

Research Instrument Management System: RIMS, an Application for Lab Instrument Reservation Utilization

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ABSTRACT

Objective: Instrument administration including accessibility control, schedule time for reservation, and periodical machine utilization are essential tasks for high-end molecular laboratory. Such repetitive work can be automated using information technology.

Material and Methods: As a part of Laboratory Information Management System (LIMS), the Research Instrument Management System (RIMS) is an online application using a user-friendly platform constructed for efficiency of access, end-user communication, instrument reservation.

Results: RIMS utilizes instrument information including the date of set up, machine identification, last preventive maintenance and financial record. Data logging and periodic reports are displayed as a graphical dashboard which is simple and flexible monitoring administration. The researchers are categorized into subgroups according to their experience in operating each instrument and facilitated reservation by the subgroups, i.e., unskilled researchers can make a reservation only after the have attended a training session.

Conclusion: The system has now been launched with a continually improving process for fundamental equipment of translational medical research.

Keywords: information management, laboratory information management system, research instrument, web application

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INTRODUCTION

The emergence of translational medicine in the twentieth century has changed the trend of medical research into a bidirectional integration between basic science and clinical research.¹ Research questions formulated from routine clinical work are translated into quests for basic science research which discovers knowledge that can be transferred back to the routine clinical work again.² In general, translational medical research can be grouped into three main hierarchies according to the types of genetic information used in the study including genomics, transcriptomics and proteomics. The studies can also be grouped by their majority technique into system biology (multi-omic study).^{3,4} Translational medical research is depended on basic molecular technology, especially high-throughput equipment including real-time thermal cyclers, automated on-chip fluorometers, capillary electrophoresis, flow cytometry, mass spectrometry and next generation sequencing.^{5,6} However, the high-throughput equipment is generally high-cost and especially requires technical expertise for good laboratory practice.⁷ Due to the delicacy of this equipment and the complexity of the standard manuals, access to high-throughput equipment needs to be allocated on a scheduled timetable under the responsibility of a supervisor. For certain machines, a user may require a training certificate before use. Moreover, all instruments need periodic calibration and maintenance to ensure good performance and accuracy of measurements.

Recently, our world has entered the next era of computerization and automation systems depending on information technology (IT). Data logging not only becomes essential information for scientific reports, but also is involved in strategical development which is an essential aim of systematic management and collection of substantial information. One of the most reliable software solutions for data collection and management is the database management system (DBMS) which involves data definitions, retrieval and manipulation in a hierarchical model

or relational component. A relational database management system (RDBMS) or relational database is a one of the database engines which uses a structured query language (SQL) to operate compact data storage and rapid query ability by indexed partitioning of the information into tables, rows, and columns.^{8,9}

MATERIAL AND METHODS

Our system aimed to optimize and standardize a computer program for research laboratory equipment management through an IT platform named the research instrument management system (RIMS), available at <https://rims.medicine.psu.ac.th>. The study was approved by Ethical Committee of Faculty of Medicine, Prince of Songkla University (REC.64-512-10-1). The system was implemented with four functions: (1) equipment schedule reservation, (2) calibration and maintenance logging, (3) financial information and (4) administrative management. To establish a user-friendly application, hyper-text markup language (HTML) was implemented in our system as front-end web pages with the responsiveness powered by the JavaScript and Cascading Style Sheets (CSS) languages. MySQL, a worldwide relational database engine, was applied as a back-end layer to store equipment logging data and a data query algorithm. In addition, our application utilized secured data transfer by a secure socket layer (SSL) protocol.

RESULTS

System implementation

The RIMS was introduced as part of the laboratory information management system (LIMS) of the Faculty of Medicine, Prince of Songkla University (PSU). Our system was deployed on the virtual computing environment of the Translational Medical Research Center (TMRC), Faculty of Medicine and secured in the data center of Songklanagarind Hospital. The RIMS was implemented with both frontend and backend interfaces facilitating connection of the system

with end-users and transferring related information to a storage engine. A web interface was designed to promote a user-friendly frontend using an online platform on an Apache web server 2.4 with the HTML, JAVA script, CSS and PHP languages. The web application includes an instrument overview, schedule calendar, user-registration, and administrative dashboard as shown in Figure 1, other hand instrument and user information are stored in MySQL server 8.0 which is independently operated from the web server. Together with the functions, we explain each operational purpose below.

Instrument overview

The overview section is the home page of the application, which visualizes all research instruments in our

faculty. On this page, anonymous users are able to access and query for all instrument information (Figure 2). The instruments are individually displayed at 20 items per page, each with a representative figure, identifier, and supervising department. To precisely approach the instruments, the user is allowed to customize the searching parameters to specific identifiers, applications, functions and departments. Matched-criteria instruments are displayed on the same page with ascending order of their identifier. When the user clicks on an item, the page will be redirected to provide additional information for each instrument, including general data, service fee, available operating times, reservation data and a revoke log. Moreover, our application is available in both Thai and English languages.

Frontend Interface



Backend Database

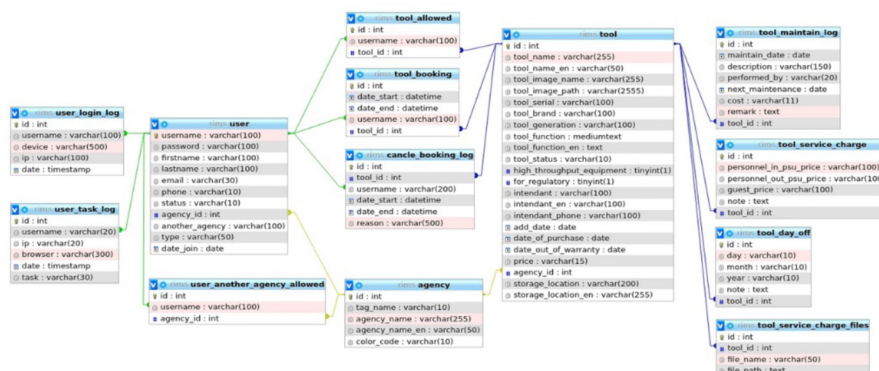


Figure 1 Graphical layers of the RIMS application and database schema

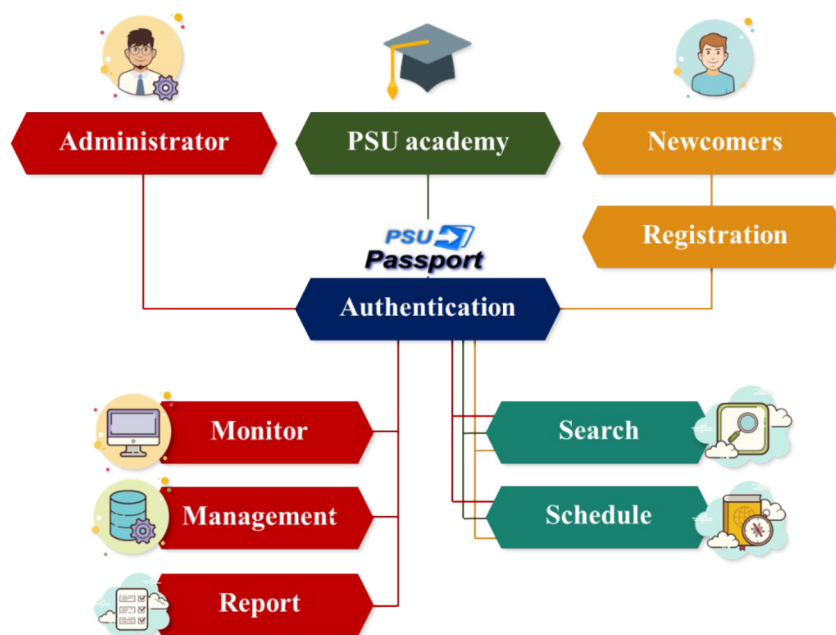


Figure 2 Application operation classified by type of authorized person and their job

Schedule calendar

The interface for instrument reservation is operable on a format of uses calendar for authenticated users which includes faculty staff, PSU students and other registered persons (Figure 2). The research instruments are initially classified into fundamental instruments which all users are free to access and high-cost instruments which need training certification or supervision. Reservation of fundamental instruments is publicly enabled by clicking on the calendar in the individualized information page. However, the high-throughput instruments require an appointment with a certified staff member from the applicant's department before scheduling. To customize the timetable information, the calendar has a flexible graphical interface arranged by month, week, and day. After being granted an appointment for operation, the user can adjust the operating time by a drag-and-drop key on their own scheduled block in the calendar. Moreover, scheduled instruments will be displayed in a "My reservation" section

on the navigation bar in which the user is able to query and visualize all of their reservations for a specific period.

User-registration

In general, our application requires authentication via the PSU passport which is a single sign-on (SSO) system available for all PSU staff and registered students. Therefore, users who have already have a PSU passport account will not be required to create a new registration (Figure 2). However, new users are required to first sign up with personal information including name, surname, email, contact telephone and department. For the first authentication, users are required to confirm they have read the terms and conditions of use and provide permission regarding their personal information.

Administrative dashboard

To simplify and flexibly monitor the system integrity, an administrative dashboard is integrated within our

system, following a perspective concept for development of our application. The dashboard is composed of instrument booking reports, instrument management, user management and data repository as shown in Figure 2. The database engine not only provides monitoring ability by continuously recording instrument schedules, but also contributes real-time monitoring and periodical information reports. Based on simplified data visualization, instrument information is queried by various criteria and time in focus and demonstrated in tables and graphs on the dashboard. Our application can export the data in comma separated variables (CSV), portable network graphics (PNG) format, and portable document format (PDF).

DISCUSSION

In an academic institute where budget is limited, centralization of high-cost research instruments is an effective way to maximize benefits and reduce maintenance costs of each instrument. The potential consequences of centralized management are compromised accessibility, utilization recording and communication between the central facility and users who may come from various laboratories or departments. Researchers with different levels of technical skills require different levels of support when they operate the instrument. Because unskilled researchers may pose a higher risk of damaging a machine, training and coaching are required until they are competent in the machine's operation. For this reason, the management should provide not only an automatic reservation system, but also precise communications between the facility and the users with different skill levels. In addition, the system should be able to summarize and report the utilization of each machine to the administrative team.

Office automation by modern IT has been gaining more popularity in personnel communication, data collection, sorting, queries, analysis, and reports. These are repeated tasks that a machine may learn and perform even better than humans. The RIMS is designed to provide a 24/7

interface for research instrument reservation, amendment of reservations and appointments for training or consultation. For each machine, the RIMS reports frequency and duration of utilization in real-time. The information is part of the Laboratory Information Management System (LIMS). Theoretically, the system aims to reduce errors and lower the burden of record-keeping. In addition, the automated system should generate and disseminate reports in the form of a user interface dashboard, in which the administrative team can query for cumulative trends and other kinds of decision-support statistics.

The RIMS was developed through a brainstorming phase which gathered requirements, was reviewed and program piloting. Implementation in the real-world environment and training of a laboratory staff were pursued thereafter. Continuous management is on-going in order to meet the theoretical objectives and user requirements.

CONCLUSION

In summary, the RIMS aims ultimately to provide extensive accessibility and obtain informative documentation of research instruments through IT platform. The application facilitates good laboratory practices with logging information and support to distribute and manage the instruments for all university members through an administrative dashboard.

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