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ROBERT WILSON, Berlin Mano, KHAZAEI, Babak and HIRSCH, Laurence
<<http://orcid.org/0000-0002-3589-9816>>

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Towards a cloud migration decision support system for Small and Medium Enterprises in Tamil Nadu

Berlin Mano Robert Wilson, Babak Khazaei, Laurence Hirsch
Faculty of ACES,
Sheffield Hallam University,
Sheffield, United Kingdom

Abstract— Cloud computing is a promising computing paradigm which has the potential to speed up Information Technology adoption among SMEs in developing economies like India. The user friendly, pay per use cloud computing model offers SMEs access to highly scalable and reliable cloud infrastructure without having to invest on buying and maintaining expensive Information Technology resources. However, moving data and application to a cloud infrastructure is not straightforward and can be very challenging as decision makers need to consider numerous aspects before deciding to adopt cloud infrastructure. A review of the literature reveals that there are frameworks available to support cloud migration. However, there are no frameworks, models or tools available to support the whole cloud migration process. This research aims to fill that gap by proposing a conceptual framework for cloud migration decision support system targeted for SMEs in Tamil Nadu.

Keywords— *cloud computing; Small and Medium Enterprises (SMEs); decision support system (DSS);*

I. INTRODUCTION

Cloud computing (CC) presents organisations with an opportunity to buy or rent precisely the Information and communication technology (ICT) services that is required for the business [11]. In a cloud environment, organisation pay only for what they use depending on the type of cloud service (Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS)) instead of purchasing and maintaining hardware and software in a traditional Information Technology (IT) environment. The pay-per-use feature of the services offered by the cloud makes it an attractive product for Small and Medium Enterprises (SMEs) sector as SMEs can have access to highly scalable technologies with less capital spent on the infrastructure [6].

The increased use of ICT services like e-mail, collaboration and Enterprise content management software's on mobile devices have opened the market for cloud based services as organisation have started to use cloud based services without realising they are on the cloud. Services such as dropbox and google drive have been accepted globally and are very good examples of SaaS offered in the cloud [11]. From a business's point of view, cloud offers flexibility, lowers IT costs and increases reliability of the services. Developed economies in Europe, Asia and America have embraced cloud computing and the adoption levels have increased considerably in the

recent years. However, in developing economies, growth of cloud adoption is still in its early stages and Chief Information Officers (CIO's) are very cautious in adopting the services offered in cloud [23].

Early research work in cloud computing were focusing on defining cloud computing and components of cloud computing. Some of the research studies were aimed at identifying the economic benefits of a cloud migration [19]. Literature review reveals there are frameworks available to understand the cost benefits of migrating data and application to a cloud environment [19] [15] [16]. Several studies have identified the benefits, barriers and risks involved in cloud migration and they are well documented through conference papers and journal articles [9] [14] [23]. Cloud computing as a technology has matured in the recent years and according to a recent survey, cost benefits are no longer a major driver for cloud adoption. Organisations have started to look beyond the economic aspect to fully leverage the benefits of the cloud platform.

Recent research studies in cloud adoption have moved towards developing a decision model for cloud adoption. The main aim of a decision support tool is to help and aid decision makers (DMs) make decisions for a particular problem effectively. Studies targeting SME population have identified lack of awareness of the benefits of cloud adoption, security and privacy issues, risks involved in cloud adoption as a major inhibitor for the adoption of cloud among SMEs in developing economies. From the cloud provider's perspective, larger organisations like CISCO, IBM, Microsoft, Amazon and Accenture have developed their own framework to support cloud adoption decisions to attract businesses to purchase their cloud product. In Academia, since 2013 several studies have been carried out to develop frameworks, models and tools to support cloud adoption. Decision makers want to know, where to start and how to plan a successful migration to fully leverage the benefits of cloud computing. This is the major driver for research toward developing a decision model for cloud adoption.

The focus of this research paper is to propose a framework for cloud migration decision support system specifically for SMEs in Tamil Nadu (Southern state of the Indian Union) by building on some of the existing frameworks with an intention to help SME decision makers in Tamil Nadu make cloud adoption decisions effectively. The structure of this paper is as follows. Section II provides an overview on the status of cloud

computing among SMEs in India and Tamil Nadu in particular and discusses related work. Section III presents the methodology for the proposed DSS. Section IV and V will discuss the future directions of the research and the conclusion

II. LITERATURE REVIEW

A. Tamil Nadu SMEs

India is a federal union consisting of 29 states and 7 union territories. Tamil Nadu lies in the southern part of Indian peninsula and has a population of 72 million. Tamil Nadu is the fourth largest economy in India and it is the first state in India to announce a comprehensive IT policy in 1997 even before the National IT policy which was released only in 2000 [12]. Due to provisions in Part XI of the Indian constitution, each state of the Indian union is entitled to have its own laws. Therefore, the legal requirements for running a business can vary for each state and a study focused on one state cannot be accurate for the whole union.

As this study is focused on SMEs in Tamil Nadu, we refer to SMEs based on the definition by Indian Ministry of Micro, Small and Medium Enterprise (MSME). According to MSME act of 2006, businesses are classified based of the initial investment made by the enterprise on plant, machinery and equipment's to run the business [34]. Only SMEs with established IT infrastructure will be considered for the main study. Tamil Nadu accounts for the largest number of SMEs units in the country producing over 8000 variety of products and has a total investment of more than 32,000 crore Indian Rupee (INR) (approximately £3 billion). The state government offers subsidies of up to 15 crore INR (approximately £1.5 million) for private businesses when setting up industrial estates and up to 10 crore INR (approximately£1 million) for setting up industrial parks. It is inferred from the statistics that Tamil Nadu is one of the most favourable destinations for investments and running a business. Anecdotal references suggest ROI to be primary focus within the Tamil society. Therefore, anything that is likely to increase the cost or reduce the profit in most cases will be ignored. Some of the issues that SMEs in Tamil Nadu are unstable power supply, high bandwidth cost, and low broadband penetration in rural areas.

In developed countries, SMEs are more agile and they are able to react to changes in technology which makes cloud a suitable and readily available solution [11]. Therefore, a decision support tool developed for a target population in UK, USA or other European countries may not be suitable for SMEs in Tamil Nadu. SMEs in India are cautious and very reluctant to change which presents the need for a decision support tool to support cloud migration decision.

B. Related Work

Since 2009, many research studies have been done to study about the suitability, benefits and risks of cloud adoption for businesses. Research work by [19] was one of the early attempts for designing a framework for cloud migration. Their cost based decision framework can be used to determine the benefits of cloud computing infrastructure instead of a traditional IT infrastructure and decisions can be made based

on cost analysis of using services offered by the cloud.

A review of the literature reveals that the direction of research has changed toward supporting cloud adoption decisions. From reviewing the literature, a cloud migration DSS should include the following features:

- A user friendly interface which allows the decision maker to navigate the system [16] [30] [7].
- Existence of a knowledge base which contains information about the cloud service providers and their service offerings, risks and benefits of each particular type of cloud adoption [16] [7].
- Ability to complete a cloud suitability assessment for different SMEs (based on organisation type, size and their requirement) [11] [16].
- Provide decision support for different alternatives considering the relevant attributes [31].
- Ability to provide a ranking of services offered by different cloud service providers by considering factors like suitability, reliability, compatibility, geographic location of data center and security [7].

Though the target population for some of the studies are very specific [11] [4] [30], the technological requirements for using cloud for the entire target are very similar. Therefore, useful lessons can be learnt to address the research objective. Currently there are no DSS available which covers the whole migration process starting from completing a cloud suitability assessment to identifying a suitable cloud provider. This study aims to fill that gap by developing a DSS for SMEs in Tamil Nadu. Table III shows the summary of literature review findings with regards to cloud adoption

TABLE I. SUMMARY OF LITERATURE REVIEW FINDINGS

Reference	Description
[23]	Enablers of cloud adoption: cost benefits of using cloud infrastructure, scalability and flexibility of cloud, increased productivity, minimises software licensing costs and reduces system downtimes
[23]	Barriers of cloud adoption: Cloud security, lack of expertise, High cost of bandwidth and availability of required infrastructure
[23]	Determinants of cloud adoption: scalability, cost reduction, reliability flexibility, faster time to market
[11], [30],[32]	Business applications with the greatest potential in cloud: General purpose applications such as Office, email and collaboration applications with no specific requirement for any particular organisation.

	Standalone applications such as CRM, and applications for which capital expenditure needs to be reduced
[32][11]	<p>Where does the cloud make sense?</p> <p>short-term need for software, applications for start-up and SME</p> <p>Where doesn't the cloud make sense?</p> <p>Legacy systems with complex integration requirements, mission critical applications, applications dealing with confidential data and sensitive data</p>
[31]	<p>Criteria for cloud adoption decision:</p> <p>Suitability of cloud application, Economic value (capital cost, operating cost, Return of Investment), Control (integration and manageability), Usability, Reliability (Disaster recovery, availability and compliance) and Security</p>
[16]	<p>Risks of cloud adoption:</p> <p>Organisational loss of control over data, organisational change due to migration, Management resistance to change, Portability and Interoperability issues, Managing a system deployed on cloud can take extra management effort, Data lock in SaaS/PaaS and System lock in for IaaS, Private data stored on the cloud can be accessed by foreign governments due to difference in jurisdiction</p>
[16]	<p>Cloud Journey:</p> <p>Cloud management, training workforce, cloud audit</p>

III. RESEARCH METHODOLOGY

As part of the literature review to identify the determinants of cloud adoption among SMEs in Tamil Nadu, a study has been conducted among SME decision makers in Tamil Nadu and the result of the study has been published in [23].

The proposed DSS will include a questionnaire based cloud suitability assessment and based on the assessment result, DMs can identify a suitable SaaS, PaaS or IaaS service for their requirement. Issues specific to Tamil Nadu have already been identified through a previous study [23] and will be included in the DSS

The step by step process in the development of the DSS is shown in Fig. 1

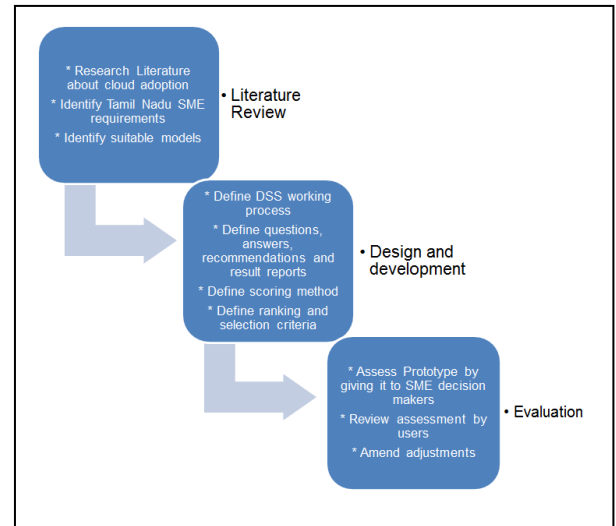


Fig. 1. Research Plan

A. Cloud suitability assessment

The first step of the DSS is to conduct a cloud suitability assessment for the SME to identify if the organisation is cloud ready. By analysis the literature, we have identified nine question categories for this assessment. Each question category represents the readiness criteria that have to be evaluated to identify the suitability of cloud infrastructure for an organisation. These criteria are based on the categories used in similar suitability assessment on the models by [16] [11] [24]. The assessment will include a set of specific questions for each category that an organisation has to answer in order to identify its readiness in that particular category. The assessment criteria are shown in the table IV. Though these categories are derived from already existing decision support tools, the questions are designed to address the requirement of SMEs in Tamil Nadu

TABLE II. QUESTIONNAIRE CATEGORIES

Criteria	Definition and Reference
SME Profile	This is used to profile the organisation (Name, sector, size of the organisation). [30][11]
Organisation	It is used to assess whether an SME is organisationally fit to adopt cloud based services (Organisational structure, Technical expertise of employees, previous experience in cloud). It also helps identifying the potential impact of changes to organisation due to a cloud adoption [16]
Cloud Strategy	It is to identify the organisations commitment for the new technology. Also to establish if they are clear about the implication of a potential adoption [11]

Software	It is used to assess whether the target application is suitable for cloud.[11] [24]
Scalability	It is used to access the growth potential of the organisation and its impact on the selected software [11] [16]
Data	It is used to access the type of data to identify any compliance or regulatory issues that organisations will face due to outsourcing data to a third party datacenter [24]
Compatibility	It is used to evaluate the current IT staff, infrastructure (internet connections, hardware and software), and integration requirements of an organisation regarding adoption of cloud. [11] [16] [24]
Added Features	This is used to indicate the mobility requirements, new enhancement requirements [31]
Cloud management	It is used to indicate post migration strategy of the organisation [16]

The format of the assessment question is shown in the Table V. This format has been adopted from the decision support tool used by [11] in their decision support tool.

TABLE III. ASSESSMENT QUESTION FORMAT

Question Number	Question	Question Weight (CR)
	Answer 1	9
	Answer 2	7
	Answer 3	3
	Answer 4	1
Recommendation (Rec)	Recommendation 1	
	Recommendation 2	
	Recommendation 3	
Reference	Reference/ source for question, answers and recommendations	

CR refers to the weight to a particular question. The weights will not be made visible to the user as it can impact the way they answer. If the answer to the question is 1, it will have a very negative impact of the overall cloud readiness and if CR is 9, it means that a cloud infrastructure is suitable for the SME. Rec refers to the recommendation that will be displayed when an answer is selected. Reference: the source of the question, answer and recommendation will be displayed on this section

Table VI shows a sample question from the cloud suitability assessment tool. The cloud suitability assessment tool will have a total of 40 questions grouped in 9 categories as shown in table. Questions for the first and second criteria are only to profile the SMEs; therefore the scores will only include the seven criteria's. Through this questionnaire tool,

the suitability of an organisation for a cloud infrastructure can be determined

TABLE IV. SAMPLE QUESTION

Do you have a defined goal for you cloud project?
Answer 1: We have a clearly defined goal that we have to achieve high reliability, scalability, increased flexibility (pay-per-use) and introduce cost reduction by implementing cloud based services.
Answer 2: We are still exploring our options in the cloud. We are still defining the goals we needs. We lack the knowledge and expertise on cloud computing
Answer 3: No, we don't have a defined goal and we don't know what we want to achieve from the cloud
Recommendation: [1] Having a clear goal in mind is a good starting point for the adoption of cloud services
Recommendation: [2] The definition of goal and setting objective is an important factor and if you're lacking knowledge, you can take advice from external experts or third party consultants
Recommendation: [3] The definition of goal and setting objective is an important factor and if you're lacking knowledge, you can take advice from external experts or third party consultants
Reference: [11]

B. Identifying suitable cloud service

The next step in the DSS is to identify the type of cloud service delivery model to deploy the target application. All three cloud service delivery models (SaaS, PaaS and IaaS) require users to either design, develop, build and deploy applications to cloud. SaaS offers user to buy an "off the shelf product" and configure it to their requirements. Therefore, the decision maker needs to make a decision whether to "build" or "buy" while deciding on the type of service delivery model for the target application. It makes more sense for SMEs to choose SaaS as the preferred service delivery model, if a suitable SaaS product is available as it does not require technical expertise to configure and implement a SaaS product [32]. However, if the user already has a legacy system or does not find a suitable SaaS service, PaaS or IaaS would be best alternative. For a given cloud adoption scenario where SaaS is not suitable or preferred, the first step is identifying the number of alternatives. The possible alternatives in such a scenario are listed below [31]:

1. Legacy IT (no action if a cloud adoption is identified as not beneficial) (A1)
2. Server consolidation/virtualisation (A2)
3. Server-colocation (A3)
4. PaaS implementation (A4)
5. IaaS implementation (A5)

To identify the best alternative, the problem can be approached using Multi Attribute Decision Making (MADM) methods. MADM is a well-known branch of decision making

and the principle of MADM is applied in developing decision support tools for various different fields [35]. Analytical Hierarchy Process (AHP) is one of the MADM methods and we have adoption AHP to identify the best alternative. The AHP hierarchy for the cloud migration decision problem is shown in Fig. 2. Level 1 is the goal of the system. Level 2 represents the different criteria for cloud adoption and Level 3 represents the five alternatives. The attributes used in Level 2 is based on Multi attribute decision making for cloud migration by Saripalli and Pingalli [31]. For example, if customer is considering improving the performance of a "Legacy web application" running from on premise data center. The decision maker has 5 alternatives to achieve the goal. To determine the best alternative, a benefit analysis can be performed according to AHP and the best alternative can be identified and can be suggested to the decision maker.

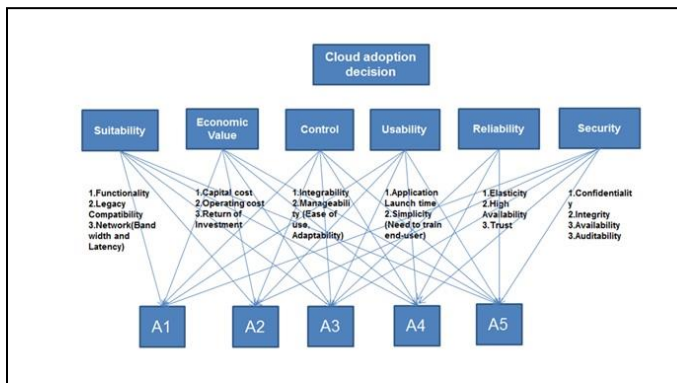


Fig. 2. AHP hierarchy for cloud adoption

C. Identifying suitable cloud provider

Once suitability of the cloud infrastructure is assessed and a suitable cloud service is identified for the target application, the next step is to identify a suitable cloud service provider. As the DSS focuses mainly on SMEs in Tamil Nadu, the vendor suggestion should include local cloud service providers in Tamil Nadu. The ranking of the services offered by the cloud will be based on 6 criteria's per SMI cloud; suitability, reputation, performance and accountability, cost, agility and security [13].

IV. FUTURE WORK

We are currently working on the technical implementation of the DSS. Through a thorough literature review and a study conducted among SME decision makers in Tamil Nadu, we have identified the requirements and the desired working of the DSS. We are planning to develop the DSS as a web application which incorporates the above mentioned steps to assess the suitability of cloud for SMEs in Tamil Nadu. If cloud is identified as a suitable option we aim to go further and identify a suitable cloud provider highlighting the benefits and risks of a prospective cloud adoption. Once the DSS is developed into a web application, it will be given to SME DM's for evaluation and feedback. The feedback gathered

from the users will help to make improvements to the DSS and make it more relevant to SMEs in Tamil Nadu.

V. CONCLUSION

In this research work, we have addressed our main research questions: How can we develop a DSS to support DM's in Tamil Nadu to make cloud adoption decisions effectively?

Through a thorough literature review and the proposed DSS we have properly addressed the research question. After reviewing the literature and reviewing previous research works, we have proposed a DSS for SMEs in Tamil Nadu. The research identifies 9 major criteria that are relevant to determine the suitability of cloud infrastructure for SMEs in Tamil Nadu; SME Profile, Cloud Strategy, Cloud Strategy, Software, Scalability, Data, Compatibility, Added Features and cloud management. We have AHP to support MADM.

This research is part of an ongoing research approved by Sheffield Hallam University

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