Intelligent Farm Expert Multi Agent System

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***Abstract*— Farming data has been rapidly increasing in volume in different Web data sources. Querying multiple data sources manually on the internet is time consuming and laborious process for farmers. Traditional information systems do not scale well to the large, diverse, and the growing number of farming data sources. Internet search engines allow users to search through large numbers of data sources, but provide very limited capabilities for locating, combining, processing, and organizing information. And also the search engines don't take context of the pages into consideration.**

A promising approach to this problem is to provide access to the large number of farming data sources through an intelligent multiagent-based framework where a set of agents can cooperate with each other to retrieve relevant information from different farming databases. The proposed system also uses a domain ontology, which uses as a global schema. In this paper we propose a multiagent-based framework that responds to farming queries according to its farming domain ontology.

Keywords- Multiagents, information agent;, agent-oriented software engineerin; cooperative information gathering; information extraction; classification

I. INTRODUCTION

As we are moving from knowledge management and other business intelligent solutions there is a need to develop intelligent agents that reduce information overload. The abundance of information resources like books, videos, online articles, advertisements ...etc makes it hard for untrained users to get the right information and the validity of the data.

In this paper we will look how intelligence can be added to agents to solve this issue. Intelligent agents can be applied to various domains. Like in any other domain, application of these new techniques will greatly help the farming community. The ability to make fast, reliable decisions based on accurate and usable information is essential to reap maximum benefits. In addition embedding elements of human style social intelligence into an agent improves effectiveness of agent communication with humans.

This paper focuses on 'Intelligent Farming Expert Agents". The later sections will go into the present problems faced by farmers and the architecture and implementation to tackle them through intelligent agents.

The main objectives of the portal site are

- To provide education and knowledge to farmers.
- Increase partnerships with universities and research institutes.
- Provide medium for Information sharing and promotion of new technologies.
- To provide accurate information to farmers like (Weather, Market Prices, Market Trends, Soil testing locations … etc).
- Content presented in a customized and well organized manner.

Searching for “yellow patches on tomato leaves” in any search engine returns us 1,570,000 Web results and 300 video links. Except for a very few categories the results are not organized by any subject relevance. Even for an educated computer savvy individual without any hint of the solution it will take a while to figure out the right strategy to deal with the problem. This is the case when we have a specific problem and trying to find out the solution for it. If we are not clear on how to specify the problem the chances of finding the right solution will be even slim.

Significant progress has been made in technologies for publishing and distributing knowledge and information on the web. However, much of the published information is not organized, and it is hard to find answers to questions that require more than a keyword search. In general, one can say that the web is organizing itself. Information is often published in a relatively ad hoc fashion. Typically, concern about the presentation of content has been limited to purely layout issues. Content on the web is growing closer to a real universal knowledge base, with one problem relatively undefined; the problem of the interpretation of its contents. Although widely acknowledged for its general and universal advantages, the increasing popularity of the web also shows us some major drawbacks [1].

This problem exists in various domains but we are looking at farming industry in particular. Farmers especially in India don’t even have basic education. Most of them might not even know how to perform basic computer functions. In this scenario if the onus is on the farmers to find information from the web they will be lost.

There are 5 million farming websites on the internet today. So there is a sea of knowledge out there. The problem is which ones to pick and choose. With the help of “Intelligent farm expert multi agent system” we hope to bridge this gap. The rest of the paper is organized as follows. In the Literature Survey section we justify why we have taken up this problem. The Methodology section looks into the various facets of the architecture. Discussion section provides details on the proposed new hybrid agent that will aggregate information from different sources and present it in a more friendly way to farmers. We finally provide the research contribution and the conclusion.

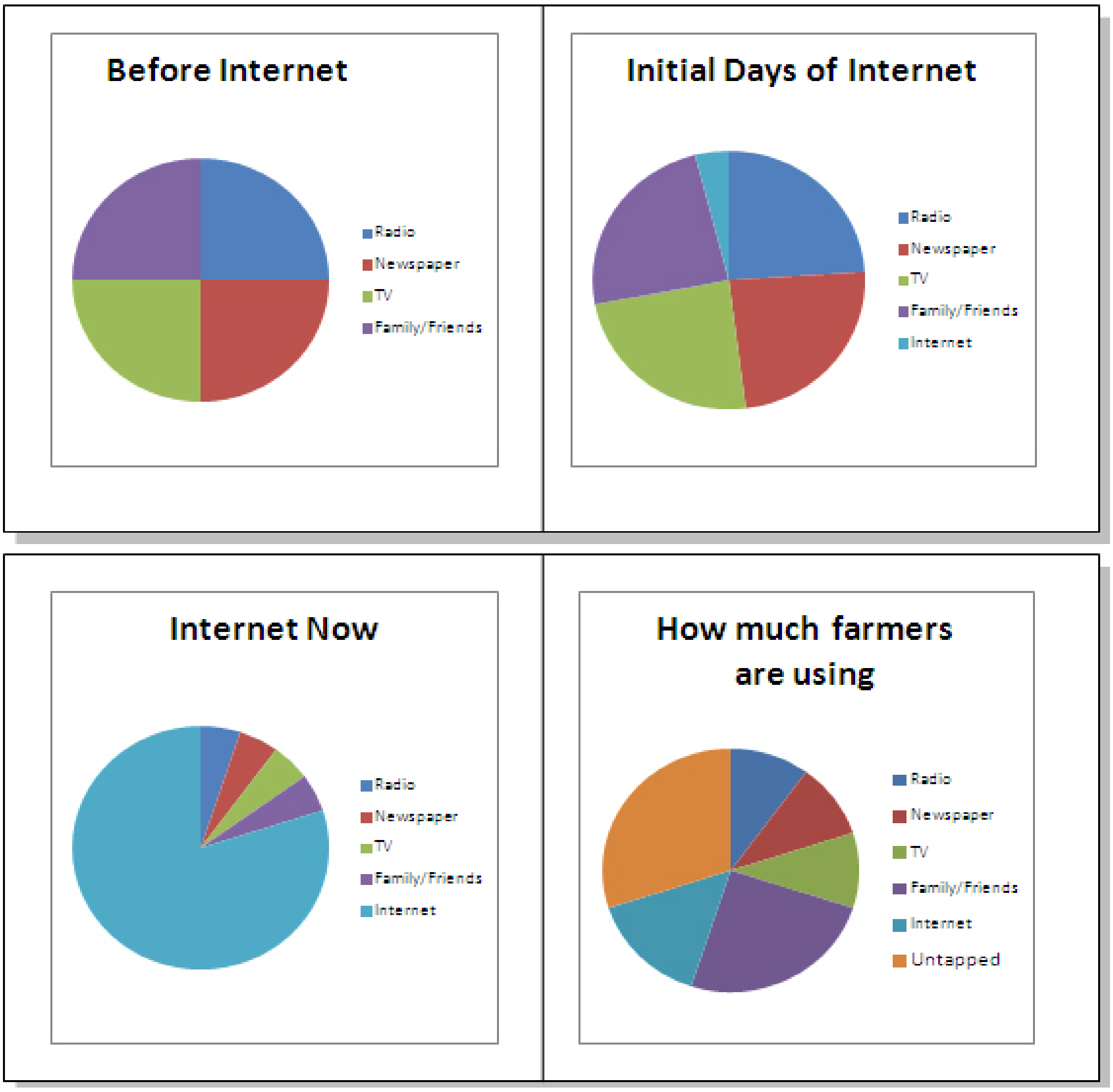

Figure 1. Information through Internet over the years.

II. LITERATURE SURVEY

The Internet has changed the world. People can now access up-to-the minute information at the touch of a button and can also communicate and engage in trading activities on-line. This Electronic revolution has changed the business world but has it affected the world of farming? USDA recently reported that the use of computers on farms has grown from 38 to 55 percent since 1997, while Internet use on farms has grown from 13 to 43 percent (USDA, *Agricultural Economics and Land Ownership Survey*). Farmers are also beginning to embrace e-business and successfully trade on-line. As a technology, the Internet has the additional benefit of minimizing some constraints on a farmer's ability to receive and manage information, regardless of where the farm is located or when the information is used. Many agricultural groups, researchers, farm organizations, teachers, and extension agents have taken an active interest in Internet use in agriculture [2].

Agriculture landscape in India is characterized by fragmented farms, weak infrastructure and the involvement of numerous intermediaries. Due to the lack of market information, rural Indian farmers have only an approximate idea of price trends and have to accept whatever the price offered them by the traders on the day that they bring their crops to the *mandi*. Typically poor and often illiterate, rural Indian farmers generally have very limited access to information and education regarding improved farming techniques, which could enhance their yield [9].

The challenge on hand is to transfer maximum information (audio-visual, audio, visual, text, in that order) and to enable maximum interaction with the farmer at least cost. And on the other, it should be a micro-enterprise opportunity for youth. Farmers are apprehensive about adopting new farming practices or crops. This is largely based upon an adherence to tradition, sometimes dating back several generations. Farmers must be shown proof that new practices will result in a better standard of living before they risk their family's wellbeing

– which is often directly influenced by their crop yield. As such, the major challenge for the adoption of new practices is one of education and trust [3].

That is what S.C. Mittal [4] talks about in his paper … "The indirect benefits of IT in empowering Indian farmer are significant and remains to be exploited. The Indian farmer urgently requires timely and reliable sources of information inputs for taking decisions. At present, the farmer depends on trickling down of decision inputs from conventional sources which are slow and unreliable. The changing environment faced by Indian farmers makes information not merely useful, but necessary to remain competitive."

III. METHODOLOGY

Today's cognitive science provides a totally new insight to optimize the performance of knowledge systems. Three factors are important in learning newly designed knowledge systems to match the skills of a human expert: the building of experience through implicit learning; the use of examples to construct reasoning; and the development of strategies through explicit learning [5]. With appropriate social skills computer agents would perform more as humans and can be used as procurement agents, personal agents, monitor agents...Etc. The architecture of cognition is able to contribute a great deal to an alternative way of reasoning for expert systems. The multi agent system proposed in this paper is based on this architecture consisting of Experience, example and strategy.

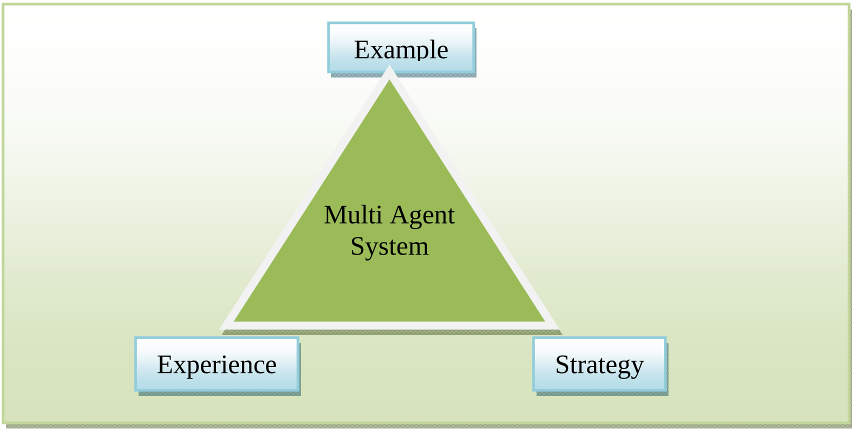

Figure 2. Cognitive Architecture

The reason for the low precision of IR systems is the difference between provider and consumer's ontology and incompleteness of information. Many works [6] show that ontology, which is used to describe document and user's query in semantic level, is a good way for solving these problems. Ontology is a system that contains concepts definitions of those concepts and the specification of relationships among those concepts. It entails or embodies some sort of world view with respect to a given domain. The world view is often conceived as a set of concepts, their definitions and their inter-relationships, which are referred to as a conceptualization [7].

In the proposed intelligent farm expert system ontology will also be used for information gathering and storing data in knowledge base. This overcomes the hurdle of regular IR systems which just look at the keywords not the context of the pages.

IV. DISCUSSION

The multi-agent framework shown below is comprised of a network of cooperating agents communicating by means of ACL. Front end will be a user friendly web interface through which information will be passed to farmers. Once the user makes a request it comes to farm interface agent (FIA). This agent talks to user preferences agent (UPA) and gets the user preferences. FIA then decides based on the input data to either send it back to user for more information or continue onto query planning agent (QPA). QPA sends the information to the database to look in the mapping schema and gets the appropriate sources to call. Once QPA gets the mapping information it constructs the execution path and send this to each query execution agents (QEA). QEA runs the actual queries. Any dependencies in the execution path will also be taken care of. The results of each query are sent to data integration agent (DIA) which organizes the data and presents it to the user.

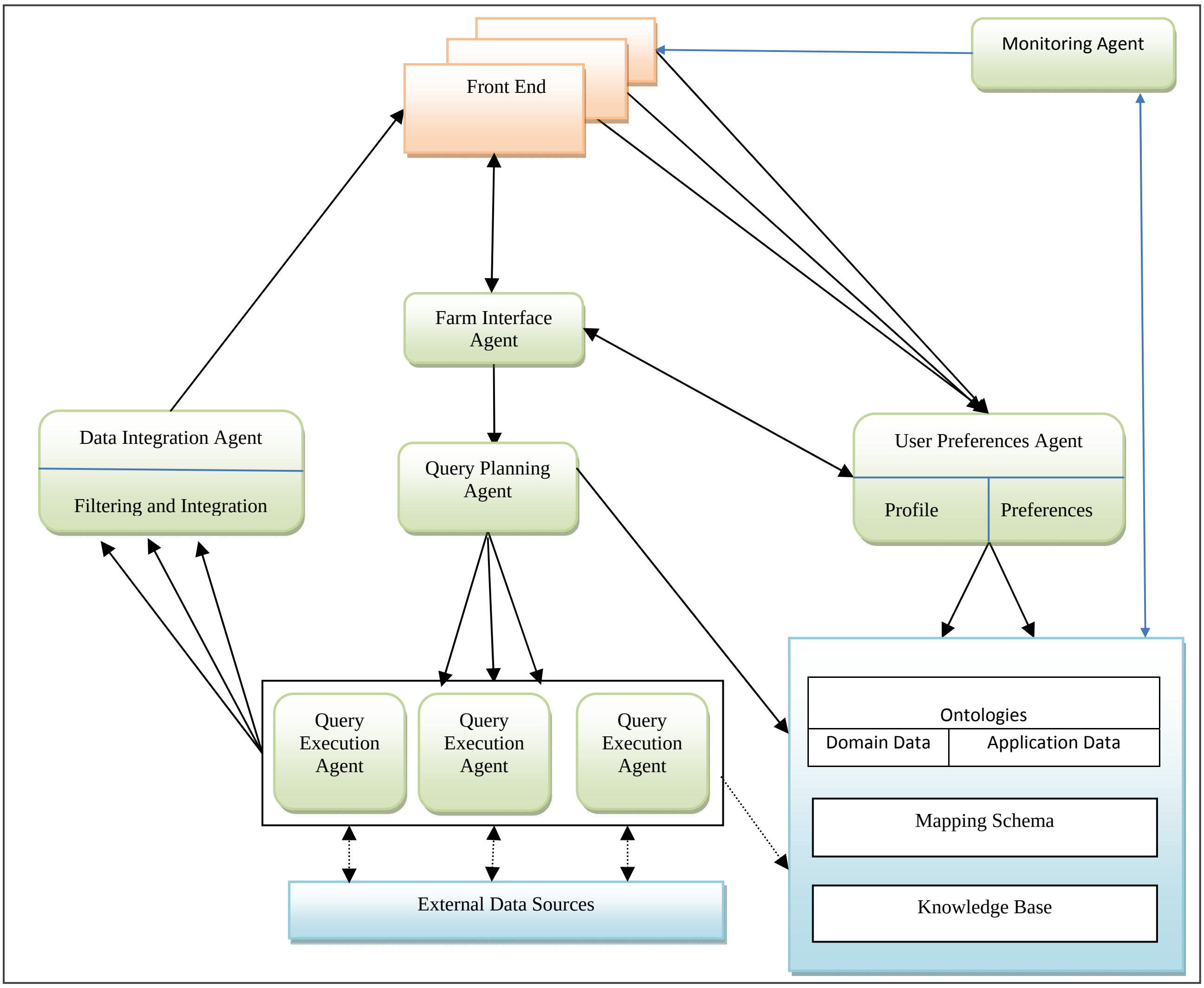

Figure 3. Architecute of Multi Agent System

TABLE 1. AGENTS IN FARMING MULTI AGENT SYSTEM

Agent Name	Percepts	Actions	Goals
Farm Interface Agent (FIA)	Query Parameters from user and user preferences from UPA	Based on the type of the query this agent will decide either to send more options back to the user from user preferences agent (UPA) or to send the search parameters to the Query Planning Agent (QPA).	Route user query
User Preferences Agent (UPA)	Input from FIA and users	Talks to database and returns user preferences to FIA. Enter user input and feedback in Knowledge Base and Mapping Schema.	Retrieve user preferences and update database.
Query Planning Agent (QPA)	Query parameters from FIA	Look into the mapping schema, determine the sources and construct queries.	Formulates sub queries.
Query Execution Agent (QEA)	Query parameters from QPA	Talk to individual data sources and retrieve content	Retrieve Content
Data Integration Agent (DIA)	Content from QEA	Get data from all the QEA's. Validate, sort and organize retrieved content.	Integrate data.

The proposed system is being developed using JADE (Java agent development framework) which is a software development framework aimed at developing multi-agent systems and applications conforming to FIPA (Foundation for of Intelligent Physical Agent). All agents are cognitive systems and Jess extraction system will be used for classification of data.

The user should be able to perform queries without knowledge of how the information is retrieved or how much and how it is stored locally. The system we propose consists of two main parts:

1. A multi-agent system, which contains a set of agents interacting with each other. Broadly the system can be considered as consisting of a search and insert subsystem.
2. Agricultural ontology and also a local ontology which will be used in classification, filtering, storing and information retrieval.

A. *Search Subsytem*

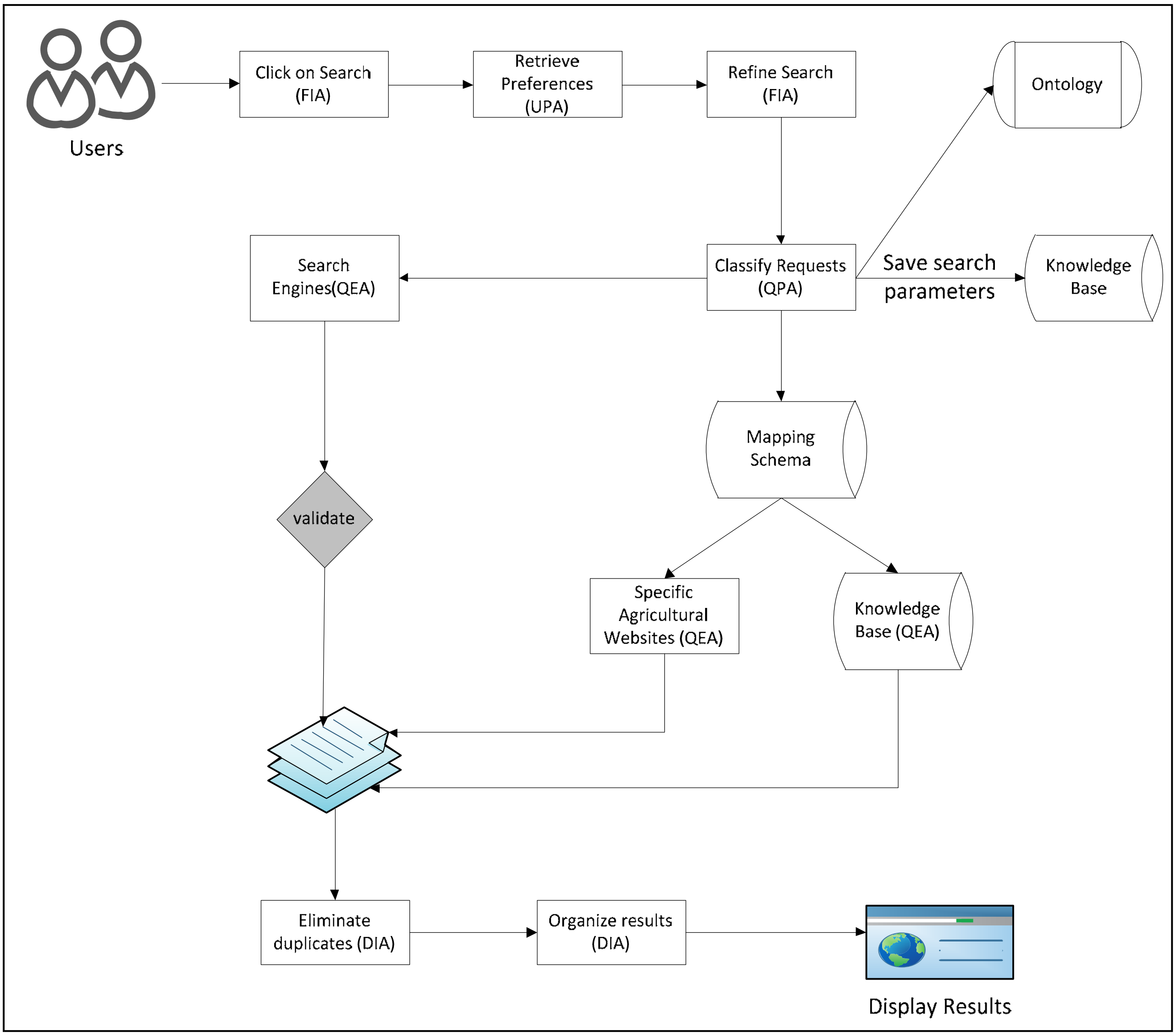

Figure 4. Data Flow through Farm MAS System

Search subsystem uses all of the agents defined previously. Let us walk through a user searching for a simple query like “solutions for yellow spots on tomato leaves”. Sample database layouts are also given for better understanding. A subset of ontology categories will be stored locally. When a category is not found in the local ontology then it is looked up in the Agricultural Main Ontology and updated in local database also.

In the example we have taken tomatoes come under “Fruit Vegetables” category. Once the search is sent to “QPA” it needs to be converted into an ontology based query. Most of the data in the database will be stored according to ontology classification. So it will be necessary to transform the free format query into ontology based query. QPA sends the ontology based query to mapping schema to know if there is data in the knowledge base and also to retrieve any specific websites or links stored for that category. Once QPA establishes the data sources it sends the queries to QEA’s.

The searches in this case will be routed in three different directions. i) First one makes calls to generic search engines like Google, yahoo...etc. ii) The second set of data will be retrieved from the knowledge base based on modified ontology compatible query. iii) And the third will look for in the specific websites admin’s of the system and experts recommend.

Once all the searches are complete basic elimination criteria will be used to remove sites which are duplicates or which are nonexistent or which are not functioning. Then the data is organized and presented in a user friendly manner to the user.

Ontology Sub Categories

Name	Category
Tomatoes	Fruit Vegetable
Potatoes	Root Vegetable
Orange	Citrus Fruit

Fruit Vegetables

Name	Region	Problem	Solutions
Tomatoes	A.P	Problem1;problem2	Spray abc; spray xyz
Tomatoes		Problem1;problem2	Spray cfr;
Orange		Problem1;	Xyz;

User Preferences

Name	Region / Address	Main Crops	Previous Searches Made
Anand Mohan	M.P	Rice	Search1; Search2; Search3;
Priya Jasti	A.P.	Cotton	Search1; Search2;
Srinivas	T.N.		

Mapping Schema

Name	Knowledge Base	Recommended Websites
Fruits Vegetables	Yes	Abc.edu;
Root Vegetables	Yes	Xyz.edu;asd.edu
Leaf Vegetables		Ssdagrouniv.edu;
Soil Testing		Xyz1.edu;
Soil Testing	A.P.	Xyz2.com;

Figure 5. Database layout

B. Insert Subsystem

As seen in the search subsystem along with results from search engines lot of data is retrieved from system databases. So in this dynamic world we cannot have a static database. This “Insert Subsystem” looks which databases needs to be updated constantly and where and when they can do it.

- As mentioned before Farm ontology is a subset of the Agricultural ontology so when Query Planning Agent looks for a category and if it is not found it looks for the information in the Agricultural ontology and also updates the information in Farm ontology.
- Next we go on to “Mapping Schema” database. For all categories there should be an entry in this database. There are two pieces of key information in this database. The first is just like a Boolean variable which tells if there is any information in the knowledge base for the category we are looking for. If there is no information in the knowledge base for the particular category there is no use looking for it so it helps to maintain that information in the mapping schema. When information for a new category is added to the knowledge base an entry will be added in mapping schema if it is already there it will be updated. The other information that is maintained in the mapping schema is specific useful websites or links for a category. These will be added by site admin’s or designated experts who have access. These can also be more than just website links. Yahoo pipes can be developed from various sites and those links can also be added. These websites are more like university sites, research sites or market data sites which maintain up to date information.

- Knowledge base is the meat of the system. It stores information for all the categories. Database tables will be created for each category so information retrieval also will be quick. The data in these can be entered by all users of the system.

User preferences will also be stored in the system. During the initial registration phase required information will be gathered. Users can update information in the system any time later. Every time a search is made key information from their searches will be stored in their user preferences. This information will be used later when user want to find out what is new out there. Let us look at an example on how this works. A user searched for new machinery to cut rice crops and got needed information. This search information is stored in user preferences. If a machinery manufacturing company releases a new upgraded rice cutting and processing machine in a few days the information will be entered into the database in the right categories. So when the user comes back to the site next time they do not have to know that a new machine has been introduced in the market and they don't have to know the name and search for it they can click on updates button on the site and all the information updates in the database based on their previous searches. This way the users will be up to date with latest information and can take the right decisions. This will also help them gain information which they never even taught to look for. Instead of being lost in the sea of information on the web selected content will be provided to guide them.

V. Research Contribution

This framework is based on cognitive science and also supports queries based on domain ontology, however, the novelty in our approach is that the framework is based on agent oriented programming (AOO) which is an extension to object oriented programming (OOP). AOO relies on the assumption that a complex distributed software system can be programmed as a set of communicating, interacting and knowledge base entities called (software) agents. Object-oriented modeling of social systems requires the integration of new concepts related to cognitive processes such as learning, planning, knowledge representation, and communication. If one defines an agent as an object that combines a mental state to perceive its environment and achieve some goals, a knowledge base to hold its memory and an interface for communicating with other entities, then all the above properties could be fulfilled [11]. Agent technology is an attempt to accommodate basic OO concepts (e.g., abstraction, modularity) and advanced artificial intelligence techniques (e.g., reasoning, learning). The promise is that they will provide the programmer with a basic unit of design (the agent), which enhances software modularity, maintainability, and reusability [8].

CONCLUSION

We started with the methodology of example, experience and strategy and this fits into the design model presented above. There are lots of examples on the internet and these are bought to users in a timely manner. Experience is a valuable knowledge through this portal we provide a platform for the farmers to store it in the database so others can benefit from it. Strategy comes into the picture when intelligence is put to use to retrieve the right kind of content to present to users. So all three put together makes this multi agent system a wonderful tool for farmers.

Future work is planned to extent possible features of the web portal to be available on mobile phones. Mobile phones have far more reach in rural areas than traditional computer systems. So providing information through mobile phones will be useful to lot more people.

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