Migration to Cloud Computing: A Decision Process Model

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Abstract. *This paper proposes a model that provides a structure to aid the decision making process for the migration of organisations' IT resources to cloud-based services. It includes consideration of business intelligence as well as design phases which have been neglected by existing decision support systems. Six main steps and the tasks within the model are identified, and their interaction with a proposed knowledge base is discussed. These provide a structure that systematically guides decision makers through the cloud migration process. Finally further research is discussed, including the development of a knowledge-based decision support system which will be undertaken by the authors.*

Keywords. Cloud computing, cloud migration, Decision-Making Process, cloud decision support, cloud knowledge base system

1 Introduction

The rapid growth of cloud-based services has opened new opportunities for enterprises to enhance the design of their IT resources and architectures, and to rationalise their information systems expenditure [1]. These have impacted on the importance of service quality and business competency as the cloud offers new capabilities, business models, and investments [2]. Cloud services are usually varied in their business models, functionality, quality of service, cost, and value [3]. The range of cloud-based services offered is growing simultaneously with the emergence of varying cloud service providers. In addition, the heterogeneity of systems within organisations and their requirements have increased the complexity of decision making in respect of migrating to cloud based solutions.

The decision to migrate existing systems to clouds can be complicated as it requires evaluating the benefits, risks and costs which are not very straightforward [4]. Therefore, this paper proposes a model to support the decision making process for migration to the cloud. It supports organisations in the evaluation of cloud-based services and their suitability to the organisation.

The motivation of this research is to enable organisations to effectively migrate their existing services to cloud-based solutions. In this respect, the following questions should be explored: why there is a need to migrate a service to the cloud? What cloud solutions are available? How to manage systems in the cloud environment? What services are suitable for the cloud? How to select a service provider?

A Knowledge-Based Decision Support System (KBDSS) would be able to help organisations to respond these questions and assist them to seamlessly migrate to cloud computing services. A cloud KBDSS can offer the flexibility to accommodate the extensive organisational requirements and cloud-based solutions by combining access to the relevant information and providing decision assisting tools in a timely and an organised manner. It would minimise the efforts for information gathering, suitability analysis, and vendor's evaluations as well as reducing consultancy expenditure. The model proposed in this paper can provide a baseline for developing a cloud KBDSS.

This paper is structured as follow: Section 2 summarizes the current situation with regards to Decisions Support Systems (DSSes) for cloud migration. Section 3 highlights the methods employed to develop the model. Section 4 discusses the proposed model. Finally, Section 5 provides the conclusion and identifies future work.

2 State of the art

Several DSSes to assist organisations for migrating to the cloud have been proposed as in [3], [4], [5], [6], [7], [8], [9], and [10]. These mostly concentrated on the evaluation and selection of cloud providers with cost being the main factor.

The works proposed in [4] and [5] were focused on the selection of the provider for Infrastructure as a Service (IaaS). In [4] Khajeh-Hosseini et al., developed a cloud adoption toolkit that aids decisions

on suitability of the technology, consumption of energy, cost, impacts of stakeholders and operational viability. It incorporates two decision support tools: cost calculation and risk-benefit analysis [6]. In [5] Menzel and Ranjan developed the CloudGenius framework that provides a multi-criteria approach in decision support for selecting providers for IaaS for migrating a web server to the cloud. It allows users to define multiple quantitative and qualitative requirements that are then matched against a knowledge base of cloud service providers.

In respect of selecting a cloud provider, Li et al., [7] considered characteristics of services provided such as elastic computing, persistent storage, intra-cloud, wide-area networking, and cost. Similarly, Chan and Chieu considered physical properties and security, integrity and availability to determine the best cloud service provider for a particular application [8].

Later works as in [9] and [10] were focused on supporting the migration of applications to the cloud. In addition to the selection of providers, the characteristics of applications [9] and the need for adaptation [11] to operate in the cloud environment were taking into account. In [10] Andrikopoulos et al. proposed a decision support system to select the cloud offerings for migrating applications that best match the parameters defined by users.

In an effort to standardise measuring and comparing cloud services, the Measurement Index Consortium (CSMIC) designed the Service Measurement Index (SMI) [12]. It uses the Analytical Hierarchy Process (AHP) mechanism to rank cloud providers, based on the QoS attributes that defined by ISO. It uses a number of characteristics and measures to support organisations in comparing different services from various providers. The parameters considered are: Accountability, Agility, Assurance of service, Cost, Performance, and Security and Privacy. The SMI has been considered to be a standard for service assessment and comparison within the Cloud Standards Coordination (CSC) [13].

Limited studies have considered the required support for the analyse and characteristics of existing company-based IT resources and also feasibility to migrate to the cloud environment. Misra and Mondal [14] identified four key characteristics of company based-IT resources which should be considered during the analysis for migrating to the cloud. They are: size of the IT resources, the utilisation pattern of the resources, sensitivity of the data they are handling, and criticality a service.

The majority of the existing DSSes do not support the assessment of business processes and relevant applications, nor do they provide information for analysing the impact of the chosen cloud services (this is referred to as the Design Phase in Fig. 1). Although, evaluation of the providers and their appropriate selection are critical, making an informed decision to migrate, requires analysing a wide range of factors at earlier stages of a decision process. Companies should become fully aware of the cloud capabilities and principles, the services offered and their potentials before coming to a decision.

Supporting these require a process for collecting information (from a knowledge-base), to assist each phase in the decision making process. Some of the cloud DSSes utilise knowledge bases that provide cloud offerings along with their pricing policies as in [5] and [10]. Decision making for cloud migration, however; requires a wider range of information to support companies in exploring cloud capabilities and principles in order to identify opportunities and the services that have the ability to enhance business and operation. This information may include: cloud principles and practical guidance, feedback on previous migrations projects (use of case), white-papers, relevant standards and procedures, and an assessment of organisations' readiness and the impact of the migration. To ensure a comprehensive decision making process, this information can be coupled with other decision support tools which are based on AHP such as SMI for selection of an appropriate cloud provider.

3 Model development

Three main methods were employed to develop the cloud migration model. Firstly, the motivations and issues affecting the migration which had been initially explored through a survey of enterprises in the UK by the authors [15] were reviewed. The main issues of concern, and organisations' requirements identified by analysing the results of the survey were considered throughout the development of the model. As indicated in [15] cost reduction followed by business agility were found to be the main factors influencing enterprises decisions of whether to migrate to the cloud. In addition, enterprises raised concerns regarding security and data confidentiality as well as vendor lock-in.

Secondly, twelve practitioners including IT managers, security professionals, and cloud professionals (from cloud providers perspective) were interviewed and the preliminary findings were published in [16]. One of the main issues raised was related to customers' lack knowledge on the cloud environment. Moreover, cloud users usually have higher expectations with regards to cloud services and they set much higher criteria than the criteria set in their local data-centre.

Thirdly, in addition to the information which was gathered above, the decision making process_model which had been proposed by Turban et al. [17] was also used. Turban's model includes three major phases: Intelligence, Design, and Choice as shown in Fig 1.

The decision making process starts with the intelligence phase where the "reality" of the

organisation is examined. It involves problem identification and information gathering activities. This includes identifying organisational strategy and goals, and exploring the environment for possible opportunities to address identified goals.

In the design phase, a model that represents the organisations' operational systems is constructed. It simplifies the organisation's "reality" and identifies relationships between variables, as well as setting the criteria for evaluating alternative courses of action. For decisions that involve risks, decision makers must consider the possible outcomes for each alternative with a given probability of occurrence.

The choice phase is to select the most appropriate alternative course of action based on the criteria identified in the design phase. It includes searching for alternatives, evaluation, and then makes a recommendation of an appropriate solution to the model proposed in the design phase. Finally the chosen solution is implemented. Successful implementation results in the delivery of the required values to meet the organisation's strategic vision, failure requires a return to an earlier phase of the process. Fig 1 shows the decision making process.

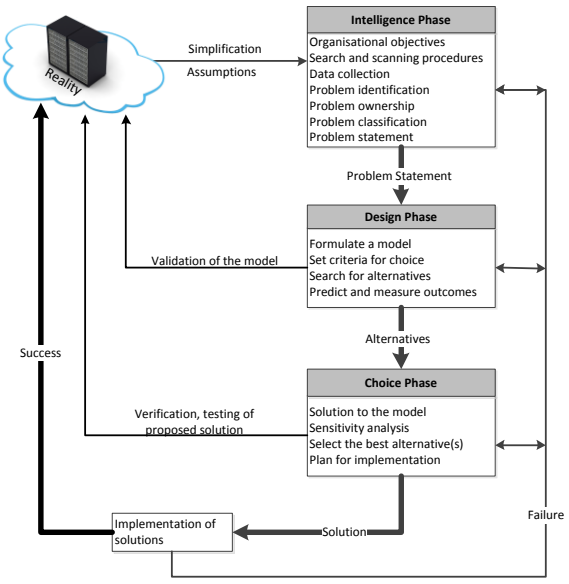

Figure 1. Turban's Decision making process [17 p41- 42]

4 The cloud migration decision process model

Based on the methods discussed in section 3 as well as relevant literature, a model to support decisions for migration to the cloud has been constructed. The model consists of four main components: information sources, the KBDSS platform and the knowledge base, as well as the cloud migration process, as shown in Fig 2.

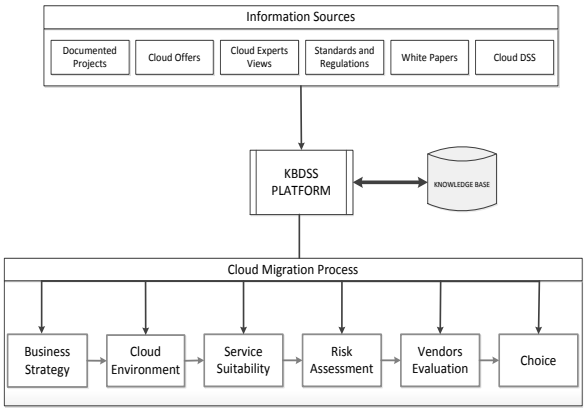

Figure 2. Cloud migration decision making process model: an overview

Building the knowledge base begins with the collection of relevant information. The sources may include: documented projects, cloud services offered, cloud experts' views, relevant standards and regulations, vendors' white papers, and existing cloud DSSes. A KBDSS platform can be utilised to structure the gathered information before storing them in the knowledge base. It will also be used as an access management point to and from the knowledge base. The knowledge base is a major integrated part in this model that stores the gathered information to assistance each of the migration phases. The knowledge base may accumulate representations of descriptive (facts about cloud environment) and procedural knowledge (cloud rules).

The cloud migration decision process comprises six main steps. They are: business strategy, cloud environment, service suitability, risk assessment, vendors' evaluation, and implementation. These steps would support the migration decisions through structuring the process of the hierarchy between the main tasks and criteria, and then analysing alternatives for selection through multiple analytical techniques.

Fig 3 shows the sequence and the inter-relationship between the six main steps of the cloud migration decision process model, and the tasks to be carried out during each step. The following sub sections provide detailed discussions on the tasks to be performed within the model as shown in Fig 3.

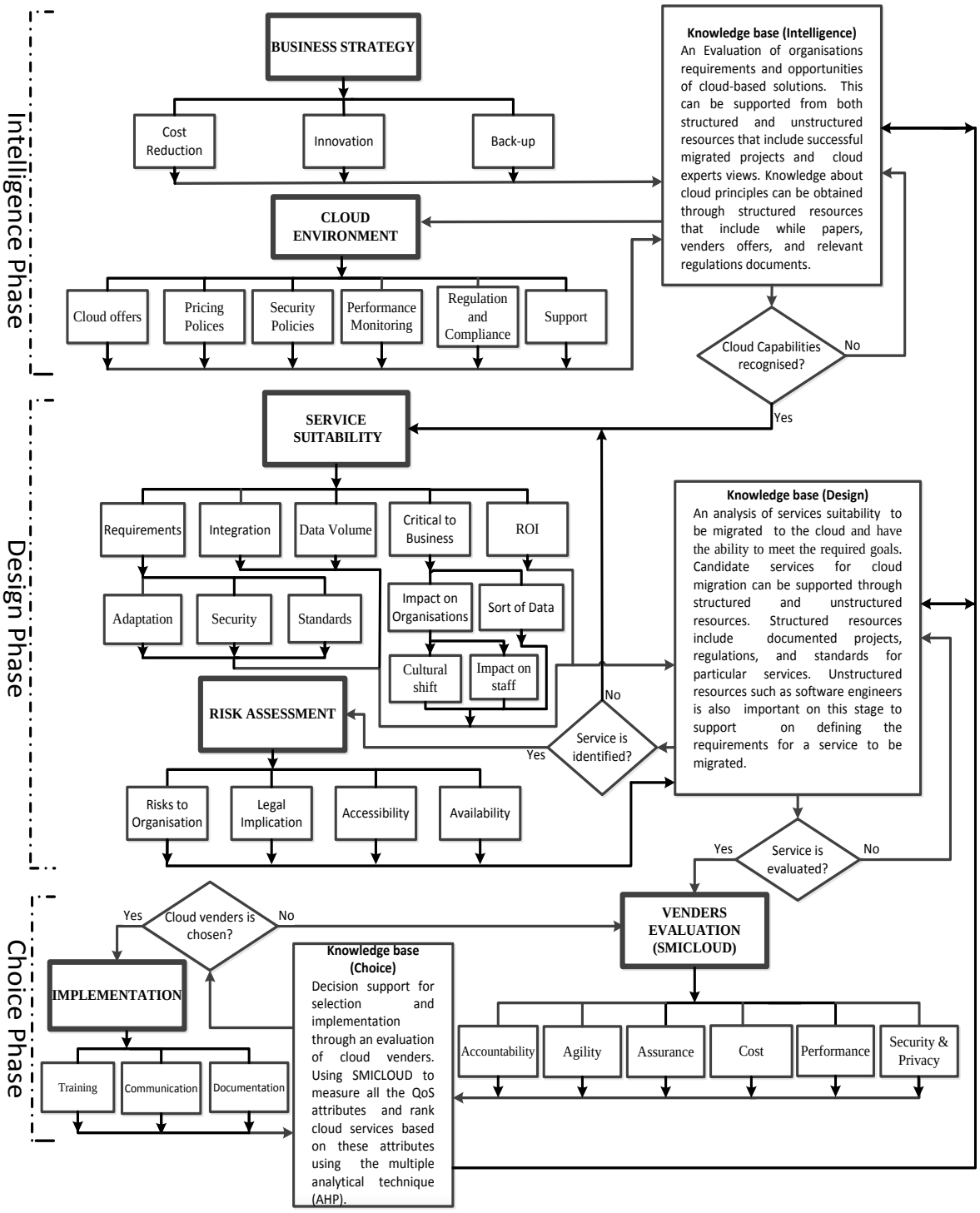

Figure 3. Cloud migration decision making process model

4.1 Business strategy

Business strategy and cloud environment constitute the intelligence phase of the decision making process and they can be supported through the intelligence level of the knowledge base. The process starts by defining the business strategy for migration. Organisations seek to exploit the cloud to achieve three main objectives, (depicted as separate tasks in Fig. 3): cost reduction, business innovation, and back-up. They need to examine internal and external environments to adopt a strategy that meets their requirements and enable them to gain a competitive edge.

Cost reduction has been the main reason that drives organisations to move to cloud computing [15]. However, cloud-based services are not always more economical than in-house services. This depends upon different factors such as the size of organisations and the data volume used. For example, as was discussed in Section 3, the cloud practitioners who were interviewed confirmed that cost was also the main reason for organisations to move back from the cloud. Reasons that emerged for moving back from the cloud are: migration to the cloud without having full knowledge about how to financially manage cloud-services, the cost of consultancy and other services, failure in accurate estimation of Return of Investment (ROI), and vendors' consumption models.

Migration to cloud computing can be a strategic decision for organisations to enhance **business innovations** through enhancing scalability, flexibility, and time to market. The need for testing and staff training before migrating to a new system has prevented many organisations from deploying new services. This usually results in an additional cost for resources and software licencing.

The time required for testing and deploying new local IT services is also another issue for many organisations. Cloud computing can reduce the requirement for the upfront cost through the rapid provision of advanced resources, an approach which may not be possible using local-based IT services. New business processes can be designed and tested through the cloud environment before their official deployment. Organisations can have a replica environment running in parallel, in the cloud and keeping the in-house legacy system running as normal. If the new system delivers the sought strategic values, organisations can then **back-up** their legacy data and have it available, starting the new system with a fresh configuration and then moving traffic across. This approach of deployment can significantly reduce the risk of impact as the two versions would be running at the same time with the ability of moving data across the two environments. The in-house system can be used as a back-up and the cloud version as the live system because of the high bandwidth capacity offered by the cloud would offer organisations more reliable and effective connection.

Cloud deployment can also be used as an opportunity to fix problems of legacy data, rebuild and rationalise current services.

4.2 Cloud environment

The second main step is to identify the cloud principles and to recognise its capabilities. The purpose of this step is to aid decision makers in acquiring knowledge that companies should be aware of prior to the migration. Six main areas are identified including which depicted as tasks (see in Fig. 3). They are: cloud offerings, pricing policies, security polices, performance monitoring, compliance to regulators, and support. This step can be carried out through the knowledge base that provides structured information which can assist organisations to fill in the lack of knowledge with regard to cloud environment. It would also support organisations in determining the appropriate services for their utilization.

4.2.1 Cloud offers

There is a key difference between cloud computing and IT outsourcing [6]. Cloud computing offers wider services and flexibility to clients compared to traditional IT outsourcing. The levels of details of functionality provided to cloud users to adopt services are varied in the three cloud service models (SaaS, PaaS, and IaaS) [15]. Therefore, organisations need to develop knowledge of how their services can be managed and controlled in the different cloud models.

Further, cloud services are usually offered by providers in a fixed consumption manner (packages). Some organisations may have their own consumption models. Therefore, they may have to adapt their services consumption to the cloud packages. This could be a challenge for some organisations, particularly the larger ones which usually have fixed consumption models.

4.2.2 Pricing policies

Reducing expenditure through the deployment of cloud services is largely dependent upon the pricing approach that is mostly compatible with the customer's behaviour [18]. Ng [19 p2] states that "*today, price models are less straightforward and the modern service economy has moved from exchanged-based pricing to more sophisticated models that incorporate relational, temporal and behavioural issues"*. Cloud-based services are usually provided in different pricing schemes. Pay-as-you-go is the most commonly used pricing model in cloud computing. Cloud pricing usually is one of the following: fixed priced regardless of volume, fixed price plus per unit rate, assured purchase volume plus per unit price rate, per-unit rate with a ceiling, and per unit price [20]. Therefore, in order to avoid the cost related issues discussed in section 4.1, organisations need to

develop knowledge with regards to cloud pricing policies.

4.2.3 Security polices

The security issues and responsibilities are varied in the three deployment models (SaaS, PaaS, and IaaS). This requires organisations define the security responsibility for each model.

Confidentiality is a critical aspect for all organisations. To ensure confidentiality of migrated data in the cloud environment, organisations are required to have full details of who has accessed or requested access to their data. This signifies the importance of developing knowledge about how to track accessibility to the cloud services and the different tracking tools offered by cloud providers.

Cloud computing has the ability to detect the global position/location of data points of remote access devices [21]. These data can trigger extra security mechanisms to control accessibility and authorization. The cloud providers have the ability to continuously monitor applications and platforms. The collected data can be then used to detect vulnerabilities. Developing knowledge about security related tools will assist organisations enhancing security landscapes such as data protection, encryption, digital signing, identity management, authentication methods, privacy standards, and auditing [22].

Information about the data-centre's location, physical resources accessibility, administration and operation, and disaster recovery plans are also vital for organisations.

Reliable access to resources is a key aspect of interest for organisations. A wide range of information including: network vulnerability, multisite redundancy, storage failure, and IP failover, and how an organisations' data can be securely transferred are required to ensure highly-available cloud services.

4.2.4 Performance monitoring

Resource sharing techniques and virtualisation in the clouds often affect performance and degradation causing computing nodes to respond slowly or even become temporarily unavailable [23]. Moreover, cloud services are usually hosted over distributed web servers and application servers and databases to achieve high scalability and reliability [1]. These issues have impact on monitoring which is a fundamental building block for many distributed applications and services hosted in cloud data-centres [23]. It includes safeguarding performance, consumptions and cost, end-user experiences, detection of attacks, data-centre-wide profiling, availability, measurement of service outages, and instant message delivery. Therefore, it is vital for organisations to develop knowledge on how to monitor performance using cloud services, the different levels of monitoring and also the cost of the tools for systems monitoring.

4.2.5 Compliance to regulations

It is critical for organisations to ensure the validity of their cloud services. Achieving this requires compliance information gathering from different regulators. These include national and international standards for a particular service and the cloud providers' regulations. The gathered compliance information will then help organisations to design and implement control objectives to meet the relevant compliance requirements.

4.2.6 Support

Cloud services are usually offered without the cost of sales. Therefore consultancy and support services offered by cloud providers require extra expenditures. Support services are provided at different levels and pricing methods, thus organisations need to identify the level of support they require and the suitable payment method.

4.3 Services suitability

Once the objective is finalised and the cloud principles and capabilities are recognised, the migration decision moves to the design phase. The purpose of this phase is to aid the determination of the services to be migrated. This phase involves two main steps: (a) an identification of the services that are suitable to be migrated; (b) performing a risk assessment for each candidate service. The process of evaluating the suitability of a service includes: identifying the service's requirements, integration, data volume, criticality to business, and a ROI calculation. These tasks are performed during this stage to ensure that the requirements and characteristics of business services are suitable to be supported by the cloud environment. Lack of transparency of cloud-based services in terms of cost and quality renders the run-time adaptation and replacement of services is almost impossible [3]. The design level of the knowledge base can provide information to support in performing these tasks. When a service is identified, then it is critical to conduct a risk assessment for each selected service, including the risks to organisation, the legal implication, the security threats and their consequences.

4.3.1 Requirements

The first task in identifying a suitable service is to conduct a comprehensive analysis of the required **adaptation**, **security**, and relevant **standards** (shown

as separate tasks in Fig 3.). Typically, organisational services have different characteristics and requirements which make the analysis far from straightforward. Failure or inaccurate assessment in this step will result in the selection of inappropriate services that could cause complexity and integration issues.

While many applications have already been developed specifically for the cloud environment (forming cloud-native applications), others must be adapted to be suitable for the cloud which require making them cloud enabled [11]. Adaptations may be required at a number of levels: data layer, database layer, accessibility, and business processes to enable existing applications to function in a multi-tenant and distributed environment. These adaptations will also ensure the acquirement of the main cloud features such as scalability and availability. However, many applications are not ready to be moved to the cloud because the environment is not mature enough for them e.g. safety-critical software [24].

Cloud security is a joint responsibility between cloud providers and users. The cloud users' responsibility starts from migrating the services that their security requirements can be addressed from the cloud vendors. Organisations must make sure that the appropriate authentication and identity management capabilities are integrated into the applications to protect and have access to encrypted data, particularly while data is transferred across cloud boundaries. Securing APIs, encryption, key management, and shared-domains must be also considered during the design phase of applications migration [25].

4.3.2 Integration

Enterprises are likely to have hybrid of cloud and in-houses systems, resulting in the assessment of integration of candidate services to ensure smooth interactions between cloud services and on-premises systems. Moreover, in some cases enterprises need to combine a range of cloud services from different cloud providers to achieve maximum efficiencies which require further assessment of integration [[26]. Assessment of integration requires relevant expertise in developing cloud-to-cloud, cloud-to-local integration mechanisms as well as cloud integration management. Further, the integration roles require the development of relevant skills within areas such as business processes, data management, data analysis, business architecture, and Service Oriented Architecture (SOA).

4.3.3 Data volume

Organisations are required to measure their data volume as it has a direct impact on the cost calculation. Usually, cloud computing is more cost effective for start-ups or newly started organisations. On the other hand, companies that have large legacy-data will find the migration more difficult and more expensive. For these organisations, cloud services would be more beneficial for the provision of new services but not to replace or migrate already deployed services. In [14] Misra and Mondal identified four factors to be taken into account, while determining the size of the IT resources of a company. They are: the number of servers the company maintains in its data-centres, the size of the customer base, the annual revenue from IT, and the number of countries across which the company is spread over.

4.3.4 Critical to business

Although, cloud computing uses up-to-date security mechanisms which can enhance the detection of vulnerabilities and threats and provides valuable knowledge about the security status, security of data governance is the major shortcomings of the cloud, which has prevented many organisations from migrating. The experts who were interviewed perceive that cloud computing has not yet reached the maturity level to migrate highly sensitive data. Therefore, organisations are recommended to analyse their services in terms of the **sort of data**, and their **impact on the organisation** (the tasks shown in Fig. 3 under Critical to business). Services that deal with highly sensitive data such as financial services usually have more stringent requirements, resulting in more difficulties during migration. Additionally, it is very likely that the transformation to the cloud will result in new jobs, a change in many job descriptions, and the elimination of existing ones. To manage the **impact on staff** task, organisations need to analyse the anticipated change to the staffing level, roles and expertise during the design phase before migrating an existing service to the cloud..

Adopting cloud computing requires a fundamental shift in organisational culture and business processes both within and outside of IT. Managing this change may present a large challenge for many organizations when moving to the cloud [27]. Organisations are required to perform the task of analysing and acquiring full understanding of the impact of migrating a service into the cloud on their organisational culture and the resulting **cultural shift**. It will minimise the impact of the change (disruption) and allow the cloud culture to be integrated within their organisations. This includes institutional values, business processes, resources utilisation, knowledge sharing, the interaction between members monitoring and internal audit, user access provisioning, departments, and with other organisations. Organisations should start by migrating less critical services and then gradually migrate higher critical ones.

4.3.5 Return on Investment (ROI)

For the majority of organisations, cost reduction is the main motivation for cloud migration. The investment of migration existing systems requires organisations to conduct ROI calculation that is a financial metric to estimate the financial outcome of an investment. Several factors are required to be considered when exploring ROI. They include the business benefits against extra costs such as the need to invest in higher bandwidth, integration and staff training. The time, efforts, and cost of moving the service back in-house or to another provider should be also considered during the analysis. The variety of cloud services and deployment models and their payments polices have increased the complexity of ROI. Additionally, organisations have different sets of requirements such as legal requirements and they are in different positions with regard to the maturity and the legacy of their existing systems. Other factors that need to be considered to enhance the accuracy of the ROI calculation are measuring the cost of the organisational impacts.

4.4 Risk assessment

The potential business advantages offered by the cloud have to be examined against the probable risks of the migration. Khajeh-Hosseini et al. state that "*From an enterprise perspective, costs are important but so too are customer relationships, public image, flexibility, business continuity and compliance*" [6]. Therefore, the second main step during the design phase is to measure the magnitude of the potential losses and their probabilities by performing a number of tasks shown in Fig. 3. This will allow cloud customers to determine the acceptable level with respect to each risk and to negotiate risk balancing or avoid the others. Potential risks can be categorised into three main areas: risk to organisation, legal implications, and security. The **risks to organisation** may include: loss of control, dependability, managing relationship with different cloud providers, process disruption, and performance monitoring. For example, in a case of being unable to access to a cloud service during a critical mission, this could lead to limited responses from organisations due to the lack of information, and they will be largely dependent on the cloud provider customer's service which might not be easily approachable. **Legal implications** may include: intellectual property rights, compliance with regulations, software licenses, and lack of standardisation. The increase of distance as a result of a migration could increase the security risks and also a change of potential threats which may result **accessibility** and **availability** risks.

4.5 Vendors evaluation

After identifying a suitable service for migration, the next step is to evaluate the cloud vendors to select appropriate providers. In this model, the SMICloud (discussed in section 2) has been adopted for ranking and evaluation of cloud providers. It consists of six primary areas shown as tasks in Fig. 3 that are needed by cloud customers for selecting a service provider. The **Accountability** attribute is used to measure specific characteristics of cloud providers to build the trust of a customer on a cloud provider by ensuring accountability of security exposures and compliance that includes a measurement of auditability, compliance, data ownership, provider ethicality, and sustainability.

Agility is a major advantage of cloud computing. This signifies the importance of measuring how quickly new capabilities are integrated into IT as needed by the business. Organisations are interested to find out whether the service is elastic, portable, adaptable, and flexible.

The **assurance** characteristic is monitored to ensure that the cloud service is performing as expected or as specified in the Service Level Agreement (SLA). Every organisation desires to expand their business and enhance their offered services. Therefore, reliability, resiliency and service stability are important factors in selecting cloud services.

Cost tends to be the most quantifiable attribute, but it is important to measure cost in such a way which is relevant to a particular business requirements.

There may be a wide variety of cloud offers to address different organisations' needs. These offers usually have different **performance** in terms of functionality, service response time and accuracy. Organisations need to understand how their applications will perform on the different cloud services and whether their deployments meet their expectations.

Security and privacy are major concerns for the majority of organisations. They are multi-dimensional in nature and include many attributes such as protecting confidentiality and privacy, data integrity and availability.

The final step in this process is to make the choice of the most appropriate cloud provider and then implementation. The implementation step includes the tasks of **training** members of staff on the new system, **communication** of the new service's information to all affected parties, and then **documentation**.

5 Conclusion and future work

Migration to cloud computing is a strategic organisational decision that is complicated and dynamic in nature. This has highlighted the requirement for DSSes to support systematic analysis for informed decision making. The majority of the existing DSSes designed to support migration to the cloud have limitations. They mostly provide information to support evaluation and selection of vendors with cost being the main factor while some fundamental issues had been left unsupported. They often lack information about the cloud environment, particularly for customers who are not familiar with it, and provide a limited amount of the information needed by organisations to assess the suitability of their own services for the cloud.

This paper proposed a model to support the decision making process for migration to cloud computing. The model includes three phases: intelligence (identify problems, requirements and opportunities within the cloud environment), design (service suitability and risk assessment) and choices. These phases are expanded into six main steps which each have a number of tasks to be performed. The steps and tasks are discussed in this paper, with reference of the interaction each task has with the knowledge base. This model offers an encouraging preliminary structure for developing a cloud KBDSS.

This paper is focused on the migration decision model and does not consider other issues with regards to cloud-based services. The small sample size has limited the conclusions to be drawn based on the need and concerns of certain organisations. The unavailability of a DSS for real testing and implementing the model is also another limitation of this study. Therefore, it is envisioned that a prototype will be constructed, and then the model can be implemented as a KBDSS to support all phases of decisions making process.

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