Full Paper

THE DESIGN OF topsis4BIM DECISION SUPPORT FOR BUILDING INFORMATION MODELING SOFTWARE SELECTION

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Graphical abstract

Abstract

The emerging of new Information Communication Technology (ICT) technology namely Building Information Modeling been proven benefits toward construction industry. As a result, the list of BIM software available in the market is keep increasing in recent years. This has led to the selection problem among construction companies. Moreover, the selection BIM software also required high investment in term of software, hard ware and training expenses. These aforementioned issues have increased the complexities of decision process and the need of decision aid in BIM software selection. Thus, this paper has introduced a new approach in MCDMDSS web development by utilization of Web 2.0 application. The rapid development of Information technology has highly benefit to the development of web based DSS. The design and validation architecture of a web base DSS called topsis4BIM for Building Information Modeling (BIM) is presented.

Keywords: Decision support system (DSS), Web 2.0, building information modeling (BIM), multi criteria decision making (MCDM), software selection.

1.0 INTRODUCTION

The adoption of BIM has been gained much attention construction players around the world [1]–[4]. The direct and indirect benefits of BIM has force the construction company to adopt BIM in their project in order to keep pace and compete in construction market. Consequently, numerous of BIM software has been developed in market to cater the demand from construction industry. Within year 2007, there were 44 BIM software's available from 11 software vendors which offer different function, features and cost. The number of BIM software has increased exponentially since 2007 [5]. Hence, this trend of increasing BIM software has contributes much to the complexities of BIM software selection process. Moreover, there are numerous of factors need to be considered in software selection process particularly in technical, managerial and cost aspect. For example, usability, performance, security and modularity [6]; cost, update, connectivity and ease of used [7], vendor support, flexibility, reliability and technology support [8]. The selection of software also involved a risk such as requirement of high investment. The adoption of BIM software caused organization hundreds of thousands dollars or more. This is due to the investment in BIM is not only for software, but also hardware and training expenses [9], [10]. In Malaysia, even though construction practitioners acknowledged the tremendous benefits of BIM, but their considered BIM as expensive software. Furthermore, in construction domain, the ineffective selection of BIM software can

turn out to be costly and negatively affect the organization performance and project outcomes [11]. However, literature revealed the current practice in BIM software selection is based on recommendation from software vendors, others construction companies or select the best software in market [11].

In addition, the evaluation and selection of software that fits organization needs has been considered as a difficult in engineering software process [12], [13]. Therefore, there is a need of decision aid in BIM software selection decision making processThere is a need of decision aid for BIM software selection [14]. DSS has been defined as interactive computer based system that assist decision maker in solving unstructured problem by utilization data and model [15]. Research has shown the ability of advance information technology such as Decision Support System (DSS) is capable of providing solution for unstructured problem in numerous of managerial fields [16]–[18]. This is due to the integration of DSS application with the mathematical model such as Multi Criteria Decision Making Technique (MCDM). In construction project management problem, several of MCDMDSS has been developed in past. For example, contractor selection [19], supplier selection [20], consultant selection [21], and project delivery selection [22].

Furthermore,   existence   World-Wide   Web technologies has also opened a new opportunities for DDS to become a more comprehensive decision support tool through web service concept [23]. The development of DSS through web technology is not only expending the effectiveness of DSS, yet also expending the accessibility of DSS. As a result, numerous development of DSS application through web platform has been done in several of field. For instance, a web-based DSS for movie forecast [24], a web based DSS with GIS technology for resources and environment management [25], a web based DSS for railway operation [26], and a web based DSS for construction and demolition waste [27].

In early 2004, a new generation of web development has been introduced which called Web 2.0. The advantages of Web 2.0 have been discussed widely in literature. For example, this platform has created an effective new approach and simultaneously shift the way of sharing, creates and distributes content and information through web [28]. This is due to the main features of Web 2.0 which allow mass participants, ease of used, interactive interface, among others [29]. Web 2.0 also provides several development tools such as blog software and Wiki engines. This kind of tools allows user to create and manage their own without requiring any technical knowledge such as programming language. These tools make the web design to become easier, quicker and cheaper [29], [30].

To the best of our knowledge, the development of DSS through Web 2.0 is still far from mature. Thus, this study has developed a web based DSS called topsis4BIM thorough Web 2.0 technology for BIM software selection.

2.0 DSS COMPONENTS

According to Turban et al. (2005) a standard model of DSS contains four basic components they are; database management subsystem, model management subsystem, user interface, and knowledge base management subsystem. However, in the development of topsis4BIM, only three out of four DSS component has been developed. There are data based management, model management and user interface.

2.1 Data Base Management

According to Turban et al. (2005), the existence of database is significant in the development of DSS. Data based acted as storage for data, information and knowledge data that have been organized in a manner to provide the user with something that user know and also enable the user to reveal unknown value. The literature showed several database modelling techniques. One of the commonly used techniques is the Hierarchical model. Hierarchical model is a second model after the development of file system model in the 1970. The development of database in topsis4BIM was based on hierarchical model. Hierarchical model represent data by upside-down tree. Hierarchical tree can be formed based on top layer (as a level or root) and the existence of segment as children below top layer.

2.2 Model Management

As shown in literature, spread sheets have been frequently used as a model management in DSS. According to Power and Sharda (2007), spread sheet is a major technology for development of model driven DSS. This is due to the abilities of spread sheet packages such as Microsoft Excel which is capable of handling data and graphic capability, enable user to run "What if" analysis, and the high potential in facilitating the building of DSS [23]. Fuzzy TOPSIS has been chosen as a decision model in model management of topsis4BIM. TOPSIS has been proposed by Hwang and Yoon (1981) to determine the alternative that is closest to an ideal solution (Chu & Lin, 2009; Ertu & Karaka, 2008; Saremi, Mousavi, & Sanayei, 2009; Wang, Cheng, & Huang, 2009). The basic concept of TOPSIS is to choose the alternative that has the shortest distance from positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) (Chen, 2000). Compare to other MCDM method such as AHP, ANP, SAW, and ELECTRE, TOPSIS has been proved that TOPSIS is more capable in dealing with more criteria and alternatives of choice [31], [36]–[38].

However, Even though MCDM method such as TOPSIS has been consider as an effective method in solving selection problem, however in order to represent a real world problem MCDM method has been widely critics due to the involvement of crisp data. Under many chances crisp data are inadequate to model real life situation [35], [39]. Human judgment in decision process is always vagueness and uncertainty. In order to enhance the decision makers evaluation during weighting and rating process in TOPSIS assessment, the linguistic language has been used. Thus, Fuzzy TOPSIS proposed by Chen (2000) has been utilised.

2.3 User Interface

The innovation of DSS towards the World Wide Web (WWW) technology has attracted much attention from researcher worldwide. The existence of WWW technology has not only provided interactive user interface but also expended the features of DSS [23]. In addition, the development of web-based DSS costly less, there is no requirement for specific software on the user is computer in order to run it, it would work on a web browser and internet connection to deliver the DSS support functionality to the user [23]. Furthermore, all type of DSS can be implement through the web technology [40].

3.0 ARCHITECTURE AND DESIGN OF TOPSIS4BIM

Topsis4BIM is a web based DSS which integrates MCDM as decision model into web 2.0 technologies and provides an innovative approach for a better efficiency and quality in BIM software selection decision making process. The topsis4BIM consist of Model Management, Data Base, and User Interface.
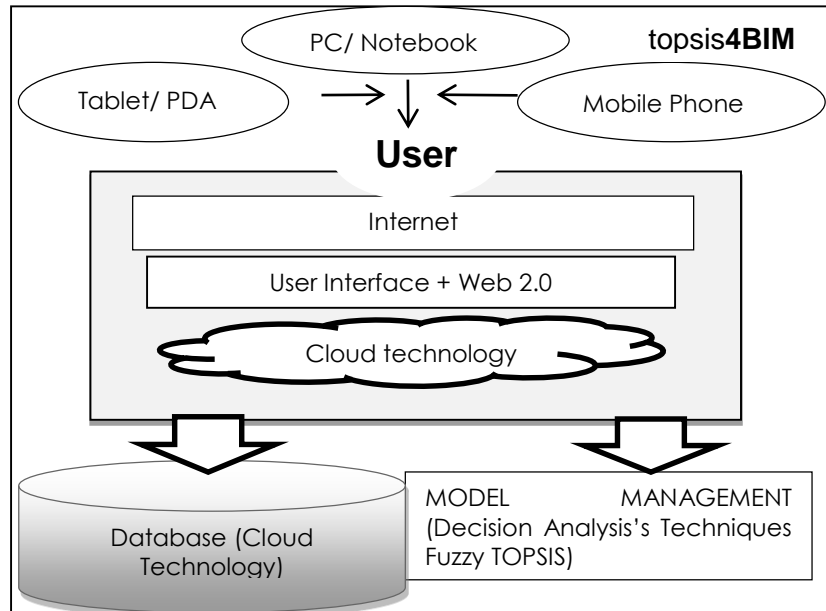

Figure 1 Architecture of tospsi4BIM

3.1 Data Base Development

The topsis4BIM also provided database function. In order to enhance the decision process for decision makers in BIM software selection, the utilization another product of Google Drive which Google Doc. The Google Doc has been utilized to keep information of BIM software (such as features, function and system requirement). Thus, activity such as document analysis has been done by filtering and categorizing of BIM software information in hierarchical database model thorough Vendor website, software template and literature. Figure 2 illustrates the Hierarchical database model for profiling BIM software in topsis4BIM.
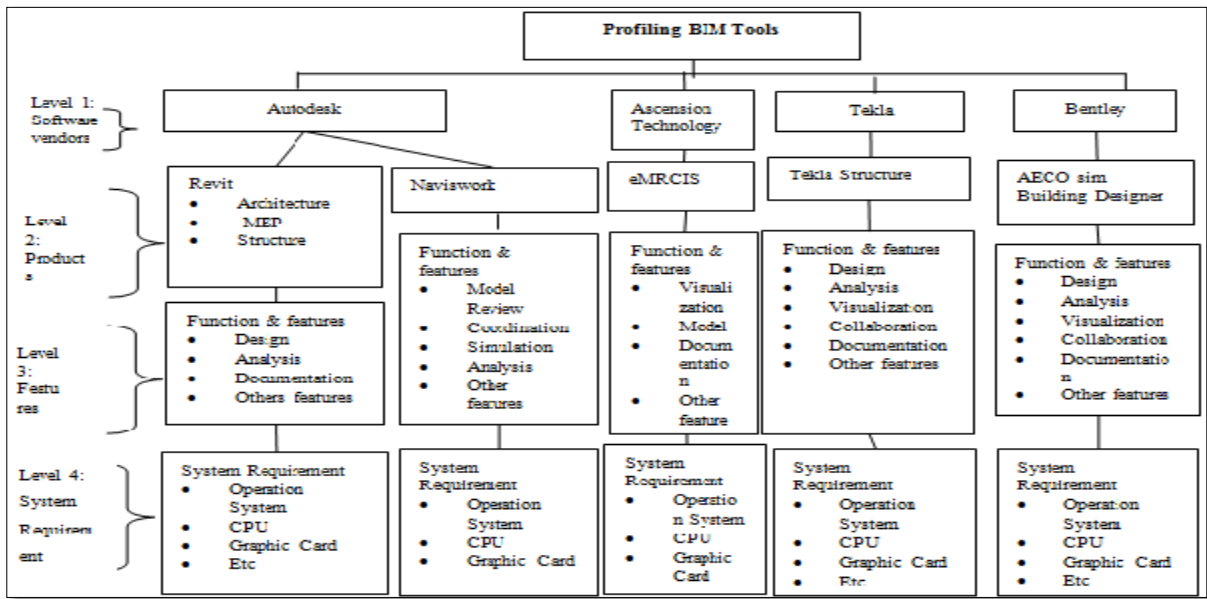
Figure 2 Hierarchical database models for profiling BIM software

3.2 Decision Model Development

In this study, DSS is designed through fuzzy environment in order to deal with the vagueness of human judgment. Thus, the input in topsis4BIM is based on linguistic input. This membership function is used to store the linguistic input from user. The deicision model was developed thtough Google spreadsheet. Figure 3 below illustrates the summarize process of fuzzy TOPSIS.
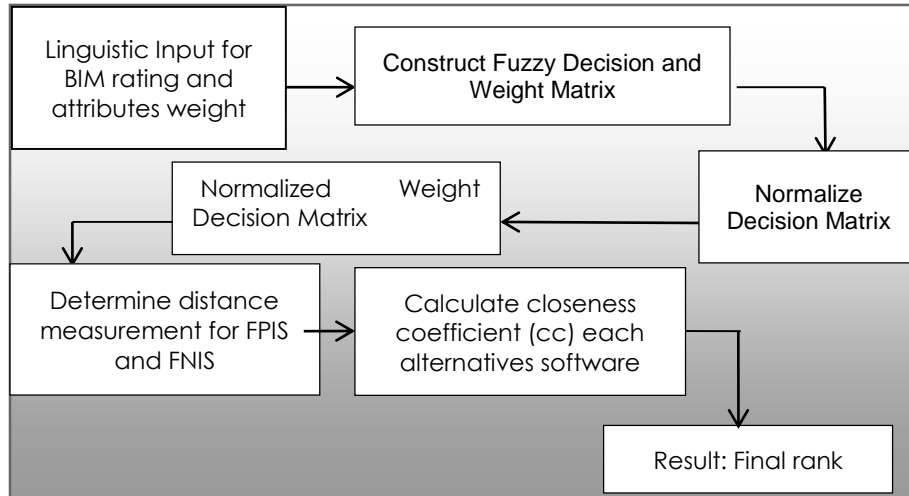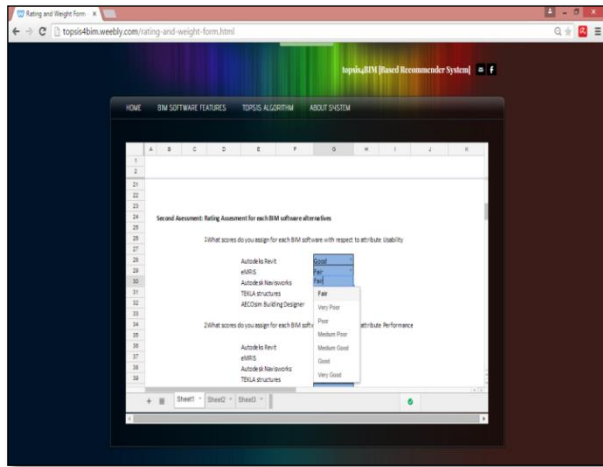

Figure 3 Fuzzy TOPSIS in topsis4BIM DSS

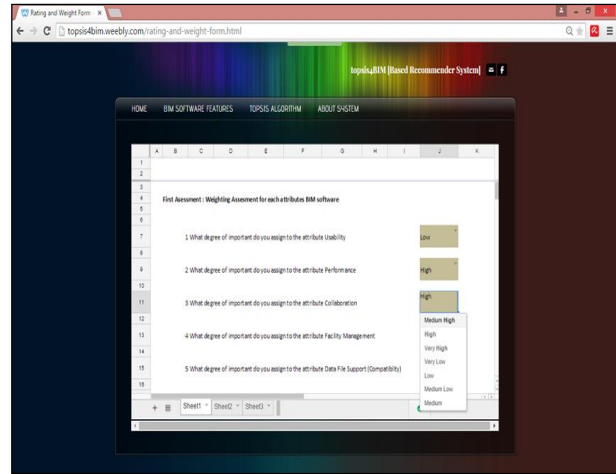**Figure 4** Linguistic inputs for weight assessment

Figure 5 Linguistic inputs for software rating

The abstraction can be depicted into user interface as follows. In Figure 4, decision makers are required to assign linguistic weight for each attributes such as VL, L, ML, M, MH, H, or VH. Figure 5 depicts the linguistic input for rating assessment. Each of BIM software is assigned variable VP, P, MP, F, MG, G, or VG. During this assessment, software details (such as features and function) are viewed to access software with respect to each attribute.

3.3 User Inteface

One of the web 2.0 platforms has been utilized as a domain and user interface for this web based. The development of DSS through this platform provide numerous of advantages such as easy to developed, light programming language, interactive user interface and remote. Figure 3 and 4 ilustrates some of the snapshot from topsis4BIM system.
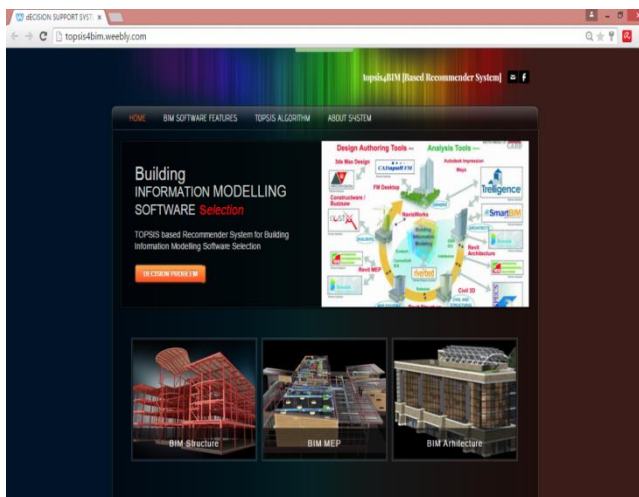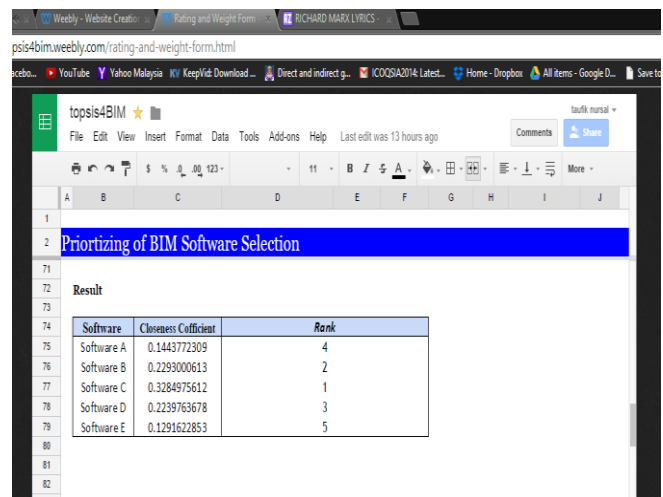

Figure 6 Front page

Figure 7 Final Result

4.0 Evaluation of Topsis4BIM

In order to measure and evaluate the usability and effectiveness of topsis4BIM, a real construction project through BIM has been deploy. Three decision makers who directly involved with the project has been selected. The evalutiion process has been

conducted into two phase, there were sub system validation and face validation. Sub system validation is order to measure the ability of decision model in topsis4BIM. Sub system valiation has been carried out by comparison of result between topsis4BIM with current practice. As a result, topsis4BIM yield similar result with current practice. On the other hand, face

validation process has been divided into 2 approach, their were quantitative and qualitative. In term of quantitative approach, decision makers were asked to rate with scale very good, good, fair and poor towards topsis4BIM based on some criteria such as perceive ease of use, perceive usefulness, preferences, and willingness. Result indicates of most of criteria was rate as good. Meanwhile, in qualitative approach, decision makers were asked to give their opinion towards topsis4BIM based on two criteria such as system quality and information presentation. Result indicates as followed;

4.1 System Quality

"The development of this DSS is quiet practical, straight forward, and also convenient to access. What important is we really need to know what to input. I really interest to seen what value this DSS would generated." DM 1

"This DSS and its methodology behind it is easy to understand, easy to learn, remote, plus it help you structured your problem, and do the calculation, it's interesting and got potential, but I still need time to build confident on the Fuzzy TOPSIS, coz I am not familiar with this kind of decision techniques." DM 2

"It is simple DSS, easy to learn and used, plus the integration with Google application is interesting. For the decision process methodology, before using this DSS, a few more things need to be set first. For example, for example, I need to know all the alternative software before using this method". DM 3

4.2 Information Presentation

"It is good to see a web based that user friendly, simple, informative and not to colourful. For me, I like the way of this web based presented. The interface look simple but interesting, the portion of each option is nicely organized." DM 1

"For the information presentation I think this DSS still lack of something, the way decision model presented in this DSS, the user interface of Google spread sheet is not impress me." DM 2

"All the information presented (display format, graphic, interface) in this DSS for me it's clear, simple yet interesting and suit it purposed. However, there still has space for improvement." DM 3

5.0 CONCLUSION AND DISCUSSION

Recently, the emergence of a new concept web development called Web 2.0 has shifted the architecture development of DSS with potential promises characteristics such as a lightweight programming language requirement, cost effective scalability, and interactive user interface. All these characteristic have increased the popularity of Web 2.0 among the users compared to web 1.0 [41]–[44].

Thus, this study has presented architecture of MCDM DSS through Web 2.0 as decision support tool called topsis4BIM. The development of topsis4BIM does not require any technical skill in programming language, minimized time and cost of development, and also can be also access through any devices that can connect the internet. This is in line with the finding by Aghaei et al (2012) that highlighted the advantages of Web 2.0 towards developing a web based DSS that is easier, quicker and cheaper compared to previous web generation.

Based on the evaluation process, even though the architecture of topsis4BIM is simple, yet it is capable of providing features such as analytical analysis, data base and as a web, topsis4BIM provide accesse to BIM software vendor web site. Thus, in consclusion a web based topsis4BIM has the following benefits; (1) The topsis4BIM provides computer aided decision making platform for multi criteria decision problem with realiable decision analysis, and (2) Development topsis4BIM through Web 2.0 technology has simplified the architecture of web base DSS.

Acknowledgement.

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