A WEB-BASED DATABASE APPLICATION FOR THE IRRADIATION SERVICE MANAGEMENT AT CVR

Guangling Chen, Adela Klepáková, Michal Koleška

INTRODUCTION

The research reactor LVR-15 at the Research Center in Řež (Centrum výzkumu Řež in Czech, hereby CVR) is utilized for basic and extended material research, neutron activation analysis, development and production of new radiopharmaceuticals and radioisotopes, silicon neutron transmutation doping for the electronic industry, medical treatment, neutron measurement, sample irradiation, and other scientific research.

The irradiation services at LVR-15 reactor and epithermal neutron beam provide:
- irradiation of material samples by the epithermal neutron beam,
- sample irradiation in vertical irradiation channels,
- production of neutron doped silicon,
- production of medical and technical radioisotopes: 99Mo-99mTc, 113Sn-113mIn, 188W-188Re, 60Co, 192Ir,
- other production of radiation sources according to specific customer requirements.

The reactor LVR-15 operates in cycles. Usually the cycle lasts for 3 weeks, followed by an outage lasting for 10-14 days for maintenance and fuel reloading. There are also other cycles which can operate for ‘short-time’ experiments.

The irradiation service can be assimilated to the common production process. A particular distinguishing feature for the irradiation service is the information management and the communication process which constitutes a determinant factor for the efficiency of human resource cooperation.

Thamhain and Wileman stated that effective communication among task groups is one of the most important factors for the success of a project.

The present time, the management and the processing of all the orders of the irradiation service are done manually using several Excel files. The efficiency of the data processing has been extremely restricted by the traditional file processing method. Therefore, it was necessary to design a database application for the order management for solving the lack of the traditional order processing procedure.

The aim of this paper is to bring the process of the Order Management System (hereby OMS) development at CVR. In the first chapter the authors present the theoretical background and current situation at the CVR. The second chapter brings the analysis, the proposals, as well as the database design and the implementation of the management system. In conclusion the authors summarize the most important points for developing the OMS and its content.

1 THEORETICAL BACKGROUND AND REQUIREMENT ANALYSIS

The irradiation service process cannot be simply considered to be a buying–stocking–selling model because of the especially strict requirement of the time and safety precision. The development of an OMS that combine database and web technologies is considered beneficial for the irradiation service management at CVR from the various aspects. Theoretical background and requirement analysis of CVR will answer the question of necessity for introduction of new OMS.

1.1 THEORETICAL BACKGROUND OF OMS

The OMS have become a critical component in the business management. The rapid development of IT technology had big impact on the traditional telecommunications market, transforming it from monopolistic market to highly competitive high-tech market where new services are required to be created frequently. Therefore, today’s OMS is a robust platform that performs portfolio modeling, runs detailed compliance checks, provides advanced trading functionality, and offers enhanced reporting capabilities.

An integrated order management system may encompass these modules:
- Product information (descriptions, attributes, locations, quantities),
- Inventory availability and sourcing,
- Vendors, purchasing, and receiving,
- Marketing,
- Customers and prospects,
- Order entry and customer service,
- Financial processing (billing, payment information),
- Order processing (selection, printing, picking, packing, shipping),
- Data analysis and reporting,
- Financials (accounts payable, accounts receivable, general ledger).

OMS first became available in the early 1990s. Early OMSs revolutionized the way the buy and sell-side conducted business. Today, OMSs are robust, multi-asset and multi-functional systems that are continually enhanced, principally performing middle and back office functions.[5]

In general, an OMS is a computer software system used in the industries for order entry and processing. The OMSs are normally developed as a database management application or platform that facilitates and manages the order execution.

1.2 THEORETICAL BACKGROUND OF DBMS

A database refers to the data themselves and supporting data structures.[1] Databases are created to operate large quantities of information by inputting, storing, retrieving and managing that information. A database management system (hereby DBMS) is a suite of computer software providing the interface between users and a database or databases.

In 1970, Edgar Codd described a new system of the relational Database Management System for storing and working with large databases.[4] Since then, the concept of the relational DBMS has been used in the industry management for information sharing and productivity improving. By the end of last century, most of the DBMS software was generally developed into the desktop-application.[3] However, some of the DBMS software was developed using the Client-Server model to accomplish the large-scale tasks. Therefore, the shortcoming for the desktop-application becomes more obvious. One inconvenience is that the packaged software needs to be installed and configured properly in the appropriate environment and operation platform after the development. Nowadays, with the development of software technology and network, it is much more popular and easier to develop the DBMS application as a website to make it user friendly. The access to the DBMS will not be restricted by the operation environment and system. Moreover, it can be visited on any kind of devices, including the desktop computers, the laptops, as well as the smart phones and the tablets.

1.3 REQUIREMENT ANALYSIS

Current situation

Similar to the common situation in the small-scale facilities or companies, the management of the orders and the production process mainly has been done manually using several Excel files. The shortcoming for the traditional management method includes:
- the documents are manually prepared for various departments;
- there is a data inconsistency and redundancy;
- it is difficult to store, sort and manipulate the documents;
- it is difficult to search or to analyze the data;
- unclear processes and responsibilities;
- the risk of making mistake might be increased by manual input of the data.

Why in this situation?
- it is not necessary to spend too much for a professional management system;
- people are accustomed to the method which they are already familiar with;
- it is hard to find a reliable, simple and convenient method to improve the current situation.

The idea of OMS should include:
- less cost but excellent in quality;
- easy to use, customized to fulfill the requirement;
- convenient for development and maintenance.

The general requirement for the new OMS should include:
- the possibility to input data from different interfaces on different terminals;
- the option to save data or information in the database on the server;
- the option to generate the reports based on the requirement on terminals.
The other requirement aspects include:
- it is better to make the new system to be a web-based Client-Server database system for the requirement of data inputting and report generating in different terminals;
- the interface for inputting data should be as simple as possible. It is necessary to provide the graphic user interface to simplify the input method;
- it is better to provide flexible options for data inquiring and data searching;
- other requirement about the system safety, reaction speed and reasonable layout should be taken into account.

We provided the requirement analysis and summarized our suggestions into the Table 1.

<table>
<thead>
<tr>
<th>Tab. 1: Three plans suggested</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan A</strong></td>
<td>- the professional OMS application from software providers are robust, multi-asset and multi-functional, - no need to involve the own employees, - application will be developed and put into the use based on the needs and requirements.</td>
<td>- high cost, - if the requirement cannot be fulfilled, the customized application will cost much more.</td>
</tr>
<tr>
<td>To purchase the professional OMS application from software provider</td>
<td></td>
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<tr>
<td><strong>Plan B</strong></td>
<td>- the technique has become refined for developing the desktop application.</td>
<td>- the developer tools such as Microsoft Visual Studio, usually cost up to thousands of EUR, - the free tools don’t provide very good support for GUI (Graphical user interface).</td>
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<tr>
<td>To develop the desktop application.</td>
<td></td>
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<tr>
<td><strong>Plan C</strong></td>
<td>- we can choose the open-source platform LAMP (Linux + Apache + MySQL +PHP), as well as the free programming language such as HTML/javascript/CSS, - the system can be visited on any kind of devices, - WYSIWYG (what you see is what you get). It is easy to develop, debug, and test the functions of the system.</td>
<td>- the technique support for the open-source platform and software is deficient, - the risk of the security of the database might exist if the security for the web site has not been well considered.</td>
</tr>
<tr>
<td>To develop a web-based database system as the OMS for the irradiation service management</td>
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</tbody>
</table>

Source: processed by the authors

Based on three suggested plans from Table 1, plan C was agreed and accepted as the most suitable for CVR. The requirement of the budget is perfect for the small-scale facility or company.

2 THE DEVELOPMENT OF THE SYSTEM OMS-CVR

The web-based database systems present diverse emphases in different industry areas. Basically, there are three types of web-based applications, the fee-based project management service, the build it yourself solutions and the web-enabled software. [11]

The web-based database systems are considered to increase efficiency of the productivity and management based on the acquisition of data, storage of useful information in databases and generation of report when needed. Additionally, the web-based database systems can be used to assist nuclear organizations or companies in doing the process optimization and stimulating the possible activities.

The proposed system named OMS-CVR (order management system for CVR) is a web-based database system that can be used to enhance the control of irradiation process to make better decisions at CVR. Besides, we suggest a time-node management method for the irradiation service process management. The main point of the time-node management method is to set up a database to store all the information by the time points of the irradiation process. The information that relative to the time-node includes the order number, the cycle number, the customer name, the exact date and time point, the location of the material to be irradiated in the core, and the action to be performed (load/unload/relocate) at the time point. Based on the time-node database, the irradiation process can
be efficiently planned and controlled. Moreover, with the help of the database, it will be convenient to optimize the irradiation process, and to adjust, modify, or update the irradiation process. Furthermore, combining with other information such as the information for the customers, orders, and operation performance stored in the database, the necessary documentation can be easily generated. Based on the model, a web-based application which is useful for the irradiation service management in the reactor LVR-15 at CVR as well as other nuclear organizations or production companies has been developed.

2.1 THE SYSTEM ARCHITECTURE

The system design is shown as Fig. 1. The OMS-CVR generally contains 3 parts of functions, the Information Management, the User Management, and the Report Generating. Each of the parts contains several modules. For example, the part Information Management contains the modules Customer, Contract, Order, Cycle and Time-node, Relative Document, Irradiation Processing, Monitor Requirement, etc. Furthermore, each of these modules (Customer, Contract, Order, Cycle and Time-node, Relative Document, Irradiation Processing, Monitor Requirement, etc) contains several sub-modules to accomplish more detailed actions. For example, the module Customer includes the sub-modules add new Customer, View Customer Info by Name, View All Customer, etc.

Fig. 1: The system design for the OMS-CVR

As a web-based database system, the OMS-CVR allows users affiliated with the company to access to the system from anywhere through their accounts. OMS-CVR provides various authorization levels for the users. The content of each section can be added, updated, or deleted according to the fact of authorization leveling. People with different responsibilities have different authorization for their actions. For example, people who is responsible for the measurement after the irradiation may have no authorization to edit the information for Cycle and Time-node. People who have no authorization to edit any content can only access the page to view the limited information such as the schedule of the operation cycles of the reactor.
2.2 THE DATABASE DESIGN

The main phases for the database design are the entity modelling and normalization. Entity modelling is used for determining which tables (entity types), fields (attributes), and relationships will be needed in the DBMS.

In the database, data is stored as a set of records in tables which is structured with a set of fields. Each table in the database can be abstracted as an entity. The fields of a table represent the attributes of the entity. After defining the tables and the field list for each table, a primary key is required to be set for each table. The primary key is used to uniquely identify each record in the table. The relationships are used to define the logic association between the entities (the different records in different tables). The foreign keys are employed to build the relationships (the connection between the appropriate fields of tables). A foreign key is a field (or collection of fields) in one table that uniquely identifies a row of another table.

The entity modelling should follow a set of rules (called the normalization) to check for any anomalies in the database design. There are three tests (normal forms) for normalizing a relational database which are commonly applied [2]:
- there must be no repeated field groups in each record;
- all non-key fields must depend on all fields that constitute a primary key;
- there must be no functional dependencies between non-key fields.

The normalization tests are repetitively applied to each field of the tables to reveal existing problems in the database. If problems exist, the database should be redesigned.

After the design and the optimization, 15 tables with a total of 102 fields have been developed for the database for the OMS-CVR. Some of the entities with their main attributes as well as the relationships among entities are shown as the Entity – Relationship diagram in Fig. 2. The rounded rectangles indicate the entities such as Customer and Order. The attributes of the entities are represented as the shape of ellipse such as Customer Name and Customer Id. The shape of diamond indicates the relationship or the connection between the entities such as Contract No. and Cycle Name.

Fig. 2: The Entity - Relationship Diagram for the database design of the OMS-CVR

2.3 THE WEB APPLICATIONS DESIGN AND THE IMPLEMENTATION

The web-based application OMS-CVR is developed as a dynamic web site which contains a set of data-driven dynamic web pages providing the interface between the web site and the users to perform certain actions according to the authorization level granted to the users. A dynamic web page is a web page whose construction is controlled by the web server processing server-side scripts. The content of
such a page at any time is determined by the user's request for information and the information stored in the database at this time. Dynamic web pages allow data insertion, retrieval, and modification in the database. A web application is a program which interacts with users through the client and server components over a network. Web applications manage user interactions, state, security, and performance.[10]

There are sorts of free and open-source software provided in the Internet for the dynamic web sites and web applications development. One of the most popular and outstanding platforms is the LAMP model. LAMP is an acronym for an model of web service solution stacks, originally consisting of the components: Linux operation platform, the Apache HTTP Server, the MySQL relational database management system, and the PHP programming language. As a solution stack, LAMP is suitable for building dynamic web sites and web applications.[7]

The LAMP stack has been built for the development of the web site for OMS-CVR. The platform Ubuntu 12.10 has been selected as the Linux operation system, while Apache 2.0 has been adopted as the HTTP server, and MySQL 5.0 as well as PHP 5.2 is used as the main programming languages for the back-end scripts for the web site. Furthermore, HTML, JavaScript, and CSS are also used for the development of the front-end webpages.

The components of web site for the proposed system follow the structure of the database model which shown as the Fig. system design for the OMS-CVR in Fig. 1. The web site contains a set of web pages for each module of the system. The basic applications have been generally designed for each module. The applications include inserting a new record into a database table, searching the information from the records in the database according to the appropriate parameters, as well as deleting the records with the provided authorization. The inserting pages allow the user to add a new record in a very convenient way by providing a set of detailed function modules such as the date and time input box, the auto-generation of the time-node number, the location choosing box, the cask type choosing box, etc. The searching pages strictly follow the search criteria to perform the data selecting and sorting functions when the user submit the searching request, and to provide the result page in a clear layout. The report generating page provides the speedy way to edit the document for describing the relative details for the irradiation service process and result by choosing the specified order number or other information. Moreover, the log-in page has been developed to check the authorization level of the users by comparing the user name and the password with the cryptic user information in the database.

Fig. 3: Example of the web appearance

An example of the interface of OMS-CVR is shown in fig. 3. The page provides the links to the major components of the system by the main menu bar in the top area. The main menu bar contains sub-menus for each component. Take the module Cycle and Time-node for example, the sub-menu will pop out while the mouse pointer has been moved to or over the menu Cycle and Time-node. It will lead the user to the Add Time Node page by clicking the item Add Time Node in the sub-menu of the menu Cycle and Time-node. Furthermore, the report documents can be easily generated by choosing
the Generate Report function from the main menu bar. The layout of the generated document has been designed according to the format of the paper document in the company. The report document can be speedily generated from the database by combining together the data tables such as Customers, Order, and Operation in the database.

CONCLUSION

The OMS-CVR system is proposed to perform more efficient management of the irradiation service at CVR instead of the traditional paperwork-based management method. The authors proposed a time-node method for the irradiation service process management. Based on the method, a web-based application which is useful for the irradiation service management in the reactor LVR-15 at CVR has been developed. The system consists of a relational database and a set of dynamic webpages that allow the users to remotely interact with the database and to perform certain actions, such as inserting data, searching information, updating records, deleting data or generating and printing reports. The database consists of 15 tables and 102 fields and contains the components including Customer, Cycle and Time-node, Order, Radiation, Dispensing Contract, Monitor Requirement and Relative Document, etc. The database was implemented using MySQL while the web pages were built using PHP and front-end webpage development languages HTML, JavaScript, and CSS. Apache 2.0 has been used as the HTTP server.

Introduction of the web-based management system at irradiation service process will decrease the risk of making mistake while dealing with datas. Also it will increase the convenience of storing and retrieving documents related to the whole irradiation service process.

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A WEB-BASED DATABASE APPLICATION FOR THE IRRADIATION SERVICE MANAGEMENT AT CVR

Abstract
The irradiation service process cannot be simply considered to be a buying-stocking-selling model because of the extremely strict requirement of the time and safety precision. Different from the other production processes, the irradiation service requires especially close cooperation among the people from different departments. This paper proposes a time-node method for the irradiation service process management. Moreover, it presents a web-based database application OMS-CVR which can improve the irradiation service management at the Research Center in Řež based on the time-node method. The system consists of a relational database and a set of dynamic webpages that allow the users to remotely interact with the database and to perform interactive actions. The database was implemented using MySQL while the web pages were built using PHP and front-end webpage development languages HTML, JavaScript and CSS. Apache 2.0 has been used as the HTTP server. Introduction of the web-based management system at irradiation service process will decrease the risk of making mistake while dealing with datas. Also it will increase the convenience of storing and retrieving documents related to the whole irradiation service process.

Key words
irradiation process, database, order management system, web-based system

JEL Classification
M15, O21, O32