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BUILDING RESTFUL SERVICES FOR ONTOLOGY BASED EXPERT SYSTEM FOR FARMERES

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ABSTRACT

There is a large amount of data related to agricultural practices being collected via different sources but it is not being u sed for maximum benefit for the farmers due to lack of mediums for the information to flow and other factors like language differences, lack of technology to access that information etc. Information Communication Technology (ICT) can help s to bridge that gap by creating systems that are easier to access and are able to answer basic queries for the farmers that might help them in improving their farming practices. Such a system should make use of all the data sources available and provide processed information that makes sense to the user. We have developed ontology based Agro- Advisory System to fulfill these requirements. It is acknowledged based system. The knowledge base is maintained in the form of ontology. Ontology contains cotton crop knowledge. Ontology is integrated with RESTful web services to develop our system. Farmers can ask their queries related to cotton crop cultivation by Android mobile and get recommendations on their mobile which improves cotton crop productivity. The system is also able to send notification and alert to farmers if any adverse change in weather condition.

Keywords: RESTful services; Ontology; Semantic Web; Agro-Advisory system; Service Oriented Architecture

I. INTRODUCTION

In agriculture domain, farmers have queries regarding crop, soil, climate, cultivation process, disease, and pest. They express their queries in a natural language which are usually answered by agriculture experts. Due to lake of access, distance or time, the expert is usually not present physically to answer all the queries of the farmers. Hence, the farmers may not understand clearly what the experts wanted to convey. In such situation, there is a possibility of communication gap between farmers and knowledge of agriculture experts. It is desirable to capture agriculture expert's knowledge in a system that understands farmer's queries appropriately and gives the recommendations for it. We have developed ontology based Agro-Advisory System to fulfil these requirements. Ontology is integrated with RESTful web services to develop our system.

RESTful services work seamlessly over the internet. They can be written in java languages and combined with various other technologies to build complex systems. The basic characteristics of web services are composition in which atomic services can be combined to form a new service that can answer queries without having to create them separately.

We have integrated such RESTful services with a variety of data sources. We are using Structured Query Language (SQL), Resource Description Framework (RDF) and Geographical data which are stored separately. We have written web services to retrieve the information, process them if necessary and display them on a mobile device or on a web browser in either plain text, tabular or map format.

II. RESEARCH MOTIVATION

Cotton cropping systems vary among farms depending on available resources and constraints such as geography and climate condition for the farm, government policy, economic, social and political pressures, and philosophy and culture of the farmers. Farmers encounter many queries related to cotton crop which depends on soil type and climatic conditions such as temperature, rainfall etc. To. Database applications are the applications which help in

retrieving information from a relational database and queries over the database. One such application BANKS[6] which helps users in extracting information from the database without having knowledge of it. It is a system which enables keyword-based search on relational databases, together with data and schema browsing. BANKS[6] enables users to extract information in a simple manner without any knowledge of the schema or any need for writing complex queries.

On the other hand, ontology based applications which retrieve information from a knowledge based like ontology. Ontology is defined as generic ontology and specific ontology. Generic ontology, defines the classes of the ontology and the relations existing between them. It explains how any two classes are related with the properties. Crop ontology is an example of generic ontology. Specific ontology is the ontology built over the generic ontology and defines the instances of the ontology classes. Instances of classes are related to each other by object property. Cotton crop ontology is an example of specific ontology. Knowledge based applications developed on the specific domain provides the user with the ease of querying in natural language rather than user should have the domain knowledge to which they are querying.

Farmers express their queries in a natural language which are usually answered by human experts. It is desired to enable the data or knowledge captured in the system to understand the query as exactly as farmers ask questions. Hence there is a need arises for developing a knowledge-based system which captures significant aspects of the reality that farmers are likely to mention. This kind of Knowledge based agro advisory answer to the queries of farmers according to what farmers mean and not what farmers say.

Our Ontology based Agro-Advisory System, KisanMitra is a query-answering support for farmers, It is an ontology based knowledge system in which knowledge acquisition is done with the aid of Agro experts. It is a querying system which allows farmers to give the flexibility of querying the system in natural language. It can respond to farmers queries such as diseases or pest on crops, preventions techniques to be used for disease/pest, timeliness of various activities such as fertilizing, sowing, irrigation etc. Our system basically encourages keyword based query where user enters his query in simple keywords which is interpreted and analyzed by the system and advices to the farmer based on its context and severity.

III. LITERATURE SURVEY

During literature survey, we found existing Agro Advisory systems like eSagu [7], Agrisnet [10], Kissan Kerala [11], aAQUA [8], mKrishi [9].

3.1 eSagu

eSagu is a IT-based personalized agro-advisory system developed by IIIT- Hyderabad and Media Labs Asia which is active since 2004. They have around 10,000 registered farms covering hundreds of villages and around 30 field and horticulture crops. In this system the farmers submit the queries via digital photos and text and get text based responses from agricultural experts. The system is accessible via web browser, SMS and Mobile phones. The major components are: (i) Farmers - They are the end users and can be illiterate. (ii) Coordinators - Someone who is educated and experienced. They are connected to eSagu local center with computer facility. They have a university degree and are qualified to advise others on agricultural matters. (iii) eSagu local center - A facility with computers available for use. (iv) Agricultural Information System - This contains all the data accessible to the users. (v) Communication System - A system to transfer information in the form of digital photos or text. If bandwidth is not sufficient postal services can also be used. Each coordinator is assigned some farms which he/she visits regularly to collect data in the form of digital photos and text. The data is sent to the main eSagu lab to analyze the data and provide recommendations and advices which can be downloaded electronically.

3.2 Agrisnet

Agrisnet provide a web based portal that gives access to various kinds of information like seed, plant protection, fertilizer, Soil Health Card, Weather, and Market Info etc. to the registered farmers. The main objective is to create a scalable data bank for agricultural inputs throughout the state of West Bengal. The target is to connect all the agricultural offices up to block level to improve the information access and to provide advices to the farming

community using ICT. Agrisnet is conceptualized by National Informatics Center, West Bengal and the West Bengal state government.

IV. KISANMITRA: ONTOLOGY BASED AGRO ADVISORY SYSTEM

We have developed system named KisanMitra where different data sources like Ontological knowledge base; GIS data etc are brought together using integration of RESTful services. The system provides information to the farmers using a mobile phone regarding farms, farmers, weather information etc. it also has automatic recommendation system that provides pest and disease prevention recommendations based on inputs by the user. The user interface is very easy to use requiring minimal training.

V. ANALYSIS AND DESIGN OF SYSTEM

We propose to create a mobile phone based and automated Agro advisory system for the cotton farmers in Gujarat state. To achieve this we will be using various concepts in ICT that will help us to create a feasible and useful solution. Figure 1 is proposed architecture of the system.

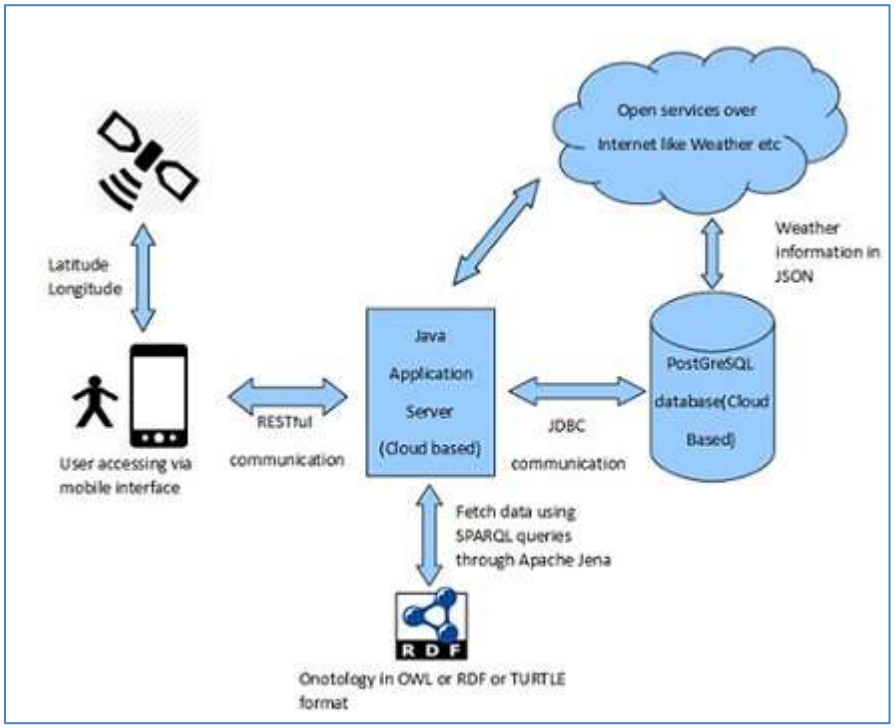

Figure 1 KisanMitra System Architecture

5.1 Components of system

The SQL database:- This database holds the general information that does not change often like the user information, farm survey information, soil information etc. This information is used to handle registrations and help end users to get relevant information. The data stored will be more constant i.e. not dynamically changing except for weather and related soil data. The data will be fetched using SQL queries and it will be stored on PostGreSQL based server on a cloud so that it can be made available to user using RESTful services.

The RDF knowledge base:- This component holds the knowledge base for Cotton crops that we have prepared. It contains a very wide variety of concepts like Climate, Diseases, Pests, Irrigation, and Pesticide etc. Techniques like

SPARQL queries and reasoning are used on the Ontology to generate results for user queries. We are using the Apache Jena [10] framework to query the ontology and communicate the results using web services.
Geographic database:- It Contains the geo referenced data for various farms, AEZ etc that can help in various processing. The data is stored in PostGIS extension of PostGreSQL. This data is used to mark the location of the Farms/regions on a mapping service like Google Earth or CartoDB [11]. We are making those maps interactive by adding more details such as farmer associated with a farm or count of diseases on a particular farm/region. This will help the users to better understand the situation and deduce patterns if any without analyzing a lot of tabular and plain text data.

The RESTful services: - This component drives the whole system. It connects to the database and the knowledge base, the internet and the mobile end user to fetch and deliver information and recommendations. The web services are REST based which is more suited to the worldwide web considering the similarities in the basic operations between the two. These services are written in Java (v1.7) using JAX- RS implementation for REST and Eclipse Integrated Development Environment. We have deployed services on a cloud based server so that the data and recommendations can be accessed easily using web or mobile.
User Interface:- The user can access the system via a mobile phone application or a web browser. We have designed it to be very simple without a lot of manual inputs i.e. user can submit the input by using drop down menus instead of the user typing the values. We have also enabled our system with local language support and the interface to enable more people to use the system.

5.2 RESTful services

These web services can be used to fetch information based on the parameters passed. The web services have been implemented using REST and output is in JSON format. The services can be invoked once URL is fixed on deployment. The output can be routed to a browser or a mobile device and can be used by performing standard JSON parsing.
SQL based web services:- These web services can be used to fetch information from the Structured Query Language databases. The Figure 2 shows the SQL based web services
LocationService:- This service returns the AEZId of the requester based on his/her current location(latitude and longitude). The URL for this service would be: URL/services/AEZLocationInfoService/latitude. Figure 3 shows the flow of it.
WeatherService:- This service records the current weather conditions of the defined location (latitude and longitude). This service is totally autonomous and doesn't require any human interaction. It can be used in combination of location service to get the weather conditions of the userâĽ™s current location.Figure 4 shows the flow of it.

VI. DEVELOPMENT OF SYSTEM

We have divided the work for developing system in different phases including the development of basic building blocks of system, deployment of the RESTful web services and building prototype of entire system.

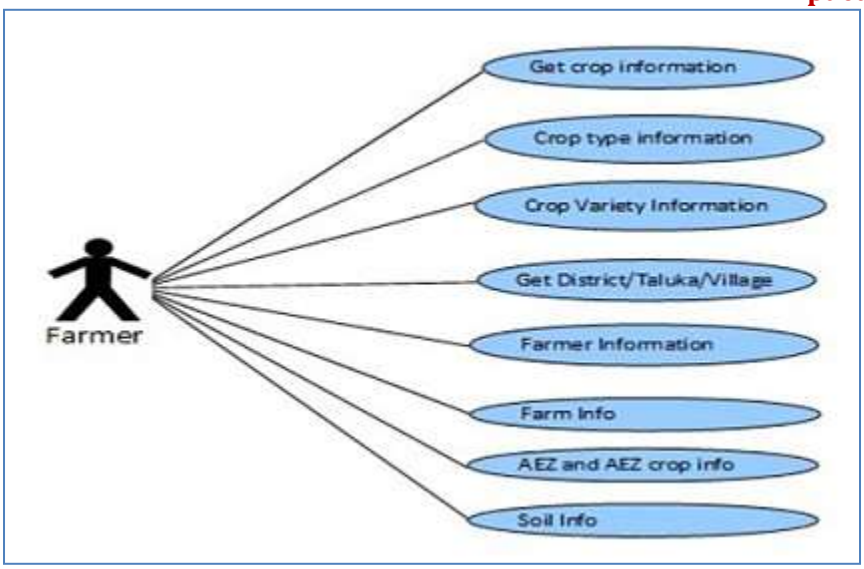

Figure 2 SQL based web services

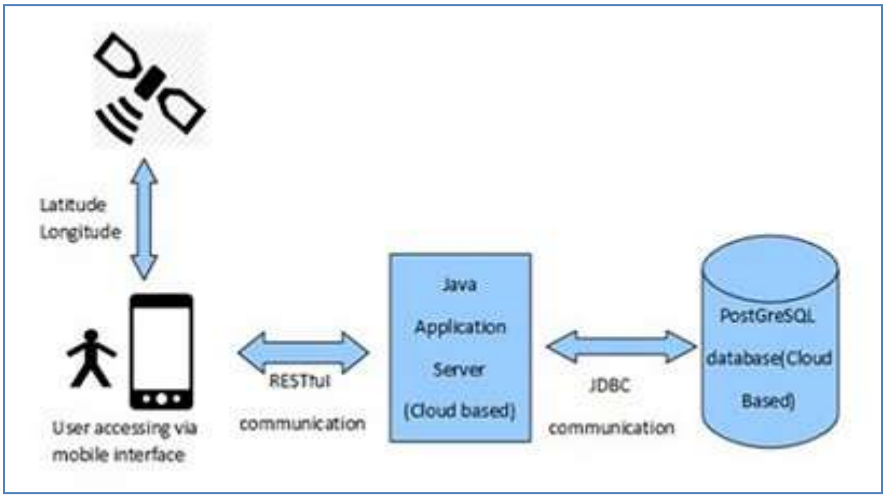

Figure 3 Location Based Service

6.1 Designing the basic building blocks

6.1.1 Creating SQL database design

6.1.2 Creation of new SQL database script

The script is generated using pgDump utility provided along with Post GreSQL server. This script can be executed to recreate the tables on any PostGreSQL server which are supporting PostGIS extension.

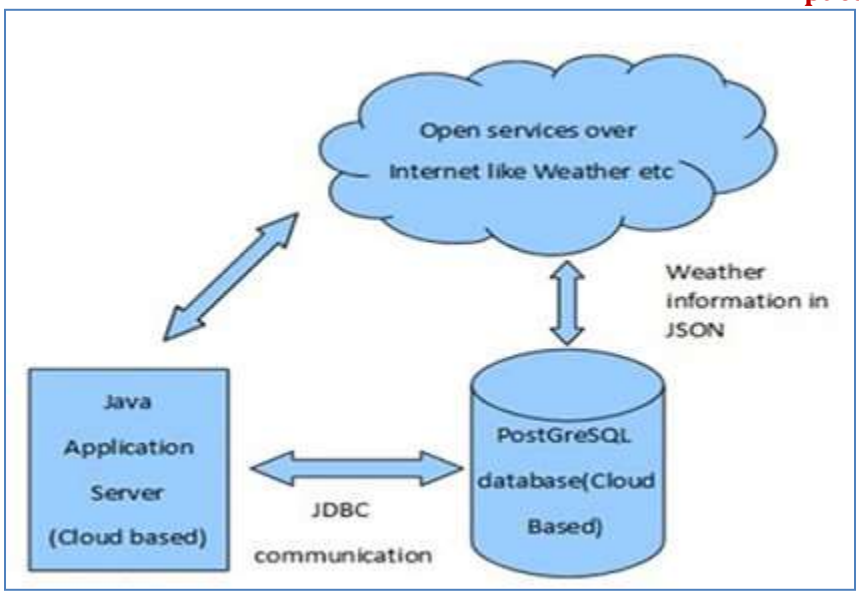

Figure 4 Weather Based Service

6.1.3 Development of REST base web services
We have developed the REST web services using JDK 1.6 which fetch the data from our data sources, We have used JAX-RS, Jersey libraries and the Eclipse IDE to develop we services.

6.2 Deployment on cloud based servers
6.2.1 Setting up deployment environment for deploying web services
To provide accessibility of our system from anywhere to user we have deployed web services on cloud.
6.2.2 Deploying database on Heroku cloud based SQL server
To make the SQL data available to the users on the internet we have deployed the database on a cloud based PostGreSQL server. We have used Heroku services to access the data from PostGreSQL server which is on the cloud.
6.2.3 Testing the web services
We have tested web services on Apache Tomcat web server in local environment as well as on the Heroku cloud. All web services works properly based on the inputs provided by user.
6.2.4 Preparing forms for data collection in Formhub
We have used Formhub service which allows us to create web forms to collect data from farmers in online and offline mode. We have also created excel templates to collect data from users. Formhub services generate the forms and it also provides us a link to fill the forms.

VII. DEVELOPING MOBILE INTERFACE AND WEB SERVICE INTEGRATION

1. Mobile interface is developed for accessing the web services which displays the recommendation of query of farmers on their mobile. We have used mobile phones as a medium of interaction between the farmers and knowledge base which is in the form of ontology. As the Android operating system is widely used in most of mobiles. We have decided to created mobile application which runs on it. We have used Android studio version 1.4 to develop it. Our application has 3 major components:
(a) Information centre: It provides all the information like farmer info, village info, weather info etc.
(b) Recommendation centre: provides recommendations for farmer's query like pest preventions techniques for pest and cure for disease based on symptoms and observations on cotton plant.

(c) Notifications and map data where the user can see all the notifications related to adverse change in climatic conditions which they received in mobile. A farmer can also see view of farm on their mobile. We have used google api services for it.

2. Adding RDF based data(OWL format) and preparing web services to query that data using Apache Jena Services that use RDF data to return recommendations to the user based on parameters provided. These services use the POST operation to transmit the SPARQL query so cannot be directly accessed via a web browser. Below are the services developed.
(a) Disease cure by Observations appear on plant.
(b) Pest and its prevention techniques by Observations. (c) Disease and its cure by symptoms.
(d) Disease Observations, Pest Observations, Disease Symptoms and Disease Symptoms by part

3. Android mobile interface is created which retrieve RDF data using sparql queries. We have made recommendation centre through which user can select the query.4. Mapping of RDF and SQL entities, we have used two data resources, ontology and sql database to answer the query of farmer. To keep the system in synchronization, we have performed a data mapping between the SQL and RDF data which is shown in Figure 5

5. Figure 6 and Figure 7 showing the service composition designed for the current system: Here two services one to parse and other to query the RDF ontology is used to obtain the final result. This composition is used for all the services in the Recommendation centre of our application.

OWL/ RDF Concept	SQL Table /Attribute
Climate- Clouds	ClimaticData -Description
Climate-Metrological Factors -Tempreature -Max	ClimaticData -max_tempreature
Climate-Metrological Factors -Tempreature -Min	ClimaticData -min_tempreature
Climate-Metrological Factors -Humidity	climaticData- humidity
Crop-CropType	CropTypeInfo
Climate-Clouds	CropVarietyInfo
Soil	Soil

Figure 5 RDF and Data Mapping

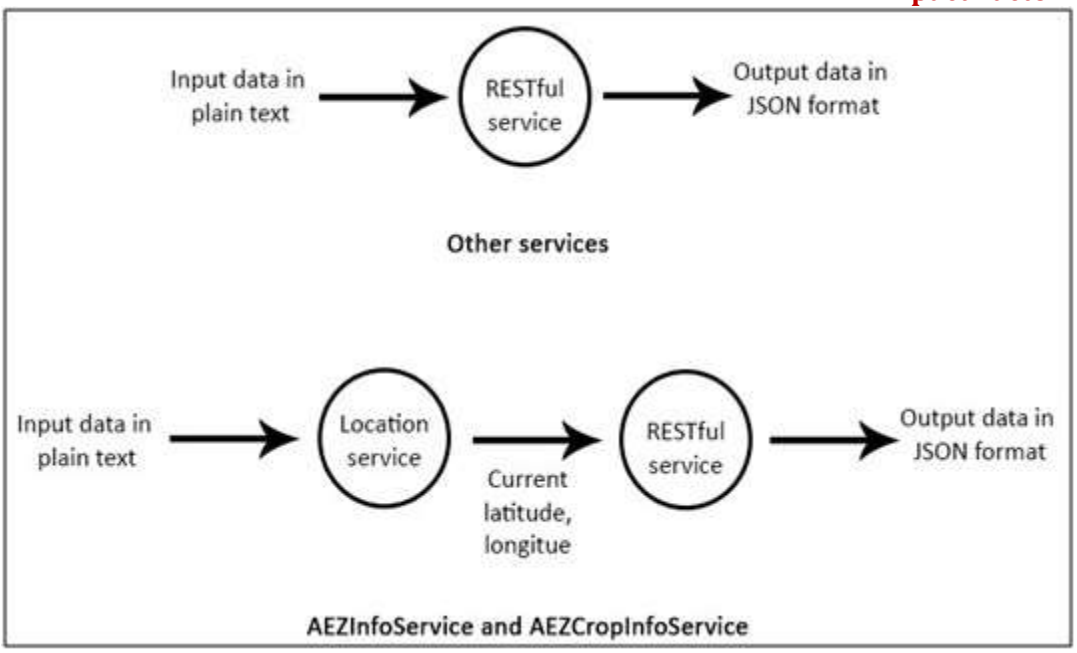

Figure 6 SQL Database Service

We have built the system which has the following functionalities.
1. Data access to variety of data like crops, crop types using mobile phone which has an Internet connection.

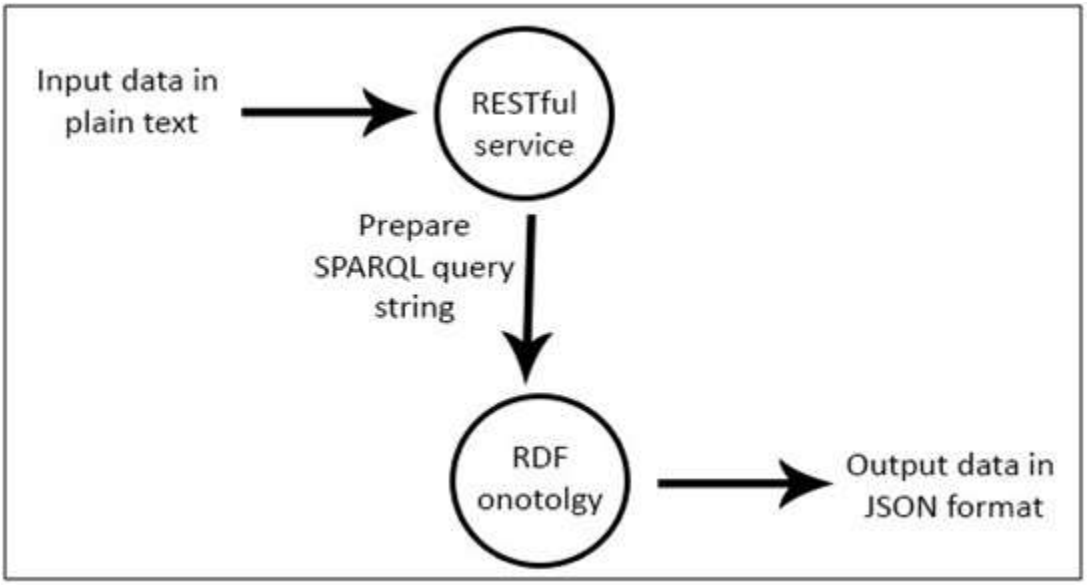

Figure 7 RDF Database Service

2. Automated recommendations can be generated using ontology and RDF concepts that will help the users get the most common queries answered in fast and easy way.
3. Using this system the farmers/users can get current weather information for their current locations.
4. The pest attacks report can be presented on a map on live data and authorized personnel can judge if intervention is needed to control it.

5. Farm and farmer information can be viewed on a map for better presentation of information.
6. Data collection can be performed via formhub to collect data.

VIII. CONCLUSION

Agro-Advisory systems like eSagu, aAQUA, mKrishi, are in use to help farmers by improving their farming practices. This thesis presents a new Agro-Advisory system named as "KisanMitra" which is an Android based and uses new semantic web technologies like ontology, SPARQL query language and reasoning capabilities. KisanMitra ontology is developed using Protégé tool and uses RDF data technique to represent ontology. The system is designed for cotton crop farmers to improve cotton crop farming practices. The system can generate automatic recommendations based on farmerâŁ™s queries regarding crop and their farming so agro experts are not needed at the other end. The user/farmers will be able to access a variety of data like soil types, cotton crop varieties, farmer information, pest/disease affecting cotton crop, insecticide, pesticide, fungicide which needs to be used to prevent disease/pest. The farmers will get recommendation or relevant information on their mobile phones without being concerned about the source of data. The farmers/users can also get current weather information for their current locations through the system. Apart from that we have gathered past weather data to deduce patterns and detect spikes in weather conditions. The system can generate alert and notification and sends to farmers if there is adverse change in climate condition so that farmers can take precautionary steps before heavy damage occurs. To access our system the mobile device only needs to communicate with the web services through internet. The interface for the mobile phone system is very user friendly which does not require much training. Our KisanMitra system is pioneer and pilot work to develop agro advisory system using ontology. This system will be also a model for building agro advisory system for other crop which leads to increase in the yield or production of crop.

IX. FUTURE SCOPE

Our system can be more useful to farmers if we could include current climate condition data and weather prediction techniques. We can add soil health card data for the farms, which will help agricultural experts to make appropriate recommendations to improve the soil condition of the farms. More concepts (like additional crops, weather parameters etc) and properties can be added to make the scope of the ontology larger. The more concepts the ontology has, the effective will be the reasoning capability of the system to provide the users with better recommendations. The ontology concepts and user interface can be converted into regional language so it will be user friendly and easy to use for regional farmers.

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