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Developing a Framework for Cost-Benefit Analysis of Cloud Computing Adoption by Higher Education Institutions in Saudi Arabia

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***Abstract*—The adoption of cloud computing technology in higher education institutions and universities to fulfill their evolving computing needs is an emerging research field. Saudi Arabia is the largest economy in the Gulf region, which makes KSA a potential market for cloud computing technologies. In addition, KSA's higher institutions differ from other institutions around the world as they have uniquely separated campuses of males and females. Cloud computing has its own advantages since it can often decrease infrastructure and maintenance costs, improve operational efficiency by allowing various computing devices to complete tasks, and increase the user's ability to access resources, applications, and data anytime, anywhere. However, there is a lack of tools to help the decision makers at higher education institutions analyze and evaluate the best cost-effective manner to adopt cloud services. Thus, there is a need for a cost-benefit computing tool that is based on a comprehensive multilayer framework to evaluate the costs of various services offered by different cloud service providers such as Amazon, Google, and Microsoft. In this study, an attempt has been made to develop the computing tool and its accompanying framework for cost-benefit analysis to study the suitability of different cloud computing deployment models for the higher education environment. The proposed tool will support decision makers at institutions to assess the various tangible benefits of adopting cloud services versus in-house services, while taking into consideration the various intangible benefits. The developed tool has been evaluated by experts through interviews. The results showed that the framework can analyze the costs and benefits through comparison between different cloud models, which saves time and effort for decision makers to find the optimal solutions.**

Keywords—cost-benefit framework, cloud computing, Saudi higher education

I. INTRODUCTION

Educational institutions rely on information technology (IT) for teaching and learning. These institutions require large investments to purchase hardware and software and employ personnel with special technical skills to prepare and configure their IT systems for operation. Currently, IT facilities are more complex and expensive. The implications for the costs of maintaining a data center involving the capital and operational costs of these facilities that have a direct impact on the profitability of business operations. To manage the costs, the institutions began to adopt cloud computing technology which originated from Grid Computing and Utility Computing.

Utility Computing rose from the development of virtualized systems for servers, storage, and networks that institutions purchased for pay-per-use services. The major advantages of this framework recognized in capital and operational cost savings since the computing environment is shared among nodes that have important computing resources. This is called Grid Computing. Grid Computing involves a set of servers that can share in servicing distributed workloads [1].

Cloud computing provides inexpensive and scalable on-demand computing services that include quality of service guarantees and offer high value for institutions of higher education. This technology offers cost-effective operations to the institutions by reducing costs of operations, staff, and resources. Additionally, it assists the institutions of higher education by reducing running costs and allowing them to focus on their core business. When institutions adopt a pay-as-you-go framework, educational departments are only charged for resources and services that they use; for example, storage and computing resources for retaining scientific and educational materials, software systems and lecture materials.

Most institutions are now moving toward cloud computing technologies, which is crucial for reducing their operational costs. The cost improvement is obvious since the services are no longer 'locally hosted', instead they are now part of a 'rental model'. Apart from the costs and benefits, cloud computing has the benefits of availability and resiliency. In reference [2], researchers demonstrated that there is an open door for both, institutions of higher education and cloud suppliers, to collaborate, keeping in mind the goals of upgrading administrations and decreasing costs.

Cloud computing has characteristics described by ISO/IEC which are on-demand self-service, network access, resources pooling, rapid elasticity and scalability, measured service and multi-tenancy [3].

One of the approaches relevant to institutions of higher education is to make resources frequently and easily available, including Microsoft Office and Google apps. The adoption of these technologies has enabled universities to provide efficient learning for their students on a large scale.

Information and Communication Technology (ICT) plays a very important role in promoting the vision of the

Saudi government 2030. Technology is a key element in all country objectives, like communications, security, education, mining, etc. The higher the level of development in the country, the greater its potential to achieve the objectives set as in vision 2030 [4]. According to reference [5], "*technologies that provide access to information through telecommunications, including the Internet, wireless networks and means of communication. ICT includes a range of hardware, software applications and intranet systems*".

Higher education institutions play an important role in the growth of societies. In present times, universities have become more dependent on ICT and Internet-based services to provide people with educational services [6]. However, big data creates new IT infrastructure challenges in universities for both hardware and software to collect, store and analyze data. The interview analysis shows that database deals with thousands of data that require high storage capacity, high speed internet and high computing power for data management, analysis and user queries. This may increase the universities spending in information technology to be in line with the requirements. However, it was noted that the ideal solution to avoid IT infrastructure challenges and to reduce the costs is cloud computing [7].

Moreover, all public universities depend on the Saudi Ministry of Education to provide the requested budget for running their ICT facilities. Thus, there is a need for a better strategy in dealing with this problem. In addition, higher education institutions must evaluate the costs and benefits of public cloud services versus in-house computing services. Furthermore, if the higher education institution uses community cloud services instead of the public cloud, those costs should also be evaluated. Hence, there is a need for a tool to assess these costs [8].

This research attempts to broaden the adoption of cloud computing with a framework that helps higher education institutions identify the costs of the cloud versus in-house solutions. In addition, the intangible benefits appear in cost savings associated with cloud computing and tangible benefits. Thus, higher education institutions should conduct cost-benefit analysis that enables them to weight their decisions more precisely when evaluating whether to move to the cloud or not. This research aims to develop a cost-benefit framework for analyzing cloud computing adoption by higher education institutions in the KSA.

II. Literature Review

A. Cloud Computing

Cloud computing is a model for enabling convenient computing resources such as networks, servers, storage, applications, and services that can be accessed on-demand with minimal management effort or service provider interaction [9]. ISO/IEC defines cloud computing as a "paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on demand" [3]. According to ISO, cloud computing consists of three service models namely, Software as a service (SaaS), Platform as a service (PaaS) and Infrastructure as a service (IaaS). It has four deployment models, namely, the Public cloud, Private cloud, Hybrid cloud and Community cloud [3].

B. Cloud Computing Benefits

Cloud computing is an emerging paradigm in computing. Many firms are shifting from traditional computing to cloud computing. There are tangible benefits and intangible benefits [10]. The tangible benefits can be quantified while the intangible benefits cannot. The tangible benefits include cost reductions, reliability, and increased productivity. Intangible benefits include increased business opportunities [11], [12]. Table 1 shows a summary of tangible and intangible cloud benefits.

TABLE. I Tangible and Intangible Benefits of the Cloud

Cloud Benefits	Description
Tangible Benefits	
Cost Reduction [12], [13]	For example, support and maintenance costs and physical hosting [11].
Increase productivity [12].	The organization can satisfy the customer's satisfaction by quickly processing his/her order, which leads to increased productivity [12].
Reliability [12], [13]	Technical quality, service quality for IS [14].
Intangible Benefits	
Increasing focus on core competencies [12]	A better focus leads to improved productivity and business proposals [15].
Data Security [12], [13]	Mitigate security breaches or prevent data loss [11].
Agility/flexibility [12], [13]	Cloud computing provides better platforms and application tools for introducing services and solutions in the most cost-effective way [11].
Scalability [12], [13]	Scalability can be measured by the number of additional resources that are automatically allocated to increase demand and are charged to them on a pay-per-consumption basis [11].
Faster time to market [12]	Companies that use batch processing technology can complete work much faster than what data center resources allow [15].
Customer satisfaction [12]	Customer satisfaction is of high priority in any business. Transition to the cloud certainly adds to the customer's satisfaction level. Quantification of benefits of CC aims not only to achieve customer's satisfaction level but also to increase it [15].
Time value [12], [13]	IT organizations take more weeks to re-provide existing hardware resources. Cloud computing reduces this problem significantly by using automation and abstraction of resources in order to reduce the time from months to minutes [15].
Disaster recovery [12], [13]	Disasters may occur due to different reasons, including earthquakes, fires, viruses, and power outages [15].

C. The Status of Cloud Computing in Saudi Arabia

The ICT sector in the Kingdom of Saudi Arabia is regulated by the Communications and Information Technology Commission (CITC). The CITC aims to provide a regulatory framework for clarifying the underlying regulations covering information security for the cloud computing sector. The framework contains several fundamental provisions on data protection. The regulatory framework illustrates how the content organization can be applied to cloud computing services [16].

Saudi Arabia remains one of the largest spenders on IT services in the Middle East and Africa according to International Data Corporation (IDC) [17]. The total investments in cloud services in the country reached \$50.4 million, and in 2015, it reached \$77.4 million. A survey by

Dun & Bradstreet revealed the growing use of cloud computing in Saudi public sectors. The survey illustrated that there is increased IT spending in the manufacturing sectors of the Kingdom of 7.5 percent from 2013 to 2018. In addition, the result indicated that the kingdom had plans to adopt public cloud in the region to take advantage of the security and privacy.

Reference [18] analyzes the current state of adopting cloud computing in KSA by employing an empirical study that uses a survey. It shows that Saudi Arabia is still in the process of considering technology with very few adoptions, none of which are at government levels. There is some future work that must analyze the remaining data obtained from their questionnaire, with a focus on the adoption barriers.

D. The Status of Cloud Computing in Saudi HEIs

Saudi Arabia's education system currently encompasses 25 public and 8 private universities which are coordinated by the Ministry of Education [19]. In Saudi Arabia, cloud computing has been adopted for various universities since many institutions worldwide now seek obtaining e-learning services in their universities. Saudi government has introduced a lot of efforts and resources to develop the educational system through providing more universities and development initiatives. The Ministry of Higher Education (MOHE) has been asked to establish, regulate and execute the law with respect to the higher education in the country [20].

Reference [7] presents conceptual framework to investigate the most critical success factors that share in the successful migration to cloud computing technologies by higher education institutions. The technological critical success factors are reliability, interoperability, security and privacy, disaster recovery and network bandwidth. The organizational critical success factors are policies of ministry of education, top management support, awareness of users, customizable service level agreement requirements and degree of control.

Reference [21] highlights the favorable factors for King Abdulaziz University (KAU) to adopt cloud computing, such as legal issues, risks, security issues and many others. The results showed an improvement in the efficiency of computing resources, and a reduction in the cost of information technology per unit, project or product. KAU IT is undertaking several initiatives to improve its infrastructure and migrate it from the client server model to private cloud infrastructure. KAU used the private cloud model to create high data centers with scalable infrastructure, to support university growth and to provide new value-added services, while reducing operating costs by automating processes implemented.

Reference [22] proposed a two-dimensional research model for motivators and inhibitors to explore the usage and the acceptance of cloud computing technology in the KSA. This model is based on the statistical analysis of the data collected from five universities in Saudi Arabia, namely, King Abdul-Aziz University, King Saud University, Imam Muhammad ibn Saud Islamic University, Taibah University and Umm al-Qura University. The results show that network access and self-service are the two top motivators from the perspective of Saudi cloud consumers for using cloud computing at 51% and 23%, respectively. The highest 5 inhibitors are availability, reliability, security, compliance and privacy. This can help decision makers further assess the adoption of cloud computing. Furthermore, Princess Noura Bint Abdul Rahman University, in a partnership with Microsoft and the Saudi Telecommunication Company (STC), provides cloud services called the Smart suitcase. The Smart suitcase makes it possible to effectively and efficiently exchange communication, information and data easily between faculties and college students [23].

King Saud University has entered into an agreement with Microsoft to provide cloud storage services for university employees. The cloud storage service includes many features, such as cloud storage up to 25 GB and the ability to securely and easily share files. An employee can use a web browser to modify files in Microsoft Office, synchronize files on their PC's hard disk drive and easily access online files stored on smartphones or PCs [24]. Many popular cloud provider services, such as Amazon Education Cloud, Google for Education and Microsoft Office in Education, have adopted the new trend of using cloud computing for education [25].

E. Existing CC Cost-Benefit Analysis Frameworks

Several studies have been discussed for the cost-benefit analysis of cloud computing. Table 2 summarizes related works with their limitations in cost-benefit frameworks. benefits.

TABLE. II LIMITATIONS OF RELATED WORK IN COST-BENEFIT FRAMEWORKS

Title of the work	Limitations
A Cost Modeling System for Cloud Computing [1]	The model was not fully developed, but the study suggested that the tool might improve with time and the model's results could generate simulations and graphs in the future.
Cost-benefit analysis of cloud computing in education [26]	Constricted data sources since the government of India is yet to adopt the technology.
A business-driven framework for evaluating cloud computing [27].	The framework does not support other types of cloud models (hybrid, SaaS, PaaS); thus, discovering their cost-benefit within this framework is given as future work.
A Model for Cost-Benefit Analysis of Cloud Computing [28]	This model is based on one vendor, Amazon. Hence, its applicability is restricted to deciding whether to adopt Amazon's cloud or not. The model was tested with small sample sizes. Hence, the results may be improved to gain better generalizability. Some basic limitations are in layer 3 of the result aggregation and in layer 2 of the demand analysis
Cost Analysis Comparing High Performance Computing Public Versus Private Cloud Computing [29]	The sample process described is limited to the high performance computing baseline configuration and will need to replicate the specific hardware platform being considered, as well as the public and private cloud vendors.
Cloud-based design, engineering analysis and manufacturing (CBDM): A cost-benefit analysis [30]	It mainly focuses on a multi-criteria decision support model to study strategic trade-offs in engineering design and manufacturing related to the adoption of CBDM.
Cost Benefit Analysis Approach for Cloud Computing [31]	The model is tested in selected projects that implemented this technology within the Czech Republic.
Towards Cost-Efficient Content Placement in Media	The study discusses some future work. First, to explore the possibility of caching some content to mobile devices Second, to capture the user's

Title of the work	Limitations
Cloud: Modeling and Analysis [32]	request pattern dynamics. Finally, to add quality of experience constants in the formulation.

III. METHODOLOGY

This research aims to investigate the existing cost-benefit frameworks to propose a new comprehensive one that satisfies the new requirements of applying cloud computing technologies in higher education institutions. Hence, the methodology, that is being utilized in the research, has four phases as shown below.

Phase 1: Literature Review; it involves identifying research goal and problem, providing and acquiring research background, analyzing and synthesizing research studies related to successful implementation of cloud computing technology in educational institutions and the cost-benefit framework of cloud computing.
Phase 2: Framework design and supporting tool development; it involves the design of the proposed framework. Computer tool has been built using the agile software development methodology [33]. The platform chosen to implement the tool is Java. Java is supported by various types of operating systems [34].
Phase3: The framework and the tool have been evaluated using the expert-based method [35].
Phase4: Experiment; analysing e-learning service at King Khaled University to enable better understanding of the proposed cost-benefit framework.

IV. COST-BENEFIT ANALYSIS FRAMEWORK

A. Proposed Cost-Benefit Analysis Framework of CC

This section defines the framework design and the configuration of the cloud systems. Fig. 1 shows that the framework is composed of a five-layer architecture which is sufficient to describe Cost Benefit Analysis.

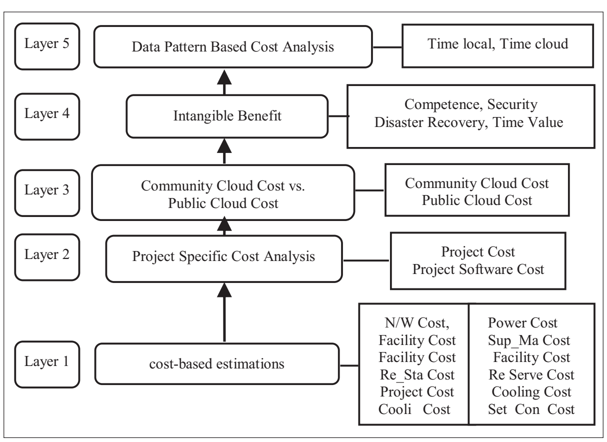

Fig. 1. *Layers of the proposed Cost Benefit Framework.*

The first layer is relying on cost-based estimations. The second layer is meant for specific cost analysis. The third layer provides the community cloud versus the public cloud. The fourth layer provides intangible cost benefits. Finally, the data pattern-based cost analysis is shown. The input and output for each layer are discussed below:

Layer 1: Cost Base Estimation. The inputs for this layer are composed of the amortization and the costs of the nine categories (software, network, facility, real estate, support and maintenance, setup and configuration, power, cooling, and server) for both in-house solutions and cloud-based solutions, as shown in Table 3. The outputs are cost-based estimations and recommendations for whether to shift to the cloud or not.

TABLE. III. COST ESTIMATIONS IN LAYER 1

Cost Estimation	Description
Cost of Amortizable rate parameter (Ap)	Ap is the Amortization period unit. Time is hours consumed.
Servers Costs	N_S is the number of servers in a firm. Cost_PS is the costs per server in Dollars.
Network Costs	No. of Ports (N_Port) Costs per port (Cost_per_Port) No. of Cables (N_Cab) interconnect cable costs (Cost_per_Cab) No. of Switches(N_Sw) Costs per switch (Cost_per_Sw) Costs of implementation (Cost_Imp)
Power Costs	Size_Pow -Size of facility (critical load) in KW Use_Pow -The average power usage Eff_Pow -The power usage effectiveness Cost_Pow -The power costs measured in US Dollars per kwh
Software Costs	N_ClassA -Number of Class A Software N_ClassB --Number of Class B Software Cost_ClassA --Unit price of Class A Software (Total Price, One time) Cost_Class B --Unit price of Software (Total Price, One time) Cost_ClassB ∏A - Server Utilization Class A (Percentage of unit price that accounts for the annual costs) ∏B - Server Utilization Class A
Cooling Costs	LF_Cool -Cooling load factor Red_Cool -Airflow redundancy constant Ineff_Cool -Inefficiency constant Cost_Am_Pow -Monthly power costs from previous sub-sections
Real Estate Costs	Space_U_Rack -Space taken by all the racks underutilization Rack_Sqf -Square Feet per Rack Rack -Number of racks Space_Rack - Space utilization of Racks- Cost_Sqf - Cost per square foot to set up the physical servers
Facility Costs	N_Rack - Number of racks Cost_Fac - Facility costs per rack
Support and Maintenance Costs	N_Admin - Number of administrators responsible for support and maintenance Salary_Support - Annual salary of administrators N_Contract - Number of visits of contract maintenance; Charge_Contract - Costs per visit
Setup and Configuration Costs	Cost of Setup and Configuration

Layer 2: Project Specific Cost Analysis. The inputs for this layer are the number of estimated servers and costs obtained from layer 1. The output is project costs as in Table 4. and recommendations for whether to shift to the cloud or not.

The data that will represent the cost of bandwidth per month is given as Cloud_Data_P = (Data_P/3). Time analysis can be performed using the input Data_P, which will provide the recommendation based on the computational time. Data P is the approximate amount of data that includes the backup amount. Consequently, the real requirement that would be given to the cloud is denoted by [28]

Layer 3: Public Cloud versus Community Cloud Cost. The inputs for this layer are the costs for the three cloud service providers (Amazon, Google and Microsoft) that were obtained from the online calculator, which are mostly used by higher education in Saudi Arabia [36], [37], [38]. In addition, the community cloud costs were obtained from the online calculator [39]. The output is determined by comparing the results of public cloud versus community cloud cost with the recommendations.

TABLE. IV. PROJECT SPECIFIC COST ANALYSIS IN LAYER 2

Cost Analysis	Parameter Description
Ratio of servers required to implement the project	N_Est_Server - Number of estimated servers and N_S servers from layer 1
Project Specific Cost Analysis	Project Costs of Servers Project Network Costs Project Power Costs Project Cooling Costs Project Real Estate Costs Project Facility Costs Project Support and Maintenance Costs Project Setup and Configuration Costs
Project Software Costs	N_ClassC - Number of Class C Software Cost_ClassC - Unit price of Class C Software (Total Price, One time) Cost_ClassC ∏C - Server Utilization Class C

The costs of the public cloud and the estimated number of students in the three universities are taken as input and are based on the similarity described between the community cloud and the private cloud in [40]. Therefore, the costs of the community cloud are calculated from the online calculator and are taken as an input [39]. Table 5 shows a summary of community cloud cost. The typical requirements for this cost calculation are given below [41]:

- Storages (High-performance, multiple TB of Core Storage).
- RAM (64 GB RAM for VM).
- CPU (High-performance, Xeon CPU cores).

The output from this layer shows the costs of using public cloud provider (Amazon, Google, and Microsoft) services and the costs of using community cloud services by three universities.

TABLE. V. COST OF COMMUNITY CLOUD [39]

Cores	Memory	Extra Block Storage	Internet Traffic	Internet Speed	Billing Cycle	Total Costs
24	64 GB	SSD 1024 GB	100 TB	3 Gbps	-	$126 1.00 USD
$57	$117	$169	$449	$300	$169	

Layer 4: Intangible Benefit. The inputs for this layer are the parameters of the four categories (time value, competence, disaster recovery, and security). The output displays the intangible benefits, as in Table 6

IT organizations take more weeks to re-provide existing hardware sources. Cloud computing reduces the time from months to minutes. "*This time saved in the cloud, which otherwise would have been spent provisioning for resources in the data center, can be quantified as the expenditure of the enterprise during that time of provisioning without any profits*". In addition, better focus leads to improved productivity and business propositions. "*Improvement in productivity can be quantified in terms of reduction in marginal costs (MC) and an increase in marginal benefits (MB)*". Another feature of cloud computing is disaster recovery. The disaster recovery and business continuity planning are becoming increasingly important for every business organization. Therefore, "*Disaster recovery planning is done by replicating resources in a number of places. This fear is very much reduced in the cloud as data in the cloud is replicated thrice and stored in servers which are geographically scattered*" [14].

TABLE.VI. INTANGIBLE BENEFITS

Intangible Benefits	Formula
Focus on Core Competence	Focus= ((Mc + Mb) × number of products or services offered / year); [14]
Security	The experts determined likelihood and business impact values; it will be converted to the risk ranges. The range based on a risk matrix with a scale between 0 and 8. Then, the risk range is mapped to a qualitative scale as follows: (Low →0-2), (Medium → 3-5), (High → 6-8); [46]
Agility/flexibility	F = constant (B)/ f(L) = B/(65- L); [14]
Scalability	Scalability = f (time value, customer satisfaction, faster time to market); [14]
Faster time to market	Value of faster time to market (FTM) = (traditional cost − new cost) + (new profit − traditional profit); [14]
Time Value	Time value = (time taken for the provision in weeks) × (weekly expenditure); [14]
Customer satisfaction	Percentage increase in profit = B × log(1 / (1− % increase/ 100)); [14]
Disaster Recovery	Savings from DR = ((% of the budget invested in DR × annual budget) − bandwidth cost of storing new data daily to cloud − storage charges); [14]

In [42], the study shows that the cloud adoption risk assessment model helps decision-making in selecting the cloud service provider based on the aggregated risks to security, privacy and service delivery. For example, this includes sensitive personal data, company data, personal data and critical personal data. In addition, the experts determined the likelihood and business impact values. They will be converted into risk ranges. The range is based on a risk matrix with a scale between 0 and 8. Then, the risk range is mapped to a qualitative scale as follows: Low →0-2, Medium → 3-5, High → 6-8.

Layer 5: Data Pattern Based Cost Analysis. To calculate local computational time (time_Local), the input is data size in giga bytes of data and number of instances. To calculate cloud computing time (time_Cloud), the input is data size in giga bytes of data and transfer rates. The outputs are time_Local and time_Cloud. In addition, the recommendations whether to shift to the cloud or not are displayed.

This layer addresses data pattern-based cost analysis in which the characteristics of the data pattern in an organization are considered, such as the amount of data it generates, the time consumed by its computational resources to transfer the data, the estimated demand, the actual average demand and the number of servers provided to meet the demand. This analysis uses nature-specific characteristics as inputs for the cost-benefit analysis model and results in two specific analysis, including time analysis and demand estimation. Time analysis considers the amount of data processed by an organization for all joint operations. It enables the organization to find the equivalent in-house computational ability to compare to the cloud's instance configuration. The result provides the computational time for the in-house processes and computational time for the cloud. The key formulas summarizing the computation of processing time [28] in the cloud is given in Table 7.

intangible cloud benefits.

TABLE. VII. COMPUTATION OF PROCESSING TIME

1 GB takes 2 hours to process	Size_Da GB will take 2* Size_Da hours to process
Size_Da GB will actually take	(2* Size_Da/ N_In) hours to process (instances)
Local computational time	Time_Local= (2* Size_Da/ N_In) hours
If Rate_TransferMbits requires 1 second	Size_Da GB will require: [(Size_Da * 1000 * 8)/Rate_Transfer)] seconds
Hence, the computational time in the cloud is	Time_Cloud= [[(Size_Da * 1000 * 8) / (Rate_Transfer)]/ (60 * 60)] hours.
While Time_Local gives the computational time in-house, Time_Cloud gives the computational time in the cloud. A decision maker could compare the two and draw some insights on the computational time benefits of cloud computing.	
If (Time_Local< Time Cloud)	The recommendation is that it is advisable to not shift to cloud computing in terms of computational time. Otherwise, it is recommended to shift to cloud computing [33].

B. *Framework Development*

A flowchart for the proposed framework is given in fig.2.

First, the tool starts by entering the parameters of the first layer that calculates the estimated costs as in figure 1. The tool will check whether these parameters are greater than zero or not. If values are greater than zero, then the calculation will complete, and the result will be in the form of a recommendation and a graph. Otherwise, the tool displays an error message. This layer is adopted from sources [28]. Second, the user will enter the number of estimated servers as shown in figure 1. Then, the program will check if the parameters are greater than zero. The calculation of the project's cost will be completed for the values greater than zero. Otherwise, the program displays an error message. This layer is adapted from source [28]. Third, the user enters the results of the community cloud costs that were obtained from online calculator [39]. In addition, the public costs of the three cloud service providers (Amazon, Google and Microsoft) that were obtained from the online calculator [36], [37] and [38] and the number of students at his or her university are recorded. Afterwards, the system computes the community costs for the three universities and compares them with the public cloud cost, as shown in fig.1. Finally, the system prints the recommendations and a graph. Fourth, the user enters the parameters to find the intangible benefits as shown in fig.1. This layer is adapted from source [14]. Then, the system prints the results and a graph. Fifth, the user enters the parameters to calculate the time consumption for in-house and the cloud as in fig.1. Then, the program will check if the parameters are greater than zero. The time calculation will be completed for the values greater than zero. Otherwise, the program displays an error message. This layer is adapted from source [28]. Finally, the user can assess the Returns on Investment (ROIs).

V. IMPLEMENTATIN & EVALUATION

In this research, the sequential phases of the Agile model are used to develop the tool in the iterative and incremental manner [33]. An iterative model is constructed with each layer by splitting each layer into a module. Testing is performed on each layer in such a way that each module is individually tested, and then the combination of the modules is also tested. All the layers are tested until the proposed tool is obtained. The tool is given to the experts for their feedback before any further changes are implemented. Then, after testing the tool and the functionality of all layers with the stated number of iterations, the tool will be released.

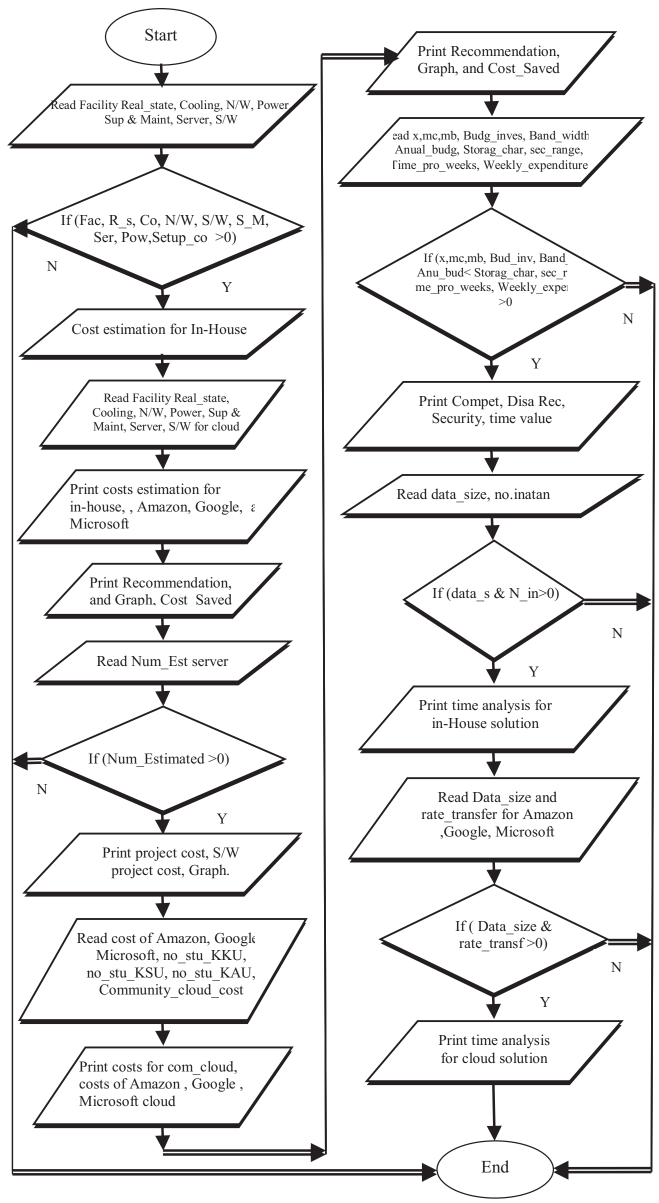

Fig. 2 *Framework Development Flowchart*

A. Proposed Cost-Benefit Analysis Framework of CC

The home page screen of the tool as shown in fig.3. The platform chosen for this tool's development is Java. Java is one of the popular programming languages. There are sets of open source software libraries that assist developers in using Java. By considering the advantages of the NetBeans platform, the proposed cost-benefit analysis tool is developed using NetBeans IDE [34], graphical user interface builder as in fig. 3.

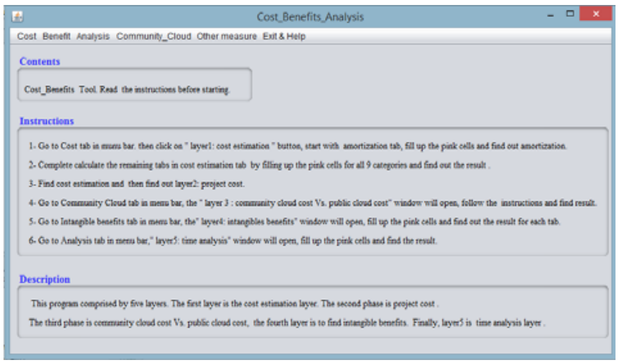

Fig. 3 *Home page screen*

B. Evaluating Usability

In qualitative research, there are different methods of data collection including observations, visual analysis, focus groups, and interviews [43].

Semi-structured interviews consist of several important questions [44]. They also allow the interviewer/interviewee to expand in their answer(s) to follow an idea or provide a more detailed answer. It also allows for the discovery of information that is important to participants but may not be previously related to the research team. Semi-structured interviews are selected for this study.

- Interview Sample: Before starting the interview, it briefly provides a clear description of the research background and the objectives of the research. Following that introduction, the interview questions will be presented. Afterwards, the interview results are documented and analyzed. In addition, the framework is improved accordingly. The interviewer/interviewee is an experienced practitioner and academic with at least six years of work expertise in the cloud computing field. A sample of five candidates was selected, and complete responses were obtained from them [45].

- Interview Questions Structure: The interview questions focused on tool development. They were divided into two sections. The first section was divided into three criteria, namely, the framework's layers, the equations and costs and benefits (understandability, ease of use, usefulness, and practicality). The questions were answered using a five-point Likert scale [46]. The second section includes open-ended questions.

- Findings of the Interview: This section presents the findings from interviews of individuals who had sufficient knowledge and work experience to present their opinions on current practices and their understanding of the tool. All interviewers were asked the same set of questions. The evaluation of the tool focused on four criteria as shown in fig. 4. The first addressed the sufficiency and accuracy of the performed layers. The second criterion addressed the relevance, comprehensiveness, mutual exclusion, and accuracy of the equations. The third criterion addressed the understandability and ease of use of the tool. The last criterion addressed the usefulness and practicality of the tool.

This evaluation ensures that the cost-benefit framework covers all functions to analyze the costs and benefits associated with the decision whether to host services in the cloud or in-house. The results indicate that the experts found that the cost-benefit framework layers are sufficient to represent all aspects of the cost-benefit framework. They also indicate the equations used are relevant to the cost-benefit framework. It covers the aspects impacting/involved in the cost-benefit framework and correctly assigns the cost-benefit framework layers. In addition, —the framework is understandable and easy to use. Moreover, the interviewers/interviewees agreed that the cost-benefit tool is practical for use in education and for conducting the analysis. Finally, expert suggestions will be used for future development to enrich the user interface with graphics.

Criteria	Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
1.Framework Layers					
The chosen layers are sufficient to represent all aspects of the domain (Sufficiency)			*	***	*
There is no overlap detected between descriptions of framework layers (Accuracy)				***	**
2.Equations					
The equations are relevant to the domain (Relevance)			*	**	**
The equations cover all aspects impacting/involved in the domain (Comprehensiveness)			*	*	***
The equations are clearly distinct (Mutual Exclusion)				***	**
The equations are correctly assigned to their respective framework layers (Accuracy)				**	***
3.Cost Benefit Framework					
3.1 Understandability					
The framework layers are clearly identified				**	***
The input and output are clearly understandable				**	***
3.2 Ease of Use					
The developed cost benefit tool is easy to use				****	*
3.3 Usefulness and Practicality					
The cost-benefit analysis is useful to conduct analysis				***	**

Criteria	Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
The cost-Benefit analysis is practical for use in education				**	***

Fig. 4 *Interview Results*

VI. Conclusion

In this research, a comprehensive cost-benefit framework has been developed for cloud computing. The layers of the framework along with existing frameworks in literature have been discussed. It is a decision support tool designed to calculate, analyze and present recommendations based on cost benefit comparison formulas. The framework is developed using Agile method for software development. The framework architecture is broken down into five layers namely; cost-based estimation, specific cost analysis, community cloud versus public cloud costs, intangible benefits and data pattern-based cost analysis. It is implemented by developing a new tool using Java language in NetBeans IDE 8.1 environment. The research results showed that the cost-benefit framework covers all functions to analyze the costs and benefits associated with the decision whether to host services in the cloud or in-house. The research highlighted the importance of adopting the community cloud model in the context of higher education institutions in Saudi Arabia.

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