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A Systematic Review on Applications of Multi-Criteria Decision Method (MCDM) in Evaluating Factors Influencing User Acceptance of Cloud-Based System

Yusufu Gambo[1]
Adamawa State University Mubi
Yusufu.gambo@gmail.com

Peter Y. Mshelia[2]
University of Maiduguri,
petermshelia@unimaid.edu.ng

Nathan Nachandiya[3]
Adamawa State University, Mubi
nachandiya@yahoo.com

***Abstract*—The cloud based system has the ability to enhance computing process and delivery computer resources and services irrespective of geographical location and time. This new technology has attracted the attention of academics and industrial experts, and offered computing anywhere at any-time, increase access to resources and provide on demand services through the internet.**

A number of studies have developed evaluation frameworks to identify factors that influence user acceptance of cloud-based system. However, we believe that these factors are complex involving lots of criteria and goals. Furthermore, these factors alone are insufficient to provide insight into user technology acceptance issues. Several approaches have been used to guide decision maker in the technology adoption process including multi-criteria decision methods (MCDM). MCDM enables decision maker to select the best option among the many alternatives.

In this review paper, we reviewed the applications of MCDM in cloud based system in general to understand the extents of MCDM applications using systematic literature from well-known databases.

The finding shows that most of the studies used MCDM for services selection and Analytic hierarchy process (AHP) was the most used method. Further there are rare studies that used MCDM in evaluating factors influencing user acceptance of cloud based system. The review recommended that further studies can focus on the application of MCDM in evaluating factors influencing acceptance of cloud based learning system, deployment model, and migration options to inform decision on adoption process.

This conceptual paper contributes and enriched literature on the use of MCDM in cloud based system's studies and provides support for the use of MCDM in evaluating the acceptance of cloud based system which can further provide insight into issues surrounding user technology acceptance.

Keywords—multi-criteria decision methods, cloud based system, Service, evaluation, frameworks, deployment

INTRODUCTION

1.1 Background

Cloud computing is a type of internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g., computer networks, servers, storage, applications and services),which can be rapidly provisioned and released with minimal management effort[25]. It is characterized by On-demand self-service, Broad network access, Resource pooling, Rapid elasticity and Measured service. It has the following services: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS); and it can be deployed as private cloud, Public cloud, hybrid cloud, and Community cloud.

Today technology is developing at an incredible speed. Further, with this acceleration, it becomes necessary to take decisions more frequently for the updates of technology development. Therefore, organizations should consider the changes and updates of the Information Technologies so that they can create more efficient working environment and strategically plan process [26].

Technology evaluation provides organization with understanding of adoption process and provides identification of appropriate tools and techniques to determine success. The success of a new information system depends on the users' level of acceptance [26]. Many significant frameworks have been used for evaluating adoption issues in cloud based system [11, 12, 7].This work however, believe that identifying these factors that influenced user acceptances of cloud-based system alone is insufficient in itself to provide insight into the adoption of cloud-based system, and that in addition it is vital to identify which among these factors are influential to inform decision in the adoption process [26]. Further, it could help organizations to take necessary actions based on the importance of the factors for which there exist an indication of low acceptance among users. For example, reference[26] have explicitly introduced the concepts of which in the user technology evaluation to determine the influential factors in the user acceptance of health care technology using multi-criteria decision approach. The results show that information quality is the most influential followed by software quality. In a similar study [4] used fuzzy multi-criteria decision approach to explicitly evaluate the critical factors of electronic medical record adoption. The results show that seven factors, namely time investment, screen/room, hybrid system, planning, resource training, workflow, and weight, were found as the influential criteria and strongest drivers in the adoption of EMR in Malaysia's primary health care setting. Furthermore, [47] used multi-criteria decision approach to prioritized factors affecting the stock portfolio and found cluster profit as the most influential followed by market cluster. The identification of the most influential factors will help decision maker to concentrate on these factors instead of all of them. Several other studies have explicitly addressed the most influential factors using multi-criteria decision approach in many other disciplines and themes such as [45, 34, 29].

The objectives of this study is to review literature on the applications of MCDM in cloud based system in general to enrich the literature with statistic related to this area to provide direction for further research.

This paper is structured as follows. Section 2 describes the methodology. Section 3 discusses MCDM in Cloud-Based System. Section 4 discusses the findings, and section 5 discusses the conclusion and further research

2 METHDOLOGY

The cloud based system is an emerging technology that attracts the attention of academic and industrial experts. A number of studies on the adoption of cloud based system have been conducted at user or organizational level, services selections, deployment, migrations options and other conceptual applications. The methodology employed in this review is the systematic review of

literature searching keywords which include Mobile cloud computing system, multi-criteria decision method, Mobile cloud system, Software as a Services, Platform as a Services, and Infrastructure as a Service, user, factors, and adoption. While the exclusion search terms are technical aspects of cloud computing, Cloud based learning system, and technical applications of MCDM in cloud based system.

The review focuses on articles published in major scholarly journals and proceedings of conferences spreading over a period from 2010–Jan 2017.

Cloud computing is a relatively new paradigm concept of computing which emerged in late 2000‟s [43]. The review does not include unpublished papers. A couple of scientific databases were searched in a bid to obtain recent and relevant papers on the topic under review. A total of 292 articles are found, and these include: Emerald (19%), Science Direct (22%), IEEE Computer Society Digital Library (18%), ACM Digital Library (8%), Researchgate (2%), IEEE Xplore Digital Library (15%), and SpringerLink (16%). An initial screening process of these articles resulted in removing of 197 articles as they were into technical aspects of cloud based system. A further screening of the articles resulted in removing of 61 articles as they were into the technical applications of MCDM in cloud based system. A total of 34 articles are considered suitable for the purpose of the study as meeting inclusion criteria, and are used for review analysis and discussions.

3 LITERATURE REVIEW

3.1 Concepts of Multi-Criteria Decision Making (MCDM)

MCDM is a branch of Operations Research that involves making decisions among many alternatives. It is used where there are many conflicting criteria and objectives to determine the best possible solution. Multi-criteria decision approach methods (MCDMs) mainly group as individual and integrated methods [17]. In other words, MCDMs are either multi-attribute or multi-objective in which decision is based upon [9]. The multi-attribute methods are designed for choosing the discrete alternatives, whereas the multi-objective methods are suited for the infinite number of alternatives defined by a set of constraints. Reference [9] & reference [33] termed the multi-objective decision-making as “determining how best to trade off increased value on one objective for lower value on another.

According to [40, 29, 3] MCDM study involves the following process:

(a) Determining the relevant criteria and alternatives

(b) Attached numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria

(c) Process the numerical values to determine a ranking, prioritizing, rating, and selection of each alternative.

These MCDMs are differentiated by the way objectives and alternatives weights are determine as prescribed by rule-based structures [40, 29, 26]. Therefore, the choice of MCDM depends on the problem at hand and objective of study.

3.2 Existing Applications of MCDM in Cloud based System

Table 1: Summary of review

Title & Year	Thematic Characteristics	MCDMs Used
QoS-based multiple service selection with fuzzy options[22]	Service selection	Fuzzy-Technique for order preference by similarity (OPS) to an ideal solution (F-TOPSIS)
A decision-making method based on interval-valued fuzzy sets for cloud service evaluation[8]	Service evaluation	Preference ranking organization method of enrichment evaluations (PROMETHEE)
Dynamic resource allocation in computing clouds using distributed multiple criteria decision analysis[45]	Resource allocation	Fuzzy-Analytic hierarchy process (F-AHP)
SMICloud: A Framework for Comparing and Ranking Cloud Services[14]	Measures the quality and prioritize Cloud services.	Analytic hierarchy process (AHP)
Improving cloud computing service in fuzzy environment[39]	Cloud services	Intervalued fuzzy(IVF) and ViseKriterijumska Optimizacija I Kompromisno Resenje(VIKOR)
A Fuzzy Logic Multi-Criteria Decision Framework for Selecting IT Service Providers[19]	The purposes is develop a robust framework to help in cloud services selection	Fuzzy- Data envelopment analysis - Analytic hierarchy process and Technique for order preference by similarity (OPS) to an ideal solution (TOPSIS)(DEA-AHP and TOPSIS)
A Framework for Ranking of Cloud Computing Services[38]	The QoS attributes used in analysis by designing metrics to every single attribute for measuring accuracy of service for each provider	Analytic hierarchy process (AHP)
The analytic hierarchy process: task scheduling and resource allocation in cloud computing environment[10]	Task scheduling and resources allocations	Analytic hierarchy process (AHP)
Consumer-centered service selection, especially for medical services[36]	Service selection	Analytic hierarchy process (AHP)
Cloud Adoption: Prioritizing Obstacles and Obstacles Resolution Tactics Using AHP[46]	Prioritizing adoption obstacles	Analytic hierarchy process (AHP)
Decision Model for Selecting a Cloud Provider: A Study of Service Model Decision Priorities[31]	A decision model to select an appropriate Cloud provider.	Analytic hierarchy process (AHP)

Building A Evaluation of Performance Model for the Cloud E-Learning Service Using Hybrid MCDM[32]	Performance evaluation	Decision-making trial and evaluation Laboratory(DEMATEL) & Analytic network process(DANP)
A Decision Making Model for the Adoption of Cloud Computing in Jamaican Organizations[24]	This research looks at the options and the barriers to adoption facing Small/Medium Enterprises (SMEs) in Jamaica using simple additive weighting(SAW)	Simple additive weighting(SAW)
The analytic hierarchy process: task scheduling and resource allocation in cloud computing environment[10]	Task scheduling & resources allocation	Analytic hierarchy process (AHP)
Best Cloud Provider Selection using Integrated ANP-DEMATEL and Prioritizing SMI Attributes[15]	Cloud Provider Selection	Analytic network process and Decision-making trial and evaluation Laboratory(ANP & DEMATEL)
A Service Selection Approach in Cloud Manufacturing for SMEs (CMfg-SME)[16]	Analyses Characteristics of CMfg-SME to build a service selection model. Introduces constraints on service selection	Genetic Algorithm (GA)
A Decision Framework for Cloud Service Selection for SMEs: AHP Analysis[23]	Service selection	Analytic hierarchy process (AHP)
Trade-off-Based Adoption Methodology for Cloud-Based Infrastructures and Services[14]	Trade-off in adoption methodology	Technique for order preference by similarity (OPS) to an ideal solution (TOPSIS) (TOPSIS) and Analytic network process (ANP)
QoS based Cloud Service Provider Selection Framework[20]	Cloud service selection	Analytic hierarchy process (AHP)
Selecting Cloud Deployment Model Using a Delphi Analytic Hierarchy Process (DAHP) [28]	Cloud deployment model	Delphi & Analytic hierarchy process (AHP)
Apply AHP for Resource Allocation Problem in Cloud[6]	Resources allocation in cloud	Analytic hierarchy process (AHP)
A Knowledge Based Decision Making Tool To Support Cloud Migration Decision Making[4]	TOOL TO SUPPORT CLOUD MIGRATION DECISION MAKING	Analytic hierarchy process (AHP) & Case based Reason(CBR)

Multi-criteria Decision in the adoption of Cloud Computing Services for SME's based on BOCR Analysis[8]	Cloud services selection	Analytic hierarchy process (AHP)
General Model for Adequate Cloud Service Selection using Decision Making Methods[30]	Organizational cloud service selection	Multiple attribute utility theory (MAUT) Analytic hierarchy process (AHP)
A Consensus-based Approach for Selecting Cloud Plans[2]	An approach that enables users to select a cloud plan that best balances the satisfaction of the requirements of multiple applications.	Technique for order preference by similarity (OPS) to an ideal solution (TOPSIS)
Cloud adoption decision support for SMEs Using Analytical Hierarchy Process (AHP)[42]	A framework based on AHP for cloud services selection for SMEs	Analytic hierarchy process (AHP)
Evaluation of Cloud Services: A Fuzzy Multi-Criteria Group Decision Making Method [44]	The paper presents a fuzzy multi-criteria group decision making method for evaluating the performance of Cloud services in an uncertain environment	Fuzzy sets
Trustworthy Cloud Service Provider Selection using Multi Criteria Decision Making Methods[37]	Cloud Service selection based on their requirements	Fuzzy- Analytic hierarchy process (F-AHP)
Cloud computing adoption decision modeling for SMEs: a conjoint analysis[1]	A model that support the decision making process, using a multi-criteria decision method PAPRIKA for the socio-technical aspects influencing SMEs cloud adoption decision.	Potentially all pairwise ranking of all possible alternatives(PAPRIKA)
The application of Fuzzy Multi Criteria Decision Making for Cloud Computing Adoption in India[36]	Adoption of cloud computing	Fuzzy-Analytic hierarchy process (F-AHP)

4 FINDINGS

A: Number of Papers per Year

The Selected papers were analyzed and categorized into years. Figure 1 shows the number of papers from 2010 to Jan. 2017. Based on the findings, the years 2013 and 2015 have the highest number of publications. However, comparing this to the last three years, the number of publications is increasing which indicates that the applications of MCDM in cloud based system are increasing which needs further investigations.

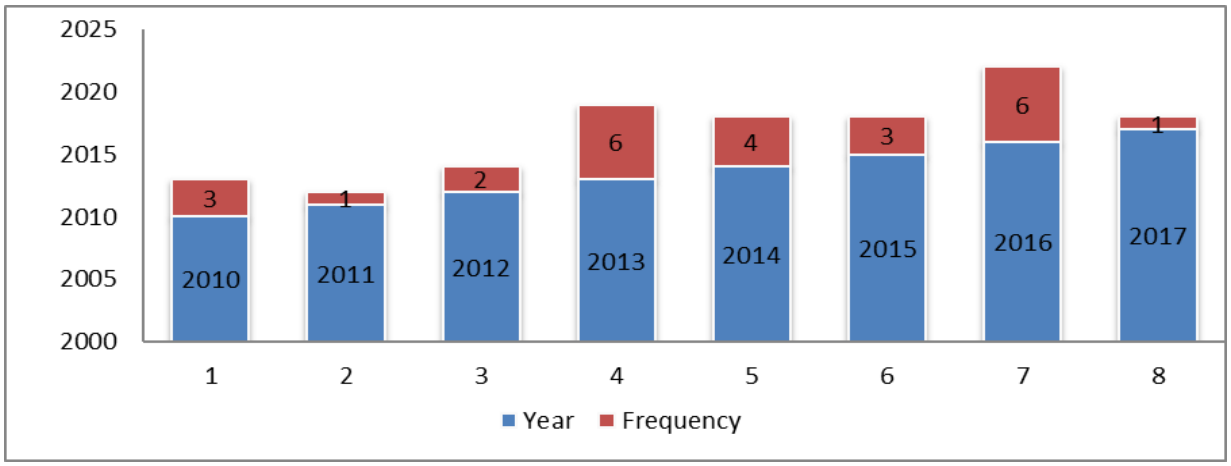

Fig1: Number of papers per year (2010-Jan. 2017)

B: Thematic Characteristics

This section presents the thematic applications of MCDM in cloud based system as shown in Figure 2. The findings show that majority of the studies used MCDM for cloud service selection (43%), followed by resources allocation (15%), adoption (9%) and quality of services (9%). The least are in migration and deployment with 3% each.

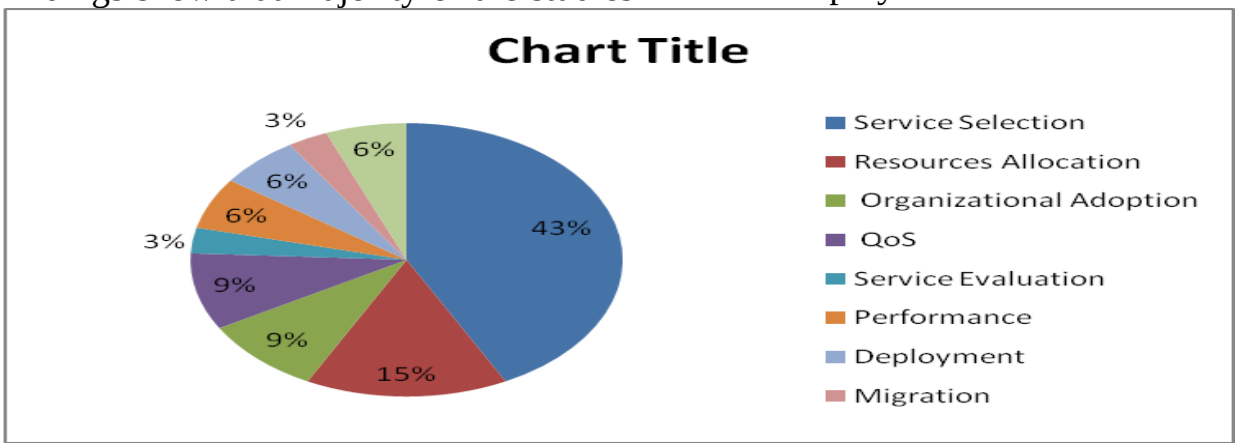

Fig2: Thematic characteristics

C: Multi-Criteria Decision Method (MCDM) Used

Majority of the studies used AHP (44%) followed by integrated approach (22%), while SAW and GA are the least used with 3% each. This indicates that the application of MCDM in cloud based system is increasing since there are transitions from the commonest use of MCDM to integrated approaches.

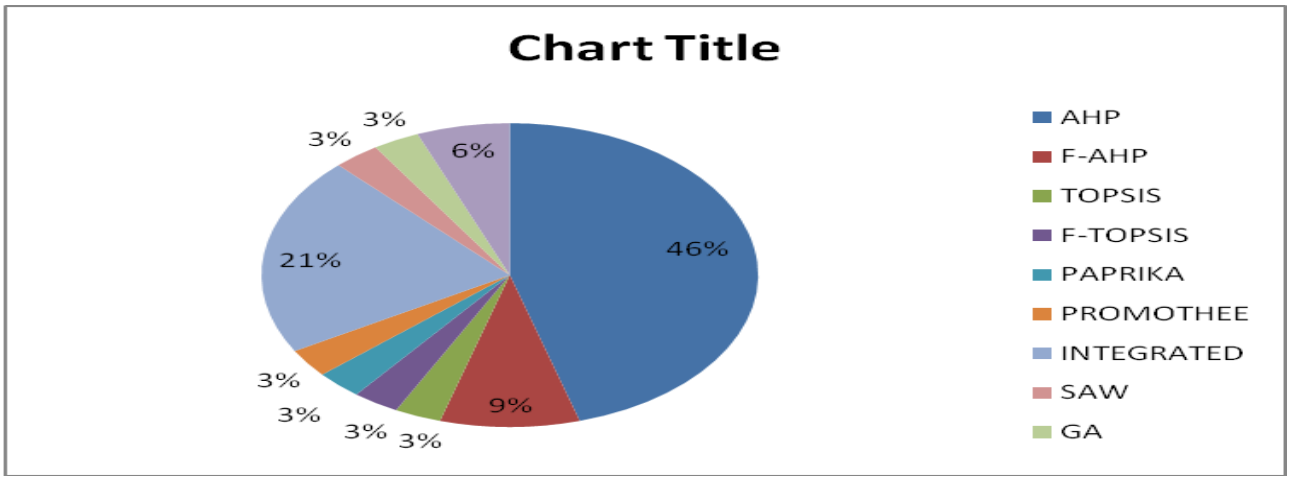

Fig 3: MCDM Used

5 CONCLUSIONS AND FURTHER DIRECTIONS

The objectives of this review were to identify the applications of MCDM in cloud based system in general to provide direction for further research. The number of articles included in the review was thirty four; this is due to lack of literatures that addressed the applications of MCDM in cloud based system as the field is still emerging. The articles were extracted mainly from Science Direct, Springer Link, IEEE Xplore, researchgate, ACM digital library, and Emerald. Furthermore, the review only included studies on applications of MCDM in cloud computing, cloud based learning in related organizations; other studies such as technical aspects are excluded. Therefore, the findings should be caution in generalization.

The findings show that most of the studies used MCDMs in cloud based system for service selection with limited studies on migration and deployment. Furthermore, there are scarce studies on applications of MCDM in evaluating factors influencing user acceptance of cloud based system. With the factors influencing the adoption of cloud based system are yet to be cleared, there is a need more investigative to uncover factors and identify importance among them to guide adoption decision. The findings further show that most of the studies used the common AHP and with some integrated approaches which indicates that the applications of MCDMs in cloud based system are increasing.

Based on this review, future researchers should investigate the applications of MCDM in evaluating the adoption of cloud based system from user perspectives as the field is still emerging. Further, it is recommended that future works should integrate more MCDMs to reduce ubiquity in its application. Moreover, it is recommended that future studies should also focus on the application MCDMs in deployment model to help in the adoption decision.

This paper contributed to literatures by providing a comprehensive review on the applications of MCDM in cloud based system which might help decision maker in adoption decision and provide directions for future works.

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