D1.3.1

Cloud-Computing: Business Requirements Analysis

Project number:	257243
Project acronym:	TClouds
Project title:	Trustworthy Clouds - Privacy and Resilience for Internet-scale Critical Infrastructure
Start date of the project:	1st October, 2010
Duration:	36 months
Programme:	FP7 IP

Deliverable type:	Report
Deliverable reference number:	ICT-257243 / D1.3.1 / 1.0
Activity and Work package contributing to the deliverable:	Activity 1 / WP1.3
Due date:	September 2011 – M12
Actual submission date:	3rd October, 2011

Responsible organisation:	UMM
Editor:	Rüdiger Glott
Dissemination level:	Public
Revision:	1.0

Abstract:	This document provides cloud computing requirements from the business perspective. Based on a cloud computing business ecosystem approach, commercial factors influencing cloud computing or being subject to the impact of cloud computing are identified. The impact of cloud computing, its opportunities and challenges are then discussed with regard to business models.
Keywords:	Cloud Computing, Business Model, Cost Model, Business Strategy, Privacy, Security

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This work was partially supported by the European Commission through the FP7-ICT program under project TClouds, number 257243.

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Executive Summary

Cloud computing is considered to be a fundamental breakthrough in the provision of IT infrastructure and services. Due to significant cost savings, increased scalability, improved agility and efficiency that are attributed to cloud computing, the majority of companies experiments with cloud computing or plans to introduce it.

Interestingly, the widespread dissemination of cloud computing takes place although there are remarkable unsolved security and privacy issues that bear the potential to jeopardize business or even a whole company.

This document provides cloud computing requirements from the business perspective. To this end, a cloud computing business ecosystem approach is developed. Based on this approach, commercial factors influencing cloud computing or being subject to the impact of cloud computing are identified. The impact of cloud computing, its opportunities and challenges are then discussed with regard to business models, cloud computing costs and ROIs, and skills effects and requirements of cloud computing.

The key argument of this deliverable is that cloud computing is, despite its widespread diffusion, still in a nascent stage, where no one is able to foresee or to overlook what medium- and long-term effects the different variants of cloud computing exercise on business, and what conditions business should meet in order to successfully and securely migrate on the cloud. In fact, there is noticeable evidence that many businesses opt for cloud computing without being prepared or aware of the possible consequences. As a conclusion, an attempt like the TClouds project, which aims at the provision of resilient security and privacy functionalities and infrastructures by means of a cloud of clouds, could be thwarted by wrong decisions at the level of business strategies, business models, cost estimations and human resources management. Hence, a technical viable solution, like TClouds strives for, needs to be flanked by appropriate and suitable business management. This deliverable provides first recommendations for such good management practice, which will be further elaborated in Year 2 of TClouds and finally result in a set of comprehensive business requirements and guidelines for cloud computing.

Contents

List of Figures

List of Tables

Chapter 1

Background and Purpose

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Cloud computing is considered to be a revolution for business, affecting not only IT infrastructures and data processing but also business models, business strategies and business processes. Glott et al. (2011) understand cloud computing as a backbone technology of the future Internet.

It is therefore not surprising that the market for cloud computing showed an amazing dynamics throughout the past four years. At the beginning of this period, Amazon Web Services and its Elastic Compute Cloud (EC2) initiated a trend that initiated evermore companies to offer or use cloud infrastructures, platforms and applications. According to the 2011 Cloud Computing Outlook (Cloud.com 2011), only one fifth of the 521 companies that participated in the survey do not have any cloud computing plans at current.

The reasons for this strong trend towards cloud computing are a combination of factors. On the one hand, cloud computing is based on a number of technologies and features that have been introduced in the past and to which enterprises are – more or less – used to, for instance the idea of utility computing, virtualization, grid computing, and SaaS (Armbrust et al., 2009; Mell & Grance 2009; Schiff 2010, Skilton 2010). On the other hand, the trend towards cloud computing has been and still is driven by economic factors such as reduced costs and space for IT infrastructure, lower management overhead and improved scalability and flexibility of computing capacity (Hickey 2011).

Overall, many companies opt for cloud computing despite viable security and lock-in concerns aligned with it (Hinchcliffe 2009, Stallman 2008). According to market observers

[1] When using the term cloud computing we basically refer to the definition provided by Mell & Grance (2011), i.e. 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. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models. (Mell & Grance 2011: 2)." However, beyond this rather technical and phenomenological definition an analysis of business requirements necessitates also a functional definition of cloud computing. To this end, we also refer to the definition as provided by Jefferey & Neidecker-Lutz (no date: 8). The authors understand clouds primarily as "platforms that allow execution in various forms (...) across multiple resources (and potentially across enterprise boundaries...)." With this functional addition to the NIST definition of cloud computing, a bridge can be built between the cloud phenomenology and cloud computing business ecosystems.

[2] We refer to

[3] See The Guardian, September 28, 2008: Cloud computing is a trap, warns GNU founder Richard Stallman. Available online at: http://www.guardian.co.uk/technology/2008/sep/29/cloud.computing.-richard.stallman

and analysts, cloud computing is now past the hype stage and is about to becoming mainstream in the economy, as many companies run or use already clouds or consider to do so in the near future. For CA technologies, one of the biggest cloud infrastructure vendors, 2011 is considered to be the year in which security concerns that hampered the diffusion of cloud computing in recent years will turn into a cloud enabler (Hickey 2011).

Many experts point out that the growing diffusion of cloud computing does not solely affect the IT infrastructure, platforms and software enterprises use to operate their business. It is expected that cloud computing will dramatically change the way business is done, resulting, for instance, in new and faster business collaboration and alliances and a number of organizational challenges inside the enterprises using the cloud. The underlying assumption of this report is that these cloud-induced changes of business opportunities, strategies, models and processes create a number of security and privacy risks – next to commercial risks – that are not fully captured yet by cloud vendors and users

The purpose of WP1.3 is to provide an account of privacy and security requirements of cloud computing that derive from the effects of cloud computing on the ways business is done. This report is a first step in this direction, as it evaluates privacy and security requirements and concerns of cloud computing from a business perspective. Based on this evaluation, a first set of recommendations addressing these business-related issues shall be given for the design and functionality of the envisaged trustworthy cloud to be built by the TClouds project.

The analysis provided in this report is used as base-line for further empirical analyses that will be carried out in year 2 of the TClouds project.

The report is structured as follows: After basic trends and driving factors of cloud computing have been presented in this introductory section, the next chapter will provide an explanation of the overall approach of this business requirements analysis. This approach is characterized by a business ecosystem and a cloud system perspective.

In the following section we will determine in more detail how cloud computing affects business by enumerating commercial factors that can be impacted by cloud computing.

Thereafter, we will examine how cloud computing is supposed to affect business models, costs and skills requirements.

Based on the results of the previous sections, section 5 identifies and discusses conditions that must be met in order to make the vision of a cloud based economy more realistic and thus to better tap the potential provided by cloud computing. These conditions will be presented in form of a list of recommendations to complement the trustworthy cloud to be built by the TClouds project with organisational guidelines.

[4] See http://www.expresscomputeronline.com/20110117/expressintelligententerprise05.shtml

Chapter 2

Cloud Ecosystems

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According to the definition of cloud computing applied throughout this document (see Footnote 1), we understand cloud computing as a pervasive system of services provided through a (or multiple) platform(s), implying interactions between a multitude of actors across company boundaries. This perspective is necessary because cloud computing, at least in its more advanced forms (i.e. beyond a private cloud) is performed in and supposed to create more or less volatile business ecosystems.

Moore (1996: 26) characterizes business ecosystems as "an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders." In a later extension (or clarification) of this definition, Moore (1998: 168) explains that a business ecosystem is an "extended system of mutually supportive organizations; communities of customers, suppliers, lead producers, and other stakeholders, financing, trade associations, standard bodies, labour unions, governmental and quasigovernmental institutions, and other interested parties. These communities come together in a partially intentional, highly self-organizing, and even somewhat accidental manner."

Approaching cloud computing from a business ecosystem angle requires to identify the key actors in a cloud computing business ecosystem in order to become able to classify business requirements from cloud computing. In the following we apply largely the classification of Jefferey & Neidecker-Lutz (no date: 11-12) although they do not use the term 'business ecosystem' explicitly – they use the term 'cloud environment', which we like to equal with 'business ecosystem'. According to these authors, following roles can be distinguished in a cloud business ecosystem:

- *Cloud Providers* offer clouds to the customer, in form of PaaS or IaaS
- *Cloud Resellers or Aggregators* combine cloud platforms from cloud providers in order to provide a larger resource infrastructure or enhanced features to their clients.
- *Cloud Adopters or (Software / Services) Vendors* enhance their own services and capabilities by exploiting cloud platforms from cloud providers or cloud resellers.
- *Cloud Consumers or Users* make direct use of the cloud capabilities, e.g. in order to execute complex computations or to host a flexible data set.
- *Cloud Tool Providers* offer supporting tools such as programming environments, virtual machine management etc.

Cloud aggregators appear interesting especially with regard to community clouds and cloud-of-clouds architectures[5] because they are able to provide a single interface to a "merged cloud infrastructure" (Jefferey & Neidecker-Lutz). The authors see as their advantage that they match the economic benefits of global cloud infrastructures on the one hand and are able to customize their offerings to their customers' needs.

Cloud adopters can offer services to their clients that scale to dynamic demands, which appears particularly interesting to start-ups that cannot assess the demand of their services. These start-ups benefit from being able to scale cost along with their actual revenue. According to Jefferey & Neidecker-Lutz, these cloud enhanced services become SaaS.

Jefferey & Neidecker-Lutz describe cloud users as typically larger enterprises that outsource their in-house infrastructure to reduce cost and efforts. For the future, the authors see the capacities of this type of actor change, as "future market developments will most likely enable the user to become provider and consumer at the same time, thus following the "Prosumer" concept."

It must be noted that these roles are not mutually exclusive. Moreover, these relations and interactions of a cloud business ecosystem are embedded in a broader environment, which Jefferey & Neidecker-Lutz (no date: 8) call the "cloud system" (see Figure 1). The authors point out that their description of the cloud system, as illustrated in Figure 1, is not exhaustive, it seems to comprise the key elements, which are

- The type or, in terms of the NIST definition of cloud computing (Mell & Grance 2011), the service models of the cloud: IaaS, PaaS, SaaS
- The modes or, again in the NIST terminology, the deployment models of the cloud: public cloud, private cloud, hybrid cloud or community cloud (with regard to the aims of TClouds a necessary extension of the cloud system might be 'cloud of clouds')
- Reference models to which the cloud must be compared, i.e. SOA, Grid, Internet of services (but maybe also a traditional data center)
- The locality of the cloud / the data: local, remote or distributed, whereby 'remote' might have be to distinguished with regard to different levels of jurisdiction (e.g. national, European, global)
- The benefits that shall be achieved with the cloud, e.g. cost reductions, scalability, ease of use, ease of management, improved innovativeness etc.
- The features of the cloud, i.e. reliability, elasticity, virtualisation etc.
- Finally the stakeholders, which corresponds to the roles of the cloud business ecosystem as described above: providers, aggregators, adopters, users and tool providers

[5] Jefferey & Neidecker-Lutz discuss only community clouds, but their line of argument and terminology (they also use the terms 'merged cloud infrastructure' and 'global cloud infrastructures') seems to be applicable to a cloud of clouds, too. However, it is not clear if 'global cloud infrastructure' is meant as 'public cloud'.

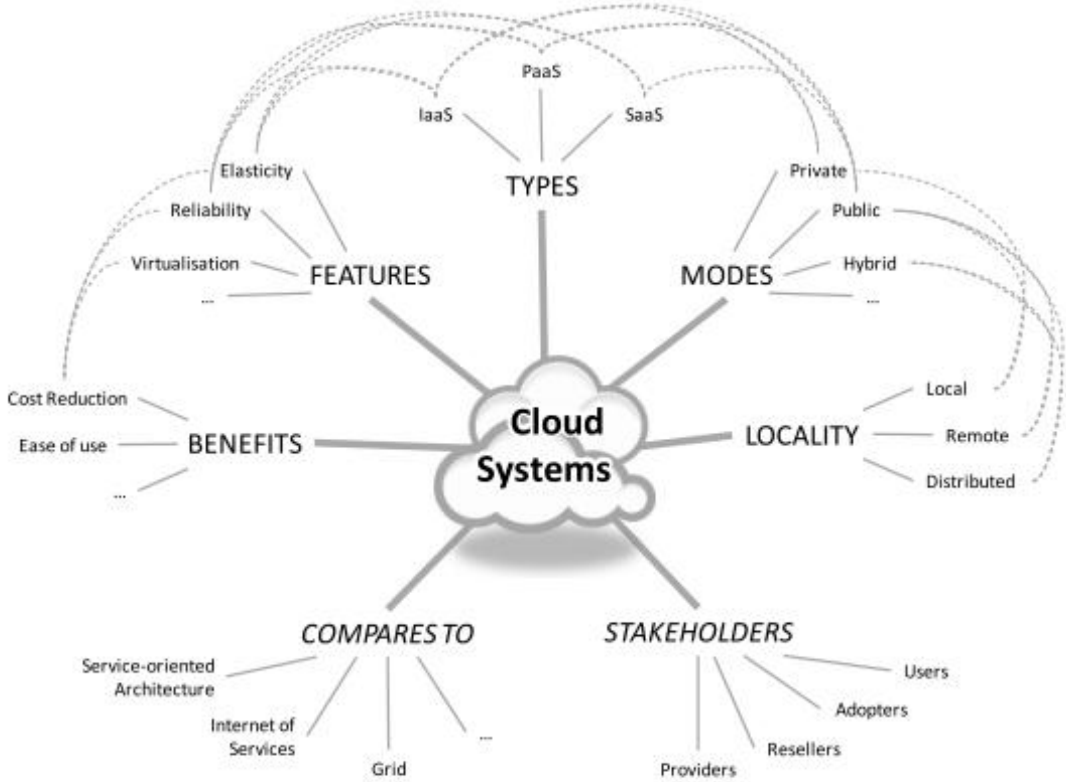

Figure 1: Dimensions of a cloud system – non-exhaustive

Source: Jefferey & Neidecker-Lutz (no date: 8)

Which of these options is chosen depends on the demand and the strategic objectives of the actor, as well as on the dynamics of the cloud system and the necessity and capacity of the actor to readjust their strategies and to reconfigure (within) the cloud system. For instance, business alliances within the cloud system might get terminated and require finding new partners with other capabilities than the previous partner, or regulatory conditions might change and require a revision regarding the locality or the mode of the cloud.

Against this background, the following section examines commercial factors of cloud computing and their impact on business. Thereafter, we provide some deeper insights in some key business activities (business models, costs and ROIs, and skills) in order to dicuss what businesses have to do in order to master the challenges provided by cloud computing.

Chapter 3

Cloud Computing – Commercial Factors and Impact on Business

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3.1 Introduction

Cloud computing is driven by a combination of commercial and operational factors. In the following we will consider these two elements separately.

3.2 Commercial Factors Impacting Cloud Computing

Commercial factors are understood as areas of demands, requirements or concerns that have an impact on the commercial relation between consumers of cloud services and providers of cloud services. They may also have an impact on the decision for or against the application of cloud computing in a specific context.

Against the background of the business ecosystem and cloud system approach of this report, this chapter further understands these commercial factors as being open to multiple and different ways how they can be addressed – however, it is assumed that in cloud business relations they will typically have to be considered.

Multiple recent studies have addressed cloud computing and have explicitly or implicitly addressed many of these commercial factors. Most notably these are:

- The RAND Report for the European Commission: “The Cloud: Understanding the Security, Privacy and Trust Challenges”
- The EU Study: “The Future of Cloud Computing – Expert Group Report”
- The ENISA Report: “Cloud Computing – Benefits, Risks and Recommendations for Information Security”
- The European Commission’s consultation document on “Cloud Computing”
- The World Economic Forum Report: “Advancing Cloud Computing: What to do now?”
- The US Federal Cloud Computing Strategy
- The NIST Cloud Computing Recommendations and Specifications

The factors in this sub-chapter have been matched against these studies and partially were informed by them.

The factors have been divided into the following 4 larger categories:

1. **Cloud Business Case Factors**

   This addresses the *why* of cloud computing from a commercial user perspective. This category includes typical factors that together build the business case for using cloud computing such as cost variabilization or lowering upfront investments.

2. **Cloud Operational Factors**

   This addresses the *how* of cloud computing from a commercial user perspective. This category includes typical factors that relate to concerns and requirements towards the operation of cloud computing such as performance, availability or reliability.

3. **Security and Privacy Factors**

   This addresses *the security and privacy concerns* on cloud computing from a commercial user perspective such as issues on data protection, isolation breach or insider fraud.

4. **Legal and Compliance Factors**

   This addresses *legal and compliance* related concerns.

The list and categorization of commercial factors provided in this report should be understood as a first guidance and will further be enriched from the TClouds cases, the focus groups and the scenario workshop.

The cloud market, the services and also the enabling technology is in rapid development. It would therefore be wrong to assign a specific manifestation to each of these factors. E.g. many of the security concerns are implicit to the concept of cloud computing and can only be addressed to a limited – but probably never to a full – extend.

Working towards a consistent set of commercial factors that impact cloud computing will remain an issue of TClouds with improvements and refinement expected throughout the entire project. This initial set of commercial factors can be used to map the requirements from the TClouds cases as well as the proposed TClouds technical innovations.

Whereas the factors are mainly described from a cloud user perspective, they may further be mapped against different cloud infrastructure provider business models and market opportunities. These arise from the fact that different users give different priorities to the factors. And further from the fact that no cloud offering will address all of them to the same extend.

This report also is based on the well accepted NIST categorization of fundamental cloud models (IaaS, PaaS, SaaS) and provisioning models (public, private, hybrid, community). These are not specifically explained. Also, the focus is on infrastructure clouds (IaaS).

3.2.1 Cloud Business Case factors

3.2.1.1 Reduction and variabilization of costs

A typical business case element in the decision to adopt infrastructure cloud computing is the potential to reduce upfront IT infrastructure investment costs as well as further variabilize costs that are typically related to fixed data-centre assets – such as hard- and software, buildings, cooling, energy supply etc.

In addition, the resource concentration in large-scale cloud data centres allows for an efficient operation of ICT and for typically lower operational costs per provided capacity (such as storage or computation) compared to smaller-sized data centres. An important driver for efficiency is increased standardisation as compared to traditional data centers. In particular this allows better utilization of hardware to a corresponding more effective management of energy as well as to further advanced possibilities of data centre management that only apply on a larger scale. Also the personnel intensity for administration is typically lower in large-scale data centres. It also allows overbooking of resources and variable pricing depending on the expected load[6].

3.2.1.2 Agility and service orientation

Whereas most of the previously described advantages would also apply to outsourced data-centres or pooling of in-house data-centre capacity in large organizations, a particular characteristic of cloud computing is the agility and the service orientation of how cloud services can be consumed.

This agility is particular relevant to cloud business cases when conditions such as the following are given

- a dynamic environment that is characterized by growth – e.g. in start-up businesses or new ICT based consumer services
- an environment that is characterized by changing temporal demands on ICT – e.g. in seasonal, week-day or day-time dependent businesses
- an environment that has high variability or insecurity of user numbers – such as online community services

In that sense, infrastructure clouds are also a backbone of a new generation of agile ICT services. In particular as infrastructure clouds via their massive resources, their allocation flexibility via virtualization and their largely automated elasticity can provide ICT truly “on demand”. This goes beyond the on-demand models used in traditional ICT outsourcing that typically required a larger degree of manual intervention.

3.2.1.3 Improved time to market

In many of today’s businesses – time to market is essential. The build-up of specific data centre capacity, storage and network infrastructure as well as the set-up of a base software environment is a major work-stream in today’s commercial IT implementation projects. When it comes to launching the likes of a new Internet consumer service, this infrastructure set-up is a project risk factor of its own and may result in a critical path.

Infrastructure clouds provide an environment in which the allocation of virtual resources is fast and flexible.

It is a typical claim of cloud business cases that this can provide cloud users with a critical time advantage in building-up their IT infrastructure.

3.2.1.4 Reduced investment risks

A corresponding factor is that of reduced investment risks. Here is a typical difference to traditional outsourcing. Whereas IT outsourcing contracts tend to be complex and long-term oriented, including extensive formulations of SLA agreements and individual contract

[6] E.g., Amazons EC2 introduced spot pricing where excess computing is auctioned off to the highest bidder: http://aws.amazon.com/ec2/spot-instances/

agreements – infrastructure cloud capacity can be used already as a commodity service. This allows piloting of even complex and resource-intensive deployments at relatively low risks of investments.

When there is however the demand to individualize cloud computing services – e.g. to cater the compliance needs of a specific business via a private cloud – much of this advantage will fade away.

3.2.1.5 Improved Operational efficiency

Operating ICT infrastructure on a smaller scale and in particular if operating ICT is not a core competence of a company may be less efficient compared to the way how a professional cloud provider runs its ICT infrastructure. This can also relate to reducing operational risks such as downtime or data loss.

Typical data-centre operation tasks such as patch- and update-management – e.g at the operating system level - are taken-over by the cloud provider. Which means that the IT administrators of the cloud customer can further concentrate on the application level.

3.2.2 Cloud Operational Factors

3.2.2.1 Performance

Performance in cloud computing is related to multiple aspects such as the capacities of the access networks which itself may depend e.g. on the geographical location or the accessing devices. Network latency may e.g. be a significant hurdle.

Performance is also depended on the architecture of the application that is hosted in the cloud. In particular it depends on the intensity of the backend data transfer between the front end and the cloud. A related consideration is therefore that application architectures may need to be fundamentally re-designed to deliver optimal performance when hosted in a cloud.

A final limitation factor for several operational factors is the delivery over a network (usually the Internet) since the performance, availability, and reliability of the network limits the service level guarantees that can be provided by the individual cloud services.

3.2.2.2 Availability

Availability in cloud computing is mostly achieved through redundancy – e.g. via replication or mirroring of data and computation. Due to the flexible allocation of resources in clouds, the vast capacities and the replication possibilities across multiple physical locations, availability may be higher compared to traditional data centres.

On the downside are the potential difficulties to access the cloud – e.g. due to network problems outside of the control of the cloud provider.

3.2.2.3 Reliability

Whereas availability is mostly concerned with the prevention of disruption of the access to cloud resources, reliability is concerned with other – mostly more business severe forms of disruption – such as e.g. loss of data or of execution in progress.

3.2.2.4 Scalability & Elasticity

Scalability refers to the capability of clouds to scale the permanent access to cloud resources according to the demand – e.g. to meet the needs of a growing business.

Elasticity is the flexibility of clouds to adapt the allocation of temporary resources – in either direction - in order to guarantee agreed service levels – e.g. an agreed maximum response time.

Satisfying scalability and elasticity requirements requires excess hardware. A benefit of a large cloud provider is that if demand from different customers varies independently, the overhead for excess hardware can be reduced as compared to each individual customer.

3.2.2.5 Portability & Lock-In

Portability refers to the possibility to transfer an application or data from one cloud to another. This is typically linked to a concern about lock-in into the services of one provider. Commodity services using standard service interfaces may reduce lock-in. Non-standard management and interfaces increase lock-in. A particular concern is the incompatibility of data formats that may prevent customers from changing cloud service providers.

3.2.2.6 Standardization

Closely linked to the issue of portability and lock-in is the question on the use of standards in clouds - typically with a requirement for open standards. Such standards may relate to areas as virtual image formats, cloud management APIs or data formats.

3.2.2.7 Cloud Management Capabilities

The user can have only limited insights and access to the cloud environment. However, infrastructure clouds differ in the management capabilities they offer towards their users and the transparency that is connected to this. This also includes the allowing of monitoring – e.g. of security relevant incidents and parameters – by the user.

3.2.3 Cloud Security and Privacy Factors

3.2.3.1 Loss of governance

The loss of governance is a typical general concern associated with cloud computing. It is linked to the transfer of management for critical data and computation to a cloud provider. It is further linked to the limitation in cloud management capabilities and transparency from the view of the user.

Cloud providers today often follow a one-size-fits-all approach where standard governance is provided and no tailoring to individual customers is done.

3.2.3.2 Isolation failure

Apart from dedicated private clouds, infrastructure clouds typically serve multiple tenants at the same time. Due to the use of virtualization technology – clouds can achieve an efficient use of hardware resources and load balancing. This includes the possibility that one machine hosts multiple virtual machines and potentially data and computation from different tenants.

Isolation failure addresses the general concern about data leakage or intrusion in between different tenant application environment hosted on the same cloud. A great concern are socalled jailbreaks that allow tenants to obtain control over portions of the cloud management fabric by 'jailbreaking' their individual service implementations.

3.2.3.3 Insider Fraud

Whereas isolation failure mainly addresses intrusion on the technical level (e.g. by malware at the virtualization layer), insider fraud addresses the risk that arises from the access of cloud administrators.

Cloud administrators need on the one hand the necessary access rights to fulfil their duties, but they need also be prevented from accessing critical data or introducing harmful software to the applications hosted in the cloud. This may be intentional or unintentional – e.g. via malware carried on a memory stick.

3.2.3.4 Management Interface Compromise

The management interfaces that allow for automated external management of capabilities of the cloud like starting or migrating a virtual machine are generally accessible via the Internet. This also offers additional intrusion possibilities.

3.2.3.5 Insecure or Incomplete Data Deletion

Data deletion is necessary pre-requisite to keep confidentiality and data security requirements. However it is not always done complete and in way that would not allow experts to restore data. While secure disposal of storage is one concern, another important concern is reliable cleansing of storage resources (memory, disk, ...) once they are released by one tenant.

3.2.3.6 Confidentiality

Confidentiality relates to the accessibility of information. This needs to be restricted to authorized persons. In clouds this is typically related also to the risk of insider fraud.

3.2.3.7 Data protection

Protecting data can go beyond the limitation of access and in sensitive cases e.g. be achieved via data encryption in the cloud. However, such solutions may include new related risk areas such as the management of keys. Also, the data encryption in the cloud has a number of disadvantages as to performance and limitation of computations on the data.

3.2.3.8 Resilience

Resilience is a wider security concern that addresses the capability of the cloud to counter unforeseen threats and maintain availability even in critical security situations. Cloud resilience is on the one hand related to the redundancy and replication mechanisms as described under "availability". On the other hand it may introduce new mechanisms like integrity check of results received from replicated computation in different cloud locations.

3.2.4 Cloud Legal and Compliance Factors

3.2.4.1 Compliance

Compliance includes all aspects of confirming to regulations. This duty applies to the cloud user and owner of the data and applications hosted in the cloud. Cloud computing creates particular new questions in this context such as compliance in the context of cross-border cloud computing.

3.2.4.2 Liability

Liability is one aspect of the Terms of Use and addresses the question of liability relations in a cloud business. This may e.g. relate to the consequences of data loss or data leakage.

3.2.4.3 Accountability

Accountability is often linked to the notion of trust. It is also closely related to the concept of transparency. In general, accountability is linked to more formalized ways of assessing the practices of the cloud provider from an organizational down to a technical level. There is also a related research debate about trusted computing and strong accountability that implies a close interplay between machine-readable policies, monitoring and enforcement mechanisms.

3.2.4.4 Transparency

Transparency is related to the question of how transparent the provisioning of cloud services is organized and what monitoring and auditing is allowed to be initiated and performed by the cloud user.

Chapter 4

The Impact of Cloud Computing on Business Models, Investments, ROIs and Skills

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4.1 Business Opportunities and Challenges of Cloud Computing – An Overview

The expected impact of cloud computing on businesses is tremendous, but there is also considerable concern about the privacy and security issues of cloud computing and some scepticism with regard to the economic benefits often attributed to cloud computing. Overall, a positive view on cloud computing prevails at the moment, but it seems that the picture might change if the most important cloud computing challenges, namely privacy and security concerns, cannot be mastered, or if it turns out that the benefits do not at all overweigh the risks.

If the potential of cloud computing gets fully tapped, so Babcock (2010: 24), “those who understand that they have the capabilities of the cloud at their disposal and figure out how to put them to use will be revolutionaries for a new day, founders of an all-encompassing, all embracing digital culture.” Similar visions are described by Buyya et al. (2008).

Indeed, cloud computing appears as the breakthrough to ubiquitous utility computing (ISACA 2009, Armbrust et al. 2010). To Babcock (2010), the revolutionary power of cloud computing derives mainly from its capacity to allow users self-provisioning with IT infrastructures and services and users’ “programmatic control” (Babcock 2010: 18) over infrastructure and processes operated in the cloud. In this sense, the most striking feature that distinguishes cloud computing from past IT strategies is considered to be user empowerment.

Glott et al. (2011) point out that the current cloud market is mainly characterized by isolated providers, whereas cloud computing in the Future Internet is expected to be characterized by a seamless cloud capacity federation of independent providers. The difference for the end user would be remarkable, as via interacting with one cloud provider she can seamlessly access resources and services provided by multiple similar providers.

Other authors, e.g. Hinchcliffe (2009) and Zhang et al. (2010), emphasize the scaling opportunities, significant space and cost decreases for IT infrastructure and operating cost, software and services, and improved agility with regard to vendors as the main benefits provided to businesses by cloud computing.

In fact, a look at the factors that motivate companies to use cloud computing illustrates that primarily scalability and cost reductions drive the trend, accompanied by ease of management (see Figure 2).

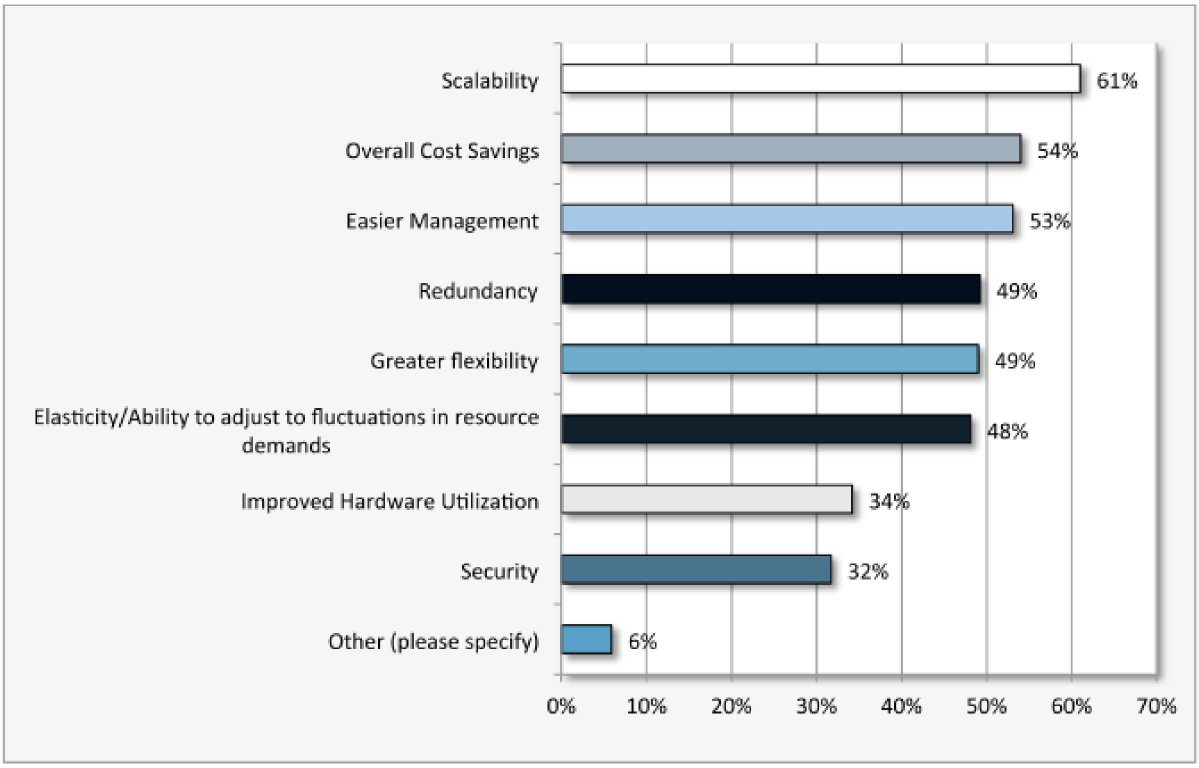

Figure 2: Factors motivating companies to use cloud computing

Source: Cloud.com, 2011 Cloud Computing Outlook

Regarding scalability, flexibility and cost savings, the BITCURRENT cloud computing survey 2011 (BITCURRENT 2011) showed similar results, while this survey did not specifically ask for the role of eased management that a cloud might help to achieve.

Interestingly, the North Bridge Cloud Computing Survey 2011 (North Bridge Venture Partners 2011) asked the survey participants not only about their current motivating factors for cloud computing but also how they assess the influence of these factors in five years (see Figure 3). Evidently, the currently dominating motivators, agility, costs and scalability, are expected to lose importance as drivers of cloud computing, while factors like APIs, mobility, competitiveness and innovation, which play only a secondary role at the moment, are expected to become more important within the next five years.

Although security plays of course a major role in all surveys when the participants are asked for their primary concerns it appears as if cloud computing will not have a significant impact on the development of future security tools – in fact the impact on this sector is estimated to be least in comparison to all other sectors (see Figure 4). Rather, it is expected that cloud computing will heavily affect software development and office software.

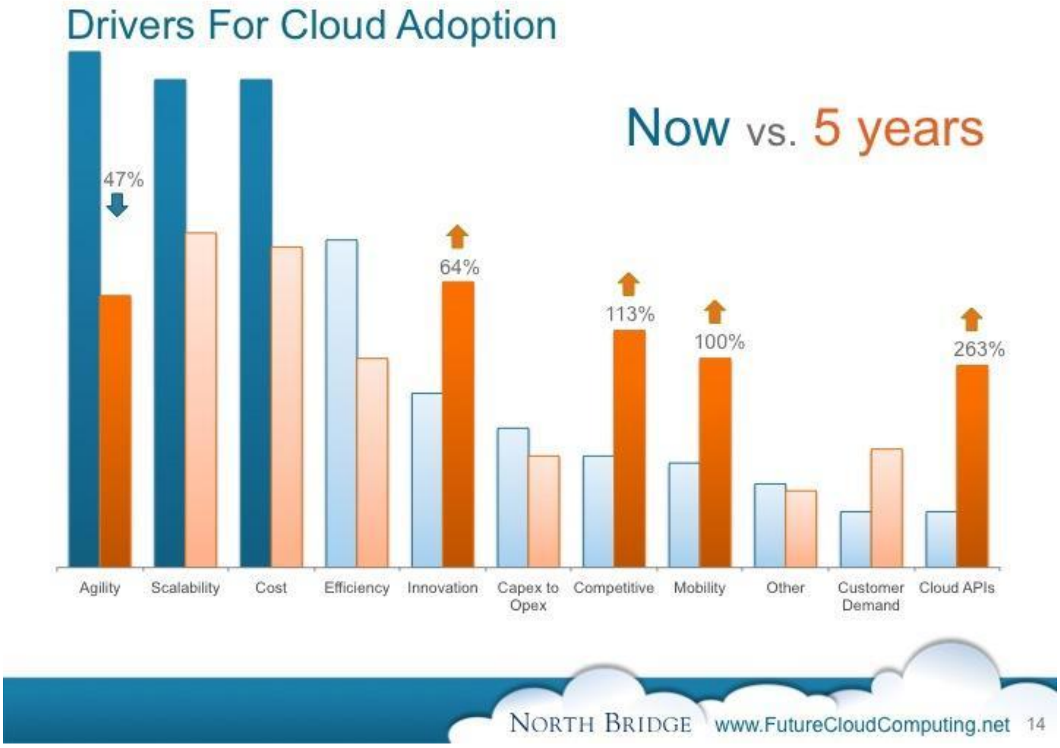

Figure 3: Role of cloud computing motivators 2011 and in 5 years

Source: North Bridge Venture Partners 2011

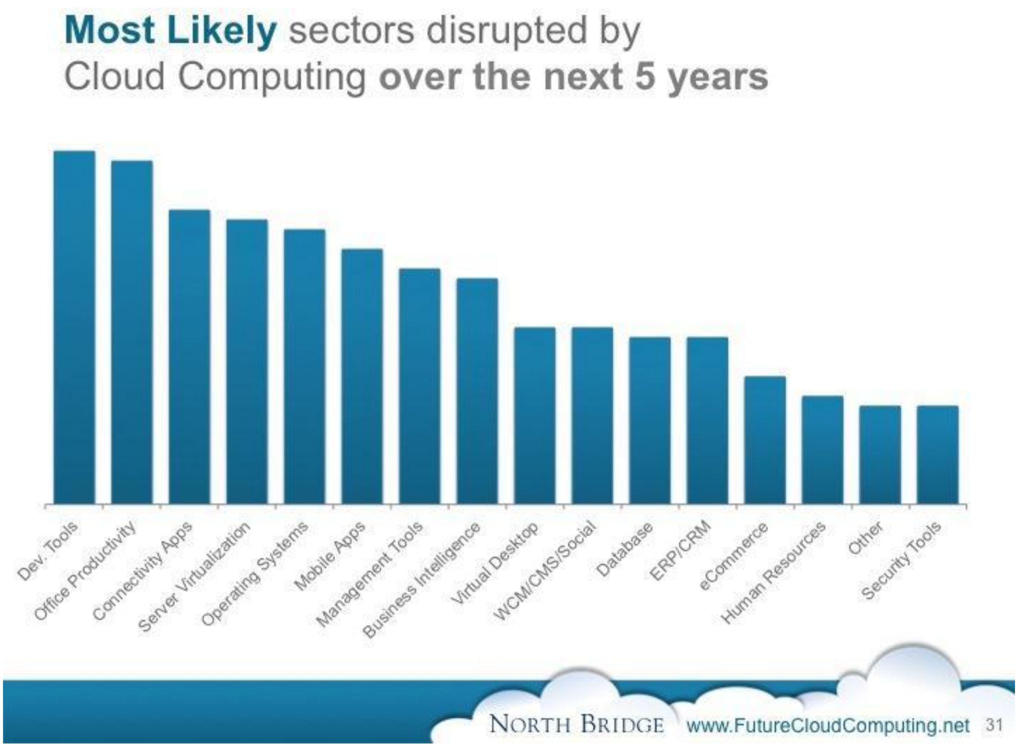

Figure 4: Expected impact of cloud computing on different IT sectors

Source: North Bridge Venture Partners 2011

Hinchcliffe (2009) identifies eight ways in which cloud computing will change business, which partly overlap and therefore can be summarized as follows:

1. The creation of a *new generation of products and services* that either weren't possible before or are significantly less expensive than the competition (or just more profitable.) According to Hinchcliffe, cloud computing provides technological solutions for business ideas that required prohibitive amounts of computing power, scale, or radically new business models (e.g. open supply chains and Global SOA) but could not be implemented due to existing technical limitations or cost-effectiveness. Finally, cloud computing is supposed to provide more tolerance for innovation and experimentation from businesses, as cloud computing enables prototyping and market validation of new approaches much faster and less expensively than before and reduces and lowers technical and economic barriers to creating new ways to improve the business. Hinchcliffe's examples of areas in which such new ways are being explored are line of business (LOB)[7], marketing, sales, customer service, IT, and horizontal services[8].
2. *New forms of business organization and of joint innovation* and service provision in new forms of business collaborations and alliances. Internally, Hinchcliffe expects more self-service IT from the business-side instead of from the IT department. Externally, regarding inter-firm collaborations, Hinchcliffe (2009: 3) expects "a new lightweight form of real-time partnerships and outsourcing with IT suppliers." In contrast to traditional outsourcing of IT, so Hinchcliffe, cloud computing will provide agility and control that traditional outsource cannot match for the most part. This would result in increased vendor independence and flexibility of enterprises. Altogether, enterprises will be enabled to faster rates of changes and have to adapt to new business conditions.
3. A *new awareness and leverage of IT infrastructure and software architectures*, such as Web 2.0 and SOA. Hinchcliffe supposes that when a company adopts cloud computing it will automatically find itself "thrown into the pool with the rest of the online world in many ways, whether this is the employment of social tools, SaaS, non-relational databases or a host of other technologies in their new cloud". Confronted with this challenge, Hinchcliffe assumes, companies will be forced and enabled to acquire the skills and perspectives required to compete effectively in a cloud-based business environment.
4. Cloud will open opportunities for the *rise of new industry leaders and IT vendors*, characterized by "radical openness and transparency, new technologies, and Web-focus (Hinchcliffe 2009: 3)", which often is required by cloud computing. On the other hand, he foresees that slow-moving, traditional large firms ("dinosaurs") will have trouble keeping up more agile adopters and fast-followers. Altogether, given the broad adoption of cloud computing, Hinchcliffe expects a significant change of the industry landscape through cloud computing.

Nevertheless, the available data and studies indicate that despite its success with regard to business diffusion cloud computing is still at a nascent stage. According to Jefferey & Neidecker-Lutz (no date, 1), "cloud technologies and models have not yet reached their full potential and many of the capabilities associated with clouds are not yet developed and

[7] Line of business denominates software applications that are critical for the business processes and the functioning of an enterprise as a whole.

[8] Horizontal services are generic services that are typical for any industry. An example of the provision of horizontal services through the Internet and based on or including cloud computing is provided by Internet Customer Solutions, Inc. See http://intercs.net/ServicesandSolutions.aspx.

researched to a degree that allows their exploitation to the full degree, respectively meeting all requirements under all potential circumstances of usage." The authors point out that many companies are only experimenting with cloud computing and that the long-term effects of provisioning and usage cannot be predicted at current. They see a number of economic issues[9] that contribute to the under-exploitation of cloud computing, namely a lack of knowledge that is necessary to

- decide about when, why, and how to use which cloud system
- assess the impact on the original infrastructure

This observation is important because it sheds a light on the fact that the changes Hinchcliffe (2009) describes will not be induced automatically by the broad implementation of clouds. Rather, cloud vendors and users will have to adapt to these challenges and take measures in order to master them proactively.

In addition, since more applications are being moved to private or public clouds, the IT infrastructure will changed significantly. Software developers will have to adjust the ways they create and deliver applications (Blaisdell 2011). Also, the effort to maintain data decreases, aligned however with the loss of its physical control, as it is stored in the vendor's data center.

Finally, software customization is often a problem because most of the software that companies use is not "cloud-ready" (Blaisdell 2011).

In the following we will analyze what is required from the actors in a cloud computing ecosystem in order to cope with these changes and to benefit from them.

4.2 Cloud Business Models and Strategies

According to Hamilton (2011), it is a one of the most common mistakes to consider cloud computing purely from a technological point of view. She criticizes that many decision-makers tend to ask themselves how they can migrate from their legacy IT infrastructure to a cloud infrastructure instead of asking what business benefits a cloud can deliver to their business. The strategic goals, e.g. IT efficiency, decreasing time to market, or innovativeness, should determine how the company migrates to the cloud, and how this cloud must be shaped.

The same tendency to ignore relevant questions or to simplify them too much can be observed when cloud business models are considered. Many experts (e.g. Zhang et al., 2010) tend to confuse the service models of cloud computing (Iaas, PaaS, SaaS) with business models (see Figure 5).

[9] Jefferey & Neidecker-Lutz also mention a number of legal and ecological aspects, which are ignored in this report because legal issues are addressed in separate deliverables of TClouds and "green IT" shows no obvious relation to privacy and security issues, which provide the focus of this report.

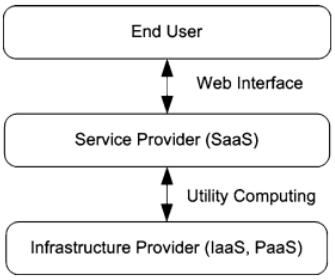

Figure 5: Cloud service models as business models

Source: Zhang et al. 2010, 10

This simplification might be due to the fact that the term business model, though widely used within the academic debate as well as by practitioners, is not at all a clear-cut expression. According to Horsti (2007: 20-21) the term was introduced in the late 1950s but hardly used in publications until the 1990s. The usage of the term increased considerably at the end of the 1990s and reached its peak in 2000, which Horsti explains with the simultaneous growth of the Internet hype. Despite this increase of interest in the topic, Horsti (2007: 21) found that “unified business model theory building” remained scarce. The finding of Amit & Zott (2001) that there is no commonly accepted or dominant theory or definition of business models holds still true.

Indeed, there are various conceptualizations of business models, resulting in a number of partly coinciding and partly contradictory definitions and taxonomies (Osterwalder 2004). For instance, Timmers (1998) defined business models as the "architecture for the product, service and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenues." Other scholars suggested less extensive concepts or / and highlighted different aspects, as, for instance, the "architecture of the revenue, in order to capture value from (a new) technology" (Chesbrough & Rosenbloom 2002),the transaction partners and channels (B2B, B2C, B2G, P2P) (Trombly 2000), or the firm’s position in the value chain and revenue (Schlachter 1995, Rappa 2004).

The problem of all these definitions is that they emphasize different aspects that may be relevant for business models but do not systematically describe how business models are composed and how the different elements of business models are related and interact in order to generate revenue. Osterwalder (2004) and Osterwalder & Pigneur (2010) proposed a comprehensive ontology of business models that provided an overview of all business model components (see Figure 6).

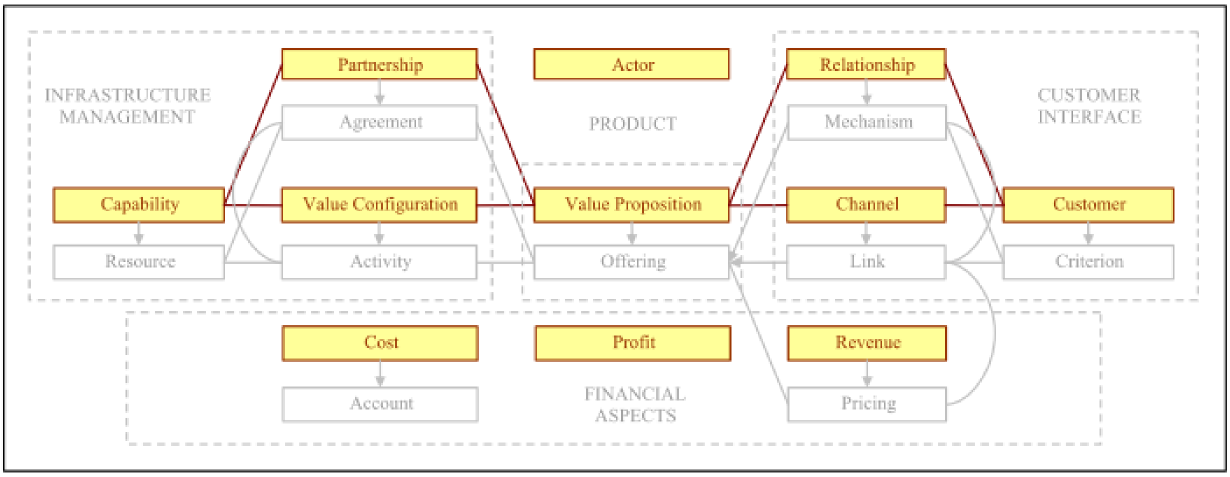

Figure 6: Business model components

Source: Osterwalder 2004: 47

Applied to cloud computing it is obvious that a cloud can play various roles in various locations of Osterwalder's business model ontology. For instance, besides the value propoition, a cloud could also serve as a resource in the infrastructure needed to perform a certain transaction within the business model, or it could be a channel to customers. Hence, it is necessary to adapt business strategy, business model, and cloud computing to each other, based on the strategic goals of the enterprise (see, for instance, Weinhardt et al. 2009, Leimeister et al. 2010). The rationale behind this demand is that business models / strategies and cloud strategies that do not match create inefficiencies and, in the worst case, privacy and security risks. In other words: While a certain cloud solution might be safe in one particular business model, it might feature some shortcomings in another one.

4.3 Cloud Costs and ROIs

Significant cost savings and high ROIs are the key selling argument for clouds. This may affect privacy and security aspects of cloud computing in two ways:

- High cost savings and ROIs might motivate the company to invest the saved money in more and better security and privacy protection
- Cost savings and ROIs might be so high that it leads to 'moral hazard', i.e. to hazard the consequences of security or data breaches because there are enough means to stand a litigation or to pay compensations to customers

Given the fact that a data or security breach does not only lead to monetary damage but also to a reputation of the company, which might translate in lost business, we believe that the latter option is rather unlikely. Nevertheless, it is a theoretical option that might become practically viable if the cloud system (see chapter 1.2) is very opaque or when SLAs make it easy to escape liability.

Another point that plays a role when costs and ROIs are considered with regard to privacy and security issues is that businesses need exact figures of their investments and costs in order to be able to compare them to possible costs resulting from a security or data breach. In the following we provide examples of cost and ROI calculations for cloud computing and discuss them with regard to their accurateness.

Mayo & Perng (2009: 4) distinguish five key areas of cost savings that can be achieved through cloud computing:

- Hardware
- Software
- Automated provisioning
- Productivity improvements
- System administration

According to Mayo & Perng, in each of these five areas cloud computing yields amounts of savings that would surprise most users. Of particular importance are, in this regard, labour savings through automation, which are said to be substantial larger than the increase of costs of software that is needed for virtualization and of costs for the service management a cloud requires (Mayo & Perng 2009: 4).

Based on a study of more than a dozen IBM cloud computing clients, Mayo & Perng analyse the costs and ROIs (including ROI periods) of investments in cloud computing for small (5-15 servers), medium (16-400 servers) and large (more than 400 servers) environments in the banking sector and in manufacturing. The sample also included one outsourcing customer, which represents the small cloud computing environment.

Overall, the authors claim that in each environment there are returns on investment and very short payback times (Mayo & Perng 2009: 5). Key results of their analysis of three of their case studies, representing different size classes and scopes of cloud computing, are illustrated in Table 1.

Regarding hardware cost savings, Mayo & Perng (2009: 7) point out that advantages of cloud computing, in the first place, are achieved through better utilization of servers, which, in a traditional data centre, are supposed to show average utilization rates of only 5% to 25% of their capacity. Other factors of hardware payback are physical server depreciation (fewer servers than before the introduction of the cloud are required) and lower costs for energy and facilities. According to Mayo & Perng (2009:8), the savings in hardware can amount to a range of 30% to 70%. An influencing factor for hardware costs is, beneath the size of the cloud environment and the annual spending, the cloud computing platform. According to Mayo & Perng, the more mature the platform the larger can be the savings.

The key components of software costs are related to virtualization software and to service management software. According to Mayo & Perng (2009: 9), software costs in a cloud environment typically grow because of software license fees, which seem to be offset only partially by the consolidation, which reduces the number of systems. The authors do not consider the potential savings effect of open source software for virtualization and service management, as open source software usually does not demand software license fees.

Regarding provisioning, automation generates substantial savings because a “skilled administrator”, as Mayo & Perng (2009: 10) point out, becomes able to provision more systems without long and error prone manual processes. According to the authors, automated provisioning tools are able to reduce the time to provision each image from 40-70 hours to 30 minutes.

Productivity savings are achieved through automation, too, as the idle time per project decreases from tens of hours to one hour (Mayo & Perng 2009: 12).

	Banking (> 400 servers)	Banking (16-400 servers)	Manufacturing (outsourced, 1-15 servers)
Payback period (months)	4,85	6,82	12,18
Total initial investment for test cloud	$ 1.313.958,33	$ 302.958,33	$ 294.583,33
Estimated ROI over 3 years	469,75%	308,91%	227,33%
Estimated average annual ROI[10]	156,58%	102,97%	75,78%
Savings share of testing productivity	4%	25%	34%
Savings share of provisioning costs	38%	22%	4%
Savings share of hardware	15%	10%	29%
Savings share of software	3%	1%	1%
Savings share of system administration cost	40%	42%	32%

Table 1: Key parameters of cloud computing ROIs

Source: Mayo & Perng 2009

Overall, the cost calculations presented by Mayo & Perng rather raise more questions and concerns than contribute to a clear understanding of how (potential) cloud users can calculate and control costs. First of all, the examples they provide show a huge variety of cost savings but give no hint as to how these differences can be explained.

Secondly, according to Li et al. (2009), there is no accurate tool that helps companies to calculate and analyze cloud computing costs.

Moreover, it appears questionable if all costs related to the migration into a cloud are captured in this approach, as it appears that only substitution (or opportunity) costs for hardware and software and productivity-related measures are included. Given this choice, it is just natural that cloud computing appears as much more cost-effective than traditional IT infrastructures and services. For instance, the costs for evaluating a solution, for negotiating with vendors and with internal staff, and last but not least the cost that must be paid to generate the knowledge needed to implement, handle and monitor a cloud environment appear to be ignored by the calculations of Mayo & Perng.

[10] In fact, this row does not represent the *average* annual ROI but the annual percentage growth rate of the ROI. However, in order to ease comparison to the figures provided in Mayo & Perng's article we have kept their label.

As Klems et al. (2009: 1) point out, the many companies that migrated into the cloud in recent years and the many other companies that intend to do so in future all lack a very important information for their decision-making, which is “a guide to tell when outsourcing into the Cloud is the way to go and in which cases it does not make sense to do so.”

Klems et al. (2009: 2) state that existent approaches towards value measurement of cloud computing tend to mix business objectives with technological requirements, underestimate the changing role of demand behaviour and the consequences it poses on IT requirements, and forget to value the benefits from cloud computing in a comparison with viable alternative solutions. They demand a business scenario approach that allows determining the costs and value of cloud computing along the following criteria:

- business domain (internal processes, B2B, B2C, or other)
- key business objectives (cost efficiency, no SLA violations, short time to market, etc.),
- demand behaviour (seasonal, temporary spikes, etc.)
- technical requirements that follow from business objectives and demand behaviour (scalability, high availability, reliability, ubiquitous access, security, short deployment cycles, etc.).

Figure 7 provides an illustration of such a comparative approach.

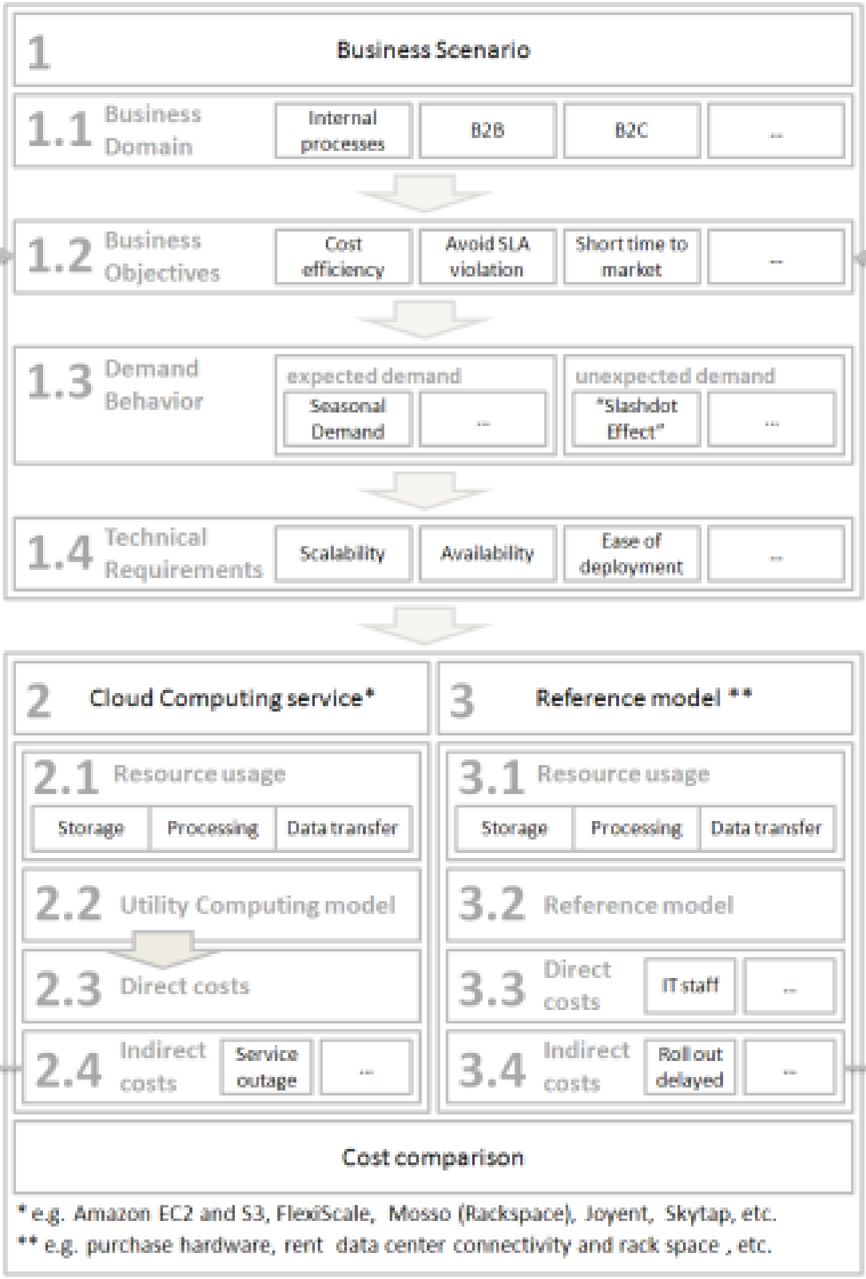

Figure 7: A framework for estimating the value of cloud computing

Source: Klems et al. 2009: 3

It is noteworthy that the approach provided by Klems et al. does not only demand a reference model to which a cloud computing strategy can be compared and evaluated but explicitly included service level agreements and security as criteria that create both, costs and value, and that are usually ignored by publications of cloud vendors. Of course, the list of criteria should be extended by privacy and availability.

The costs Klems at al. allocate to a cloud computing migration seem to go far beyond the scope Mayo & Perng suggested, as Klems et al. (2009: 6) suggest to include direct costs, such as capital expenditures for facility, energy and cooling infrastructure, cables, servers, etc., and operational expenditures like energy costs, network fees and IT employees. Finally, indirect costs from failing to meet business objectives, e.g. time to market, customer satisfaction or quality of service as related to service level agreements must be included in the cost calculation, too.

Klems et al. admit that it is difficult to measure these factors and that there is no "one best way" that can be applied to all cases – rather, such cost calculations have to be adapted to each individual case. Nevertheless, it is obvious that any attempt to integrate and calculate these costs provides cloud users valuable information for their decision-making, whereas the currently prevailing cost calculations that ignore these costs require the cloud user to either hope for the best or make a good guess, which both should not be the basis for decisions about important IT investments. Moreover, the more transparency a cloud provides to a user the better the user can assess the privacy and security risks. Finally, the decision for or against a migration into the cloud should be made dependent on the user's business strategy, processes and models. The most decisive factor for determining "whether or not computing services can be performed locally depends on the underlying business objective. It might for example be necessary to process data in a distributed environment in order to enable online collaboration (Klems et al. 2009: 11)." The same line is taken by ISACA (2009: 4), which recommend the cloud user to carefully check the business objectives and risks aligned with the cloud in order to decide "what types of data should be trusted to the cloud, as well as which services might deliver the greatest benefit."

4.4 Cloud Skills

According to Blaisdell (2011), cloud computing will change IT job requirements significantly because it calls for new skills and specialties. He considers it crucial that before a migration to the cloud starts the IT staff is able to fully understand the advantages of cloud computing and how it can be integrated into the company's current business model. Of particular interest in this regard are issues such as security and maintenance, which Blaisdell recommends to discuss in advance of the migration with the cloud computing vendors. In addition, the IT department should be able to oversee the migration and the ongoing relationship with the cloud provider.

Another impact of cloud computing on the structure and the quality of a company's workforce is that the need for IT support staff is reduced, whereas the demand for training the employees to work with and understand the new systems and applications will increase.

However, in practice, most companies seem neither to be prepared nor to be ready to migrate to the cloud in a controlled and secured way, nor are they able to overlook their decisions and the consequences thereof. According to Forrester Research (Dignan 2010), many companies opt against a public and for a private cloud because they don't trust the security of a cloud outside their own firewall. However, this decision is often made because of distrust to one option without checking carefully if the company has the capacities for the other option.

Actually, according to the 2011 Cloud Computing Outlook (Cloud.com 2011), the lack of training to use and control a cloud is a more important inhibitor for a company to migrate on the cloud than security concerns (see Figure 8). Though the survey does not give any hint to what the reason behind this attitude is, it could be assumed that with the growing share of companies experimenting or otherwise using clouds the awareness grows that cloud computing requires a lot of specific knowledge that usually lacks within enterprises.

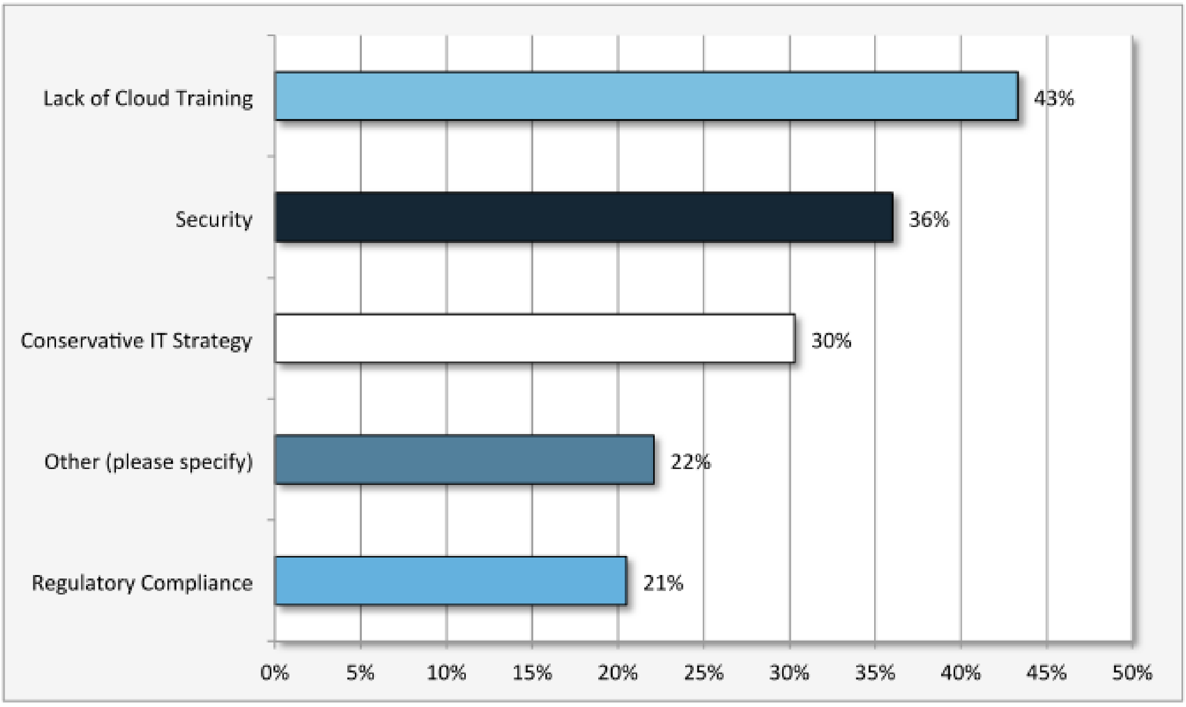

Figure 8: Obstacles towards the cloud

Source: Cloud.com 2011

Chapter 5

Conclusions & Recommendations

Chapter Authors:

Rüdiger Glott (UMM)

Though cloud computing is already a widespread phenomenon in the economy it still is in a nascent stage, as the majority of firms are experimenting with it or wait for the market to mature before actually migrating on the cloud.

While protagonists of cloud computing, in particular cloud vendors, see cloud computing as enabler of a completely new way of computing with tremendous impacts on businesses, the available data suggests that companies are much more careful in using cloud computing, therefore it is currently not clear to what extent the potentials described by the cloud computing protagonists will be reaped in the future.

Other reasons that hinder a trustful and secure adoption of cloud computing are apparently a lack of appropriate business models and tools to calculate costs and analyze cloud performance accurately.

Nevertheless, the growing demand for training seems to signal that CIOs become more aware of the practical conditions that must be met in order to safely use or offer a cloud. This together with the fact that experts assume security issues to be (partially) resolved within the next five years gives reason to assume that the chances to tap better the potential provided by cloud computing will increase.

However, in order to achieve this goal, businesses should keep to the following basic recommendations in order to flank technical solutions for enhanced security and privacy protection, such as the envisaged TClouds cloud of clouds, on the organisational and policy level:

1. Migrating to cloud computing should be aligned with business strategies and business models
2. Thereby, the cloud strategy must be adapted to the business strategy and business models, not vice versa
3. This may require to combine CIO and CEO skills, either through collaboration, task sharing, or creation of a task force or new department
4. Before migrating to the cloud, the existing IT infrastructure should be checked with regard to its adaptability (e.g. level of virtualization)
5. Aligned with this, the skills profile of the IT staff should be checked and, if necessary, training courses for cloud computing should be organized
6. A clear-cut migration strategy should be developed and overlooked by the IT department
7. In order to enhance security and privacy, a Chief Security Officer should be installed

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