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Requirements Modeling for University e-Ranking Dashboard System (e-RDS)

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Abstract: World university rankings have positively influenced the development of organisations and widely attracted the attention of policy makers, especially in educational institutions. Universities have since developed systems to help decision makers in strategic planning for the ranking agenda. However, to date there has been no standard or generic model established for the university ranking information system. By implementing standard or generic requirements, developers and system analysts can simplify the system design phase and improve the reliability of system deliverables. Therefore, the main aim of this study is to construct a requirement model for the e-Ranking Dashboard System (e-RDS) by using Unified Modeling Language (UML). Requirement development phases have been adopted to achieve the objectives of this study and a set of questionnaires has been used to validate the prototype. As result, users gave positive feedback on the e-RDS's effectiveness and ease of use.

Key words: Universitie's ranking, decision makers, strategic planning, requirement model, Unified Modeling Language (UML), e-Ranking dashboard system, organizations

INTRODUCTION

World university rankings have risen sharply in response to globalisation and worldwide competition. This ranking agenda has caught the attention of policy makers, especially in educational institutions (Hazelkorn, 2014). Universities are facing fiercer global competition and greater social accountability than before and consequently, there has been greater emphasis on educational management for its significant role in enhancing the performance of schools and colleges and improving their quality (Han and Zhong, 2015). Quality improvement has widely become an essential element for competing successfully (Wu *et al*., 2009). It is highly disconcerting to see well-established organisations such as universities continuously improving its services without incorporating strategic planning to its core managerial elements.

Strategic planning is regarded as a corollary effort to produce fundamental decisions and actions that provide guidelines on what an organisation or university stands for and how it operates. It also gives universities and colleges the opportunity to chart their own course and develop a blueprint for future use (Steiner, 2010). Therefore, the ability to predict the future needs of an institution with some degree of accuracy is a factor that now ranks on par with the quality of the faculty's teaching and research (Salter, 2014).

Ranking is one of the instruments used by higher education to assess the quality of a university. It is defined as a positioning of universities based their performance on chosen indicators, including peer reviews and external judgment (Al-Juboori *et al*., 2011). In addition, Hazelkorn (2014) has shown that nearly 60% of university managers claimed that rankings have positively influenced the development of their institutions; correspondingly, many admit that their universities have developed systems to analyse and utilise existing data to help decision makers in planning strategically for the ranking agenda. When making a reliable and effective decision, stakeholders must clearly identify the goals to be achieved, predict future occurrences and eventually make plans for action under different conditions (Albar and Jetter, 2009).

Furthermore, a dashboard can be used to monitor the flow of data and information regarding organisational strategies. It is a single-screen display of essential information that enables stakeholders to make strategic and important decisions on their daily activities. By implementing the dashboard in universities, decision makers can quickly acquire broad insight on complicated sets of data and information and display the most important ones required by the university in a single view (Dolan and Veazie, 2015).

Overall, to set strategies and make decisions for university rankings, an electronic ranking dashboard

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system can be introduced as a suitable platform. The proposed system can support the management and presentation of data and information, improving efficiency for university decision makers. It can also provide useful information to decision makers to facilitate and help them map out logical and meaningful strategic plans for their universitie's ranking agenda. To the researcher's knowledge, no standard or generic model has been established regarding the university ranking information system. By having standard or generic requirements, the software development process could be simplified for developers and system analysts (Wiegers and Beatty, 2013). Therefore, requirement gathering and modelling of a generic electronic ranking dashboard system are needed to be used as guidelines. Hence, this study aims to construct a requirement model for e-RDS using UML.

Literature review

Requirements: Requirements are defined to specify what should be implemented during the initial phases of system development (Pressman, 2010). They are divided into two main categories: functional and non-functional. In the simplest form, functional requirements are those that define what the system should do while non-functional requirements are used for that specify how a system should perform. Additionally, functional requirements are more important than non-functional ones because they are provided by the user and expected in the system. These are features and functions that must exist in the system to satisfy the end user. In contrast, non-functional requirements are not concerned with system functions, such as usability, security, reliability and performance and are not captured in standard requirement modelling diagrams (Fingerhut, 2008). For those reasons, this study has focused only on functional requirements.

Requirement model: Requirement modelling is one of the most important phases in the Software Development Life Cycle (SDLC). It is the process of describing the functional requirements of the system to develop useful and proven models. In addition, it emphasises requirement specifications, management and validation. Moreover, it eases the capture, communication, tracking, analysis, verification, validation, viewing and management of hundreds of hierarchical and interrelated engineering requirements necessary for large and/or complex systems (Wiegers and Beatty, 2013). Requirement modelling is an important activity in systems development because it helps to analyse and understand the system architecture as well as achieve correct and complete specification of requirements. Importantly, it reduces the cost of systems development and the probability and severity of cost and schedule growth by enabling human readability and meeting systems engineering requirements (Pressman, 2010).

Table 1: Global ranking systems (Al-Juboori *et al*., 2011)

System names	Publishers	Published countries
The-QS World University rankings	QS Quacquarelli Symonds Ltd.	England
Webometrics	Cybermetrics Lab	Spain
Academic ranking of world universities	Shanghai Jiao Tong University	China
Scimago institutions rankings	SC Imago Research Group	Spain
Leiden ranking	Leiden University	Netherland
4icu.org university web ranking	4 international colleges and universities	Australia
The new global ranking of world universities	RatER	Russia

Universitie's ranking system: Reportedly, university ranking systems have been developed globally, nationally, regionally and locally for improving the service quality of universities. Consequently, many global and national ranking systems have been developed through different reports from international sources (Al-Juboori *et al*., 2011). Table 1 presents some of the global ranking systems with their respective publishers and the country of their publication.

Regionally, higher education of Ohio's states has designed an online dashboard system to measure progress and improve the relative rankings by viewing the achievement of a state compared to other top states and nations. Besides that the university system of Ohio has developed as a unified system of higher public education. It connects all Ohio's states to guide decision makers about the future. The idea of this system is to pursue and execute strategies (Fingerhut, 2008).

The president of NorthWest Missouri State University and his staff brainstormed on the most important indicators of quality at the institutional level. These indicators were monitored via. the dashboard system to provide the faculty and administrators a readily quantifiable method for evaluating and improving performance (White and McLaughlin, 2011). Recently, in a study by Widjaja and Santoso (2014), a dashboard system was developed for decision makers at BINUS University for accessing information in visual form to accelerate and improve the readability of the information itself. This system makes sense of massive university data. However, this dashboard system is not equipped for the ranking agenda, so it needs further development to facilitate the quality management of the university to conduct analysis and decision-making.

The developed systems mentioned above present the use of the dashboard in the university, the utilisation of the university's data and the attention to the quality

and ranking of the university. These systems are overwhelmingly consistent with the aim of this study to demonstrate useful information to universitie's decision makers.

On the other hand, the QS world ranking system is considered as one of the most prominent ranking systems because of its global reputation and scientific approach (Dobrota *et al*., 2016). Since, its first compilation in 2004, it has expanded to feature more than 800 universities around the world with far more assessed. The top 400 universities are given individual ranking positions and after this, universities are placed within a group, starting from 401-410, up to 701+. This ranking uses six indicators with different weights: academic reputation (40%), employer reputation (10%), faculty-to-student ratio (20%), citations per paper (20%), international student ratio (5%) and international faculty ratio (5%). Moreover, QS Asian University rankings, a part of the QS World University rankings was published for the first time in 2009. It ranks Asia's top 500 universities and uses nine indicators with different weights: academic reputation (30%), employer reputation (10%), faculty-to-student ratio (20%), citations per paper (15%), papers per faculty (15%), international faculty ratio (2.5%), international student ratio (2.5%), inbound exchange student ratio (2.5%) and outbound exchange student ratio (2.5%).

MATERIALS AND METHODS

This study adopted requirement development phases in the Requirements Engineering (RE) domain to acquire the objectives to construct a model for e-RDS. Requirement development focuses on analysing and validating requirements (Abran *et al*., 2001). Figure 1 presents the five main stages involved in this study.

In the conceptual study phase, data and information were identified and collected through revision of the journals, documents and reports to get a comprehensive knowledge about the requirement modelling, UML, dashboard systems and world university rankings as well as their methodologies.

In the next phase, the requirements were elicited to identify the generic requirements for the proposed e-RDS system. The generic requirements were identified based on interviews with the experts and observations on existing manual ranking systems. In this study, a semi structured interview technique was used because it provides comparable and reliable qualitative data, allows the interviewer to be prepared and gives interviewees the freedom to express their insights without reservations (Eriksson and Kovalainen, 2008). Three experts that have deep knowledge in university rankings were involved in the interview session to explain the process. The output of this phase is a list of requirements for e-RDS. For example, only administrators can maintain users and years.

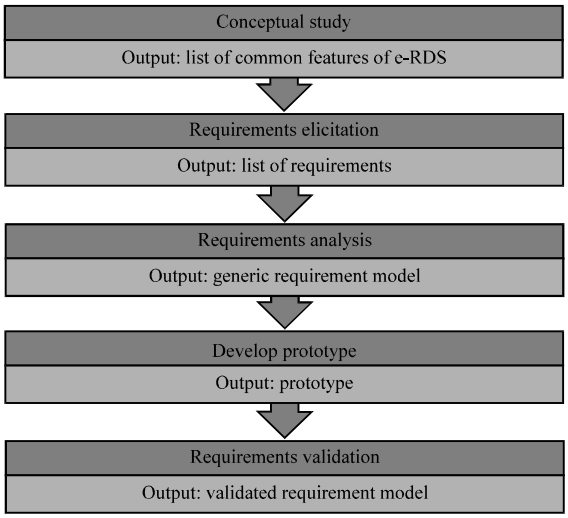

Fig. 1: Adapted requirements development phases

After all functional requirements for e-RDS have been identified; the generic requirement model of e-RDS was constructed by using UML which is a standard language for specifying, visualising, constructing and documenting the artifacts of software systems as well as for business modelling and other non-software systems. It has notations which are used to depict the different views of a software system design (Pressman, 2010). This study has focused on three main models: use case diagram, sequence diagram and class diagram. These three diagrams were considered as core diagrams and covered 80% of the object modelling requirements (Ambler, 2012).

In the fourth phase, a horizontal prototype was developed to improve the process flow and user interface of the e-RDS. The horizontal prototype gives an overview of the whole system with a focus on user interaction. Therefore, it is useful for verification of user interface (Wiegers and Beatty, 2013).

In the last phase, the requirement model was validated to confirm that requirements were achieved. This phase was attained by the experts who participated in the usability evaluation to determine the user's awareness on usability and their acceptance of the e-RDS prototype. To evaluate usability, a questionnaire was adopted from the Perceived Usefulness and Ease of Use (PUEU) questions (Davis, 1993). Details of the usability evaluation will be presented in the next study.

RESULTS AND DISCUSSION

This study presents the results of this study that can be used as a guideline in developing the e-Ranking Dashboard System (e-RDS).

Use case diagram: A use case diagram is a visual representation of the relationships between actors and use cases. Actors provide a service to the system under design that could be human or external systems. Use cases are the specification of sequences of actions that interact with system actors. After interviewing the experts and observing the existing manual ranking system, there are two actors and six use cases. The actors can be an administrator or a user, however the use cases are login, manage system users, manage years, maintain data, set plans and display dashboard. The administrator is the person in-charge who is able to manage system users and years, maintain data and have authority to set strategic plans through the benchmarking dashboard. However, user is a clerk who responsible for data entry. Figure 2 shows the use case diagram that visualizes the functional requirements of e-RDS.

Sequence diagram: Sequence diagram shows a detailed flow for a particular use case or even just part of a particular use case. It is almost self-explanatory; it shows the messages between the different objects in its sequence and can show different messages to different objects. Sequence diagram shows how the process operates with another one and in what order (Pressman, 2010). For this study, sixteen sequence diagrams have constructed based on the use case specifications. Figure 3 shows the sequence diagram of the core use case of e-RDS that used by administrator to set university plans. Administrator can preview, update and save the plan for the current year.

Class diagram: A class diagram is used to identify the domain concepts and analyse the requirements in the format of analysis model. It identifies methods and variables for all objects which are specific entities in the system or sub system. In addition, the class diagram shows all classes in the system including attributes and operations of each class and the relationship between each class (Pressman, 2010). Figure 4 shows the class diagram of the core use case of e-RDS that used by administrator to set university plans.

Prototype development: The e-RDS prototype has developed based on the use cases that were defined previously by using ASP.NET technology, C#.NET programming language and SQL Server as the database platform of that prototype.

Figure 5-9 show some of interfaces of e-RDS. Figure 5 shows login page that can be used by administrator and user. User name and password are required to login. Administrator can manage users by permitting them to access the e-RDS.

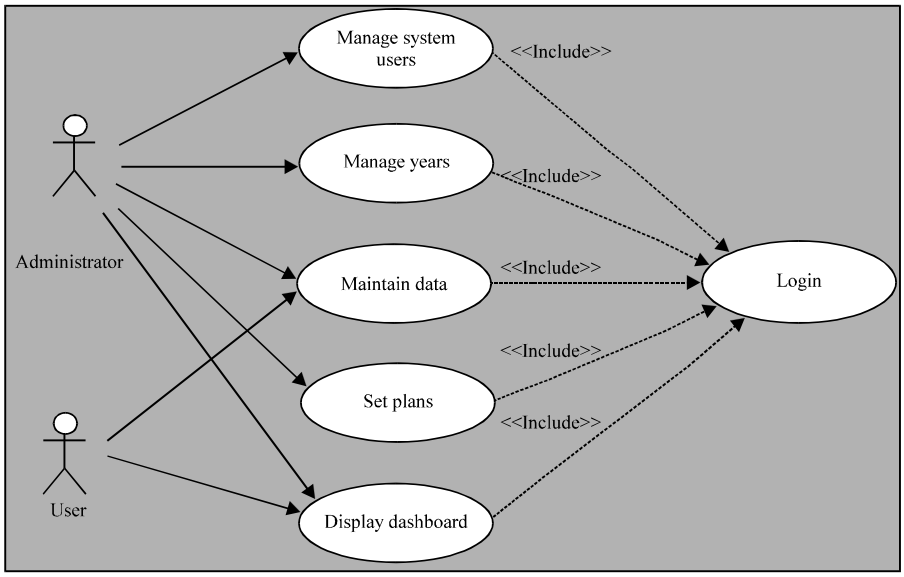

Fig. 2: Use case diagram

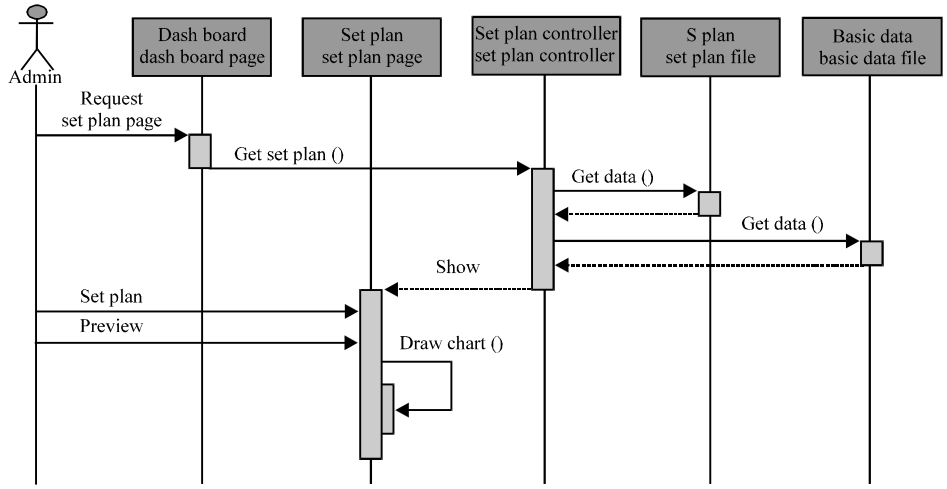

Fig. 3: Set universty plan sequence diagram-basic flow

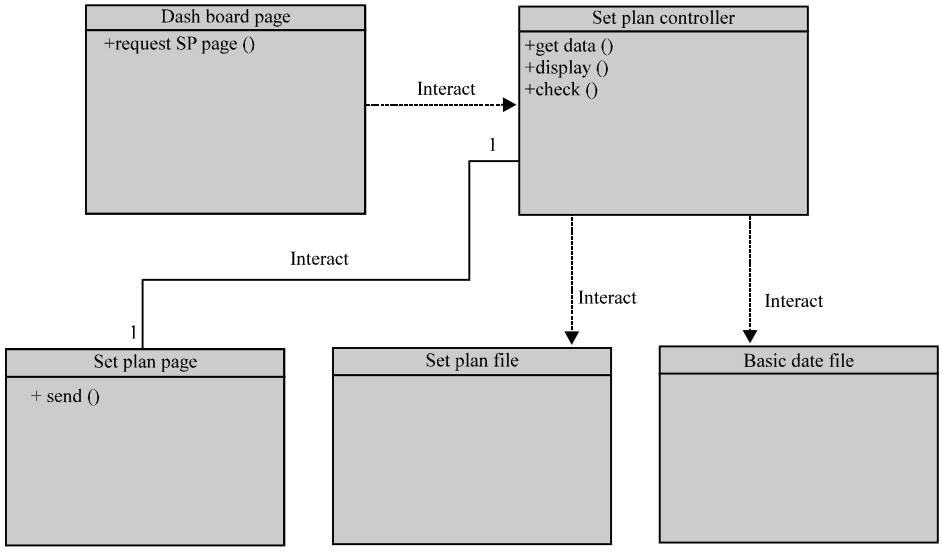

Fig. 4: Set universty plan class diagram

Figure 6 shows the year's management page. In this page, administrator is authorized to manage the years. Years must be added before inserting any data. Figure 7 shows the university basic data page. Basic data refers to data that university should provide to QS ranking such as total numbers of full time and part time students, international students and academic staff.

Figure 8 shows set university plans page. Administrator can enter expected values and set plans for the next years based on achieved data. Figure 9 shows dashboard page that is used to benchmark university achievements with the highest and the nearest university's ranking.

Prototype validation: The five participants consisted of staff involved in daily university ranking and have participated in the usability evaluation of an e-RDS prototype. Albert and Tullis (2013) stated that five experts are an acceptable number for usability testing. Therefore, in this study, five experts participated in prototype validation. Those experts explained how to use the e-RDS and what its functions and capabilities are. After using the e-RDS, the experts answered the PUEU questionnaire to evaluate the prototype. The PUEU questionnaire has two main categories: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). It has twelve questions, each with 1-5 scales. Scale 1 corresponds to 'strongly disagree', Scale 2 'disagree', Scale 3 'neutral', Scale 4

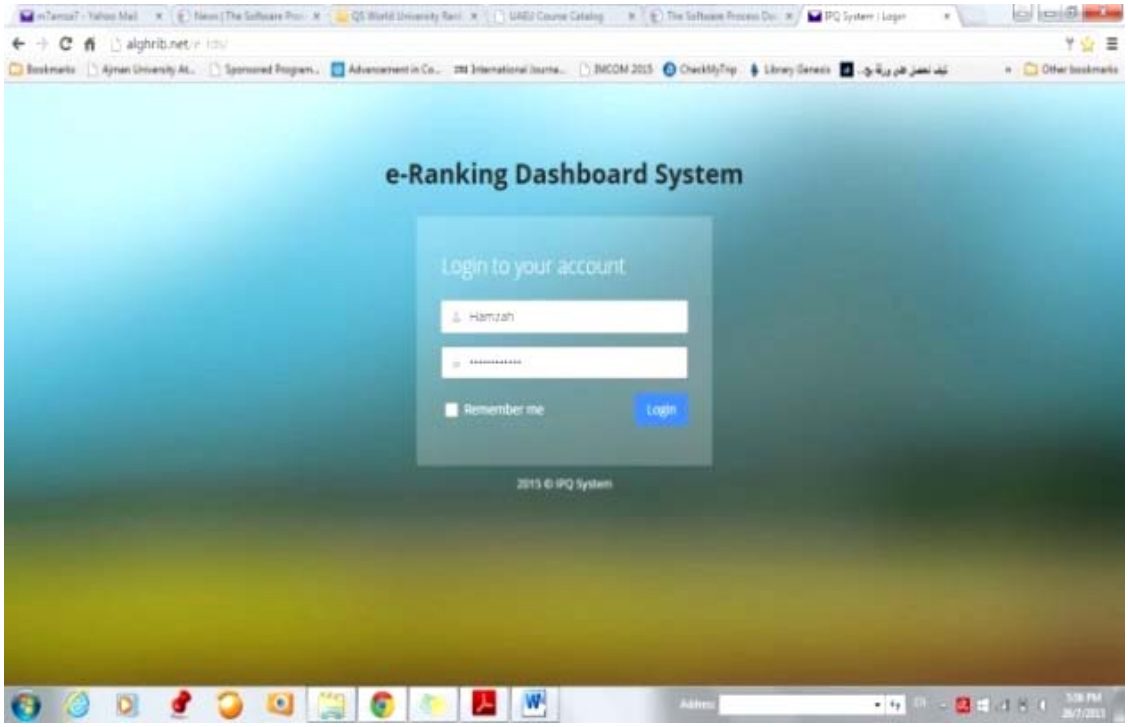

Fig. 5: Login page

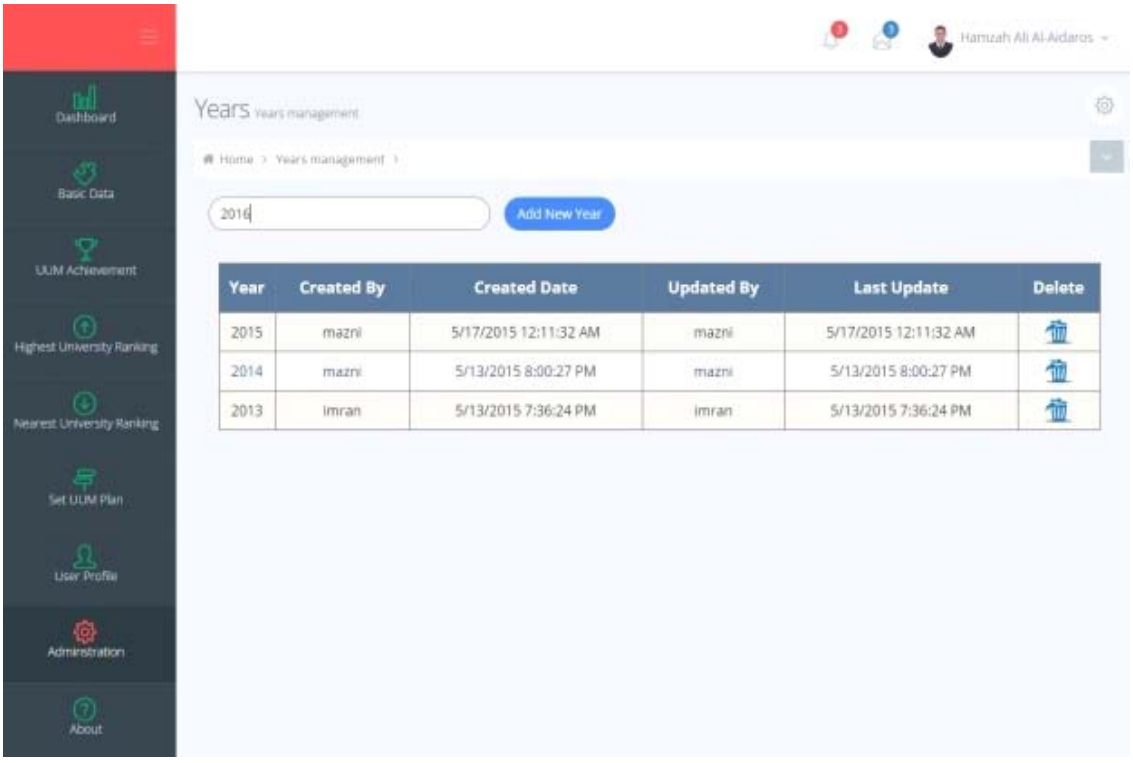

Fig. 6: Years management page

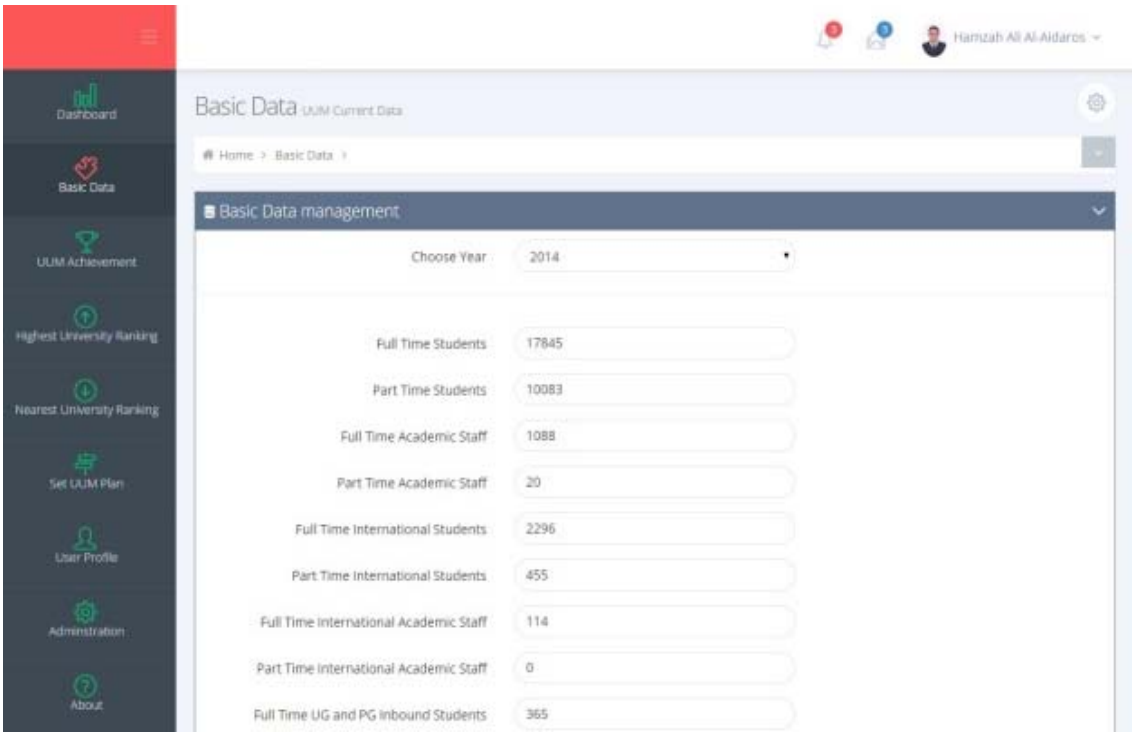

Fig. 7: University basic data page

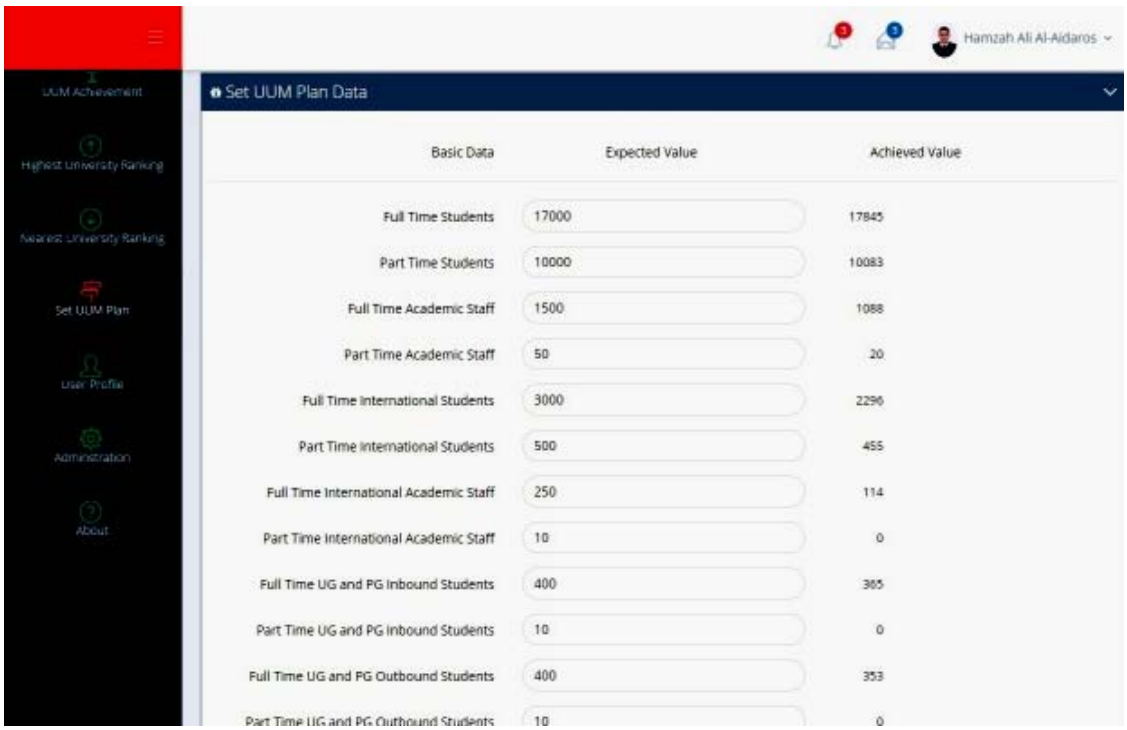

Fig. 8: Set university plans page

Fig. 9: Dashboard page

Table 2: Overall usability evaluation

Usability scales	N	Mean M (% score)	SD
Perceived usefulness	5	4.37(87.33)	0.62
Perceived ease of use	5	4.30(86.00)	0.74

'agree' and Scale 5 'strongly agree'. The reliability test of the questionnaire showed a good internal consistency with Cronbach's alpha, $\alpha = 0.89$, for PU; however, it showed excellent internal consistency with Cronbach's alpha, $\alpha = 0.94$ for PEU. Overall, the questionnaire showed excellent internal consistency with Cronbach's alpha, $\alpha = 0.96$. Table 2 shows the overall result of the usability evaluation.

The results showed that the e-RDS is useful and easy to use. This also meant that the e-RDS could show useful information to decision makers to help them give logical and meaningful strategic plans for their universitie's ranking agenda. Feedback from evaluators indicated that the e-RDS required minimum modification such as supporting the use of a QS Excel file that contains all university rankings instead of keying in data. This would help any university to benchmark its performance with other universities.

CONCLUSION

This study described the requirement model of the e-RDS for universities. This model has been successfully constructed by using core UML diagrams which are the use case, sequence and class diagrams. This model was used as a guideline to develop an e-RDS prototype. In the end, a set of questionnaires was used to validate the prototype. The results revealed positive feedback from users on usefulness and ease of use. It also showed that the e-RDS could help in managing, analysing and benchmarking any ranking of a university with other universities. It is hoped that future researchers would expand this study by developing a complete e-RDS. Moreover, the e-RDS can be enhanced by integrating universitie's ranking performance data to Excel files to minimise data entry. Additionally, the e-RDS could be improved to retrieve and extract the required data from the available database systems of the university. This is can be done by using data mining techniques.

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