Understanding Cloud Requirements - A Supply Chain Lifecycle Approach

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Abstract—Cloud Computing is offering competitive advantages to companies through flexible and, scalable access to computing resources. More and more companies are moving to cloud environments; therefore understanding the requirements for this process is both important and beneficial. The requirements for migrating from a traditional computing environment to a cloud hosting environment are discussed in this paper, considering this migration from a supply chain lifecycle perspective. The cloud supply chain is examined from a lifecycle perspective for the management of the migration project. This paper illustrates the requirements that need to be considered when adopting a cloud migration strategy and the steps to take in order to manage this process.

Index Terms—cloud computing; supply chain; cloud sourcing; cloud lifecycle.

The cloud provides scalable, on-demand network access to virtualised computing resources [1]. This is a very attractive concept for enterprise Information Technology (IT) landscapes to adapt. However as with any new concept or emerging technology, IT departments face challenges with the opportunities being offered by the cloud. Some of the challenges include security, privacy and lack of control. The physical location of hardware in addition to who can access the data is not always known which, can lead to security and privacy issues. As the cloud is run by a cloud service provider, users have limited control of factors such as maintenance or resource usage as these are the responsibility of the cloud service provider. Although cloud computing reduces capital expenditure by using a pay-per-use model, there can be hidden costs in order to ensure adequate backups and disaster recovery processes are in place. Despite these drawbacks many companies still strive for cloud adoption as the advantages more than compensate for these drawbacks, e.g., the cost benefits including, scalability and flexibility. Cloud computing resources can be "right-sized" to meet real-time requirements. When high capacity is needed at peak times the cloud can provide additional resources on-demand, these can be instantly adjusted when less capacity is needed. The functional benefits of cloud computing consist of increased response times as well as instant software updates that are automatically provided. Other benefits of the cloud include resource benefits, as employees can access information anywhere and can focus on high priority tasks rather than the routine maintenance tasks. These are a selection of the reasons enterprises want to move to the cloud.

Businesses in the cloud computing area are interconnected by what is known as the cloud supply chain [2]. This can be defined as two or more parties linked by the provision of cloud services, related information and funds [2]. These businesses are involved in the end-to-end provision of products and services from the cloud service provider for end cloud customers. Within the cloud supply chain, there are several components and actors. There always exists a product/service at the beginning of the supply chain and a consumer at the end who is requesting the product/service. E.g., on-demand software could be the product/service that is provided by the cloud service provider to the customer (cloud consumer) who wants to use the software.

A well-defined cloud supply chain is needed to encourage the adoption of cloud computing. Not only are products and services passed through the supply chain but also information and funds. It is important to be aware of what and who is involved in the cloud supply chain to understand the potential of this new technology chain and how it is used to identify the requirements of moving to the cloud. The cloud supply chain clarifies the process involved with both providing and consuming cloud services. Supply chains generally serve two functions, a physical function which, is the production of the product and transportation of all components to the right place and a market mediation function which, ensures the product meets market needs. A supply chain must be classified according to its components and the end-product it supplies.

For a business to successfully utilise the cloud, it needs to migrate some or all of its IT services to the cloud, and then manage the new environment. The research undertaken has shown that by using a cloud lifecycle [3] both the migration and the on-going management of the cloud can be planned and controlled to ensure success. The lifecycle provides a mechanism of breaking down all of the activities required for a move to the cloud, into discreet manageable steps which, allows an organisation to seamlessly migrate its services, whilst minimising the risk to the business.

The following sections of the paper are structured as follows: In Section 1, cloud computing is discussed on a company level from a supply chain approach, and the different cloud types and service models are considered as well as an analysis of the cloud supply chain by identifying the actors within the

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chain. In Section 2, the structural setup of the supply chain is also considered based on the identified needs. Section 3 looks at the requirements from a lifecycle approach for cloud migration and on-going management. Section 4 includes the conclusions and future work.

I. Introducing Cloud Computing on a Company Level - A Supply Chain Approach

There are various models and ways in which, cloud computing can benefit a company. It is important to understand, that there are multiple cloud types and service models that can be adopted and these need to be considered as requirements. Each company's individual setup will determine the model and the benefits of these services. Based on the identified type of cloud to use and the services needed, a supply chain setup needs to be established and relevant partners and distribution channels need to be chosen.

A. Service Models and Cloud Types

In order to understand the concept of the cloud supply chain, it is important to be aware of what it is composed of. There are different service models that need to be considered in the cloud such as:

- Infrastructure as a Service- this focuses on providing the resources for the service such as, network, memory and storage capacity which, is essentially the primary stage of the process.
- Platform as a Service - this is the second stage that presents the user with an additional abstraction level for software to run on or for the user to build on [4].
- Software as a Service - this provides complete turnkey software applications that may be of interest to the users and allows these to be fully-utilised using the cloud.

Each of these service models can be used more than once in the cloud supply chain. As these not only provide single services, they can also be combined to provide value-adding services that act as single objects in the cloud supply chain. These aggregated services can be made up of two or more services, e.g., Infrastructure and Platform can be combined as a service for software developers.

The different types of clouds that can be used to consume cloud services are public, private, hybrid and community clouds, and the decision to use a particular cloud can depend on the individual business needs and requirements. However, the current position of the company also needs to be considered. Firstly, the choice of the appropriate cloud to use depends on the prerequisites within a company; if they have an existing data center, they may be more likely to choose a private cloud structure as their current data center can be reconstructed. On the other hand, a company with no data center what so ever may go for public cloud with zero upfront spending. In practice, consumers use different cloud instances to fulfill different requirements, e.g., they may use a private cloud for data storage and a public cloud for everyday processes such as e-mail. This leads to using a hybrid model which, allows the consumer to source from multiple clouds, therefore resulting in better value and a customised service.

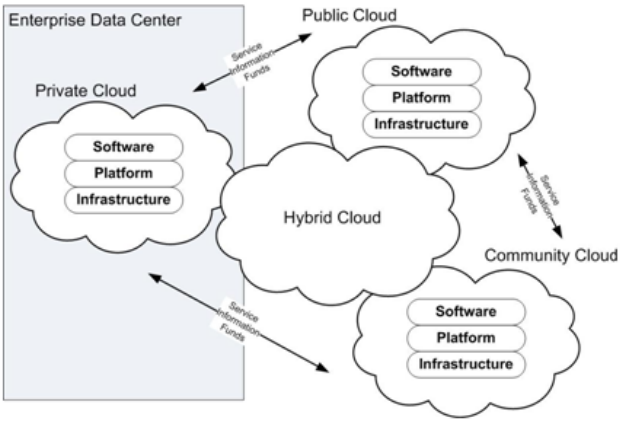

Figure 1. Composite Service Cloud

Hybrid landscapes can be defined as an IT environment that uses both public and private clouds. This type of cloud allows users to take advantage of the scalability and reduction in Capital Expenditure (CAPEX) yet still have the security of a private cloud. Effective and efficient management of hybrid landscapes will allow for users to receive better benefits and an optimal service from the hybrid cloud. It is important to consider the cloud types when determining the requirements for migrating to the cloud.

Figure 1 illustrates the transfer of the service, information and funds through the supply chain of each cloud and shows how a hybrid cloud is made up of a combination of two or more of these clouds. Looking at the area of cloud computing from different perspectives raises the issue of conflicting aims between the provider and consumer of the cloud services. We will look at who is involved in each of these models and the relationship between these.

B. The Cloud Supply Chain

Once a decision on a specific cloud type and service setup has been made, the comprehensive supply chain can be determined and built up. For this, relevant partners have to be identified and a clear product structure has to be established. The cloud supply chain is illustrated in Figure 2 showing the components and actors within the chain. The product is passed along the supply chain to the end-customer. The service provider can provide the end-customer with just one service (software, platform or infrastructure) or they can act as a service aggregator and combine these services to provide a composite service for the customer.

Accounting, billing and monitoring should also be considered throughout the cloud supply chain when understanding requirements, as information and funds are passed through the chain. As a continuous example of a public cloud provider, we will use Amazon who provide an IT company with storage using Amazon Simple Storage Service (Amazon S3). Various

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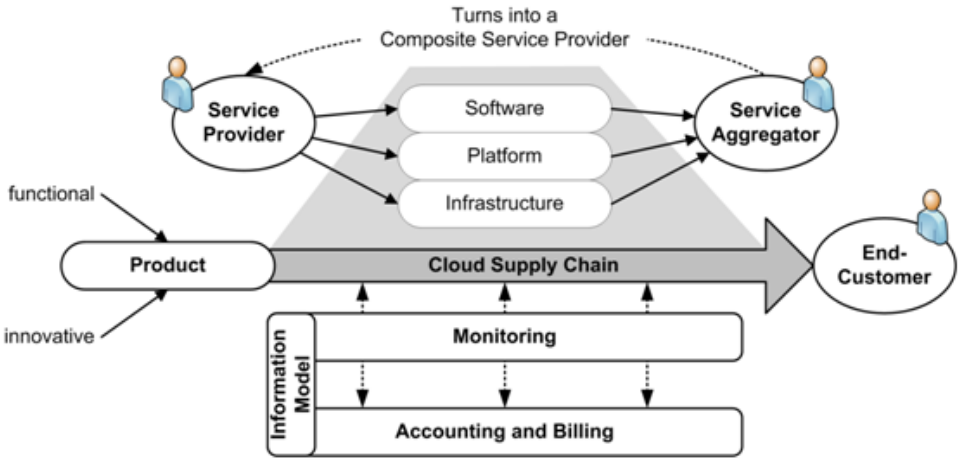

Figure 2. Cloud Supply Chain

actors and goods have to be considered to determine and define a supply chain. The cloud service provider is an actor who provides the service to the end-customer and they can take various roles depending on whether they provide infrastructure, platform or software as a service. In this case the service provider is Amazon who is providing the IT company with storage for their data. Amazon can have direct contact with the customer or they can act as a broker who uses the service and combines it with other services in order to enrich it. This depends on the needs of the IT company, so if they know specifically the service they require, they can directly communicate with Amazon for that service. If they are unsure and only have an idea of what they need, they could use a cloud broker, who will find the best suited package from a selection of service providers for the consumer. However, sometimes if a broker is involved, the service provider is in contact with the broker who then deals with the end-customer.

A broker combines and enriches the services provided by Amazon with and by others to provide a composite service for consumers (the IT company). Therefore, the product for the end-customer is an enhanced service provided in a flexible manner. The broker communicates with the service provider and the end-customer, therefore the IT company receives the cloud service through the broker. It is important to maintain visibility and transparency of all processes and data within a supply network to ensure the end-product remains clear and defined. The end-customers usually consume a product that is a single or composite service which, is provided by a service provider over the cloud supply chain [2]. It is important to examine the cloud supply chain and to be aware of the requirements in order to decide whether a broker is preferred to receive a cloud service. With many actors involved, it is important to maintain clarity and visibility within the supply chain especially when it can become quite complex.

As well as the actors in the supply chain, the components and structural setup needs to be considered when determining the requirements of a cloud project.

II. Structural Setup of the Supply Chain Based on Identified Needs

The setup of the supply chain depends on the needs and requirements of the organisation. This section discusses the components of the supply chain and considers the possible complexities involved.

A. Components Within the Supply Chain

Components within the supply chain that lead to costs include the management and restructuring of services, information and funds. The typical payment model for cloud is pay-per-use, however providers such as Salesforce and Microsoft use a subscription based model for payment of their services. The pay-per-use model is one of the key benefits that outweigh the traditional method of fixed-rate exploitation. These funds flow from the service provider to the cloud infrastructure provider who provides the IT infrastructure. However it can be considered that this can flow the opposite way in some circumstances if there has been a violation in the Service Level Agreement (SLA), which, would result in a compensation penalty from the supplier.

B. Implications of a Complex Supply Chain

In order for users to receive the best possible service to fulfill their requirements, it is important to consider that more than one type of cloud can be used in the supply chain. Using a number of various components such as services or types of clouds can cause the supply chain to be complex and this needs to be considered. Depending on user requirements or company requirements, one cloud may not be able to offer the complete service they have requested. For example, a user/company could request a service in a public cloud but require some of the data to be in a local cloud, i.e., within a certain region. Therefore the cloud could outsource this portion of the service temporarily to a cloud within their desired region in order to

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be able to offer the consumer the full package. In-sourcing of previously outsourced solutions to the cloud can also be considered, so the data in the local cloud could be moved back to the original when required. The different types of clouds can work as a synergy to provide the best service for the consumer.

From a consumer perspective, the consumers are receiving the optimal service to meet their needs as a result of the hybrid model as well as a more efficient supply chain. By choosing to outsource non-core service capabilities to the public cloud, it will allow them to develop a dynamic service supply chain [5]. Most consumers would not choose to outsource their core service capabilities as they are more secure within their private cloud.

On the other hand, from a provider perspective running e.g., a private cloud within a business, at seasonal or event-based peak of traffic, they can move their data or applications to an external cloud to cope with the surge of work. When the work calms down to the normal pace, they can in-source their data or applications back into their private cloud. This eliminates the need to purchase additional hardware and software for those peak times only, saving costs in the short-term and long-term.

This process of leasing compute capacity from an external cloud in peak times is called cloud bursting. It is useful if additional compute capacity is required in a short period of time, as this can be leased from a cloud service provider for the required time. The resources acquired from the cloud service provider are, secured, provisioned, and made available to load balancers so they then have the ability to manage the additional requests. This can happen on an approved, scheduled, or as-needed basis [6]. From an internal IT provider perspective, with a setup of an internal cloud, cloud sourcing and cloud bursting offer numerous cost and value benefits to their business. From an end-consumer perspective, all of the advantages of using cloud are relevant, as well as the additional benefit of receiving the best possible solution to meet their needs through the use of the hybrid model as long as all of the initial requirements are fulfilled.

By analysing the cloud supply chain, the technical requirements for migrating to the cloud can be identified. As discussed, the type of clouds need to be considered and whether more than one cloud will be used, as well as the number of services required, what pricing model suits best and whether to use a broker or directly contact a cloud service provider.

III. The Cloud Lifecycle

Management of this process can be carried out by using the cloud lifecycle. This represents the process of moving from a traditional to a cloud infrastructure. This section describes each of the steps in the lifecycle and how the supply chain plays an active role in this process.

The lifecycle has four phases and eight steps that have been proposed to follow in order to manage the process of migrating to the cloud. It is an improvement cycle, therefore allowing the process to be evaluated and improved continually. Each step is explained in the following section.

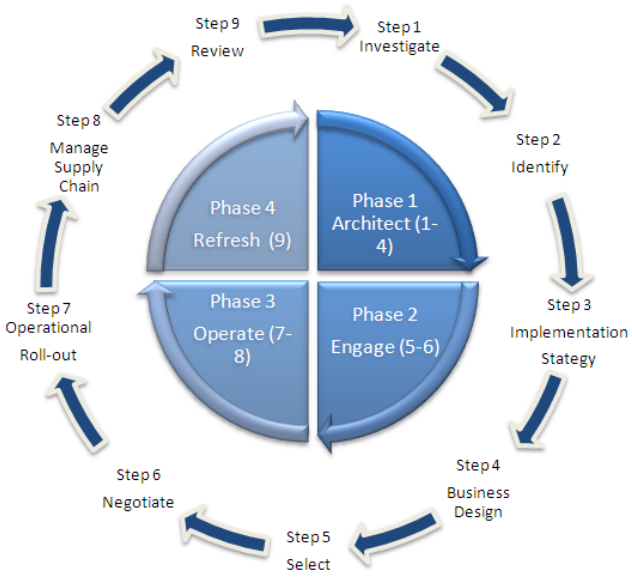

Figure 3. Cloud Lifecycle

A. Steps of the Lifecycle

Phase 1: Architecture

1) Investigate

This step provides an insight and understanding of what the organisation wants to achieve by moving to the cloud and what goals and expectations are to be met. This will be based on an analysis of the appropriate industrial segment, with insights from experts and experiences from peer organisations, together with knowledge of potential suppliers.

Outputs:

- IT strategy for cloud computing
- Strategic intent of moving to the cloud and how it progresses the business objectives
- Intelligence document on service offerings and providers
- A document describing what will be achieved by comparing the strategic requirements with the available services and providers

2) Identify

The purpose of this step is to objectively assess what areas of the business are appropriate to outsource to the cloud and what impact this will have on the current delivery model. This will require an understanding of the current state, so that it can be compared to the desired future state. At least, the impact on the service, people, cost, infrastructure, stakeholders and how it will

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be managed should be considered.

Outputs:
- List of services to be outsourced to the cloud
- Outsourcing delivery model
- The current and future states of the IT structure

3) Implementation Strategy
The aim of this step is to define at a strategic level how the services that are to be outsourced will be rolled out. This will document how key decisions will be made later on, by defining strategies on staffing, communication, program roll-out and risk assessment.

Outputs:
- Program Roll-out strategy
- Communication strategy
- Strategy to manage staff impacted by the migration to cloud

4) Business Design
This step involves designing what is to be outsourced to the cloud and what the future state will look like. It will detail the new service, how it will be managed, how it interfaces to the existing/remaining systems, and how it will be monitored and reported. It exists to provide requirements with sufficient detail to have a meaningful conversation with suppliers so that they can be objectively compared, based on cost and quality of service.

Outputs:
External
- Contact template
- Service Level Agreement (SLA)
- Pricing model

Internal
- The future Enterprise Architecture with support and technical interfaces
- How the contract negotiations will be managed
- How the supplier will be managed

Phase 2: Engagement

5) Selection
Based on the requirements and the other criteria defined by the Architect phase, this step will select the best supplier based on value, sustainability and quality.

Outputs:
- Tender process
- Evaluation criteria
- Short-list of suitable suppliers with caveats
- Due diligence report

6) Negotiation and Sign-off
The purpose of this step is to pick the preferred supplier(s), complete the final negotiation, get internal approval and then sign the contract.

Outputs:
- Negotiation strategy
- Results of the negotiation
- Signed final documents: Contract, SLA and Pricing document

Phase 3: Operate

7) Operational Roll-out
This step involves putting together a transition project team that will manage the transition of the agreed services to the new cloud environment. This will require the transition of the service itself, the management of staff impacted, communication to all stakeholders, knowledge retention / transition and acceptance sign-off.

Outputs:
- Roll-out plan
- Progress updates
- Signed acceptance document

8) Management of the Supply Chain
The aim of this step is to manage the new environment as efficiently and effectively as possible. The organisation will need to adapt to the new setup particularly at management level, rather than directly managing internal resources. The requirement will be to manage the supplier and in particular the supplier relationship. This will require effective monitoring and control so that issues, variations and disputes can be resolved to both parties satisfaction.

Outputs:
- Day to day performance metrics
- Status on issues, problems, variations and disputes
- Supplier meeting minutes
- Change management report
- Audit reports

Phase 4: Regenerate

9) Review
This step is important to review the service based on requirements of the service itself, other changes within the business, changes within the supplier organisation or the need to change supplier.

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Outputs:

- Intelligence report for next generation options
- Supplier audit results
- Business case for any proposed changes

B. Influence of the Supply Chain

The lifecycle is intended to provide an organisation with a management structure to assess the following:

1) The readiness/maturity of an organisation to move to the cloud.
2) Once they are migrated, assess how the organisation is managing the new environment on a day-to-day basis.
3) Assess what new services can be moved to a cloud environment.

The lifecycle interfaces with the supply chain in a number of ways as follows:

- In the Architect phase when deciding what services to move to the cloud and what suppliers can provide, this will set the scene on what is technically viable to move to the cloud.
- The Engage phase will determine what supplier will be used and if they can deliver the requested services to the required levels of reliability and quality.
- The Operate phase is the most critical as the chosen service(s) will be migrated and then become the responsibility of the chosen supplier. If the lifecycle is used correctly this phase should run smoothly, otherwise either the migration will fail or once migrated the service will not be at the required levels to support the business.
- The final Regenerate phase will assess the current supplier and cater for the migration of new services.

In summary the lifecycle and the supply chain are intrinsically linked and for the lifecycle to be successful there is a dependency on a fully functioning, flexible and robust supply chain.

IV. Conclusion and Future Work

In conclusion, the paper analyzed the requirements that need to be considered for migrating from a traditional IT environment to the cloud from a supply chain approach. The paper looked at the area of cloud computing in relation to organisations and the various benefits and problems associated with this. The supply chain was explained as well as the different types of cloud and different service models within cloud computing. The cloud supply chain was illustrated through the diagram as well as an explanation of the various actors and components within it and how these interact. The paper focused on the structural setup of the supply chain and how it is composed and considered the possible complexity of the supply chain taking into consideration the number of clouds and services used at once within it. This introduced the area of cloud bursting and showed the benefits from both a consumer and provider perspective of this process. The management of the migration process is described through the use of a cloud lifecycle. Each of the steps within the lifecycle were identified and the steps that were influenced by the cloud supply chain were discussed. Overall, by using the cloud supply chain, the technical requirements for a move to cloud can be identified and the cloud lifecycle can be used to manage the migration and the ongoing improvement of the cloud environment.

Future work includes the assessment of the cloud lifecycle process to measure how effective it is in helping organisations move to the cloud. This would allow for further improvements to the cycle and possibly lead to a more efficient migration process. In relation to the supply chain, cloud supply chain management and controlling would be a future topic of interest. This would consist of the management from the cloud service provider to the end-cloud consumer including all of the components across the supply chain such as, cloud services, information and funds.

V. Acknowledgements

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