Design of a Multi Model Decision Support Software Tool for Multi Criteria Group Decision Making in Software Product Selection

Ekenta E. Odokuma¹, Prince O. Asagba², Bartholomew O. Eke³

^{1,2,3}(Department of Computer Science, University of Port Harcourt, Port Harcourt, Nigeria) Corresponding Author: Ekenta E. Odokuma

ABSTRACT: The design of a cloud based multi model software product selection and decision support software tool incorporating three Multi Criteria Decision Making (MCDM) models: Weighted Sum Method, ViseKriterijumsaOptimizacija I KompromisnoResenje (VIKOR) in Serbian; meaning Multi Criteria Optimization and Compromise Solution and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) has been presented. Existing systems rely one or a hybrid MCDM model for the evaluation which can produce erroneous results. The proposed software tool considers the ranking results from all three models when making a decision. The DSS tool was implemented using freely available Google Cloud technologies: Sheets, Drive, Sites, for easier collaborative decision making. The cloud based software tool was employed in a software product selection problem. The results show that the tool effectively produced the ranking from the models for the evaluation and selection with ease.

Keywords: Decision Support Systems, MCDM, Google Sheets, TOPSIS, VIKOR, WSM.

Date of Submission: 23-10-2017

Date of acceptance: 02-11-2017

I. Introduction

Decision Support Systems (DSS) guide individuals, businesses and organization make effective and transparent decisions. DSS are influenced by factors such as the skills and requirements its users, the technological development, the expected result, etc. Shibl, et. at. (2013); power and Phillip-Wren (2011). A DSS provides three basic components: the database component, a model base, and a user interface component Jun and Jun, (2011). The database keeps both the data and information of the system. The model(s) provide the means of analysing available options and the user interface provides a user friendly environment for users to enter data and also view results. Cloud computing services are rapidly increasing. Nouh et al (2013) With a promise of reduced maintenance and operational cost, and increased computation and processing power; organizations are moving to the cloud. Decision makers have used spreadsheets as tools for decision making in the last two decades Decision Support with Spreadsheets have advanced to the point of providing powerful, general-purpose functionality and are among the most widely used decision-support tools in business today.

1.1 Aim and Objective.

In this paper we present the design of a cloud based multi model decision support software tool with the objective of: (1) incorporating three Multi Criteria Decision Making models: Weighted Sum Method, VisekriterijumsaOptimizacija I KompromisnoResenje (VIKOR) in Serbian; meaning Multi Criteria Optimization and Compromise Solution and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for collaborative decision making, (2) implementing same using freely available Google Cloud technologies and (3) applying the software tool in a software product selection problem.

II. Literature Review

Software selection problems have been solved by mathematical programming methods, Lengacher and Cammarata (2012);Kokangul, (2009); Freitas and Souza (2011), artificial Intelligence methods Guo et al. (2011); Kaur and Singh (2014), multi criteria decision making methods such as AHP, WSM, TOPSIS, VIKOR, PROMETHEE, ELECTRE, etc. Malik et al. (2016); Aouadni, et al., 2017, Eldrandaly, (2007) and integrated multi criteria decision making models, several of which are combinations of AHP and other methods Hanine et al (2016); Zaidan et al, (2015); Jadhav and Sonar (2009). In Multi Criteria Decision Making (MCDM) problems there are characteristics and sub characteristics that are often conflicting with high uncertainty. Different users of the software product also have differing perspectives and multiple interests, therefore extending the MCDM problem into a Multi Criteria Group Decision Making Problem (MCGDM) where two or more experts are involved in the evaluation process. Kara and Cheikhrouhou (2014); Efe (2016).

2.1Related work

TOPSIS4BIM decision support for Building Information Modelling software selection. They applied cloud based technology in the deployment but applied only one MCDM model: Fuzzy TOPSIS model. Radu et al, (2014) presented iDS, a system designed to become a collaborative and cloud-based Group Decision Support System. The use of MCDM models were not mentioned in this work. The proposed system was to be made available as a Business as a Service cloud model. Abdelhakim and Shirmohammadi (2014) proposed a knowledge driven, web-based group decision support system for the selection and evaluation of educational multimedia based on knowledge of intelligence, design, choice, implementation, and evaluation.

With the amount of software products in the market today and the importance attached to selecting the most appropriate software product, there is need for decision support systems that will automate the processed of software product selection problem. Software product selection activities have often relied on one or a hybridMCDMmodel for the evaluation. Relying on only one model for the selection may result in recommending the wrong software product. Also, available decision support tools are proprietary and require the user to have installed software programs on their systems for the evaluation. In this work, a Multi Criteria Decision Making software tool, incooporating the WSM, TOPSIS and VIKOR as seperate decision making models is designed and developed applying Rapid Application Development (RAD) methodology using Google cloud based tools and technologies.

III. Design of the Proposed Cloud Based Decision Support Software Tool

The proposed cloud based, multi model driven decision support software tool was made to ease data entry from decision makers, automate the ranking processes by the three Multi Criteria Decision Making models and generate results. Figure 1 shows the architecture of the system. The tool consists of the user interface, the database and the model management components.

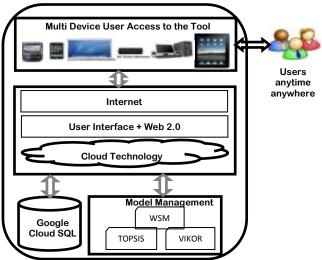
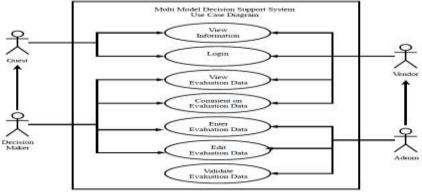
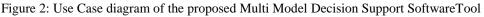


Figure 1: Architecture of the Proposed Software Tool

3.1 The User Interface Component

Users access the software application through Google Sites and may or may not have the permission to access its functions on Google Sheets; a cloud based spreadsheet platform provided by Google. Figure 2 shows the users and their use cases.





3.2 The Database Component

The Relational Schema for the database is shown in Figure 3.

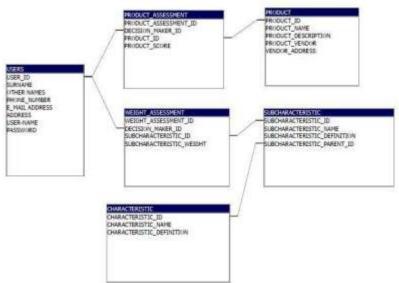


Figure 3: Relational Schema for the database Tables

3.3 The Model Management Component

Three Multi Criteria Decision Making Models: Weighted Sum Method (WSM), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Vise KriterijumsaOptimizacija I KompromisnoResenje(VIKOR) meaning Multi Criteria Optimization and Compromise Solutionare included in the model management component of the Multi Model Decision Making software tool. The detailed explanations of the algorithms outlining the operations of each of these models have been given by several researchers including Odokuma and Asagba, (2017);Zaidan et. al., (2015); Mardani et. al., (2015). The evaluation process is summarized in Figure 4.

IV. Implementation Tools and Technologies

The following technologies and tools were employed in the implementation.

- 1. Google Sheets
- 2. Google Drive
- 3. Google Sites

Google Sheets-Google Sheets is a free, functional, cloud base spreadsheet application that can be used by individuals or groups for collaboration anytime, anywhere. Multiple people can work on the same spreadsheet at the same time and all their contributions will be effected, making it suitable for group decision making. Sheets offers cloud storage, which ensures that the spreadsheet is editable from any web enabled device. Sheets provided both the user interface for the decision maker and the model management in the proposed application. **Google Drive** – Data storage and retrieval was provided by Google Drive. Drive makes Sheets spreadsheets available anytime and anywhere.

Google Sites – Provided the means of creating the web pages for the cloud based application. The spreadsheets created in Google sheets were stored in Google drive and accessed through Google Sites.

V. Evaluation and Results from the Multi Model DSS Software Tool

To evaluate its effectiveness and usability the developed cloud based DSS software tool was employed in a software selection problem. Figures 5 to 18 show sample screens from the evaluation of five software products by four decision makers. Figure 17 shows Product B as the best alternative from all three MCM models employed in the research. Design of a Multi Model Decision Support Software Tool for Multi Criteria Group Decision Making

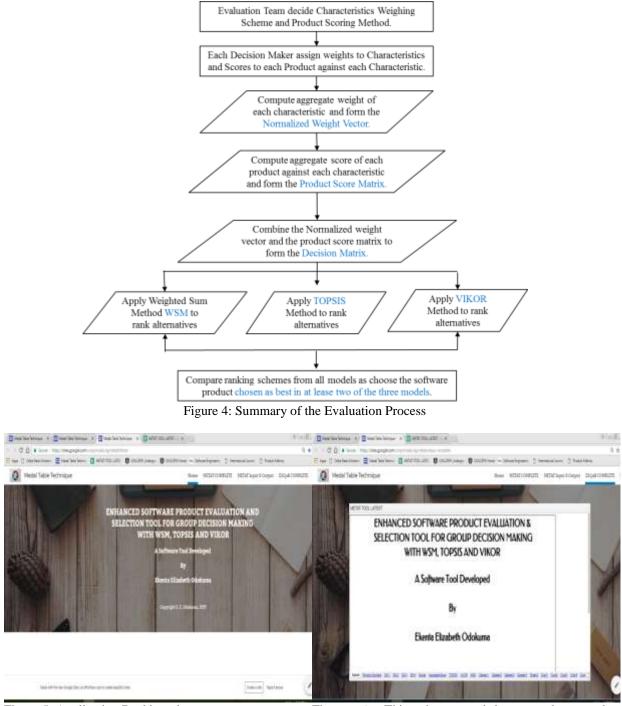


Figure 5: Application Dashboard

Figure 6: Thirty-three worksheets and several functions and formulae work in the background. Some worksheet names appear in blue.

Design of a Multi Model Decision Support Software Tool for Multi Criteria Group Decision Making

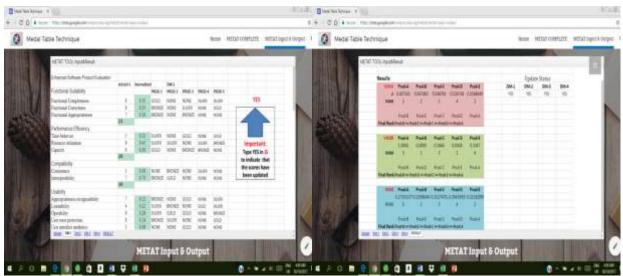


Figure 7: The screen for decision maker input. Cells shaded green contain formula and cannot be altered

Figure 8: The result sheet after all decision makers have entered their weights and ratings

00		and re-	-								1.4	- e	0				1	-							
Medai Table Te	7mique		ILIAI	ome	URTR		-	ernit over	mim	erratiopal	ouged (0	Media Table	Techni	die.			Meda	a i comj	Diete			ent or	nim. I	ematoques de
				county															an conq	piece					
1EX	100.								1	÷.				EKO	04.									10	i
		1	1 1		1		1.		t. 🗄						- 10	41	6	. 417						100	81
1. Extran	of Schweis Product Saluation			14000-1	Apreside I														1.344	- Pala	Fall	AndI	.Held	Profil	
		Hangh	hep:	Dates	to Pasket 1	í.		- Holat	Net	9										I LIND	1.0440	130686	0.0340	111171	
Funds	ed hibdolity	Regite	Antalat	ONL-	INI	-5MF	284	100	54					tite 3	kine tittetä	2 19 84	- 20	(***) i	300	0.000	1	1	6.1	1	
	nal Corpinmon	248	0000198	3015	6060	000	383		4	11				1	0.010	- 1	TR.	pi.							1
	ad Linchse	-314	-10701048	9041	90921	40.0	1014		1	1				- 1	1.2011		21	- 27	1000	Pall	3 lat		Pall.	Pasta	
Facto	nd Approximent	- 141	3021746	(46)421	HOLE	HNG	1005		ŧ	5					1.041		M2(Trailar	a Root Bank	No. of Cold Party	AL IN PART	Lowald.	ALC: NO	
Patto	manue Diffusiono																		1 YES	- Paula	Pull	Pade	Pold	Pold	
	elation	240	660.87	6484	\$244	4044	101		1	1					1121	1	101	-8		- REAL	2008	Charles.	LND	1.665	
Barrow	or selection	0.04	0000000	500	NOR	NNE	30.01		8 1	î				-1	1100		1	30	1.00		1	.3	10	1	
Cent		0.00	0001009	8080	8080	100	101		1	1				1.2	11001		10	1.8							
																				-	high	8,415	mail	Prod 4	
Camp	utbilly																		Feelfar	6.8668 (m)	red 8 on Fes	e(nind	Links!		
Cana			0011817		NOM:		3041		£	I.				- 1	1.1001		10	18							
Linese	nili i i i i i i i i i i i i i i i i i i	:1.0	108046	1000	406	406	- 101		1	1				1	4,004		4	- T.	-884	I. Postd	-	Auet.	Paid	1000	
																				A Design	EMERT	0.0.000	52901	ILC:NO	
Usubi																				1.1.1		1		1	
	Altern respectivity	14	960368			8.05	104		P						1,201		W.,	19							
Low		18	101807		8080	90.0	1042		1-1	Ŧ					6.118	-	18	-12		141	9442	Pedl.	Pres D	Personal Across	
02560	and the second se										24							- Court	100				needs	ALC: NO.	F
-See	Annual Milling B	U 167 311	184 Sec.	-	100	38 1	N lent	1 TRANE I	inti i	\$.T.	1			See he	ations 212	352 10	1.982	an mu	THE NAME	Part 120	8 88 1	Di lett	I Statu	insti 3e	6-10-1

Figure 9: Showing the worksheet where a set of data is collated from all decision makers for use by all the three models. Figure 10: The Final result from all the ranking methods end the worksheet

Medai Table Technique			ene HERUNHERE HERUPPER	Medar Table 7	actuique			Acres Hills	COMPANY - MIX	Attaicts-order
	PLIAI COM	were				PLIAI COMPRE	æ			
u€107.100,			10	νE	W100					
20101-0420-00	A2484	10%	MENOR .	10	1000 1004	8.89 Paside	1,000 1.1	1040 3038	ALMAN . SHEPPE	
	204git 24 10 94	N R		12	1055 1000	SXC International Access	1,000 1.1	BAT 1000	1281 082	
Farmond Completeners	initiation n 31 3	1 31 Fast	and Energistments	12	1001 1005	1821 Plan hand Links			1385 0.000	
Functional Environment	11000443880 20 11 4	21 27 Fact	anal Europetases	100	1996 1997	0.0040 Fertiliant Reprintment			1,2680 (1,07,07	
Prestined Approximate	1 N 11	at if Part	and Appropriateneys	54	1054 10202	\$2008 Latent Topons			11000 01200	
Tim-Arbeiter set	63036028 B J B	1 3 1=	the set	12	10010 00000	BOOM LTHE REPORT			11000 04210	
Reverer etilation	1224036428 11 21 25	31 7 Rea	er salaster o	24	1000 0000	KX00 Lifest Association and a			11000 00000	
Capacity	122020004888 20 4 21	1 4 Case	4	100	1000 1000	PXX2 Litters hat prove sets		827 1014	the second se	
Continue	10000000000 3 .00 00	21 28 Kash	Sec. 1	191	1023 10005	9.851 Princi france and pagest			1,003 30130	
Takingwabith		31 J. Janua			1052 8:000	8,X9 rymer havened hold for			£204 (dfb)	
Ageneration and		7 3 200			100/ 829	8X06 righted Big-territy bold logar			8,900 (000)	
Cometrities	0.015015080 M .H .H .4				2008 0000	8,000 Library Represents dorling to the			1.000 0.000	
Openheirs		3 2 Open		47	1000 1000	1000 Sheet Revenue's With Super-	104 1	100 2000	1047 0018	
User ones permitivas		at at New		-		241902-020-02030-020-000			the second se	
User appthis within a		3. 27. Neri				tal star it is a climate in the			and the second	
Accesibile		21 7 Acres				Inter of two of Equation Distances have \$100				
Seerc.	100402502 10 11 14							MELL SOUTH	40949411111	
Asaida	humane by by but	a contration	Ne			and ref		1	1.1.1	
Saint Robot Larger 10	or west last last that have incoment	-	a loss week that the ?	l lie	Manian III	a new part that the last the second has a	PH (10.00 100)	Clean: Mar	Cont. Anne	
			and the second sec	2						
							_	_		= 7.5

DOI: 10.9790/0661-1905053541

Design of a Multi Model Decision Support Software Tool for Multi Criteria Group Decision Making

CO.	doeters to	-		_				19	+ - 00 +	- P.		-	all designed	8.000						1
Medal Table Technique	Media Table Technique Berry Mittan Complete								0 Hota	Table Tr	ict mique			METAT COM	piete		Han 1	itat posi	122 11	tat lapa s Galpat
HEIKI 700							10			IE	1110.								100	
V5006 A821908							10000.021000			311.	1.1091		407						- 54	
STORE INC.		Rolel	free and	end de		1.775					142		101		den tel a	Inches I	WIEC	HOUR .	MODIC	
Rid-Caunceys	Appe	1	1.2		4	1				- 21	1.00		1100		ITH I	142	6.03	143	LOB	
Packad Dayleses	Tephy Displayers	10	2	800	10.01	301	Twinoid aginese			12	Luit.		147	Laing h 1		1 144	1.00	1	1.100	
Partiend Carry too	1034184		1	+	1.0	17	Factorication			144	in the local		_			1 Arrow	6.189	108	2348	2
Particul Approximit	HEIGHT	1	1	11	11	17	Patient Agreption			100	1018		1.194	balage 1		1		1.1	4	
Tarlata quipane	HERE	11	1.0	- 10	12	1	Tarlinir			100	1 high		4.001			l inter	1441	136	144	
Rente alcana	SCOULD	10	- 21	.2	8	10	Beau states			100	100		1300	Testingh Q	1	1	1	1	1	
Carett	11001004.81	14	1	10	1	1	Cave.			125	1011		1100			24	-		_	
Contients	1015780	1 t	- 15	- 18		18	Circuitor			-04	100		4400	longiale	149-2	104	12	and.		0
Interpretation	1044023	11	17	- 20	1	1	Interprofiler			100	307	1000	(30)	Suble Q	1.00 mb	chu TTT	8			
Agring strive encrystables	other:	t	3	- 20	1.2		Aprepident respublic			101	juber.	-botte	4100							
Lunitie	(1110/088	30	1	1	3	2	Lundite			-142	192	0103	1300		1031	PE0.8	HIDIC	8633.0	3089	
Cambridge	(dettrolation)	10	B	18	3	11	(analytic)				185	1000	189	8	1.541	1000	1943	1.54)	1405	
Uncomprising.	10109071	п	11	.2	10	-2-	Decergence			-	1010	1004	1002							
Contaction to design	1.084021	H	1.18	11	1.1	IT	Dia tetelar antesa			12	3185	3294	103		120,994					
Alexables	HICCHINE	38		1	- 8	1.1	a consister			(28)	108	1000	1200							

Figure 13: First page of the VIKOR method

Figure 14 Last page of the VIKOR method

C D)				-		-	67	R .1	CO I and the statement of the statement
Medal Table Technique	ML						and the second se		
	ML	1.11					Baller Hand coleman Hand Courted	4	🚱 Medal Table Technique et al transmission and the technique et al transmission and transmission
		141	LON	1pie	ene -				METAT Complete
HE107300									(E1070))
Weghted Sam Marhael (W204)	Rept	1			- 44		Waghted Sum Kiefeed (W20)		at a 2 4 to behave become to an exception and a second sec
Contriend TompHysiopa	1.1215305	11					Punction # Contentianes		p p z i i i biteritermetilesite (0868)(10784)(1784)(1658)(1988
Purchased Exercision	1325403	11					Functional Terrorism		27 II B B B Mittain Federation Anthe Active Acti
Functional Reportunitationses	1.011744	1					Proversional Representationness		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Time-Infanio:	0.822811	12					Time befactor		A T R R Diversitient data Arts American and American Arts
Record (dfadlor	1.1235360						Necessi di ladici		3 J 1 1 1 1 Patron Reports Volt Same VOR (44) 125810 (2544) (2543)
Casialty	1.1025004	10		_			Cevents.		(ii) 1 (2) (2) (3) (4) (4) (4) (4) (4) (4) (4) (4) (4) (4
Geiterne	A STREET	4	ii	11	żi	11	Communi		32 F D D D D Monov Septement We Law: http://doi.org/10.001/1001/10000/1000000
bringed/fly	LOBATE	IJ		_			Through the		In several measurement of the
Approximation respiration	101231400	1	.51	.11	1	11	Appropriate and an approximity		X X X X X
Lourse (Tto	8.610276	11	H				Lawrantin		N 12 N 14 M
Operating .	8.9115346	.8	-10	н.		П	Overview in the second se		Facture 1:3046661210466 (21098) 244010 (20108)
tion proportionflast	1.11.145866	11	11	п	10	11	Vereni altatai		
Specification and halfs	10066	-11	10	п	1	π	Coor interfacia assimpting		14) (H) (H) (H) (H) (H)
ALCOUNTY .	8.7(1209)	31	.11	.1	H.	Ϋ.	Acceptifie .		
18.4-0	in our contract	-++	1.90		. 84	- 14	Marth.		Find Back 72 + F(x) H = F2

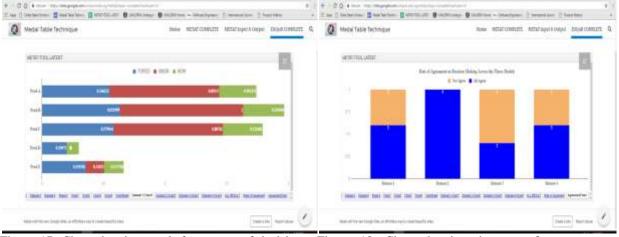


Figure 17: Chart showing result from a set of decision
makers' Inputs. Product B is seen as the best.Figure 18: Chart showing the rate of agreement
among the models.

VI. Conclusion and Future Work

The proposed system has many advantages when compared to the existing systems:

(1) the ranking results from three different models are simultaneously obtained, making it easier to select the best software product if all the models point to the same.

(2) The decision maker is more confident about his choice since there are three opinions.

(3) The cloud based software tool is easy to use and can be employed at no extra cost to the evaluation process.

Researchers may add more models to the proposed cloud based tool. The tool may be adapted to solve other multi criteria decision making problems.

References

- Abdelhakim, M. N., and Shirmohammadi, S. (2007). A web-based group decision support system for the selection and evaluation of educational multimedia. Proceedings of the international workshop on Educational multimedia and multimedia education. Augsburg, Bavaria, Germany 27-36.
- [2] Aouadni, S., Rebai, A., and Turskis, Z. (2017). The Meaningful Mixed Data TOPSIS (TOPSIS-MMD) Method and its Application in Supplier Selection. Studies in Informatics and Control, **26**(3), 353-363.
- [3] Efe, B. (2016). An integrated fuzzy multi criteria group decision making approach for ERP system selection. Applied Soft Computing, 3(8), 106-117.
- [4] Eldrandaly, K. (2007) GIS software selection: a multi-criteria decision making approach, Applied GIS, 3(5), 1-17
- [5] Freitas, F. G. and Souza, J. T., (2011) Applying Mathematical Programming to Efficient Software Release Management. Optimization in Software Engineering Group250(1), 564–568
- [6] Guo J, White J, Wang G, Li J, Wang Y (2011) A genetic algorithm for optimized feature selection with resource constraints in software product lines. Journal of System Software,84(12):2208–2221
- [7] Hanine, M., Boutkhoum, O., Tikniouine, A., and Agouti, T. (2016). Application of an integrated multi-criteria decision making AHP-TOPSIS methodology for ETL software selection. SpringerPlus, 5(1), 263.
- [8] Jadhav, A. S., and Sonar, R. M. (2009). Evaluating and selecting software packages: A review. Information and software technology, 51(3), 555-563.
- [9] Jun, L. and Jun, W. (2011) Cloud Computing Based Solution to Decision Making. Procedia Engineering15 (1) 1822 1826
- [10] Kara, S. S., and Cheikhrouhou, N. (2014). A multi criteria group decision making approach for collaborative software selection problem. Journal of Intelligent and Fuzzy Systems, 26(1), 37-47.
- [11] Kaur, L. and Singh, H., (2014). Software Component Selection techniques A review. International Journal of Computer Science and Information Technologies, Vol. 5 (3) 3739-3742
- [12] Kokangul, A., (2009) Integrated analytical hierarch process and mathematical programming to supplier selection problem with quantity discount. Applied Mathematical Modelling. 33(3) 1417-1429
- [13] Lengacher D. and Cammarata C. (2012) A Two-Phase Data Envelopment Analysis Model for Portfolio Selection". Advanced Decision Science :1–9
- [14] Malik, A. A., Khan, T. M. R., and Mahboob, A. (2016). Evaluation of OLSR Protocol Implementations using Analytical Hierarchical Process (AHP). International Journal of Advanced Computer Science and Applications, 7(11).
- [15] Mardani, A., Zavadskas, E. K., Govindan, K., Senin, A. A. and Jusoh, A. (2015), VIKOR Technique: A Systematic Review of the State of the Art Literature on Methodologies and Applications. Sustainability 8(37)1-38
- [16] Nouh, M., Hadhrawi, A., and Sanchez A., (2013) Towards Cloud-Based Decision Support Platform for Group Decision Making. Proceedings of the IEEE International Conference on Systems Man and Cybernetics, Manchester, UK. 50-55
- [17] Nursal A. T., Omara, M. F., and Nawi, M. N. The design of topsis4BIM decision support for building information modelling software selection.JurnalTeknologi, 77(5), 1-7
- [18] Odokuma, E. E. and Asagba P. O. (2017) Similarities and differences between the ranking schemes of the WSM, TOPSIS and VIKOR Multi Criteria Decision Making methods in software product selection. International Research Journal of Computer Science,4(10), 1-9
- [19] Power, D. J., and Phillips-Wren, G. (2011). Impact of social media and Web 2.0 on decision-making. Journal of decision systems, 20(3), 249-261.
- [20] Radu, C., Cândea, C., Cândea, G., and Zamfirescu, C. B. (2014). Towards a cloud-based group decision support system. In Recent Developments in Computational Collective Intelligence (187-196). Springer, Cham.
- [21] Shibl, R., Lawley, M. and Debuse, J. (2011) Factors influencing decision support system acceptance. Journal of Decision Support Systems54 (2) 953-961
- [22] Zaidan, A. A., Zaidan, B. B., Al-Haiqi, A., Kiah, M. L. M., Hussain, M., and Abdulnabi, M. (2015). Evaluation and selection of open-source EMR software packages based on integrated AHP and TOPSIS. Journal of biomedical informatics, 53(1), 390-404.

Ekenta E. Odokuma Design of a Multi Model Decision Support Software Tool for Multi Criteria Group Decision Making in Software Product Selection." IOSR Journal of Computer Engineering (IOSR-JCE), vol. 19, no. 5, 2017, pp. 35-41.

DOI: 10.9790/0661-1905053541