DEVELOPMENT OF A COMPUTATIONAL DATABASE FOR PROBABILISTIC SAFETY ASSESSMENT OF NUCLEAR RESEARCH REACTORS

Vagner S. Macedo, Patrícia S. Pagetti de Oliveira and Delvonei Alves de Andrade

Instituto de Pesquisas Energéticas e Nucleares (IPEN – CNEN/SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
vagner.macedo@usp.br
patricia@ipen.br
delvonei@ipen.br

ABSTRACT

The objective of this work is to describe the database being developed at IPEN - CNEN / SP for application in the Probabilistic Safety Assessment of nuclear research reactors. The database can be accessed by means of a computational program installed in the corporate computer network, named IPEN Intranet, and this access will be allowed only to professionals previously registered. Data updating, editing and searching tasks will be controlled by a system administrator according to IPEN Intranet security rules. The logical model and the physical structure of the database can be represented by an Entity Relationship Model, which is based on the operational routines performed by IPEN - CNEN / SP users. The web application designed for the management of the database is named PSADB. It is being developed with MySQL database software and PHP programming language is being used. Data stored in this database are divided into modules that refer to technical specifications, operating history, maintenance history and failure events associated with the main components of the nuclear facilities.

1. INTRODUCTION

Probabilistic Safety Assessment (PSA) is an important tool for the analysis and quantification of risk in industrial plants and, particularly, nuclear plants. The approach used in the PSA is comprehensive and structured, aiming to identify possible accident scenarios and it consists of conceptual and mathematical models to evaluate the risk associated with facility operation [1].

For the development of the PSA, reliability data of structures, systems and components of the facility are required and these data are used for calculating the parameters of interest in the analysis. The main parameters obtained from the PSA models are: safety systems reliability, accident scenarios frequency, core damage frequency, among others. Thus, a database for application in PSA should contain all the necessary information for models development and parameters estimation that will result in the measurement of the facility overall risk.

Thus, the most important data obtained from a database for application in PSA are [2]:
- Component failure rate;
- Component probability of failure on demand;
- Component mean time to repair;
- Component and/or system test interval;

- Component and/or system average test time;
- Component and/or system maintenance interval;
- Component and/or system average maintenance time;
- Data on dependent failures and common cause failures;
- Probability of human errors.

In the case of nuclear research reactors, the uncertainty associated with data available in the literature is still an issue that deserves careful attention in the development of PSA. Even though research reactor designs are much simpler and the inventory of radioactive material is lower compared to power reactors, there are some aspects of research reactors that need special consideration from a safety and availability modelling point of view. Yet, there is not a generic database that can be considered adequate for application in the PSA of all types of research reactors.

The database described in this work is being outlined for use in the PSA of IEA-R1 research reactor, which is located in the premises of IPEN - CNEN / SP. Therefore, its main features were determined based on this specific reactor type and on how the information of this facility is conveyed.

Data collection activities in IEA-R1 Reactor have been carried out for over a decade, as they started when IPEN – CNEN/SP took part in an International Atomic Energy Agency Coordinated Research Project (IAEA CRP) [3, 4]. During this period, all the operation and maintenance records from January 1999 onwards have been studied.

Database features and the web application designed to manage the information contained in the database are described in Section 2.

2. SYSTEM DESCRIPTION

An information system may be defined as a set of interrelated components that collect, retrieve, process, store, and distribute information, in order to facilitate planning, control, coordination, analysis and decision-making in organizations [5].

Moreover, a computer-based information system uses computer technology to implement all the tasks mentioned above. It may be composed of one personal computer and software, or it may include thousands of computers of various configurations, hundreds of printers and other equipment, as well as networking and database [6].

Information systems that use the Internet platform allow multiple concurrent users to search and manipulate the information stored in a database by means of a network computerized system. The Intranet system used for the management of the database described in this work is named PSADB. It is being developed with MySQL software and PHP (Hypertext Preprocessor) programming language is being used [7]. MySQL is an open source database developed by Oracle that has been used by many organizations to implement cost-effective database solutions. PHP is a general purpose free script language suitable for generating dynamic content on the World Wide Web.

The initial screen to entry the system is shown in Fig. 1. After user identification is done by system administrator, other modules can be accessed. The system was programmed so that the user can choose the language for its use, Portuguese or English.

Figure 1: PSADB initial access.

The registration of system users and the functionalities available in the main menu are illustrated in Fig. 2.

Figure 2: Users registration by means of PSADB main menu.

Database structure and functionalities are defined in items 2.1 and 2.2, respectively.

2.1. Definition of Database Structure

The Information Engineering (IE) methodology, which is suitable for planning, analysis, design and implementation of applications in corporate network systems, was applied to the development of the PSADB system [8]. The IE methodology has been widely applied in modelling databases, since it comprises techniques for the definition of entities, analysis of processes and data flow management.

The IE method called Entity Relationship Model [9] was used to determine the tables that would compose database modules as well as the relationship type among these tables. In this

case, the main tables are used to store technical specifications of facility structures, buildings, systems, subsystems and components, as well as operating and maintenance history of facility items.

Database tables are composed of columns which may be primary keys that allow data to be uniquely identified in the table, or columns of tables that can store diverse information about each table. Columns defined as primary keys determine the relationship among tables, which may be of type 1: 1 (one to one) or 1: N (one to many). Therefore, database structure can be represented by means of the Entity Relationship Model shown in Fig. 3.

2.2. Description of Database Functionalities

After defining database structure, the commercial software that could meet the requirements for storing and processing the type of data involved in this work was chosen. The selected software is named MySQL, which is consistent with the use of Hypertext Preprocessor (PHP) programming language [7]. PHP is a general purpose script language, widely used for the development of Internet platform applications, and which allows developers to write pages dynamically generated. Besides, the universal language SQL (Structured Query Language), which is a powerful tool to control and manage complex data stored in different types of databases, was used to access data stored in database tables [10].

The program written using PHP language was developed to perform the following functions:
- Store information obtained from facility records that are relevant to the Probabilistic Safety Analysis (PSA);
- Manage data through web application screens;
- Generate reports of the information contained in the database for application in PSA and other important analyses.

Data stored in this database are divided into modules, as follows:
- Technical data on plant buildings, structures, systems, subsystems and components: item identification, description, location and technical specifications.
- Operation records which consist of component operating times and number of demands during specific periods of time.
- Maintenance records which consist of information on predictive and preventive activities as well as corrective actions applied to plant components.
- Failure records which consist of information on component failures, mainly related to plant safety, during specific periods of time.
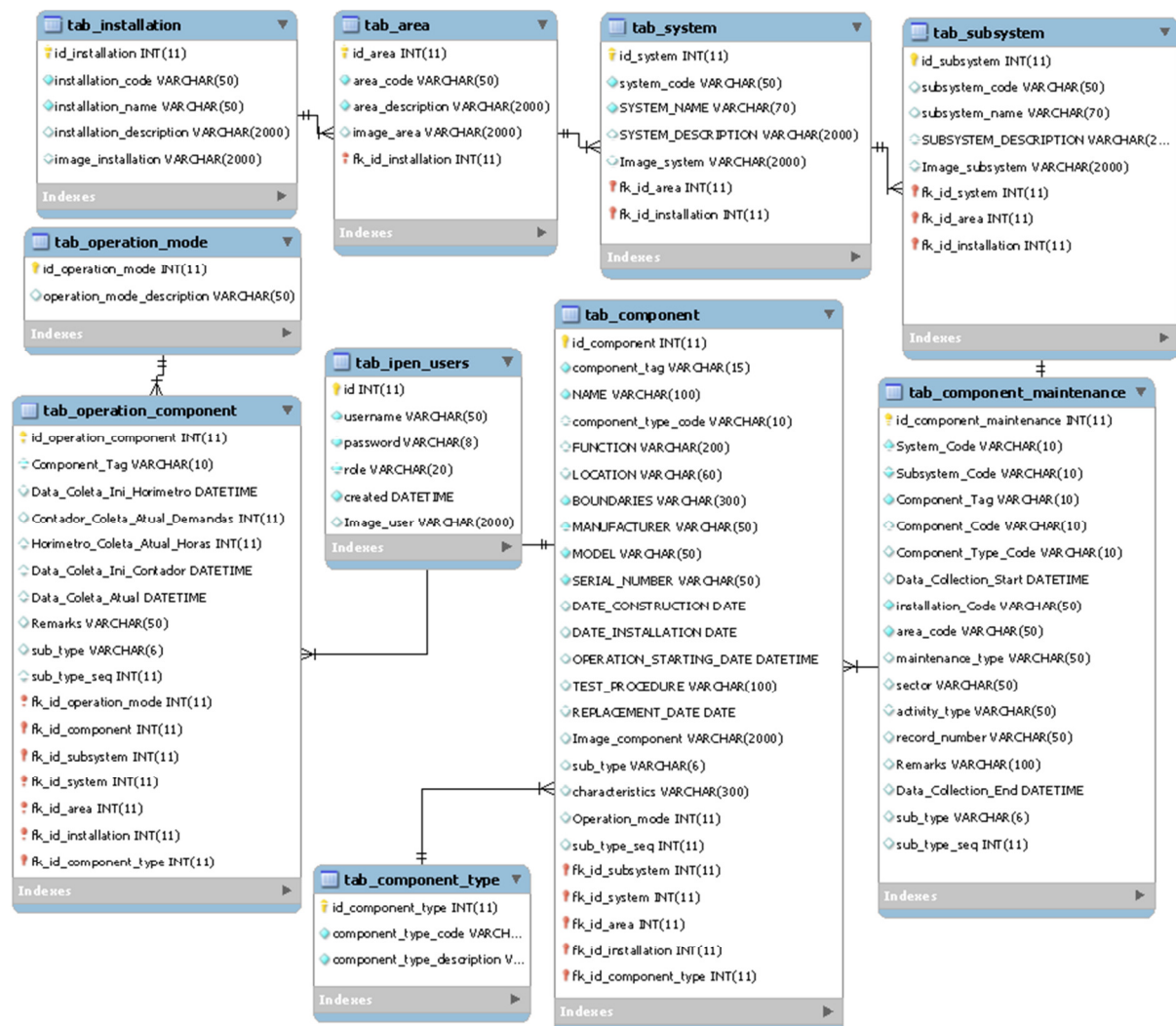
Figure 3: Database Entity Relationship Model.

3. CONCLUSIONS

In this work the database being developed to store and process data relevant to the IEA-R1 Reactor PSA is described.

An Entity Relationship Model was used to develop the logical models and physical structure of the database and it is based on the operational routines performed at the facility. The system named PSADB, which is being developed to access and process data stored in the database via the corporate computer network, namely IPEN Intranet, uses the MySQL software and the PHP programming language. Thus, PSADB functionalities will provide users with stored information in an optimized way, both with regard to data processing and system performance.

Finally, current database structure allows additional new modules to be developed and integrated into the database. Furthermore, data collection through mobile devices such as smartphones or tablets is being planned.

REFERENCES

1. F. Niehaus, "Use of Probabilistic Safety Assessment (PSA) for nuclear installations." *Safety Science*, **Volume 40**, pp. 53-176 (2002).
2. International Atomic Energy Agency, "Generic Component Reliability Data for Research Reactor PSA", **IAEA-TECDOC-930**, Vienna, Austria (1997).
3. P. S. P. Oliveira et alii, "Base de Dados de Confiabilidade de Componentes para os Reatores de Pesquisa IEA-R1 e IPEN/MB-01: Objetivos, Estrutura e Conteúdo", *Anais do XIII ENFIR*, Rio de Janeiro, 11 a 16 de Agosto de 2002, CD-ROM (2002).
4. P. S. P. Oliveira et alii, "Base de Dados de Confiabilidade de Componentes para os Reatores de Pesquisa IEA-R1 e IPEN/MB-01: Resultados e Aplicações", *Anais do XIV ENFIR (ISBN: 85-99141-01-5)*, Santos, 28 de Agosto a 2 de Setembro de 2005, CD-ROM (2005).
5. K. C. Laudon & J. P. Laudon, *Sistemas de Informação Gerenciais*, Pearson, São Paulo, Brasil (2011).
6. E. Turban, E. McLean and J. Wetherbe, *Tecnologia da informação para gestão*, Bookman, Porto Alegre, Brasil (2004).
7. L. Welling, L. Thomson, *PHP and MySQL Web Development - Developers' Library,* Addison Wesley, United Kingdom (2005).
8. K. Son, *Database Management and Practice (MS SQL Server),* Hanbit Media, Inc. (2003).
9. C. A. Heuser, *Projeto de Banco de Dados*, Bookman, Porto Alegre, Brasil (2008).
10. D. C. Jamison, "Structured Query Language (SQL) fundamentals", *Current protocols in bioinformatic,* **Chapter 9: Unit 9.2,** pp.9.2.1-9.2.9 (2003).