6.1 Introduction

Previous chapter explains how the system successfully tackles real world problems and its benefits are given. This chapter looks into the research contribution made by this thesis in the field of computer science. The inspiration for this research work was taken from cognitive science. Cognitive science methodology of example, experience and strategy presents new methods that can be used to optimize knowledge based systems and enhance the learning experience of the new systems. Thesis goals and if the application satisfies the hypothesis are talked about in the next section. Even though the system tackles many real world problems faced by farmers there are some improvements that can be made. Future work focus areas where the system can be improved and further enhancements are mentioned in this chapter.

Application developed as a part of this research focused mainly on issues faced by farmers in India. The base framework is generic and it can be easily applied to many other domains. With small changes in application and database design the system can be implemented in other domains like tourism, health care systems, education portals etc.

Section 6.2 of this chapter goes over the thesis contributions. Section 6.3 talks about future work and Section 6.4 concludes this chapter.

6.2 Thesis Contributions

The design started with the methodology of example, experience and strategy. These three are the vertices of a triangle working together to ease the concerns of using a new system which is designed to handle information overload problems. There are lots of examples on
the internet and these are bought to users in a timely manner. Experience is a valuable knowledge and through this application a platform is provided 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. These three views are used when retrieving content and presenting it to users. All three put together makes this multi-agent system a wonderful tool for farmers.

90% of the data in the world today is created in the last two years alone [21]. Technology improvements have made creation of data very easy and affordable. Similarly dissemination of this information has also become equally easy these days. This aggregates already existing information overload problems. There is valuable information which is scattered around the Web in many forms. It is very time consuming and becomes quickly complex to visit individual information sources. Especially if users are not computer savvy this task gets even more daunting.

The main goal of this research is to tackle this information overload problem by using multi-agent technologies. There are various tools and technologies that can be integrated and implemented using agents. The advantages of storing and retrieving information from local knowledge bases are known from a long time. With the dynamic nature of data local knowledge base data becomes stale pretty quickly. On the other hand reliability of data on internet is hard to verify. Accessing data mainly from local knowledge bases and getting to internet as and when needed from the same application provides a mid way approach to get appropriate content and also which is more reliable and much faster. This new hybrid approach of information retrieval is proposed in this research work and implemented in the application developed for farmers to aid in their agricultural activities.

It is observed from the developed application that this new hybrid approach can access different sources of information and can make the best of both the systems. Users don’t have to be overwhelmed by the vast knowledge on the Web. Using the application developed as part of this research they can search for data and get it from multiple sources seamlessly. Data will be retrieved from local knowledge base and when the application cannot get any results back users are provided with an option to extend the search to Web. This way it satisfies the goal of this thesis to handle information overload problem.
If users find the information they are seeing on the Web useful they can easily add it to local knowledge base with the click of a button. Data in local knowledge base can be kept up to date with this approach. It eliminates the need to manually keep track of data and eases system maintenance duties. After the initial set of data is loaded there is very little maintenance involved as far as data in local knowledge base is concerned.

The advantages of customizing data through the application of personalization and filtering methods have been explained in previous chapters. The application built in this research work uses these customizing methods in data retrieval and also while presenting the data. Different users with varying user profile information are created to test how customization will be beneficial. Logging in with different user login ids and navigating through the pages bring back different results based on their set preferences. Even the first page they land on once they login is also decided based on their profile information. This way it helps them to reach to the content they are really interested in less number of page clicks.

Similarly usage of fuzzy logic and how it helps to capture uncertainty and vagueness in user’s input are already elucidated in previous chapters. Test login ids are created with different fuzzy inputs. When logged in with different ids each one has varying fuzzy outputs and this produces different results on portal data page. This shows how user profile data is sent to fuzzy system and the output is used to retrieve only content which users can make use of. Portal data also uses mash up tools like Yahoo! Pipes. Usage of these tools shows how easy it is to aggregate and apply needed filters to content from multiple sources.

The following are the major contributions of this thesis work.

- Development of a generic framework.
- Development of search, browse, utility and monitoring agents using JADE to handle core logic of the framework.
- Design and implementation of an experimental system in agricultural domain.
- Development of domain specific ontology for storing soil testing locations.
- Application of fuzzy logic to handle uncertainties and vagueness in users input.
- Documenting and publishing the research work.
- Integrating third party tools in agents to alleviate information overload problem.
6.3 Future Work

The application developed as part of this research is a Web interface. Desktops or laptops are the main devices which are used to access this application. This application is devised for farmers who are mainly in rural areas. Mobile phones have far more reach in rural areas than traditional computer systems. Future work is planned to extend possible features of the application to be available on mobile phones. Providing the same content through mobile phones it can reach lot more people. When farmers are working in the fields it is convenient to take pictures or send enquires from there itself. Communication is lot easier with phones and with the advancements in mobile technology data, audio and video can also be easily transmitted.

Yahoo! Pipes links are created by admin’s now and added to database. Future enhancements can be added where users can create their own pipes links and through Web interface store them in the database. This way they can have a tailor-made application.

Ontologies are used for soil testing part of the application. Search for locations is done based on the state and city. More logic can be added to ontologies so data can be retrieved based on pin codes and all closer locations are returned back. Also ontology technology can be extended to be used in other parts of the application. If there are any existing ontologies from other sources they can be easily incorporated into the application.

There are lots of third party open source tools used in the application. They are used while retrieving, aggregating and filtering data. New tools are introduced into the market very often. If they can add value to the application they can easily be added in. Database and application here are loosely coupled leaving room for addition of new features and integration of third party tools.

Data returned while browsing for “videos”, “web links” or “advices” is organized in different silos. New silos can be added in very easily based on users experience and their feedback. Feedback will also be critical in shaping future work of the application.
6.4 Concluding Remarks

This research work’s aim is to provide solutions to existing problems faced by farmers in India. A closer analysis of the requirements makes us realize that multi-agent systems are suited for tackling the problems. Multi-agent systems like other technologies, has its own characteristics and when applied to specific application context provides the best viable solution.

This thesis starts out with introducing the problem taken. The background research done and the problems faced are given in detail. A brief overview of the technologies available and the objectives of the research are talked about.

Second chapter explains the basis of agent technology and different kinds of agents available. The characteristics of multi-agent systems and its potential are explained. Along with this literature survey carried out gives brief history of multi-agent systems and presents the solutions available in the market. Shortcomings of the solutions available justify a need for this research and the developed application.

Once the objectives are set and technologies are finalized general architecture is explained. Multi-tier architecture is used and the various layers are illustrated. Tools and technologies used and the workings of each layer are explained in detail. Chapter four explains how to implement the general architecture and develop the application. Next chapter presents the output of running the application.

This thesis contributes techniques for tackling information overload problems with the use of intelligent agents. Multi-agent systems have been used in various domains and have proved to be very beneficial in providing solutions for real world dynamic problems. The application developed as part of this research eases information extraction process for farmers. The robustness of agent technology allows information to be retrieved from local knowledge bases and also from Web. Agents make integration of third party tools very impressive. Usage of these tools help aggregate and filter data and overcome technological limitations of users. Ontologies are used in this research for handling soil testing part of the application. This elucidates that it is very simple to integrate Ontologies and traditional databases in the same application. Similarly this research also uses fuzzy logic concepts to
handle uncertainties and vagueness in users input. The design is also kept uniform and simple throughout the application.

Farmers can greatly benefit from embracing this application. They can not only improve yields but can command better prices for their produce. The gap that exists between farmers, research and educational institutes can be bridged. Practical problems faced by farmers can be communicated in real time to experts. This application also facilitates creation of an online community making it easy to be in touch with other farmers to gain and share knowledge with others. The application is very practicable and can be easily extended to function as a commercial application to serve large audiences. I hope that the thesis contributions will prove useful in addressing the problems that arise in this and other domains.