be accurate. The future work includes enhancing the dataset and evaluating the recommendation system based on user questionnaires in different fields within the dataset boundaries. The search can be enriched with some deep NLP techniques so that we can get results very effectively for different types of questions where more domains regarding diet plans can be covered and answered. In addition to that, the application can be implemented through the cloud and could be built through Android applications so that its scalability and compatibility is increased.

REFERENCES

1. Napat Suksom, Marut Buranarach, Ye Myat Thein, Thepchai Supniithi, Ponrudee Netisopakul. A Knowledge-based framework for the development of personalized food recommendation system. School of information technology, King Mongkut's Institute of technology ladkrabang, Bangkok, Thailand.
2. Munioz-Garcia, A. Gomez-Perez, M. Iglesias-Sucasas, and S. Kim, "A workflow for the networked ontologies lifecycle: A case study in FAO of the U", [Hrsg.] D. Borrajo, L. Castillo and J. M. Corchado. Berlin, *Springer Verl. CAEPIA*. Bd. 4788, 2007, pages 200-209.
3. J.P. Pardal, "Dynamic use of ontologies in dialogue systems. Association for Computational Linguistics", *in Proceedings of the NAACL- HLT Doctoral Consortium.*, 2007, pages 25-28.
4. H. Uszkoreit, F.Xu, J.Steffen, and I. Aslan, "The pragmatic combination of different cross-lingual resources for multilingual information services", *in International Conference on Language Resources and Evaluation.* Genova, Italy, 2006, pages 1870-1873.
5. Dewi Ika Sari, Sari Widya Sihwi, Rini Anggrainingsih. Ontology Model In Paediatric Nutrition Domain. Information Department, Faculty of Mathematics and Natural Science, Sebelius Maret University, Indonesia, 2014.
6. Maged N.Kamel Boulos, Abdulslam Yassine, Shervin Shirmohammadi, Chakkrit Snae Namahoot and Michael Bruckner. Towards an "Internet of Food": Food ontologies for the Internet of Things,2015.
7. Ahmed AL—Nazer, Tarek Helmy, Mohammed Al-Mulhem. User's Profile Ontology-Based Semantic Framework for Personalized Food and Nutrition Recommendation. Information and computer science department, college of computer science and engineering, King Fahd University of petroleum and minerals, Dhahran, Saudi Arabia, 2014.
8. Shreya B.Ahire, Harmeet Kaur Khanuja. HealthCare Recommendation for Personalized Framework. Department of Computer Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, 2015.
9. Sivilai.S, C.Snae, M.Brueckner. Ontology-Driven Personalized Food and Nutrition planning system for the Elderly. ICM MIS, 2012.
10. J.Cantais, D.Dominguez, V.Gigante, L.Laera and V.Tamma. An example of food ontology for diabetes control. International Semantic Web Conferences 2005 workshop on ontology patterns for the Semantic Web, 2005.
11. C. Snae and M. Bruckner. FOODS: A Food-Oriented ontology-driven system. IEEE International Conference on Digital Ecosystem and Technologies. 169-176, 2008.
12. F.Batista, J.P.Pardal, P.Vaz, N.Mamede, and R. Ribeiro, "Ontology construction: cooking domain", *Technical Report,* INESC-ID. Lisbon., 2006.

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Dr. Shridevi Subramanian is currently working in School of computing science and Engineering at VIT University. She completed her Doctorate from MS University. She has published many research papers in reputed International Journals. Her research interests are semantic technologies, web services and web mining.