Redefining the Cloud based on Beneficial Service Characteristics
A New Cloud Taxonomy Leads to Economically Reasonable Semi-cloudification

Bastian Kemmler and Dieter Kranzlmüller
Leibniz Supercomputing Centre (LRZ), Bavarian Academy of Sciences and Humanities,
Boltzmannstr. 1, 85748 Garching n. Munich, Germany

Keywords: Cloud, Semi-cloud, Service, Cloud Service, Semi-cloud Service, Service Management.

Abstract: Cloud services promise benefits for customers and providers such as scalability, elasticity and reduced investment costs. Unfortunately, many of the promised benefits are not fulfilled by today's cloud offerings and not every service can be cloudified, e.g. if the service's intrinsic structure contains unavoidable time-consuming or manual tasks. A new cloud definition, based on a survey and comparison of existing cloud definitions, but derived from beneficial cloud characteristics, leads to a service-oriented understanding of clouds and provides an extension to the usual cloud service types. The characteristics of the given cloud definition uncover the so-called "*MOUSETRAPS*" of cloud services. The term "*semi-cloudification*" for the transformation of services towards a cloudified state presents a solid foundation for further discussions on the topic and enables the improvement of non-cloudifiable services by semi-cloudification. Even services which partly consist of unavoidable time-consuming or manual tasks qualify for semi-cloudification.

1 INTRODUCTION

Cloud computing influences the way today's IT related businesses work. The percentage of companies which utilize clouds continually increases (Wallraf and Pols, 2014, p. 15). According to Gartner *the use of cloud services is growing faster than the overall enterprise IT market. (...) Cloud computing is set to have a considerable impact on business in the future. (...) Three key factors (...) will significantly impact enterprise cloud use in the near to midterm future* (Rivera and Meulen, 2013):

1. Cloud services will be primarily used as a **solution for specific problems** with limited scope.
2. Cloud services will have an **increased business impact**, while the use of **cloud services moves up the service chain** from infrastructure towards business process services.
3. Cloud solutions will lead to **a more diverse solution portfolio**, widely varying in timelines, resource requirements, benefit profiles, business criticality and complexity.

Although the migration challenges for the cloud service customer are debated extensively (Khajeh-Hosseini et al., 2010a, Khajeh-Hosseini et al., 2011, Khajeh-Hosseini et al., 2010b, Kaisler and Money, 2011,Ward et al., 2010, Andrikopoulos et al., 2013, Paulus and Riemann, 2013), there is little discussion on the service provider challenges for transforming legacy services into cloud services.

Besides other aspects, the three key factors indicate four major requirements, which will be highlighted in this work:

1. Cloud taxonomies need to consider the promised benefits of the cloud.
2. Services besides the general well-known classification Infrastructure-as-a-Service (IaaS), Platform-as-a-Services(PaaS) and Software-as-a-Service(SaaS) need to be included in a more generalistic approach to the cloud. Especially, solutions with limited scope, IT-related services of the service chain towards business processes and highly complex services should be considered.
3. Cloud taxonomies should enable and improve discussions about the emerging service provider challenges, which accompany the transformation of a legacy service towards a cloud service.
4. Cloud services in the long run have the potential to substitute the vast majority of legacy IT services (Münzl et al., 2009, p. 22). Therefore, the cloud service definition needs to be based on a solid definition for IT services.

Kemmler B. and Kranzlmüller D..
Redefining the Cloud based on Beneficial Service Characteristics - A New Cloud Taxonomy Leads to Economically Reasonable Semi-cloudification.
DOI: 10.5220/0005446401350144
In *Proceedings of the 5th International Conference on Cloud Computing and Services Science* (CLOSER-2015), pages 135-144
ISBN: 978-989-758-104-5

Based on this list, we extract the following:

- Which benefits are expected from a cloud service?
- Which of the existing cloud definitions support these benefits?

Unfortunately, the promised benefits of cloud services are often not fulfilled. A potential reason for the lack of fulfilled benefits could stem from a major design fault in existing cloud definitions. Therefore, we need to ask the question:

- Which cloud service characteristics need to be fulfilled for a service to become a cloud service, thus fulfilling the promised benefits?

In order to evaluate these questions, we also need to investigate the following:

- Which services are cloudifiable, which are not?
- Which cloud service characteristics can be fulfilled for non-cloudifiable services?

Following this introduction, Section 2 discusses cloud benefits, that are promised in relevant literature. Of these benefits several are still unfulfilled in existing cloud implementations. Section 3 compares existing cloud definitions and presents their inherent inability to fulfill the promised benefits, while Section 4 proposes a new cloud taxonomy. By focusing on the limits of cloudification Section 5 introduces the term semi-cloud as a midway point for cloudification and a possible solution for non-cloudifiable IT services. To give an example for the use of the benefit oriented approach Section 6 presents a scenario and a possible solution. Section 7 concludes the paper and provides an outlook on future work.

2 CLOUD SERVICE BENEFITS

2.1 Promised Benefits

Several research papers and practitioner reports promise cloud service benefits, which are listed in this subsection. Particularly we included the research done by Khajeh-Hosseini et. al., who identified *the benefits and risks of using public IaaS clouds [...] by reviewing over 50 academic papers and industry reports* (Khajeh-Hosseini et al., 2011). The (promised) benefits of cloud computing depend on the enterprises perspective and can be distinguished into cloud service customer benefits and cloud service provider benefits.

Promised Cloud Service Customer Benefits

B1 DISTRIBUTED ACCESS[1]: Enhanced mobile and geographically distributed access enables customers (and consumers) to access cloud services almost anywhere. Cloud services provide (end-user-)device mobility, which improves collaboration, and geo-distribution of similar cloud services, thereby increasing existing backup facilities, availability and continuity capabilities.

B2 INCREASED SCALABILITY[1]: Customers benefit from scale-up/-down capabilities of cloud services by adjusting their cloud service usage according to the existing workload. Under-/ and overprovisioning can be reduced.

B3 ELASTICITY[2]: *Elasticity is the degree to which a system is able to adapt to workload changes by provisioning and deprovisioning resources in an **autonomic** manner, such that at each point in time the available resources match the current demand as closely as possible* (Nikolas Roman Herbst et al., 2013).

B4 IMPROVED ORGANIZATIONAL FLEXIBILITY AND AGILITY[3]: Cloud services can be flexibly adjusted to business needs. A higher IT abstraction level leads to (IT-related) business decisions which focus on core business activities and not on IT details. Organizational changes are less restricted by the local IT environment.

B5 TERM TRANSFORMATION OF INVESTMENT[4]: The use of services transforms capital expenditures (CAPEX) for investments like hardware or software into operational expenditures (OPEX)(Etro, 2011, p. 12). Thereby longer, unmodifiable investment periods, which can last up to several years, are transformed into several much shorter terms, which can be adjusted on short notice. The frequently occurring charge-per-use or pay-as-you-go accounting-models for cloud services greatly encourages this transformation.

B6 REDUCED TIME TO MARKET[1]: Cloud services enable the faster creation of new or redesigned services or products. The timeframe between idea and service/product is reduced.

[1](Khajeh-Hosseini et al., 2011; Carroll et al., 2011; Phaphoom et al., 2012; Wallraf and Pols, 2014)

[2](Khajeh-Hosseini et al., 2011)

[3](Khajeh-Hosseini et al., 2011; Carroll et al., 2011; Wallraf and Pols, 2014)

[4](Etro, 2011; Khajeh-Hosseini et al., 2011; Wallraf and Pols, 2014)

B7 ENTRY BARRIER REDUCTION[5]: Initial resource demand for new or redesigned services can be decreased. The term transformation of investment *reduces the constraints on entry and promotes business creation* (Etro, 2011, p. 12).

B8 LOWER ADMINISTRATION COSTS[1]: The expenditure for administration, maintenance and general operation is reduced for the customer.

B9 IMPROVED AVAILABILITY AND PERFORMANCE[1]: Both can be improved due to the huge resources of cloud service providers. Quality assurance and control is centralized.

B10 ENHANCED DATA SECURITY[6]: Professional centralized security management, which is transferred to the service provider, is often better than the security management of customers.

B11 DISASTER RECOVERY[7]: Centralized disaster recovery and geo-distribution of resources is beneficial for cloud customers.

Promised Cloud Service Provider Benefits

B12 IMPROVED MANAGEMENT EFFICIENCY[8]: Economies of scale lead to more efficient management and provider automation.

B13 ENERGY EFFICIENCY[9]: The aggregation of system components should also have a positive effect on the level of power consumed on hardware and software(Rajan and Jairath, 2011).[10]

B14 ECONOMIES OF SCALE[2]:Because computing, storage and other service needs are aggregated at provider level, cloud services make better use of economies of scale.

B15 IMPROVED CAPACITY MANAGEMENT[11]: Providers benefit by an improved capacity management through using otherwise idle system components.

2.2 Unfulfilled Benefits

A study based on the contributions of users, developers, consultants, entrepreneurs and researchers to the Cloud Computing Google Group indicates, that the promised benefits B8, B9 and B10 have not been fully achieved, while the results on the benefits B2 and B5 demonstrate their fulfillment. (Phaphoom et al., 2012)

Moreover, KPMG and BITKOM state, that the initial goals B1, B2 and B4 have been achieved by the majority of enterprise cloud users. The promised benefits B6, B8, B9, B10 and reduced IT investment costs still lack fulfillment.(Wallraf and Pols, 2014, p. 26)

Obviously the benefits B13, B14 and B15 could not be achieved, because if otherwise, IT investment costs could have been reduced. Additionally, the failure to achieve benefit B6 also indicates the failure in achieving benefit B7.

Although benefit B5 can be considered fulfilled, because of the general construction of IT services, there is no real proof that management efficiency could be improved (B12) by providing cloud services. For the benefit of existing cloud service implementation it can be assumed that B11 is fulfilled, due to the existing experience with legacy IT services. Unfortunately, there is no proof for the (un)fulfillment of benefit B3. Even though the argumentation in this section mainly follows a paper which summarizes contributions of the Google Cloud Computing Group (Phaphoom et al., 2012) and a report which describes the situation in Germany (Wallraf and Pols, 2014) it can be assumed that many of the presented unfulfilled benefits are also unfulfilled worldwide. Otherwise, globalisation and the ubiquitous nature of the cloud would ruin any cloud service provider in the US (Google Cloud Computing Group) and in Germany shortly. An overview of the fulfilled and unfulfilled benefits is given in Table 1.

Nevertheless, eight out of ten enterprise users tes-

Table 1: Fulfilled and unfulfilled cloud benefits.

Fulfilled Cloud Benefits	B1	Distributed Access
	B2	Increased Scalability
	B4	Improved Organizational Flexibility and Agility
	B5	Term Transformation of Investment
	B11	Disaster Recovery
Unfulfilled Cloud Benefits	B6	Reduced Time to Market
	B7	Entry Barrier Reduction
	B8	Lower Administration Costs
	B9	Improved Availability and Performance
	B10	Enhanced Data Security
	B13	Energy Efficiency
	B14	Economies of Scale
	B15	Improved Capacity Management
Undecided	B3	Elasticity
	B12	Improved Management Efficiency

[5](Etro, 2011)

[6](Carroll et al., 2011; Phaphoom et al., 2012; Wallraf and Pols, 2014)

[7](Khajeh-Hosseini et al., 2011; Phaphoom et al., 2012)

[8](Byung et al., 2013; Khajeh-Hosseini et al., 2011; Carroll et al., 2011)

[9](Rajan and Jairath, 2011; Carroll et al., 2011)

[10]Although this needs further proof.

[11](Khajeh-Hosseini et al., 2011; Carroll et al., 2011)

tify that the utilization of a cloud is beneficial for them.(Wallraf and Pols, 2014, p. 24)

3 EXISTING CLOUD TAXONOMY

Almost any big player in the business of software and computer services[12] and additionally several companies in the business of technology hardware and equipment[13] use the term "*cloud*" as an integral part of their advertising language. Despite widely used for several IT environments, the terms "*cloud*" and "*cloud computing*" are still not used with a commonly accepted understanding.[14]

3.1 Characteristics of Existing Cloud Definitions

The ongoing research on cloud computing resides on several incomplete and in parts contradictory definitions, like the definitions of NIST(Mell and Grance, 2011), Forrester(Staten, 2008), Gartner(Cearley, 2010), European Commission(EC)(European Commission, 2010, p. 8), BITKOM(Münzl et al., 2009, p. 16) and BSI(Federal Office for Information Security, 2011, p. 13). These definitions describe the cloud with specific characteristics like access, service type, customer type, business benefits and provisioning features, which are listed in detail in the following.

Cloud Access Characteristics[15]

AC1	ubiquitous	AC5	over a public network
AC2	on-demand		
AC3	self-service	AC6	over a broad network only
AC4	over a private network	AC7	API

Cloud Service Type Characteristics

SC1	IT service	SC4	configurable service parameters
SC2	SaaS, PaaS, IaaS		
SC3	XaaS [16]		

Cloud Customer Characteristics

CC1	public	CC3	community
CC2	private	CC4	hybrid

Cloud Business Characteristics

BC1	measured (priced) service
BC2	specified level of quality
BC3	tailored to a market need
BC4	CAPEX $\Rightarrow$ OPEX

Cloud Provisioning Characteristics

PC1	elastic	PC5	pooling
PC2	scalable	PC6	no management effort or provider interaction[17]
PC3	rapid		
PC4	real-time		

3.2 Comparison of Existing Cloud Definitions

By using the extracted definition characteristics to take a closer look at these cloud definitions, the differences become visible (see Table 2).

Especially if the introduced expected benefits (see Section 2) of the cloud are also considered, the deficits of existing cloud definitions are obvious. A mapping between the expected benefits of the cloud and their counterparts (characteristics, see Table 3) applied to the definitions of the NIST, Forrester, Gartner, EC, BITKOM and BSI clearly shows those deficits (see Table 4). Therefore, a clean definition set for the terms *cloud, cloud computing, cloud service, cloud service provider and cloudification* is essential for further scientific work regarding the limits of the cloud and non-cloudifiable services.

4 CLOUD TAXONOMY PROPOSAL

As discussed above, cloud taxonomy (see Figure 1) should be build on top of the definition for the generic

[12] like Microsoft, Google, IBM, Oracle and SAP, listed in the Financial Times global top 500(Financial Times, 2014),which provides *an annual snapshot of the world's largest companies* (Dullforce, 2014)

[13] like Apple, Intel, Cisco and EMC, listed in the Financial Times global top 500(Financial Times, 2014)

[14] The iCloud *connects you and your Apple device[,] safely store[s] all your presentations, spreadsheets, PDFs, images, and other kinds of documents* (Apple, 2014), finds your Apple device and protects it against theft; IBM is *building a smarter planet with IBM SmartCloud cloud computing* (IBM, 2014) and Microsoft brings higher education into the cloud [Microsoft Deutschland GmbH, 2012-10-11].

[15] Convenient access is also a possible characteristic which is required by the NIST definition. But since convenience is only measurable subjectively and depends very much on the users point of view, it does not qualify as a cloud characteristic.

[16] besides S/P/IaaS

[17] Some definitions use terms like *with minimal management effort* or *minimal provider interaction*. From a theoretical approach this is synonymous with *no management effort* or *no provider interaction*, because minimal is nothing if there are no constraints and with unspecified constraints minimal is meaningless.

Table 2: Comparison of cloud definitions.

Dimension	Characteristic	NIST	Forrester	Gartner	EC	BITKOM	BSI
Access	AC1	✔					
	AC2	✔					
	AC4	✔				✖	✔
	AC5	✔	✔	✔		✔	✔
	AC6	✔					
	AC3	✔	✔				
	AC7						✔
Service Type	SC1	✔	✔	✔		✔	✔
	SC2	✔	(✔)			✔	✔
	SC3	✖				✖	✔
	SC4	✔			✔		
Customer	CC1	✔		✔		✔	
	CC2	✔		✖			
	CC3	✔		✖			
	CC4	✔		✖			
Business	BC1	✔			✔	✔	✔
	BC2				✔		
	BC3					✔	✔
	BC4					✔	
Provisioning	PC1	✔		✔	✔	(✔)	✔
	PC2			✔			
	PC3	✔					
	PC6	✔					✖
	PC4					✔	
	PC5	✔					

✔: cloud definition contains characteristic
✖: cloud definition contradicts characteristic

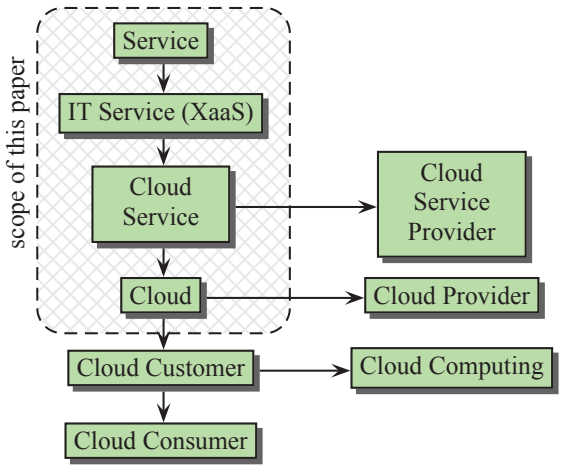

Figure 1: Cloud taxonomy.

service.[18] In this paper only the terms "*service*", "*IT service*", "*cloud service*" and "*cloud*" will be defined. All other terms listed in Figure 1 can be derived easily and are omitted due to space limitations.

[18]Byung et al.(Byung et al., 2013) also state that the management of some cloud services is more efficient than the management of standard IT services.

Table 3: Benefits targeted by cloud definition characteristics.

	Benefit	Essential Definition Characteristics	Nice-to-have Definition Characteristics
Customer	B1	AC1	AC5
	B2	AC7, PC2, PC3	AC2
	B3	PC1	AC2, AC7, SC4, PC2
	B4	AC2, PC2	CC3, CC4
	B5	BC4	BC1
	B6	AC2, AC3, AC7	BC2, BC3
	B7	AC3, BC4	BC2, AC7, BC3
	B8	AC7, BC3	
	B9	AC1, AC2, BC2, PC1, PC2	AC4, AC5, AC6
	B10	BC2	CC2
	B11	AC1	
Provider	B12	BC3, PC6	
	B13	PC5	
	B14	AC3, AC7, BC1, PC2, PC6	PC5
	B15	BC2, PC2	PC5

Table 4: Benefits targeted by essential cloud definition characteristics.

	Benefit	NIST	Forrester	Gartner	EC	BITKOM	BSI
Customer	B1	✔					
	B2	❍		❍			
	B3	✔		✔	✔	(✔)	✔
	B4	❍		❍			
	B5					✔	
	B6	❍	❍				❍
	B7	❍	❍			❍	
	B8					❍	✔
	B9	❍		❍	❍	❍	❍
	B10				✔		
	B11	✔					
Provider	B12	❍				❍	❍
	B13	✔					
	B14	❍	❍	❍	❍	❍	❍
	B15			❍	❍	❍	❍

✔: targeted by at all essential cloud def. characteristics
❍: targeted by at least one essential cloud def. char.

4.1 IT Service

According to ITIL (Iqbal and Nieves, 2007, page 16) a service is defined as follows[19]:

Definition 1 (Service)**.** *A service is a means of delivering value to customers by facilitating outcomes*

[19]See also ISO/IEC 20000-1:2011; a service is *a means of delivering value to customers by facilitating outcomes customers want to achieve* (ISO/IEC, 2011, 3.26).

customers want to achieve without the ownership of specific costs and risks.

Definition 2 (IT Service)**.** *An IT service is a service, which consists at least partly of IT-related aspects.*

Generally spoken, an IT service can be created by a specific business unit utilizing assets of the IT organization to add value to the customers business. These assets A can be segmented into sets like management A^m, organization A^o, processes A^{pr}, knowledge A^{kn}, people A^{ppl}, information A^{inf}, applications A^{app}, infrastructure A^i and financial capital A^{fc} (see (Iqbal and Nieves, 2007, page 39)) and their subsets like $A_i^{app}, i \in \mathbf{N}$, which hold the following:

$$\Sigma^{type} := \{m, o, pr, kn, ppl, inf, app, i, fc\} \quad (1)$$

$$A = \bigcup_{k \in \Sigma^{type}} A^k \quad (2)$$

$$\forall k \in \Sigma^{type} \exists n \in \mathbb{N} : A^k = \bigcup_{i=1}^{n} A_i^k \quad (3)$$

Definition 3 (XaaS)**.** *The value of an IT service is generated by providing X-as-a-Service (XaaS), which (as of today) can be segmented into the following service types:*

- *Management-as-a-Service (MaaS), like interim management*
- *Organization-aaS (OaaS), like franchising*
- *Processes-aaS (PRaaS), like franchising*
- *Knowledge-aaS (KNaaS), which splits into Education-aaS (EDUaaS) and consulting*
- *People-aaS (PPLaaS), like temporary work*
- *Information-aaS (INFaaS), like Reuters or Bloomberg*
- *Application-aaS (APPaaS), which splits into Software-aaS (SaaS) and Platform-aaS (PaaS)*
- *Infrastructure-aaS (IaaS), which splits into Hardware-aaS (HaaS), virtual-Infrastructure-aaS (vIaaS) and Desktop-aaS (DaaS)*
- *and Capital-aaS (FCaaS), like a call loan or a credit facility*

Mixtures of these service types are also XaaS.

In accordance to the definition of XaaS (Definition 3) an IT service can be characterized by service type and the needed input assets iA^k and output assets oA^k, which can be split up into provider assets PiA^k and PoA^k and customer assets CiA^k and CoA^k.

Furthermore, an IT service can also be created by a specific business unit, additionally utilizing available XaaS of the IT organization to add value to the customers' business. As already discussed, those XaaS S can also be segmented into sets like management S^m, organization S^o, processes S^{pr}, knowledge S^{kn}, people S^{ppl}, information S^{inf}, applications S^{app}, infrastructure S^i and financial capital S^{fc} and their subsets like $S_i^{app}, i \in \mathbf{N}$

Altogether, these assets and services are the building blocks of a generic IT service. They serve as input parameters to the service function

$$f_S : CiA \times CiS \times PiA \times PiS \rightarrow CoA \times CoS \times PoA \times PoS \quad (4)$$

which creates the service according to a service level agreement (SLA) or an operational level agreement (OLA). These agreements specify the the level, scope and quality of the service in detail.

Definition 4 (Service Level Agreement (SLA))**.** *SLAs are the documents agreed with the customers that specify the level, scope and quality of service to be provided (Lloyd et al., 2007, page 24)).*

Definition 5 (Operational Level Agreement (OLA))**.** *OLA are any underpinning agreements necessary to deliver the quality of service agreed within the SLA (Lloyd et al., 2007, page 24)).*

Additionally the SLA/OLA may contain specifications about occurring customer obligations. The provided service itself is an entity of the set CoS. Therefore the SLA can be defined as the function

$$f_{SLA} : CiA|_{SLA} \times CiS|_{SLA} \rightarrow CoS|_{SLA} \quad (5)$$

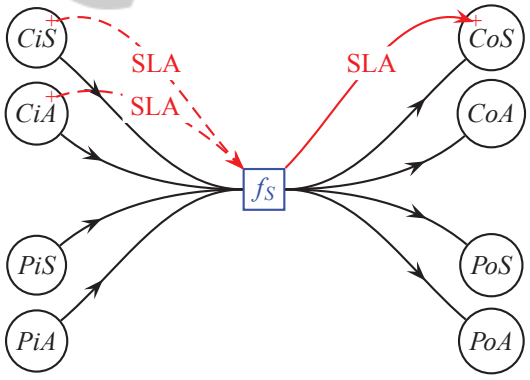

Figure 2: Generic service model.

Finally, the service may contain a configurable service parameter vector p, which leads to

$$f_{S_p} : CiA \times CiS \times PiA \times PiS \rightarrow CoA \times CoS \times PoA \times PoS \quad (6)$$

$$\text{and } f_{SLA_p} : CiA|_{SLA_p} \times CiS|_{SLA_p} \rightarrow CoS|_{SLA_p} \quad (7)$$

4.2 Cloud Service

Based on the discussions above a new cloud definition can be derived, which, on the one hand gives, a solid foundation to fulfill customers/providers expectancy

Table 5: Benefits targeted by cloud definition characteristics without service benefits and characteristics.

	Benefit	Essential Definition Characteristics	Nice-to-have Definition Characteristics
Customer	B1	AC1	AC5
	B2	AC7, PC2, PC3	AC2
	B3	PC1	AC2, AC7, PC2
	B4	AC2, PC2	CC3, CC4
	B6	AC2, AC3, AC7	BC2
	B7	AC3	BC2, AC7
	B8	AC7	
	B9	AC1, AC2, BC2, PC1, PC2	AC4, AC5, AC6
	B10	BC2	CC2
	B11	AC1	
Provider	B12	PC6	
	B13	PC5	
	B14	AC3, AC7, BC1, PC2, PC6	PC5
	B15	BC2, PC2	PC5

and, on the other hand, considers the already listed commonly accepted cloud characteristics. The most important cloud service characteristics can be summarized by the acronym "*MOUSETRAPS*".

Definition 6 (Cloud Service)**.** *A cloud service is a* ***Measured****,* ***On-demand****,* ***Ubiquitous****,* ***Scalable*** *and* ***Elastic*** *IT service* ***Tailored to a market need*** *with a specified level of quality (SLA/OLA). It is provisioned, deprovisioned or reconfigured* ***Rapid****ly without provider interaction, by using an* ***API****,* ***Pooling*** *mechanisms and a* ***Self-service****. The service should be accessible over a broad network.*

By utilizing the previously given definition for an IT service (see Definition 1 and 2) benefit B5 and the cloud characteristics SC1, SC2, SC3, SC4, BC3 and BC4 already have been fully included. Thus Table 3 can be significantly reduced as shown in Table 5. Additionally, the inclusion of SC3 already disqualifies the definitions of NIST and BITKOM (see Table 2).

Particularly, the mandatory SLA/OLA of cloud services enable customers to conduct an appropriate risk-analysis for the cloud operation and migration of legacy customer systems. This enables customers to migrate even mission-critical systems into the cloud.

Definition 7 (Cloud)**.** *A cloud is a multitenant electronic marketplace, accessible by a broad network, with strictly defined interfaces for customers and provider(s), where cloud services can be traded*[20]*. Access to the cloud can be restricted to a private, community, public or hybrid audience.*

[20]General linguistic usage: Services do not "leave" the cloud. They "live" in the cloud.

Table 6: Comparison of cloud definitions without service characteristics.

Dimension	Charact.	NIST	Forrester	Gartner	EC	BITKOM	BSI	Def. 7	Def. 10
Access	AC1	✔						✔	✔
	AC2	✔						✔	✔
	AC4	✔				✖	✔	✔	
	AC5	✔	✔	✔		✔	✔	✔	
	AC6	✔						✔	
	AC3	✔	✔					✔	✔
	AC7						✔	✔	✔
Customer	CC1	✔		✔		✔		✔	✔
	CC2	✔						✔	✔
	CC3	✔						✔	✔
	CC4	✔						✔	✔
Business	BC1	✔			✔	✔	✔	✔	✔
	BC2				✔			✔	✔
Provisioning	PC1	✔		✔	✔	✔	✔	✔	
	PC2			✔				✔	✔
	PC3	✔						✔	
	PC6	✔					✖	✔	
	PC4					✔			
	PC5	✔						✔	✔

Table 7: Benefits targeted by all essential and nice-to-have cloud definition characteristics.

	Benefit	NIST	Forrester	Gartner	EC	BITKOM	BSI	Def. 7	Def. 10
Customer	B1	✔						✔	
	B2							✔	
	B3							✔	
	B4	✔						✔	✔
	B6							✔	✔
	B7							✔	✔
	B8						✔	✔	✔
	B9							✔	
	B10							✔	✔
	B11							✔	✔
Provider	B12							✔	
	B13	✔						✔	✔
	B14							✔	
	B15							✔	✔

This newly defined cloud definition fulfills all needed characteristics to achieve the promised benefits (see Tables 6 and 7), and therefore gives a better understanding of the cloud. Although the characteristic PC4 could be dropped, because according to Table 6 it is not beneficial to any of the promised benefits, it is included in Definition 6. Obviously, the dependence between AC2 and PC4 cannot be fully denied.

Consequently "*cloudification*" can be defined as:

Definition 8 (Cloudification)**.** *Cloudification is the transformation by which an IT service becomes a cloud service which is provisioned using a cloud.*

5 LIMITS OF CLOUDIFICATION

Unfortunately, not every IT service can be fully cloudified. IT services like the hardware maintenance of desktop computers or laptops, full service copier lease with ink refill service, education, consulting or other services which at least partly consist of physical work in not properly standardized environments, do not qualify for cloudification, because of their unavoidable manual (and time consuming) work load. Additionally, full service cloudification would be very costly and contradicts benefits which target the overall reduction of costs. By dropping the cloud characteristics AC4, AC5, AC6, PC3 and PC6 an economically more reasonable definition can be found. The new terms, "*semi-cloud service*", "*semi-cloud*" and "*semi-cloudification*" should be used as terms to discuss those "nearly" cloudified services. The most important semi-cloud service characteristics can again be summarized by the acronym "*MOUSETrAPS*".

Definition 9 (Semi-Cloud Service)**.** *A semi-cloud service is a* ***Ⓜeasured****,* ***Ⓞn-demand****,* ***Ⓤbiquitous*** *and* ***Ⓢcalable*** *IT service* ***Ⓣailored to a market need*** *with a specified level of quality (SLA/OLA). It is provisioned, deprovisioned or reconfigured with* ***Ⓔconomically reasonable*** *provider interaction, by using an* ***ⒶPI****,* ***Ⓟooling*** *mechanisms and a* ***Ⓢelf-service****.*

Definition 10 (Semi-Cloud)**.** *A semi-cloud is a multi-tenant electronic marketplace with strictly defined interfaces for customers and provider(s), where semi-cloud services can be traded. Access to the semi-cloud can be restricted to a private, community, public or hybrid audience.*

Definition 11 (Semi-Cloudification)**.** *Semi-cloudification is the transformation by which an IT service becomes a semi-cloud service which is provisioned using a semi-cloud.*

As can be seen in Table 7, only the benefits B1, B2, B9, B12 and B14 are not fully targeted by the semi-cloud as defined in Definition 10. Further investigation shows, that these benefits are only slightly missed:

B1. All essential definition characteristics fulfilled

B2. Only PC3 unfulfilled

B9. All essential definition characteristics fulfilled

B12. Benefit B12 is based on characteristic PC6.[21]

B14. Only PC6 unfulfilled

Altogether, the shortcomings of the proposed definition for the semi-cloud focus around the missing characteristics PC3 and PC6, which were omitted on purpose to encourage the development of designs which balance investment in the semi-cloud systems with economical benefits. Additionally, non-cloudified services which at least partly consist of unavoidable manual tasks, can be semi-cloudified. Therefore the term semi-cloud can be considered a substantial extension to the cloud taxonomy.

6 APPLICATION SCENARIO

To show some real-life aspects of the given approach towards (semi-)cloudification, we introduce the following scenario and observe possible solutions. By the nature of a scenario, the given problems and the solution can not touch the full extend of this work, but give an impression on the change of perspective set by the new cloud taxonomy.

6.1 Scenario

Consider a midsize IT company which started business activities in 1965 by selling copying machines and fulfilling corresponding maintenance contracts. In 1985 the CEO decided to include office printers for personal computers into the product range. Later on the company began selling PCs, servers and network equipment always together with their corresponding maintenance contracts until in 2005 the new CEO introduced a new service oriented strategy. Today the enterprise has around 200 employees, 5 VIP-Customers (three of those since 1965) and around 400 SME customers total. The company mainly provides four services: printing (on-site and off-site), printing and mailing, desktop management and virtual root servers, which are located at a company owned facility. Last year an ISO/IEC 20000 certification was achieved. Most of the employees are booked to capacity and there is little time left for innovative projects. In the last two years the CEO heard about the cloud and its benefits but deferred a project to enable cloud computing for his customers, because of the resources involved with the organizational transformation towards ISO/IEC 20000. Although the budget is tight the CEO expects his new CIO to "*cloudify*" his company. He privately assumes that the company will especially benefit from the resulting management effi-

[21] which is dropped deliberately

ciency, energy efficiency and the improved capacity management of the cloud. By this, he believes, his company will reach the turning point towards making profit again. With great commitment the CIO initiates the cloud project.

6.2 Problems

In this setting, besides many other, several problems arise which were discussed in this paper.

1) Each of the company's employees has a slightly different understanding of the cloud:
   - The customer relationship manager looks forward to the new cloud service, which will be added to the company's service lines and is highly demanded by the company's customers.
   - The infrastructure department head expects benefits by accommodating desperately needed resource demands with an external cloud provider.
   - The hardware maintenance group thinks, that the cloud is a topic for the software guys.
   - The virtualisation specialists state, that cloud computing is already their daily business.
   - Another approach is given by the head of research and development, who proposes to install a software called FreeStack.
2) The CEO wants to fully cloudify the company. But the CIO thinks, that many services of the company can not be cloudified. Installing the proposed IaaS software FreeStack for virtual machines provisioning, which also provides interfaces to external cloud providers, could be a solution for the VM service. But who is going to manage the emerging new cloud service, if most of the employees are booked to capacity?
3) The CIO's project budget is limited. Therefore she would like to focus on the most important benefits and implement an economically reasonable cloud solution. But which are these and which one of the several available cloud definitions support these benefits?
4) Especially the VIP customers might stick to their legacy services and refuse the new cloud services.

6.3 Solution with the Given Approach

By introducing the employees to the benefit oriented cloud taxonomy of Section 4, a commonly accepted understanding of the cloud can be reached (Problem 1). Especially because of the benefit oriented approach, the characteristics in the given definitions can be directly connected to the CEOs desires.

Additionally, a structural analysis and proper decomposition of the company's services according to Subsection 4.1 reveals that the services printing (on-site and off-site), printing and mailing, desktop management can not be cloudified, but semi-cloudified because of their unavoidable manual workload. Moreover, existing services should be transformed into semi-cloud services with at least equal service features one-by-one to free employees from working on legacy services (Problem 2).

An Interview with the CEO based on the given list of benefits in Section 2 reveals, that he is especially interested in gaining the benefits B12, B13 and B15. Semi-Cloudification of the company's services with a special focus on characteristics PC5, BC2 and PC2 will specifically address benefits B13 and B15 (see Table 5), while characteristic PC6 and therefore benefit B12 contradicts the budget constraints(Problem 3). A moderate, cost-conscious automation of service production steps seems to be advisable.

By the transformation of existing services VIP customers can be migrated without loss of the existing service features (Problem 4).

7 SUMMARY AND OUTLOOK

As indicated by our analysis, most of the promised cloud benefits are not addressed by existing cloud definitions. This presents a possible root cause for the unfulfillment of most of those benefits. Based on an analysis of the generic IT service and by identifying beneficial cloud service characteristics, the so-called MOUSETRAPS, a new cloud definition has been derived, which focusses intensely on the desired benefits of the cloud. The terms "*semi-cloud*", "*semi-cloud service*" and "*semi-cloudification*" present a solid base terminology for further discussions of the topic. On the one hand, semi-cloudification can be understood as a midway point towards full cloudification and, on the other hand, many of the existing non-cloudifiable services can be semi-cloudified.

Further studies are needed to analyze the transformation process between the steps non-cloudified, semi-cloudified and cloudified to improve the cloudification of legacy services. Generally cloud research should shift towards a more benefit-oriented approach, especially, when it comes to subjects regarding the service provider and their motives for implementing cloud solutions. Service providers have to realize that the impact of (semi-)cloudification will not only enhance their own services, but also services of their competitors, resulting in a tighter, but better focused service portfolio for each service provider.

REFERENCES

Andrikopoulos, V., Binz, T., Leymann, F., and Strauch, S. (2013). How to Adapt Applications for the Cloud Environment. *Computing*, 95(6):493–535.

Apple (2014). iCloud. http://www.apple.com/icloud/. 04.12.2014.

Byung, C. T., Urgaonkar, B., and Sivasubramaniam, A. (2013). Cloudy with a Chance of Cost Savings. *Parallel and Distributed Systems, IEEE Transactions on*, 24(6):1223–1233.

Carroll, M., van der Merwe, A., and Kotze, P. (2011). Secure Cloud Computing: Benefits, Risks and Controls. In *2011 Information Security for South Africa (ISSA)*, pages 1–9.

Cearley, D. W. (2010). Cloud Computing: Key Initiative Overview. http://www.gartner.com/it/initiatives/pdf/KeyInitiativeOverview_CloudComputing.pdf. 21.11.2014.

Dullforce, A.-B. (2014). FT 500 2014 Introduction and Methodology. http://www.ft.com/intl/cms/s/0/6fdb9d70-fdf5-11e3-bd0e-00144feab7de.html. 08.07.2014.

Etro, F. (2011). The Economics of Cloud Computing. *IUP Journal of Managerial Economics*, 9(2):7–22.

European Commission (25.01.2010). The Future Of Cloud Computing. http://cordis.europa.eu/fp7/ict/ssai/docs/cloud-report-final.pdf. 02.01.2013.

Federal Office for Information Security (2011). Security Recommendations for Cloud Computing Providers: Minimum information security requirements. https://www.bsi.bund.de/SharedDocs/Downloads/EN/BSI/Publications/Minimum_information/Security Recommendations Cloud Computing Providers.html. 2015-01-05.

Financial Times (2014). Global 500 Companies Ranked by Sector. http://im.ft-static.com/content/images/70710ff2-fded-11e3-bd0e-00144feab7de.xls. 08.07.2014.

IBM (2014). http://www-07.ibm.com/hk/cloud/cloud-computing/. 04.12.2014.

Iqbal, M. and Nieves, M. (2007). *Service Strategy*. ITIL. TSO (The Stationery Office), London, 2 edition.

ISO/IEC (2011). ISO/IEC 20000-1:2011 - Information Technology - Service Management, Part 1: Service Management system requirements.

Kaisler, S. and Money, W. (2011). Service Migration in a Cloud Architecture. In *System Sciences (HICSS), 2011 44th Hawaii International Conference on*, pages 1–10.

Khajeh-Hosseini, A., Greenwood, D., and Sommerville, I. (2010a). Cloud Migration: A Case Study of Migrating an Enterprise IT System to IaaS. In *2010 IEEE International Conference on Cloud Computing (CLOUD)*, pages 450–457.

Khajeh-Hosseini, A., Sommerville, I., Bogaerts, J., and Teregowda, P. (2011). Decision Support Tools for Cloud Migration in the Enterprise. In *2011 IEEE 4th International Conference on Cloud Computing (CLOUD)*, pages 541–548.

Khajeh-Hosseini, A., Sommerville, I., and Sriram, I. (2010b). Research Challenges for Enterprise Cloud Computing. *CoRR*, abs/1001.3257.

Lloyd, V., Rudd, C., and Taylor, S. (2007). *ITIL - Service Design: [IT service management practices; ITIL v3 core publications]*. TSO, London.

Mell, P. and Grance, T. (2011). *The NIST Definition of Cloud Computing: Recommendations of the National Institute of Standards and Technology: Special Publication 800-145*. Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology, Gaithersburg, MD.

Microsoft Deutschland GmbH (2012-10-11). Hochschulen in der Wolke: Immer mehr Bildungseinrichtungen setzen auf Cloud Computing. http://www.microsoft.com/germany/newsroom/pressemitteilung.mspx?id=533628. 05.12.2014.

Münzl, G., Przywara, B., Reti, M., Schäfer, J., Sondermann, K., Weber, M., and Wilker, A. (2009). Cloud Computing: Evolution in der Technik, Revolution im Business: BITKOM-Leitfaden. http://www.bitkom.org/files/documents/BITKOM-Leitfaden-CloudComputing_web.pdf. 02.01.2013.

Nikolas Roman Herbst, Samuel Kounev, and Ralf Reussner (2013). Elasticity in Cloud Computing: What It Is, and What It Is Not. In *Proceedings of the 10th International Conference on Autonomic Computing (ICAC 13)*, pages 23–27, San Jose, CA. USENIX.

Paulus, S. and Riemann, U. (2013). An Approach for a Business-Driven Cloud Compliance Analysis Covering Public Sector Process Improvement requirements. *CoRR*, abs/1310.2832.

Phaphoom, N., Oza, N., Wang, X., and Abrahamsson, P. (2012). Does Cloud Computing Deliver the Promised Benefits for IT Industry? In Männistö, T., editor, *the WICSA/ECSA 2012 Companion Volume*, page 45.

Rajan, S. and Jairath, A. (2011). Cloud Computing: The Fifth Generation of Computing. In *Communication Systems and Network Technologies (CSNT), 2011 International Conference on*, pages 665–667.

Rivera, J. and Meulen, R. v. d. (2013). Gartner Says the Road to Increased Enterprise Cloud Usage Will Largely Run Through Tactical Business Solutions Addressing Specific Issues. http://www.gartner.com/newsroom/id/2581315. 05.12.2014.

Staten, J. (2008). Is Cloud Computing Ready For The Enterprise? A Client Choice Report: Not Yet, But This Disruptive Innovation Is Maturing Fast. https://www.forrester.com/Is+Cloud+Computing+Ready+For+The+Enterprise/fulltext/-/E-RES44229? 05.12.2014.

Wallraf, B. and Pols, A. (2014). Cloud-Monitor 2014: Cloud-Computing in Deutschland – Status quo und Perspektiven. http://www.kpmg.com/DE/de/Documents/cloudmonitor-2014-kpmg.pdf. 05.12.2014.

Ward, C., Aravamudan, N., Bhattacharya, K., Cheng, K., Filepp, R., Kearney, R., Peterson, B., Shwartz, L., and Young, C. (2010). Workload Migration into Clouds Challenges, Experiences, Opportunities. In *2010 IEEE International Conference on Cloud Computing (CLOUD)*, pages 164–171.