Implementation of MVC (Model-View-Controller) design architecture to develop web based Institutional repositories: A *tool for Information and knowledge sharing*

Vinod Kumar[1], Abhinav Kumar[2], A.K. Sharma[3] and Dhiraj Singh[4]

1&3, Sr. Scientist, 4. Director, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur - 321303

2. Department of Computer Science & Engineering, Birla Institute of Technology, Mesra, India

Corresponding author e-mail: vky20@hotmail.com

Paper Received on June 08, 2016, Accepted on August 18, 2016 and Published Online on August 21 , 2016

ABSTRACT

The Institutional Repositories (IR) is a very powerful idea that can serve as an essential tool for Information and knowledge sharing. IR is a new method for capturing, collecting, managing, disseminating, and preserving scholarly works created in digital form by an institution. Therefore, need arises to develop an institutional repository (IR) to maintain the information on publications in an organized and accessible manner. The existing software tools for publications information management are not well suited for evaluation purpose, particularly for agriculture research with interdisciplinary aspects. We implemented a prototype web based institutional repository for the documentation of research publications and evaluation of performance. This prototype, which supports a wide range of publication types, is designed by implementing MVC (Model-View-Controller) architecture to meet the specific requirements of agricultural research institutions and has features like advanced search option, extraction of publications statistics based on a variety of visual form based queries, etc. System developed using open source technology LAMP allows to the researchers or users to access and enters the publication data in the database themselves. Public search facility has also been provided for searching records, dynamic browsing of publication lists and exporting the contents to various formats for creation of reports. This prototype can serve as a versatile tool for monitoring progress and facilitating evaluation of research quality at the individual and institutional levels in term of publications output. Most importantly system is very useful for the students pursuing post graduate and doctoral study, to search institute publications of their research interest.

Key words: *Research Publications; Research evaluation; Web-based information; MVC; LAMP system;*

In all scientific and academic research, publications are the most important form of communication of research. The scientific work of the researchers or research institutes is generally assessed by the quality of resulting research publications. To evaluate a researcher, research group or an institution, it is important to maintain a database of research publications. Therefore, need arises to develop institutional repository for maintaining information on publications in an organized and accessible manner. An Institutional Repository (IR) is a new method for capturing, collecting, managing, disseminating, and preserving scholarly works created in digital form by the constituent members of an institution (*Chang, 2003*). The Indian Council of Agricultural Research (ICAR) is one of the largest National Agricultural Research Systems (NARS) worldwide involved in agriculture research, education and extension having 5 deemed to university and nearly 100 institutes dedicated to different aspects of agricultural research (*ICAR, 2014*). Having the vast network of research facilities and the scientists working in diverse disciplines, it is necessary for ICAR to develop a publication database for monitoring and evaluating the quality of the research outputs through an objective assessment of the research publications.

The existing software tools for information

management of publications are not well suited for evaluation purpose, particularly for agriculture research with interdisciplinary aspects. In some scientific and academic areas, there are publication databases that cover their respective areas (*Poruban et al., 2005; Riedling, K., 2012*). Furthermore, these publication databases usually permit search for publications of a particular author, but do not have provisions for extracting complete publication statistics of scientists or institute for the purpose of evaluation of performance. In agriculture sciences with interdisciplinary aspects, publication information systems which may be appropriate for a comprehensive evaluation of particular scientists or research team or institute are not readily available. Keeping in view this, an exercise to develop an Institutional Repository (IR) for maintaining, monitoring and evaluating the research communication output from the Directorate of Rapeseed-Mustard Research (DRMR), which is mandated with the research and development of rapeseed-mustard crop in India, and is one of the constituent institutes of ICAR.

Since, the research publications are one of the important indicators of evaluation of quality research and attract the research collaboration; therefore, to evaluate a researcher, research group or an institution, it is important to maintain a database of research publications and communications. After inception of DRMR, quality research have been made and published in national and international repute journals. The volume of research publication at DRMR is increasing and information of research publication available at is scattered and not ready accessible for evaluation purpose. In response to fulfill the need of an intelligent publication information system to evaluate individual scientists or research teams at the institute level, DRMR decided to develop custom-designed online publication information system for the research institute to organize and maintain the information of publication and serve as an evaluation tool for publication outputs, through providing a powerful attribute-based search capability. The overall objective to develop this repository was to enhance the ability of the DRMR to manage all research publications of the scientists and generate the information for evaluation. The system developed supports a wide range of publication types and is designed by implementing MVC (Model-View-Controller) architecture to meet the specific requirements of agricultural research institutions having the features like advanced search option, extraction of publications statistics based on a variety of form based queries. The benefits of MVC architecture have the separation between model and view allows multiple views to use the same model. Consequently, an application's model components are easier to implement, test, and maintain, since all access to the model goes through these components (*Balani, 2002*). Metadata formats suitable for describing agricultural scientific and research publications have been used in creating the database (*Semik et al., 2012*).

This system was developed by using open source technology LAMP that allows the researchers or users to access and enters the publication data in the database themselves. With maximum of versatility in mind, IR was designed with functions to enter and display publication data, search the database for text in certain fields or in the entire entries, create publication lists, and calculate statistics data. It also reduces the time significantly needed for answering specific questions related to publications of an author or institution and the repository is named as DRMRPubInfo. Though, DRMRPubInfo is a prototype system developed for a single institution, the system can be implemented for any agricultural research organization for management of publication information and research evaluation.

METHODOLOGY

The design of a publication information system has to take into account two possible requirements, the completeness of the data held in the database, and ease of use for the intended users. Information in the database has to be as comprehensive and detailed as possible to allow for all conceivable queries. The system should also be capable of handling queries which requires processing of information related to the type and quality of the publication (*Karl, R. and Siegfried, S., 2006*). System design and development usually proceeds through several phases of software development life cycle (SDLC) that includes feasibility study (problem identification), requirement analysis (user's requirements), system design, testing, implementation and evaluation (*Kumar et al., 2008*). In general, users are not aware with, what to request and what really

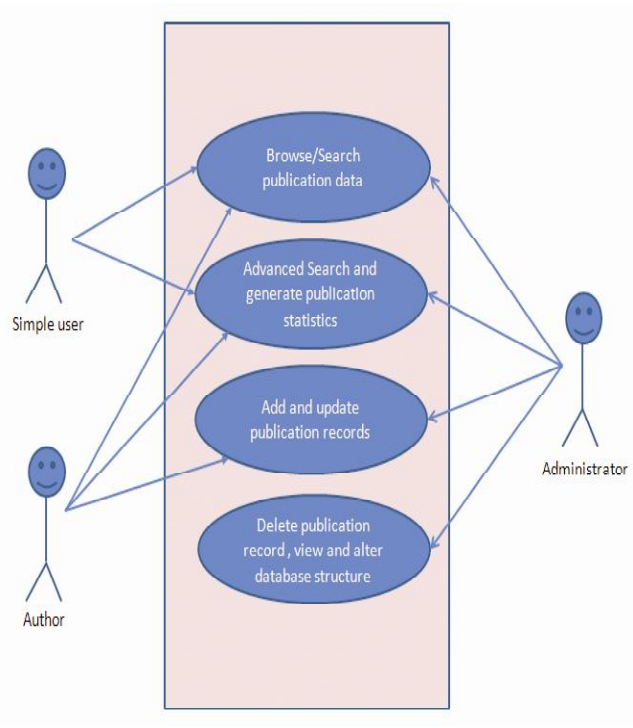

Fig.1- Use case diagram of the system

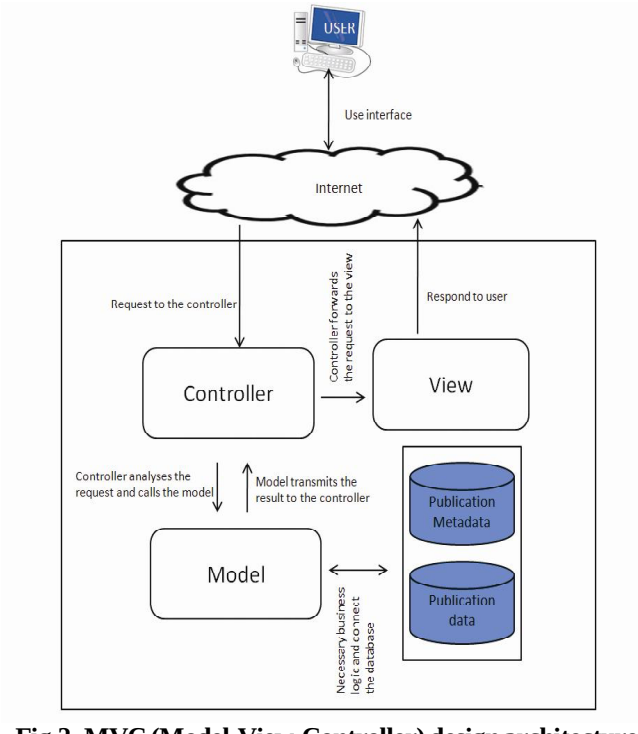

Fig.2- MVC (Model-View-Controller) design architecture of the system

may facilitate and simplify their work. The success or the failure of a software system depends mostly on its utilization. If the software doesn't help and facilitate user's work and complicated or time-consuming for them, then they will never use it. Therefore, the correct definition of functional requirements is essential. Following this concept, the discussion sessions were organized with the possible users of the system i.e. personnel involved in publication information management, researchers and administrators at the DRMR, Bharatpur to find out their requirement. After acquiring and collecting the necessary required information from the users, structuring the information and defining what really will facilitate the work of each of them were needed. In figure 1, a use case diagram of the system is depicted.

MVC (Model-View-Controller) design architecture: The system designed using MVC (Model-View-Controller) design architecture which is very useful for architecting interactive web based applications (*Leff, A. and Rayfield, J.T., 2001; MVC, 2013*). MVC encapsulate data along with its processing (model) and isolate it from the process of manipulation (controller) and presentation (look/view) to be represented on the User Interface. MVC follows the most common approach of Layering. Layering is nothing but a logical split up of our code in to functions in different classes. This approach is well known and most accepted approach. The main advantage in this approach is re-usability of code and easier to maintain and develop as well as to further upgrade with new features in the future (*Satish, 2004*). In the process of developing DRMRPubinfo, each layer in the architectural of MVC (Model-View-Controller) have been implemented differently such as MySQL database which serves as a model, HTML, Java Script used for the user interface(view), and PHP web service as a controller. PHP is a powerful language to develop dynamic and interactive web applications. One of the defining features of PHP is the ease for developers to connect and manipulate a database. PHP prepares the functions for database manipulation. However, database management is done by the Structure Query Language (SQL).

The resulting system architecture designed to develop an efficient research publication information system that has been built using the implementation of the MVC (Model-View-Controller) design pattern is presented in fig.2

The model means the business logic of the application and is the core of the application (*Li et al., 2006*).

The common classes in the model are: connect DB, insert, update, delete, select, etc. These classes are to be used for manipulating the database and here MySQL database serves as a model. The view is the user interface of the controller and is the public face of the user event's response (*Padilla, A., 2009*). In publication database, multiple views for different purposes are designed and developed with HTML, cascading style sheets (CSS), Javascript, etc. The controller component implements the flow of control between the view and the model (*Karam, et al., 2006*). It contains code to handle the user actions and invoke changes in the model.

Data Model design: Database contains the information on publications and authors who have written. Multiple authors may write one publication, and an author can write many publications. Authors are publishing different type of publications; in this system we distinguish all publications come out from agricultural research institute such as DRMR into 12 different categories. These includes, research paper published in journals, conference or seminar paper, research thesis, technical bulletin, extension folder, annual report, book, book chapter, training manual, popular article, news letter and magazine. The data actually kept in an entry depend on the categories of the publication. The publication entity includes fields, title, abstract, contributing author, journal name, year of publication, volume, issue, pages, publisher name, address and doclink of document. The author entity includes the attributes, author name, discipline, research interest and address. The publication categories and simplified representation of ER diagram of the database structure of publication database is presented in the fig. 3.

Publication data : Since its establishment in 1993, the Directorate of Rapeseed-Mustard Research (DRMR) has been conducting multiple research programmes in an effort to improve the rapeseed-mustard crop. The research outcomes have been communicated by the personnel of the directorate through different publications. The comprehensive list of publications under different categories viz, research papers,

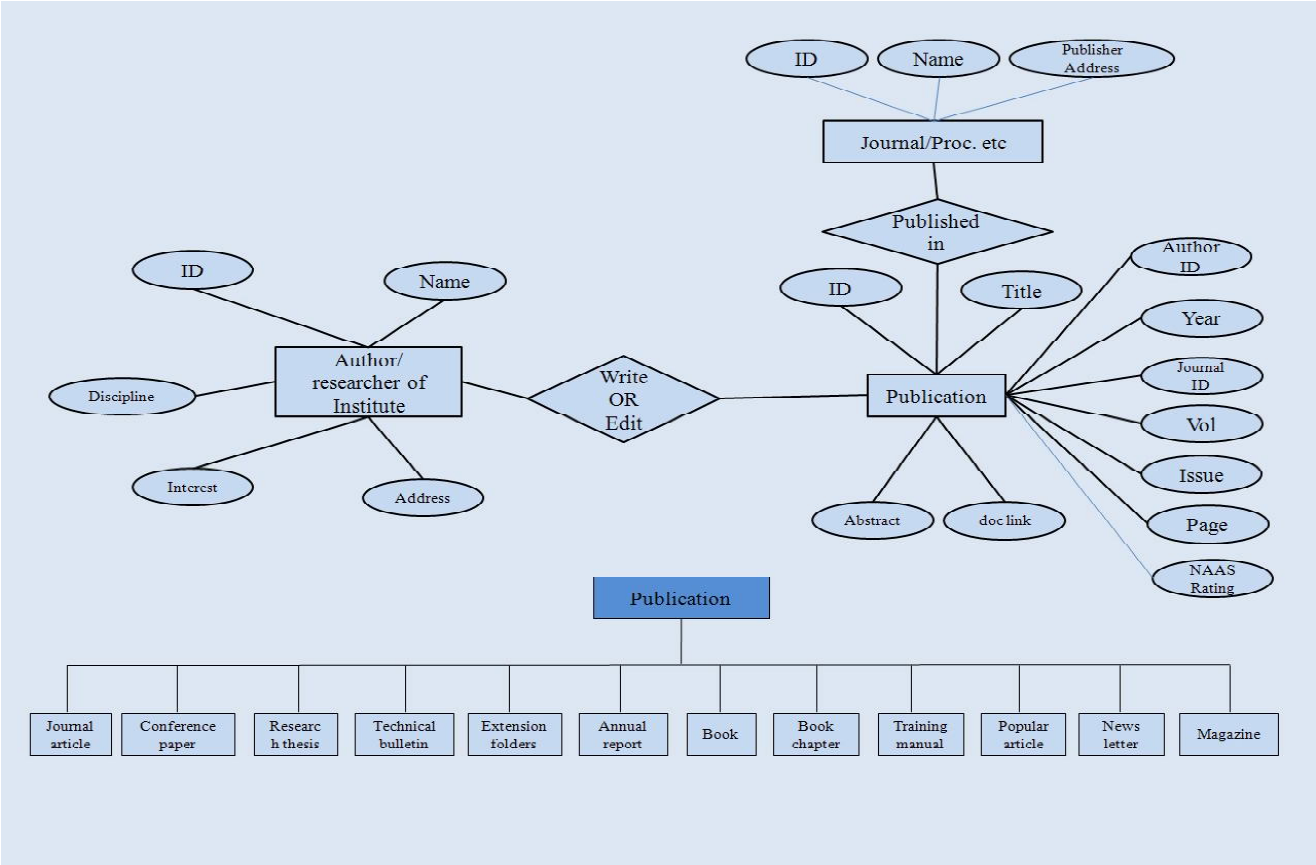

Fig.3- ER diagram and publication categories

Metadata Schema categories	Metadata vocabulary terms
ID	DPUB1301
Publication category	Research Paper
Title	Design and implementation of web-based aphid (Lipaphis erysimi) forecast system for oilseed Brassicas
Author	VINOD KUMAR, AMRENDER KUMAR and CHIRANTAN CHATTOPADHYAY
Journal name	Indian Journal of Agricultural Sciences
Abstract	Oilseed Brassicas are major crops in India and world over. Keeping in view severe losses caused by aphid (Lipaphis erysimi) in these crops, efforts were initiated to devise user-friendly web-based software for forecasting their occurrence. Multiple stepwise regressions have been followed.....
Year of Publication	2012
Volume	87
Issue	7
Pages	618– 622
NAAS Rating	6.6
Publisher name	ICAR, New Delhi
Doc_link	Doc/DPUB1301.pdf

Indian Journal of Agricultural Sciences 82 (7): 618-22, July 2012

Design and implementation of web-based aphid (*Lipaphis erysimi*) forecast system for oilseed Brassicas

VINOD KUMAR[1], AMRENDER KUMAR[2] and CHIRANTAN CHATTOPADHYAY[3]

Directorate of Rapeseed-Mustard Research (ICAR), Bharatpur, Rajasthan 321 303

Received: 22 October 2011; Revised accepted: 23 March 2012

ABSTRACT

Oilseed Brassicas are major crops in India and world over. Keeping in view severe losses caused by aphid (*Lipaphis erysimi*) in these crops, efforts were initiated to devise user-friendly web-based software for forecasting their occurrence. Multiple stepwise regressions have been followed for developing aphid prediction models in practice. Interpretation and use of these models was difficult for any person not having proper statistical knowledge. Further, keeping in view the need of online software tool to help the plant researchers, extension personnel and farmers in forecasting of aphid infestation and timely application of control measures, the study was carried out. This paper introduces design and implementation of web-based forecast software for prediction of aphid on oilseed *Brassicas* in India. The software uses statistical prediction models developed based on weather parameters as independent variables and crop age at time of first appearance of aphid on crop, peak number of aphid and crop age at peak population as dependent variables, which were fitted by multiple stepwise regressions. The software has been developed by deploying ubiquitous unbeatable open sources technology. The system provides a prediction of mustard aphid infestation well in advance of their actual arrival on the crop along with recommendations for need-based insecticide application.

Key words: *Brassica*, Forecast software, *Lipaphis erysimi*, Prediction model, Web-based system

Globally India ranks third in production of oilseeds Brassicas and contributes 14.8% of world production. In India, oilseeds Brassicas contribute 23.7% of acreage, 26.0% of production of and play an important role in oilseeds economy (Chauhan and Jha 2011). Of the various insect-pests and diseases limiting rapeseed-mustard productivity, *Lipaphis erysimi* (Kalt) continues to be an enigmatic problem in husbandry of oilseeds Brassicas in India. It is favoured by low temperatures (8-18°C) coupled with 60-80% relative humidity and cloudy weather. Losses due to mustard aphid can reach upto 80% when conditions favour multiplication of the insect-pest (Mandal *et al.* 1994) and are very difficult to manage when conditions are favourable. Yield losses due to aphid on oilseeds Brassicas could be regulated

destructive insect-pest of rapeseed-mustard despite decades of research towards its management. Weather has a very important role to play in the appearance, multiplication and spread of the insect-pest. Considerable efforts have been directed towards developing aphid resistant cultivars. But due to absence of stable, desirable and diverse source of resistance to the mustard aphid with a broad genetic base, systematic use of insecticides has been the most practical way to manage *Lipaphis erysimi*. However, due to high cost of chemicals as well as their hazardous effects, use of insecticides need to be only need-based. Although consumption of systemic insecticides on rapeseed-mustard crops in India is high (IASRI 2009), timing their application has been erratic. Crops requiring treatment have been left

Fig.4- Metadata and schema design

conference proceeding, technical bulletins, thesis, etc. were acquired by scanning old institutional publications. Most of these publications were acquired electronically from the publishers and some of the publications were available as openly accessible documents. The publication database contains information about all the publications related to rapeseed-mustard research conducted by the researchers of the institute under the categories listed above. The database contains full-text material of the published publication available in electronic form wherever possible.

Metadata base and schema design : The concept of metadata of publication is used in the creation of database. This will allow filtering and provide enhanced search effectiveness within the database. Publication metadata elements provide standard information about the research publication. The most commonly used metadata formats and thesauri suitable for describing scientific communications in the agriculture domain include the Dublin Core (DC), Metadata Object Description Schema (MODS), Virtual Open Access Agriculture and Aquaculture Repository Metadata Application Profile (VOA3R AP) and the AGROVOC thesaurus. The DRMRPubinfo system uses the VOA3R Metadata Application Profile integrated with DC and AGROVOC thesaurus (*Semik et al., 2012*), which is one of the most suitable and viable metadata formats for content description in agriculture. Figure 4 presents the metadata schema designed using MYSQL for effective management and retrieval of research publication. Data parameters to be indexed along with each publication are: ID, title, authors, journal name, publication year, volume, issue, page numbers, etc.

User interface and system implementation strategies: User interface was designed keeping in view the three types of users which includes simple user, authors and administrator. The page diagram of system for user interface has been presented in fig.5, where simple users can only go through the solid lines while authors and administrators can go through both solid and dashed lines. A user-friendly interface for the system has been developed by suitably designed GUI. The system has been designed to provide metadata-based filtering to facilitate appending, editing, browsing and searching.

DRMRPubinfo is implemented using Model View Controller (MVC) architecture and the open source technology LAMP (Linux - Apache - MySQL - PHP). MySQL database was used for back end data storage,

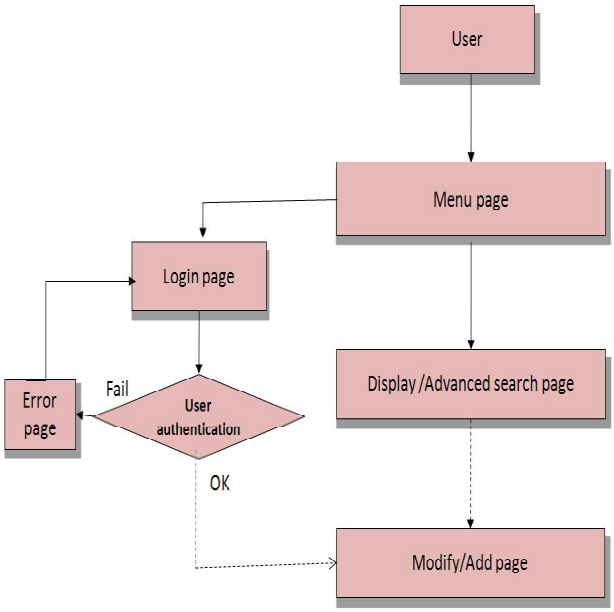

Fig. 5- User interface diagram of the system

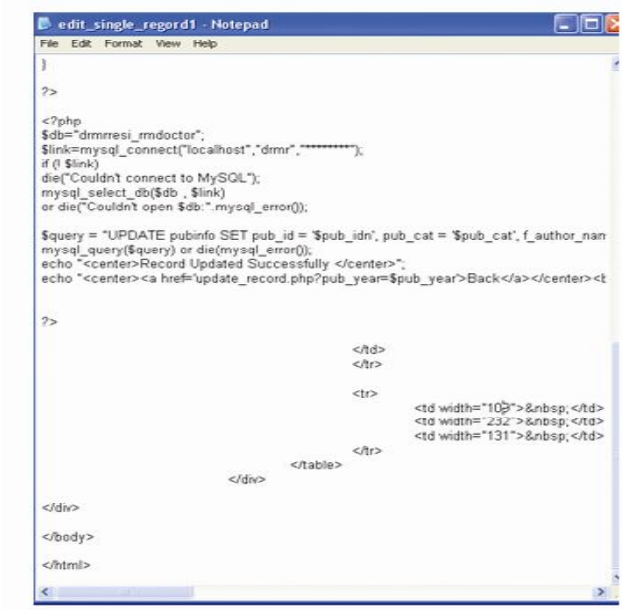

Fig.6 The code for model

Fig.7 The code for Controller

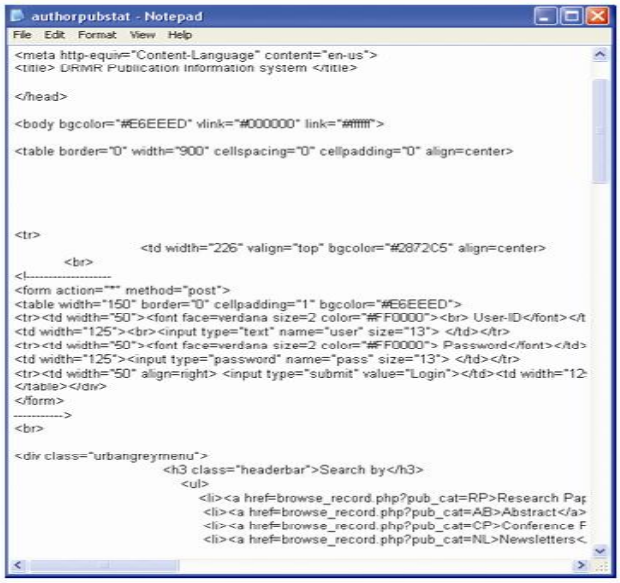

Fig.8 The code for Controller

and required tables were created.

For describing implementation of Model View Controller (MVC) architecture in the developed system, the part of codes have been presented in illustrations. The MVC architecture is implemented in every application module. Every module has one model, one controller and some view. The model consists of at least one file which is responsible for accessing the data into the database. Fig 6 is a sample source of model.

A controller consists of three types of files. The first file is to handle user responses, the second file is to handle feedback and the other file is to connect with the model, the controller user responses handling shown in fig 7.

A View is responsible for displaying the information into a graphical interface. One view must have one controller that handles requests from users and feedback. Fig.8 is an example of the view:

The interface has been developed in “English” language with a view to provide global access to the system. The hardware specifications include high end servers and storages devices. The system operates in sharing mode on a server running Linux kernel 2.6.18-

194 operating system, MySQL version 5.1.56, Apache 2.2.21 and PHP version 5.1.17.

RESULTS AND DISCUSSION

DRMRPubinfo is the DRMR's system for managing research publications. The system can maintain details of all publications about the research carried out at the DRMR and provides information to different stakeholders both within and outside the country. The system is used to populate author pages with publication details and provides quantitative and qualitative information on publications for evaluation of performance of researchers. The DRMPubinfo is an interactive user-friendly system that allows users to perform record searches, insertions, updates and deletions conveniently without any specialized training or knowledge of Structured Query Language (SQL). The users using the system are divided in three classes. The first one contains the users with administrative privileges, called 'Administrators' who have the responsibility of maintaining the whole system through the addition, deletion or modification of the publication records. The second class contains the 'Authors' who is only be able to modify aspects of their previous added publications. Finally the third user class consists of 'Simple users' who have only read privileges. Read privileges have also been granted to all users. The application is mostly benefit 'Administrators' and 'Authors' classes by making their job easier through the use of the system facilities. It is obvious however that a well maintained and up to date system will also benefit 'Simple users' as they will always be kept informed with fresh information. Manager of research institute even being simple user be able to evaluate the performance of institute or individual researcher so-called 'Authors' in term of publication output.

The system offers significant saving of digital space and requires lesser time for updating and management of digital research publication information. The integration of the capabilities to add new publication, search, browse, export, generate statistical reports and to e-mail selected publication makes the system a versatile tool for research evaluation and monitoring. Besides the system administrator, each scientific personnel are provided with a login account to add their own publications to the DRMPubinfo database. Figure 6 is a sample screen-shot of user interface.

IUD records operation : The potential use of the system for maintaining publication data and researcher i.e. author evaluation purpose mandates that the record operations; INSERT, UPDATE and DELETE (IUD) must be performed in a secure manner. For secure transaction of records, the system operates in administrator and user mode. After login as administrator the insert, update and delete of records can be performed. After successful login, system populates the only results that relate to the author and enable to modify records. Figure 6 shows a screen-shot of the interface for inserting and updating new records of publication to the database. There may be multiple authors belong to a publication, therefore before adding new publication record, the system checks for the duplicity of records in database. To avoid typographic errors, the system provides a dropdown menu option for selecting different attributes.

Search features of the system : This is the main feature of every publication information management system. The system provides a powerful facility to search the publications within the database. There are three primary methods of searching for publications in DRMRPubinfo: (1) Browsing by publication categories, (2) Keyword based search, and (3) Advanced search based on different attributes (Fig.9).

Browsing publication categories : Publications in the database have been organized into different categories such as research paper, abstract, conference proceedings paper, edited book, book chapter, research report/notes, technical bulletins, newsletters, edited conference proceedings, training manuals, etc. In category search the system provides complete information of the publication published by the institute in the category. Besides these, it also gives the counts of publications available in database for a category (Fig.9).

Keyword-based search: DRMRPubinfo has comprehensive information of publications including books, monographs, research papers, discussion papers, conference proceedings, technical bulletins, etc that reflect the research interests of the institute. Retrieving information on a specific publication is usually time-consuming since the users have to browse the entire information of a category in publication database. To overcome this limitation, the software provides a keyword search facility. In keyword search the whole database can be searched for specific keywords and

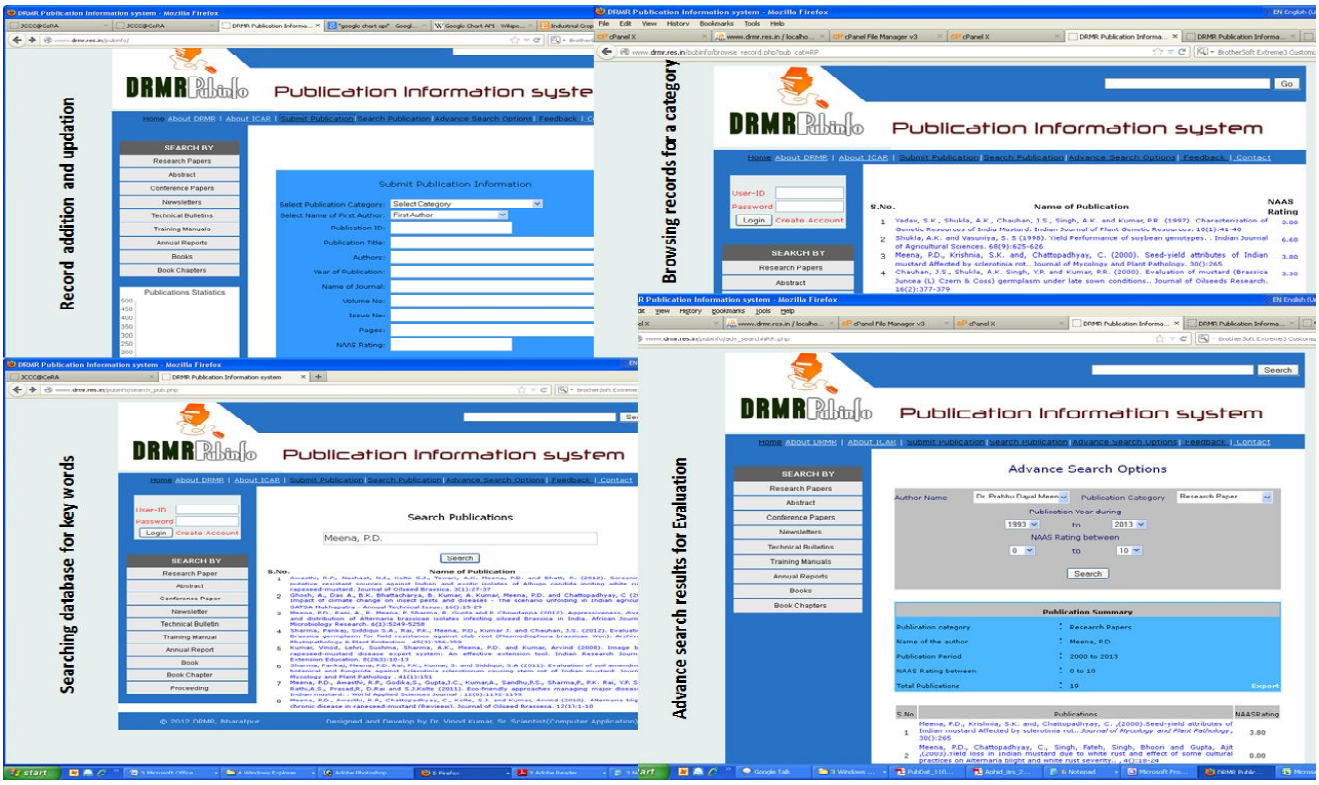

Fig.9- A sample screen-shot provides the user interface

the list of publication that matches the keywords is displayed (Fig.9). It also provides the list of important keywords and automatically enters the keywords for better search results.

Advanced search options : The database uses third party publication quality evaluation data for enabling search based on quality parameters under advanced search option. The National Academy of Agriculture Sciences (NAAS) evaluates research journals related to agricultural research and provides a rating which is a widely recognized rating index in India. The journals having the Thompson Reuters Impact factors are assigned a rating between 6.0 and 10.0 based on their standing in Thompson Reuters Impact factor list published yearly. The journals which are not available in Thompson Reuters Impact factor list are assigned a rating between 1.0 and 5.9 (NAAS, 2013). The integration of rating parameter in the database allows certain complex searches and provides more control over the quality and relevance of the results. The advanced search option is designed for users who wish to specify exact search criteria to search the publication in database on user-specified attributes. In addition to listing only publication detail specific to that individual author, it provides the faculty member's educational degree, discipline, research interest and contact information. Most preferred advance search options provided by the system are presented in the Fig.9.

Publication statistics : An important feature of the system is to generate customized dynamic statistics of publications which can be utilized for report generation, performance evaluation and monitoring of research publications, institutions and individuals. For evaluation of a researcher, system provides statistics such as number of different publications published by author, even of research papers published in different impact factors rating journals. Statistical of publications generated dynamically as and when query made and depending upon query, therefore it has not been stored in the database. Coding has been done for presentation of statistical data. For graphical presentation of data, Google Chart API was integrated into the software. Google's Chart API is a tool that allows embedding dynamic charts and graphs to enhance interactivity (*Google Inc. 2012*). In this way, summary of publication statistics for DRMR can also be generated in graphical form.

CONCLUSION

The potential uses of Institutional Repositories content in other digital environment are countless.

Institutional Repositories content does not need to 'sit' in the Institutional Repositories only. It should be brought into new digital environments where it can be easily consulted, represented and integrated with other current research extension and educational activities. The DRMRPubinfo is a web based application aimed at facilitating the management of large collection of research publications, by implementing automated organization techniques, powerful but concise interface methods and optimized data handling. The user interface provides several means for browsing, navigating, searching, filtering and exporting publications information. MVC (Model-View-Controller) design pattern using LAMP technologies were selected as an implementation platform for the system. DRMPubinfo database contains comprehensive coverage of DRMR's research/technical publications dating back to the inception of institute in 1993. Although a formal assessment of the system has not been done, informal feedback shows very positive reviews by DRMR librarians, researchers or authors, and administrators due to effective management and the easy user interface. There exists sufficient inbuilt flexibility in this publications system so that it can be adapted by other agricultural research organizations specially other ICAR institutes. Further refinement and augmentation of the capabilities of the application in response to user feedback is important to enhance the quality of the software.

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