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Issues in Migrating Legacy Systems to the Cloud

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Abstract—There are several concerns that legacy systems pose to their host organization. A major problem is the inability to support new functionality and innovations required by the organization. Consequently, organizations recognize the need to migrate to new technologies, such as cloud computing, to meet changing demands. Little has been published about the socio-technical changes brought about by cloud computing and the important considerations for an IT department when migrating a legacy system to the cloud. This study investigates this issue through a case study. Interviews were used to collect qualitative data from participants, comprising systems engineers, project managers, and directors. The data was analyzed using thematic analysis to identify emergent themes. The findings suggest that changing user demands and the need for more functions were the major drivers for cloud adoption. Having redundant and reliable, fast Internet links was regarded as one of the most important considerations. Changing roles can arise: engineers will be required to be more versatile and develop new business analyst and management skills. Interestingly security was not regarded as an issue as most participants felt that the cloud is more secure than the traditional data center. The primary contribution of the paper is to highlight the economic and socio-technical issues that decision makers should consider when migrating a legacy system to the cloud.

Keywords—cloud migration; legacy information systems; socio-technical theory

I. INTRODUCTION

Information technology (IT) is an indispensable part of growing economic competitiveness [1]. Technological innovations such as cloud computing, Service-Oriented Architecture (SOA), and Business Process Management (BPM) are changing the way IT services are provisioned [2] and the way organizations do business [3]. However, legacy information systems (IS) still underpin the flow of information within some organizations [4].

Rapid IT adoption can result in complex systems that resist further development [4]. According to [5] many organizations with legacy systems are constrained to reactive practices to remain competitive. This is because legacy systems have become obsolete and cannot support new innovations. Consequently, organizations see the value in adopting new methods and technologies, such as cloud computing, to satisfy changing demands [2].

Cloud computing, and the adoption of SOA, drives value in organizations by reducing operation costs, local resources, and staff [6]. A few case studies have investigated the migration of an established IT systems to cloud computing [e.g. 7; 3].

However, little has been published about the economic and socio-technical changes brought about by cloud computing and the important considerations for an IT department when migrating a legacy system to the cloud [3].

This study investigates the drivers, the important considerations, socio-technical changes, economic implications, security, and privacy issues that cloud migration raises. It uses a case study approach, investigating a single large organization. The study focuses on the migration of a legacy email system to software as a service (SaaS) at the organization.

The rest of this paper is structured as follows. The next section provides a review of relevant literature. Following this, the research methodology is presented. Then, the data analysis and findings are discussed. Lastly, the conclusion summarizes the research contributions.

II. LITERATURE REVIEW

A. Legacy IS

Legacy IS frequently support the flow of information within an organization [4] and can play a crucial role in merging business data. However, enhancing legacy systems is a challenge to many organizations due to their resistance to change. Reference [8] defines legacy IS as “...any information system that significantly resists modification and evolution.”

Problems that legacy IS pose to a host organization include [4]:

- Maintenance costs and a reduction in productivity due to the slow performance of old hardware.
- Costly software, with undocumented patches that cannot be traced, and lack of overall system understanding.
- Lack of clean interfaces on applications which hinders integration efforts.
- Inability to support new functionality and innovations required by organizations.

The information being housed in many of these legacy IS is regarded as an important business resource [4; 9]. This means data stored in legacy systems cannot be ignored and discarded without first migrating it to new systems [9]. Migration from a legacy system is not a minor process and could be very expensive and time consuming [10].

Studies have shown that many projects aiming at replacing legacy IS with completely new ones have failed [5]. One of the major reasons for IT adoption failure is that it handled as a technical problem, while human and organizational aspects are ignored [11]. Lack of understanding the determinants of IT adoption, and deficiencies of theoretical frameworks, also contribute to legacy IS migration failures [1].

The above observations highlight the need for a strategic and systematic approach to have a successful legacy IS migration project [12]. There seems to be a consensus among industry players with regards to what a systematic approach should support. The strategy should consider the organization's business needs [13; 12] and the technical architecture of the legacy IS [12]. There is a need for realistic context-based technology evaluations and a complete mind-set change from all stakeholders involved [12].

All the elements that are crucial to the success of any legacy IS migration project as stated in the preceding paragraphs are supported by migration methodologies that have been proposed.

B. Migration Methodologies

The migration of legacy IS need a detailed, strategic, and well-defined methodology that is easy to implement while minimizing the risk of failure [10]. Methodologies that were suggested by [4] seem to form a good basis for new migration strategies:

- Forward Migration (Database First). This method entails first migrating legacy data to a new database management system and then incrementally migrating applications and interfaces. The legacy system interoperates with the new system while the interfaces are being developed. This is facilitated by a Forward Gateway which is a software module acting as a mediator between the two systems.
- Reverse Migration (Database Last). This method starts by gradually migrating applications while data remains on the legacy system. Legacy databases are then migrated at the end of the whole process. The interaction between the legacy database and the new platform is facilitated by a Reverse Gateway. This method is however considered complex and slow.
- The Chicken Little Method was proposed by [14]. In this approach the legacy and new system operate concurrently during the migration project. The legacy system is removed when the new system is fully functional.
- The Butterfly Methodology is considered a simple, fast, and safe way of migrating mission-critical legacy systems to a modern platform [14]. This method removes the need to access both systems at the same time as the target system will only be in production when the migration has been completed. This approach however, will not be a practical one for some migration projects like the one being investigated in this study as

the need to have both systems running in parallel is unavoidable.

Legacy IS will continue to have a place in the IT industry, but changing demands [2] and budget cuts [15] are forcing many organizations to be innovative [12] and do more with less [16]. Integrating cloud computing, SOA, and BPM is a solution for organizations to be more agile and gain rapid access to IT [2].

C. Cloud Computing, SOA, and BPM

The main drivers for legacy IS migration is the need for cost-effective and scalable solutions [17]. The use of cloud computing has become essential for many organizations [2]. Cloud computing is defined by the National Institute of Standards and Technology (NIST) as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [18].

The use of cloud computing alone does not guarantee complete organizational success; neither does the use of SOA alone [2]. Cloud computing is mainly concerned with changes in the technical domain [3], whereas SOA concerns both business processes and IT services [13]. The complexity and the scale of legacy IS migration projects require a strategic and integrated approach [19]. Legacy IS migration should align with the organization's IT strategy [2] as well as business objectives [13]. The migration's success relies on a SOA which provides the needed cloud computing infrastructure. Without SOA and BPM migration of legacy IS become more expensive and makes less business sense [2].

D. A Socio-Technical Approach

The socio-technical approach is a theory incorporating human (social), organizational, and technical factors in systems design and IT adoption. It aims to provide a better understanding of how these factors affect the way IT services are provisioned and the way organizations do business [20]. The theory is relevant to this research as it addresses the crucial elements in legacy IS migration:

- The technical element includes the technological processes that enable the organization to function profitably.
- The social element includes the organizational culture, employee knowledge and skills, incentives, and management structures in the organization.

An organization will only be able to achieve its objectives and successfully adopt new IT if the mutuality of these elements is considered when planning a legacy migration project [11].

III. RESEARCH METHODOLOGY

A qualitative research approach was selected since the intention is to understand and explain the social phenomena as perceived by the participants [21]. A qualitative study allows

the researcher to source in-depth information about the crucial determinants and considerations in IT adoption [22]. This research explored individual experiences and perceptions with regards to legacy IS migration in a specific organization.

The research method was a case study within a single organization. A case study provides an opportunity to understand the totality of an individual's experience and perception of a certain phenomenon [23]. A case study was deemed suitable for this research as it uses data from multiple sources to gain an in-depth contextual understanding of a situation [22], instead of individual stories as in narrative research. Sources of data can include interviews and existing organizational documents [21].

This case study was conducted in a single organization which was chosen on the basis that it had already carried out a legacy IS migration project and adopted cloud computing as an ICT solution. The organizational structure and diversity in culture at the organization, with more than thirty thousand ICT users, makes for a suitable environment to test the theoretical framework being used. A purposive sampling technique was used to identify interview subjects that were deemed likely to provide pertinent information [23]. The target population was the IT management and staff involved in the cloud migration project. Interviews were conducted with seven participants (named P1-7 subsequently).

Multiple data collection methods were used in this research. These include semi-structured interviews, with open-ended questions, and analyzing existing documents. These methods aligned well with a qualitative research approach [23]. Once the interviews were transcribed and verified, thematic analysis was used to identify, analyze, and report emergent themes and patterns in the data [24].

IV. DATA ANALYSIS AND FINDINGS

The emerging themes covered the social, technical, organizational, economic and security issues that should be considered when migrating an IT system to the cloud. This is also supported by the theoretical framework that was used in this study. The organizational changes can also be referred to as the socio-technical changes as the study focused on the views of the IT department and not the entire organization.

A. Drivers for Change

Shrinking IT budgets and escalating IT needs are the major factors driving the adoption of cloud-based services [16]. However, the findings of this study show that the reason for moving to the cloud was not purely a financial one. There was a lot of unhappiness from the user community due to the old system (GroupWise) being unstable and the IMAP client not working. This shows that user perception and the technical posture of the existing system play a role in cloud adoption decision.

It was stated in literature that organizations realize the benefit of improving processes and migrating to new technologies, such as cloud computing, to satisfy changing demands [2]. This concurs with the response from two participants who confirmed that changing user demands are an

important consideration in cloud migration. Five participants emphasized the importance of user perception on any IT solution that the IT department provides. According to Int3 "The IT department felt that the solution as per design was fit for purpose whereas the users felt that it was not fit for use. Not fully catering for their needs and as such a petition was raised to request IT to investigate and review other solutions."

The popularity of cloud computing can be attributed to the fact that IT services provisioned using cloud computing are accessible anytime, anywhere and from any platform [25]. Mobility is one of the major themes that came up throughout all the interviews as the driving factor and benefit of cloud computing: "Cloud computing allows for mobility, allows you to work from anywhere, anytime" (P7).

The sharing of resources and unlimited storage capacity are some of the core benefits of cloud computing [26; 7]. All the participants in this study seem to confirm the sentiments made in literature that storage capacity was among the top driving factors of cloud adoption as users were complaining about their mailbox sizes, e.g. "50MB mailbox size... you can imagine how many calls we were getting about increasing the mailbox sizes" (P2).

B. Social System

Cloud computing is still regarded as a new phenomenon among industry players [26]. As such, any cloud migration project requires proper planning and research. It is interesting to note that the organization did not set out to look for a cloud-based solution, but they wanted a solution that is modern, robust enough and meets their business objectives. It was through drawing-up business requirements and research that a cloud-based solution became apparent:

"...and the request was that we investigate and review other solutions, it didn't specifically say cloud...It was only after building a business case and looking at future needs that we decided to go in that direction" (P3).

There are a lot of management challenges that come should be considered when migrating a legacy information system to the cloud. The sub themes that were coming up under the management theme were: project management, management of user expectations and management of the migration processes. The complexity and magnitude of legacy IS migration projects require an organization to have a realistic strategy for performing such a migration [12]. The IT department considered project management as a crucial element in legacy IS migration: "Choosing a vendor that can provide local support was crucial. One that we can easily engage with. Evaluating what level of expertise they have in terms of support and project management" (P3).

It was revealed earlier in the data analysis that user expectations play a big role in cloud adoption. Management of such expectations is therefore critical to the success of any cloud migration project. One participant had this to say about managing users: "There was basically constant consulting and engaging with all stakeholders. Certain stakeholders were for open source. The IT department had to decide on what is suitable for the business and meets the organization's

objectives. Relationship management and organizational change management was very important. Lots of explaining and understating your stakeholders” (P1).

The above sentiments seem to tie-in well with the strategy suggested in literature. The strategy should consider the business requirements [13; 12] and technical architecture of legacy IS [12]. The migration process must consider the operational needs of the business to avoid a conflict of interest during the migration. This is in accordance with literature which states that an in-depth understanding of the organization’s operations and resources is fundamental before a migration project commences [5]. This provides a solid background for analyzing the system and documenting the dependencies between business processes and its supporting IS [9].

One participant highlighted the need for processes that do not hinder productivity as this could cause some resistance from the users. It was mentioned in literature that many migration project failures can be caused by resistance of change by some stakeholders. The replacement of IS raises the need for organizational changes which many stakeholders are not comfortable with. The fear of change in working practices contributes to some resistance [5].

Communication was regarded as a key consideration during the migration. It was one of the major themes that were emerging in all the interviews, e.g. “Communication is key, you may have a very good, working strategy in your mind, but if it’s not communicated properly, people won’t buy into it.” (P1)

C. Technical System

One of the objectives of this research was to determine the key integration considerations when it comes to adopting cloud computing as an ICT solution. It is worth mentioning that the important technical considerations were similar across participants. Broad network access is a major characteristic of cloud computing and as such networks, especially the Internet, is an essential aspect in provisioning cloud applications and services [18].

Having redundant and reliable fast internet links was regarded as one of the most important considerations when one is thinking about cloud migration. This was a prominent theme in most interviews. Two participants indicated that lack of redundant internet links was the major concern:

“...people still need the network to access cloud based services. That gives pressure to keep the internet running. You definitely need backup servers locally and redundant internet connections” (P5).

Having user data stored in different areas across the world is a defining characteristic of cloud computing. However, participants in this study still emphasized the need for having a backup system locally.

The integration of the new cloud-based system was regarded as an important consideration, particularly in the design phase of the migration project. This ties-in with the Chicken Little Method that was proposed by [14]. In this

approach, the legacy and the new system operate in parallel throughout the migration project. One participant accentuated the need to eliminate the chance of failure by having several migration phases which minimizes complexity. The importance of such approach was also highlighted in literature. The migration of legacy IS require a detailed, strategic, and well-defined methodology that is easy to implement while minimizing the risk of failure [10].

Legacy information system migration must be aligned to the organizational IT strategy [2] which should also be aligned to the overall business objectives [13]. A major theme which came up in the first interview and an important consideration in cloud migration is that the chosen strategy must be in line with the organization’s IT vision: “...the IT department had to decide on what is suitable for the business and meets the organization’s objectives” Int1.

The migration strategy and motivations that were mentioned by the participants does support the IT department’s vision of enabling users by giving them fast, sustainable, secure and optimized IT solutions. A strategic migration of legacy IS to the cloud gives an organization the capacity to support users who want to bring their own devices and have access to resources from anywhere.

Organizations also need to consider how they will handle system failures in the cloud. This was indeed a concern for several participants, e.g. “It changes the complexity of the environment, troubleshooting becomes difficult. No control, no immediate access to logs, the process of having somebody to look at the problem takes longer” (P2).

It is worth mentioning that these concerns were factored in and considered in deciding which service provider they chose: “Choosing a vendor that can provide local support was crucial. One we can easily engage with” (P3).

D. Socio-Technical Changes

One of the objectives of this research was to determine the socio-technical changes brought about by cloud computing from an IT department perspective. According to [3] cloud computing is not only concerned with technological changes in the data center, but there are many organizational changes associated with it. Three of the participants at management level highlighted some of the changes that are inevitable as organizations move more services to the cloud. They emphasized that these changes need to be factored in in the planning phase of any migration project:

“...yes, a lot of mind-set change is required. Your typical engineer is now becoming more business analyst than a subject matter expert (SME). Integration of technology and understanding the business requirements. Engaging with the customer and the service provider (SP) to provide a service to the customer...” (P3).

It is argued in literature that role of the IT department will change from a provider of technology to certifier, consultant, and arbitrator [3]. The findings of this research clearly confirm this role change as one of the socio-technical changes resulting from cloud migration. An interesting trend to note is that while the participants at management level seem to be very much

aware of the changing roles and responsibilities of the IT engineers, very little can be said about the participants at technical level. Only one participant seemed to acknowledge the prospect of changing though not very clear as to what exactly that change means.

The differences in views between management and technical participants became even more pronounced in the responses from the management participants: “No need for specialists as the cloud service provider already caters for that. Need more generalists and versatilis” (P1) and “You basically transfer the responsibility of looking after the infrastructure, patching, servers, applications to the Service Provider and only focus on administration” (P3).

It was stated in literature that a complete mind-set change from all stakeholders is required to have a successful migration project [12]. Refocusing, re-skilling and re-utilization of resources were some of the themes that were regarded as the organizational changes brought about by cloud computing: “Cloud is a sourcing strategy where you move things away that are not important so that you can free your people to focus on what is critical to your primary activities” (P1) and “There is obvious need for re-skilling, especially soft skills with regards to relationship management” (P3).

Many organizations continue look to better understand the way they manage their IT resources and find ways to do more with less [16; 15]. The findings of this research suggest that cloud computing is a major contributing factor to these role changes. One participant who considered the role changes as a benefit of cloud migration stated: “70% of effort is wasted on managing and operating the environment. Little time is spent on innovation and implementation. Retain the skill and have more people on the innovation and implementation side” (P1).

E. Economic Implications

According to [16] shrinking IT budgets and escalating IT needs are the major factors driving the adoption of cloud-based services. The theme of saving was highlighted as one of the important benefits of cloud computing adoption. However, the saving is not entirely on finances as one participant gave an interesting comparison between a cloud-based and traditional in-house solution. Business changes associated with the migration project need to be quantified [5], as this will impact the required effort and cost of the migration project [12]: “We asked vendors to provide total costing in terms of software, licensing, implementation, maintenance and technical resources. You will be surprised that we got almost similar overall costing, whether local or cloud-based. Cloud saving is on infrastructure and technical skills” (P3).

The most cited business driver for cloud migration was reducing the cost of IT operations and capital investment in core IT equipment (e.g. servers). The lower costs associated with cloud computing were not regarded as a priority by two participants who felt that financial costing is almost the same between local and cloud-based solution.

Cloud computing works using economies of scale [16]. Scalability is a major theme that was more pronounced

throughout the interviews. All participants regarded it as an important benefit of cloud computing.

F. Security, Legal, and Privacy Issues

Contrary to existing literature that security is a major risk in cloud adoption [e.g. 16] the findings of this study seem to differ. Three of the participants did not consider security to be a cause for concern. They argue that cloud service providers invest a lot of money on security and have more secure data centers: “Those guys invest mega bucks (money) in security, you just cannot compete...” (P1).

Participants at managerial level emphasized the need for research before deciding on where your data will be located. This means that they considered the privacy and legal issues that cloud computing raises. It is interesting to note that lack of visibility of data location was not a concern:

“There is no law in South Africa that says your data should be confined within the borders of South Africa, however we tried to avoid the US due to the Patriot Act. Our data is sitting in three different areas within the European Union. The service provider gave us a guarantee that they won’t be scanning any emails and no one will have access to our mailboxes” (P2).

There is still common concern though with regards to data lock-ins. The existing literature [e.g. 27] and the findings of this study seem to suggest that data lock-ins is a big issue. It is however worth mentioning that the participants did consider the data lock-in issue and came up with a work-around to address that problem: “There is a way out with Microsoft but not with Google. That’s the other reason why we went with Microsoft. With Microsoft you can move back to your local exchange server and then to a different platform” (P1).

There seem to be conflicting views on Service Level Agreements (SLA). One participant seems to question the value of SLAs: “I’m yet to see somebody who has sued Microsoft and won. Big companies have lots of money to throw at a problem than you can imagine. We do have a contract with Microsoft, but they just tell you what they will do. So, it’s not your typical SLA...” (P1). The second participant argues that SLAs should be part of user requirements that the service provider commits to meet: “We required a Service provider who is very mature in their IT service management processes from a service delivery perspective and management of SLAs. For me that’s very critical...” (P3). An SLA is indeed a critical part of any contract with a cloud provider [28].

V. CONCLUSION

The purpose of this research was to highlight the important consideration for an IT department when migrating a legacy IS to the cloud. The key considerations were investigated from several dimensions. The first dimension was the factors driving the adoption of cloud computing as an ICT solution. The findings suggest that there were push and pull factors that led to the decision: the need for a modern, reliable and scalable solution that supports mobility was a pull factor whereas the instability and limited functionality of the existing system was considered a push factor. Based on the theoretical framework

the key migration considerations were then divided into technical and social sub-systems. Having redundant and reliable Internet links was considered an important technical aspect to consider when adopting a cloud-based solution. Managing user expectations, relationships, project management, planning, and research were considered as important social aspects.

A sub-objective of this study was to ascertain the economic implications of cloud computing. Cloud computing is set to change the way IT services are provisioned due to its apparently cheap, simple and scalable nature. However, the findings suggest that cloud savings is not primarily on financial costs as one still pays, but for different things. Another angle of investigation was to explore the socio-technical or organizational changes brought about by cloud migration. Changing roles for the IT departments becoming brokers of service and the IT staff becoming more versatile specialists is an imminent factor. The focus shifts from operating the environment to being more innovative and develop business analyst and management skills.

Lastly the study examined the security, legal, and privacy issues that cloud computing raises. An interesting finding was that security was not a concern as the participants felt that cloud service providers invest a lot in security. However, data lock-in is still a concern. Privacy was considered an important factor which is why the participants preferred that data be stored in the European Union.

The findings of this study are limited to a single organization and as such caution should be taken in attempting to generalize. An open issue for future research is to develop and evaluate a stakeholder impact analysis method which can be substantiated by empirical research.

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