ITEA 2 Project 10014

EASI-CLOUDS - Extended Architecture and Service Infrastructure for Cloud-Aware Software

Deliverable

D1.5 – Final Business Models for EASI-CLOUDS

Task 1.3: Business model(s) for the EASI-CLOUDS eco-system

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Abstract

The purpose of the business working group within the EASI-CLOUDS project is to investigate the commercial potential of the EASI-CLOUDS platform, and the brokerage and federation-based business models that it would help to enable. Our described approach is both 'top down' and 'bottom up'; we begin by summarizing existing studies on the cloud market, and review how the EASI-CLOUDS project partners are positioned on the cloud value chain. We review emerging trends, concepts, business models and value drivers in the cloud market, and present results from a survey targeted at top cloud bloggers and cloud professionals. We then review how the EASI-CLOUDS infrastructure components create value both directly and by facilitating brokerage and federation. We then examine how cloud market opportunities can be grasped through different business models. Specifically, we examine value creation and value capture in different generic business models that may benefit from the EASI-CLOUDS infrastructure. We conclude by providing recommendations on how the different EASI-CLOUDS demonstrators may be commercialized through different business models.

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1 Executive summary

This report is an update of the first deliverable D1.3 and analyses the market potential of cloud computing service infrastructure developed under the ITEA2 EASI-CLOUDS project.

The objective of the ITEA2 project EASI-CLOUDS is to provide a comprehensive cloud computing infrastructure as a future pillar of this fast growing market. The EASI-CLOUDS infrastructure will feature the three classical categories of cloud computing offerings IaaS, PaaS, SaaS – with superior reliability, elasticity, security and ease-of-use characteristics at all levels. Moreover, to promote an efficient, trusted system, this cloud infrastructure will include standardized interfaces allowing service portability, a powerful service composition and orchestration framework, facilities for cloud interoperability and federation, and advanced Service Level Agreement (SLA) management to help guarantee the required Quality of Service (QoS)[1].

The purpose of the business impact work group and task 1.3 is to investigate the commercial potential of the EASI-CLOUDS infrastructure, and the federation-based and broker-based business models that it would aid. In our analysis, we highlight that the terms 'brokerage' and 'federation' can have different meanings depending on whether the context is purely technical, or whether the context involves how different operations should be organized. We do also touch related areas like cloud management and cloud orchestration which are elementary solution elements on the evolution process for multi-cloud management.

Based on our review of various market sources, the public cloud computing market is estimated to be approximately €35-75Bn in 2013, and set to almost double in the next three years. The cloud value chain has much in common with many other value chains: most value is created and captured at the top where differentiation is the highest (consulting services and SaaS), whereas lower levels of the value chain face commoditization and intense price competition driven by economies of scale (PaaS, IaaS). This static and simplifying picture is however being constantly shaken by the boom in innovation, which is creating new value chain positions as resources are being combined in novel ways. When viewed against this landscape, the EASI-CLOUDS project is helping its partners to enhance their positions in growing value chain positions and helping them enter new ones.

On the other hand, it remains unclear how recently increasing privacy awareness will affect future growth. We consider it likely that especially in Europe the importance of private and hybrid cloud computing offerings will increase leading to somewhat slower growth in public cloud that has been forecasted during the past few years. Nevertheless, we can determine that the market for private as well as hybrid cloud computing is exploding as the growth rates above 30 percent per year are indicating.

However a key driver in this development is also slowing macroeconomic growth that is generally slowing down the growth of ICT spending. Also despite its rapid growth, the size of the public cloud computing market currently represents about 1-2% of the overall ICT market. While large players dominate particularly the IaaS and PaaS markets, there is also a great deal of fragmentation on the market as new entrants seek to differentiate. As a consequence, the complexity of hundreds of different cloud services are overwhelming particularly small and

[1] Source: EASI-CLOUDS Full Project Proposal Version 1.0

medium sized companies. Hence, while the cloud revolution is inevitably shrinking traditional IT service markets for local company servers, it has also created new markets to help customers either to navigate the cloud jungle or to efficiently integrate offerings of different cloud providers into their business landscape by using orchestration and management services.

While complexity is increasing in some areas, standards are also making enabling better functioning cloud markets to form. Analysts are placing much hope on the proliferation of software-enabled cloud brokering businesses, whose revenues are currently in the order of one billion Euros or less. If we also consider manually operated brokerage businesses that contain various consulting services, the market is significantly larger. Based on our analysis, the brokerage market is attracting many players from start-ups to large established firms to innovative platform providers. We also observe that commercial cloud federation is now a reality through London-based OnApp's offering. We expect that in the future, both the federation and brokerage will increasingly move toward vertical markets. In the midst of intensifying cost competition especially in the IaaS and PaaS markets, brokerage and federation-based solutions may also help smaller cloud service providers to survive by improving their resource utilization and reach to broader markets. The platform components and demonstrators in the EASI-CLOUDS project all represent developments in the brokerage and federation space. In this deliverable, we examine the value they create, which lies at the core of any sustainable business that is to be built around them.

Despite high interest toward brokerage and federation, the concepts remain quite immature, and as highlighted by our survey, even cloud experts are surprisingly unfamiliar with the concepts. In order to examine these emerging markets, we sought to learn and generalize from novel businesses. Inspired by theses existing companies in the cloud brokerage and federation space, and businesses that trade resources in other markets, we describe a set of generic business models that are currently applied, or may emerge in the future. Among these models, the broker/aggregator model ('brokerage') is the closest rival to the cooperative model ('federation'). The success of the cooperative model depends largely on its ability to deliver superior QoS and completeness compared to the broker/aggregator model.

We hope that our business model descriptions will inspire the reader to consider the breadth of opportunities that lie in this emerging cloud space, and also in the process of moving toward this future reality.

2 Introduction

2.1 Background

The main purpose of this deliverable is to investigate the commercial potential of the EASI-CLOUDS infrastructure. This involves the question of how value is best created for the cloud consumer and how cloud service providers can capture this value. This assessment task is accomplished by reviewing the cloud market and emerging new concepts within to establish a baseline for assessment. We then generalize different areas of value creation and business models that might apply or contribute to the development and deployment of the EASI-CLOUDS infrastructure. The business models and value frameworks are then used to assess EASI-CLOUDS demonstrators and platform components.

2.2 Structure of the document

Chapter 3 provides an overview about the general cloud computing market. It begins by drawing on various analyst reports regarding established cloud computing segments, and views these findings in the context of the cloud value chain. It then proceeds to reviewing emerging topics on cloud computing, and proceeds to analyse cloud brokerage and federation (incl. directly connected cloud services like cloud management and cloud orchestration) through market and expert sources, as well as two new surveys.

Chapter 4 delves into the fundamental question of value creation on cloud brokerage and federation. The chapter presents a framework (‘value tree’) that can be applied to decompose value creation in brokerage/federation based offerings. The framework is then applied to selected EASI-CLOUDS platform components.

Chapter 5 reviews how federation and brokerage-based opportunities can be approached through various business models. The section presents a set of generic business models where the EASI-CLOUDS platform components might be used. The business models cover both running a brokerage/ federation based business and the process of building such offerings.

Chapter 6 draws on the insights of the previous chapters to review the business cases for the demonstrators in the project. Finally, we present our conclusions in Chapter 7.

3 Overview of the global cloud market

3.1 Overview

Cloud computing represents one of the major paradigmatic shifts in ICT that is comparable to the decoupling of software and hardware and the rise of personal computing. Cloud computing, and the cloud computing market capture many value chain activities from hardware manufacture to the sales of software-as-a-service offerings. There is currently no undisputable market size estimate on cloud computing due to the differences in assumptions that market analysts make about the scope of the market.

There are two high level drivers for developments in the cloud market. First, economies of scale can be vast in cloud computing. For example, public IaaS is fundamentally volume business. In this space, it can be expected that a handful of firms will increasingly dominate the market, as larger volumes will make them increasingly cost competitive. On the other hand, even in IaaS, one size does not fit all. For instance, various public sector services (e.g. healthcare) require that data is stored and processed within national borders ensuring a market for local players. Furthermore, there are multiple avenues for differentiation especially at higher levels of the value chain. For example, smaller firms can develop various professional services tailored to the specific needs of their customers.

Second, the cloud value chain is currently becoming increasingly fragmented by the emergence of smaller niche players. This is not only a direct result of general technological development that makes cloud offerings more diverse. More importantly, it is a result of technology that makes the development, deployment, and management of cloud services easier (e.g. through availability of public APIs, configuration and deployment management frameworks, etc.), which benefit from and facilitate the development of both de facto and de jour standards. As a result, the costs of coordination[2] are decreased, making it possible for smaller players to emerge instead of having most value chain activities internalized (or coordinated) by larger firms. Public cloud computing in itself represents a development in this broader space, as its emergence benefitted from the separation of cloud resource offerings from broader IT service offerings.

In the following review, we mainly emphasize the public cloud market[3]. This approach is undertaken because it is the most significant area that EASI-CLOUDS project seeks to shape. That is, by improving cloud brokerage and federation capabilities, both cloud service providers can obtain new distribution channels, and cloud service consumers can obtain new channels to obtain services. From the perspective of cloud service providers (IaaS/PaaS), data centre utilization, and hence cost efficiency, can be improved if excess cloud capacity can be sold off in a dynamic manner. While this can reduce smaller firm's cost disadvantages compared to larger firms, general the nature of cloud service provisioning as a volume business will remain unchanged. A more effective market for undifferentiated cloud services also means more price competition raising the question of how the benefits of higher data centre utilization rates will be divided between suppliers and consumers. However, if the cloud service provider has a well differentiated offering (e.g. data centres in a specific region), improved ways of doing cloud

[2] In a more general sense, transaction costs (Williamson, 1981; Coase, 1937)

[3] We acknowledge that private cloud represents a significant element in cloud computing particularly for larger firms. However, private cloud is based on exclusivity for one company. Hence, it does not form an inter-firm cloud resource market in the same sense as public cloud.

brokerage and federation may save the company's marketing and distributions costs when obtaining new customers with unmet needs. When looking at services higher in the cloud value chain, having easier access to lower level resources can have several advantages. For example, SaaS providers can save costs in selecting most suitable IaaS and PaaS providers. These benefits can result in customer value for example through lower prices, higher quality (e.g. less downtime), or through more versatile services (e.g. the possibility of selecting the location for data storage).

The EASI-CLOUDS project also addresses the private cloud market, as brokerage and federation can also be undertaken within organizations (e.g. between regional business units). Especially in the context of hybrid cloud computing, when user are looking forward to combine the best elements of private and public cloud computing, solutions enabling an efficient management and orchestration of different cloud offerings but also newer concepts like brokerage and federation might play an important role.

3.2 Summary of the general cloud computing market

Typically the cloud market is segmented into infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) and software-as-a-service (SaaS). The general pattern in these sub-markets is that their market size grows when moving up the value chain. That is, the SaaS market is considerably larger than for example the IaaS market. Similarly, direct price competition is more intense in the IaaS market, whereas the SaaS markets offer firms plenty of opportunities to differentiate. Despite the promise of public cloud computing, it is common for particularly large organizations to possess information that they simply are unwilling to place into public cloud. For example, a survey by RightScale reports that 58% of firms used both public and private cloud[4].

Public Cloud Computing. Figure 1 depicts Gartner's view on the main public cloud computing segments and their sizes and forecasts. The largest individual component of the cloud computing market is Cloud Business Process Services (BPaaS)[5]. It is debatable whether these services are actually a part of the cloud market[6], because the concept includes a rather open-ended inclusion of legacy systems and business process outsourcing as long as relevant parts are sourced from the cloud[7]. Depending on its inclusion, Gartner's estimates of the public cloud computing market reside between $35Bn and $75Bn for 2013[8]. IDC's estimates the public cloud market to be at $45.7Bn in 2013[9]. Forrester estimates the public cloud market to be $58 in 2013[10]. Both IDC and Gartner expect the public could market to roughly double in the next three years. These estimates were however mostly made before the widely publicized Snowden revelations regarding the NSA, which further fuelled concerns related to information privacy (see Section 3.5). Yet, while some more recent market estimates have been slightly revised down, the primary reason appears to be related to the macroeconomic situation.

[4] Source: http://www.rightscale.com/blog/cloud-industry-insights/cloud-computing-trends-2014-state-cloud-survey
[5] Future reports by Gartner also consider cloud advertising as a part of the public cloud services market with $677Bn revenue.
[6] For reference, the NIST definition of cloud computing: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
[7] Gartner's definition of BPaaS: http://www.gartner.com/it-glossary/business-process-as-a-service-bpaas
[8] Here we also exclude 'cloud advertising'.
[9] Source: http://www.gartner.com/technology/research/it-spending-forecast/
[10] Source: http://www.forrester.com/The+Public+Cloud+Market+Is+Now+In+Hypergrowth/fulltext/-/E-RES113365

Other research institutes have also given estimates on the sizes of the different cloud market segments. Hosting provider Parallellis estimates that the SaaS market for small and medium businesses was $14.5Bn[11] compared to Gartner's estimate of $16Bn for the entire SaaS market. Forrester, on the other hand, places the SaaS market at $47Bn in 2013. According to Gartner, the most significant SaaS segments in 2013 are CRM ($3.4Bn), ERP ($1.5Bn) and conferencing/team platforms ($1.8Bn), and these segments are expected to maintain their relative order also in 2016. Overall, North America is a clearly the largest market for public cloud services (Figure 2); It has been estimated that the West European market constitutes as little as about a quarter if its North American counterpart with Asia's combined modest market share being dominated by Japan. However, market growth in West Europe would also be significantly faster.

If BPaaS is excluded, most of the cloud market resides in SaaS. Analysts, however, seem divided between the revenue distribution between IaaS and PaaS: Gartner sees IaaS to be significantly larger ($9Bn vs. $1,6Bn in 2013), and that its dominance over PaaS would continue. Forrester also sees that IaaS dominates over PaaS ($5,6Bn vs. $4,4Bn in 2013), but that their order would change as early as 2014[12]. The variations in forecasts may reflect both the fundamental difficulty in predicting how a dynamic market will evolve, and differences in how key concepts are defined. Gartner expects the global SaaS market to grow at approximately 20% during the new few years, while growth in IaaS is above 40% and approximately 30% for PaaS [13].

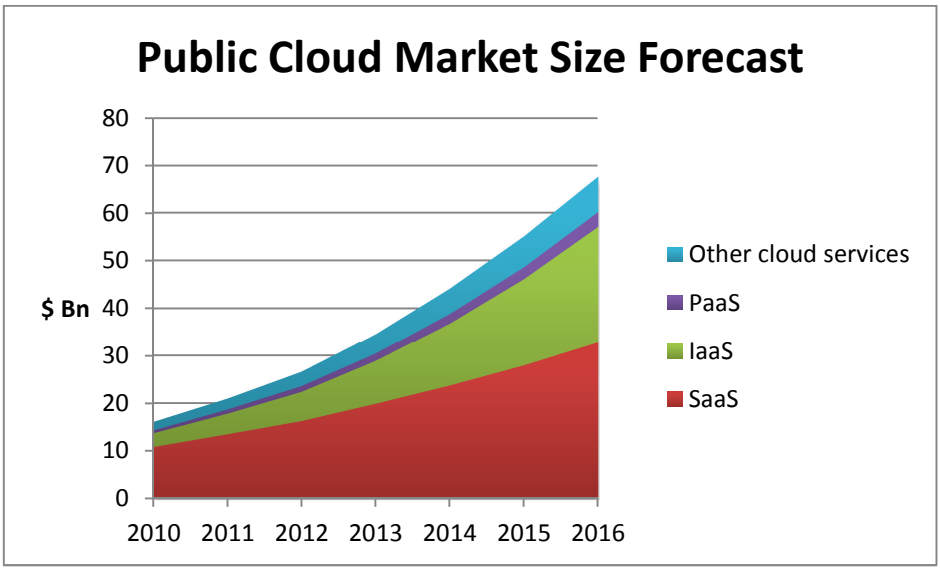


Figure 1: Estimates of main cloud computing segments (excluding BPaaS). Source: Gartner[14]

[11] Source: http://softwarestrategiesblog.com/2013/07/30/roundup-of-small-medium-business-cloud-computing-forecasts-and-market-estimates-2013/
[12] Source: http://blogs.forrester.com/stefan_ried/11-04-21-sizing_the_cloud
[13] Source: Gartner's Forecast Analysis: Enterprise Application Software, Worldwide, 2010-2016. URL: http://blogs-images.forbes.com/louiscolumbus/files/2013/02/public-cloud-forecast.jpg. Authors' calculations.
[14] Source: Gartner's Forecast Analysis: Enterprise Application Software, Worldwide, 2010-2016. URL: http://blogs-images.forbes.com/louiscolumbus/files/2013/02/public-cloud-forecast.jpg
4Q12 Update: 31 January 2013

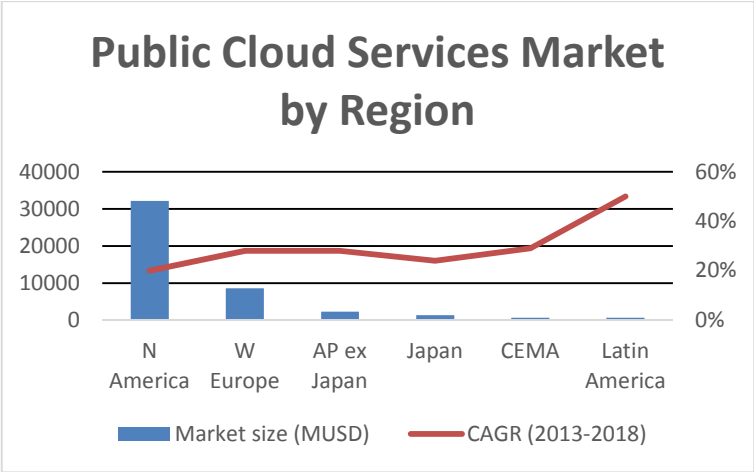


Figure 2: Geographical distribution of the public cloud market according to IDC[15].

Private and Hybrid Cloud Computing

Since the Snowden revelations private cloud computing is seen more and more as an option for business enterprises. In this context IDC expects the worldwide private cloud IT infrastructure market to grow from $12.3 billion in 2012 up to more than $22.2 billion in 2017[16].

As cloud consumers seek to combine the best elements of private and public cloud computing the market for hybrid cloud is going through the roof. Gartner forecasts that by 2017, half of large enterprises will have hybrid cloud developments[17]. The company also observes that in terms of aspiration and adoption, hybrid cloud is currently in a similar position as private cloud was three years ago. According to a new market research report MarketsandMarkets[18] is forecasting that the hybrid cloud market will grow from $21.27 billion by 2013 to $79.54 billion by 2018 which comprises a CAGR of 30.19 %.

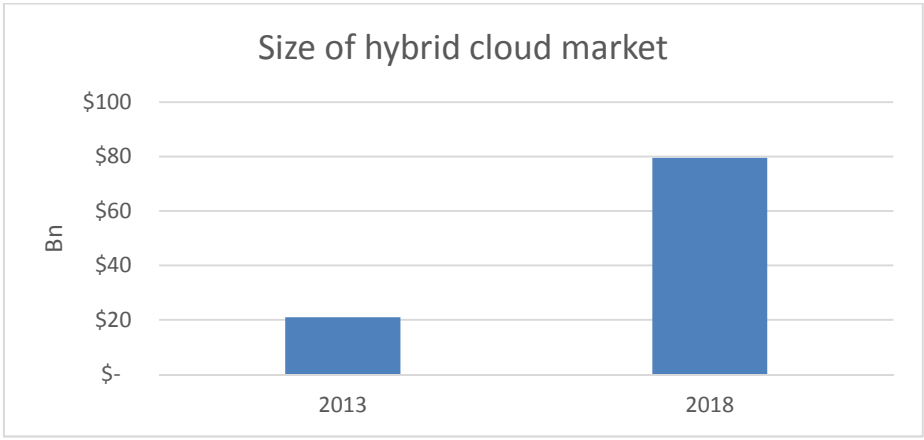


Figure 3: Estimates of the hybrid cloud market. Source: IDC and author's calculations [19]

[15] Source: http://www.idc.com/getdoc.jsp?containerId=prUS24977214
[16] http://www.idc.com/getdoc.jsp?containerId=240624
[17] Source: http://www.gartner.com/newsroom/id/2599315. Varying surveys of cloud vendors arrive at similar figures (e.g. RightScale http://www.rightscale.com/blog/cloud-industry-insights/rightscale-state-cloud-2013-new-industry-survey and Infosys http://www.infosys.com/newsroom/features/Pages/cloud-hybrid-adoption-survey.aspx)
[18] Source: http://www.marketsandmarkets.com/PressReleases/hybrid-cloud.asp
[19] Source: Gartner's Forecast Analysis: Enterprise Application Software, Worldwide, 2010-2016. URL: http://blogs-images.forbes.com/louiscolumbus/files/2013/02/public-cloud-forecast.jpg
4Q12 Update: 31 January 2013

Within the next years, strategic technology trends such as hybrid cloud deployments and diversified infrastructure integration will have a major impact on enterprises. Especially access to on-demand resource provisioning, coupled with in-house data security will drive the hybrid cloud market.

Conclusion
To give these numbers some more context, Gartner forecasts that total global IT spending in 2014 will be $3,75 trillion[20], while Forrester gives an estimate of $2,2 trillion[21]. In other words, public cloud services would be in the order of one or two per cent of total IT spending. Public cloud services also remain fragmented when looking at the whole market. However in IaaS/ PaaS it has been estimated that Amazon is the clear leader by having approximately one quarter market share, which is slightly more the three following competitors: IBM, Microsoft and Google[22]. The SaaS market is more fragmented because it addresses a broad range of user needs that are not in direct competition with each other. For example, Salesforce.com, a leading SaaS company, obtained revenues of $3Bn in its 2013 accounting period[23], which would give it a 18% market share in SaaS[24].

Taken together, the public cloud market as a whole poses good potential for new technology-based entries: there is strong growth, and new positions are opening up in the cloud value chain as the market matures and standards –whether formal or de facto– gain ground. Also even some of the strongest players in IT (e.g. IBM, Google, Microsoft) in have limited market shares in IaaS/ PaaS, while Amazon remains a clear leader as competition has picked up. Apparently the market has not fully consolidated into a pure volume business, and that new entrants may be able to differentiate through their offerings. On the other hand, the growing cloud services market constantly requires new enabling technologies and services that form an interesting opportunity on their own – both in the realms of public and private cloud.

3.3 A more detailed look at the cloud value chain

In this section, we provide a more thorough view on the cloud computing market by analyzing different parts of the cloud value chain in addition to IaaS, PaaS and SaaS. A value chain is a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market[25]. Value chain positions are commonly used to segment markets and analyze general competitive dynamics, such as market entries and exits. Adopting value chains as a lens provides a higher perspective on implications of the EASI – CLOUDS project, even though the project resides at higher levels of the cloud value chain.

When looking at the cloud market, it is important to acknowledge that it is not “fluid”, in the sense that any player in a given level of the value chain can freely transact with all entities below and above it. In other words, value chain positions are linked to each other through markets that

[20] Source: http://www.gartner.com/technology/research/it-spending-forecast/
Note: The estimate does not contain online consumer spending (e.g., ecommerce and apps).
[21] Source: http://www.computerworld.com/article/2491170/it-management/forrester-lowers-its-2014-global-it-spending-forecast.html
[22] Source: https://www.srgresearch.com/articles/microsoft-and-ibm-chase-amazon-while-google-falls-pace
[23] Source: http://www.sfdcstatic.com/assets/pdf/investors/AnnualReport.pdf
[24] Authors’ calculations using Gartner’s numbers (and making the simplifying assumption that all of Salesforce’s revenues come from SaaS)
[25] Porter, Michael E., "Competitive Advantage". 1985. The Free Press. New York.

are far from perfect[26], though the emergence of new firms in areas that were previously internalized by large players is taking place. For example, preferential access to large player's IaaS resources and data communication infrastructure are important market drivers. Second, the IaaS, PaaS and SaaS space witnesses frequent market entries from players that occupy other positions in the cloud value chain. For example, network service providers have been actively entering the public cloud market, i.e. they have vertically integrated into data centre operation and IaaS/PaaS parts of the value chain.

In the following, we review some essential positions in cloud value chain. Our view is focused on an end user, who is of non-technical nature, and is primarily a consumer of SaaS-based offerings[27]. Figure 4 depicts a summary of the value chain, which is discussed in the following.

Cloud-related business consulting services refer to a segment of management consulting services that are related to cloud business. Customers of these services are business decision makers who seek to exploit business opportunities related to cloud computing. Cloud business consulting services can include for example analysis of market entry strategies, the actions and positions of competitors, merger and acquisition opportunities, new production technologies, and product and service portfolio management. The focus on technology (including cloud computing) is on its business implications, and the resources and actions that are required to develop and exploit the technology, rather than how the technology actually operates.

Despite its long history, analysts reach varying results when sizing the global management consultancy market mostly due to differences in definitions. Estimates of the global market size vary between $ 95 Bn and $ 344 Bn[28] with market growth estimates ranging between 4-5%[29]. According to estimates, the management consulting market is dominated by the EMEA region and North America, which both have roughly the same size, and jointly occupy about 80% of the total market[30].

Cloud computing touches upon many areas of management consulting and to a varying degree. However, perhaps the most significant areas are strategy and operations. These segments are estimated to have revenues of 30 and 60 billion USD respectfully, with growth rates slightly higher than the general management consulting market (approx. 7%) [31]. Based on these figures and centrality of cloud computing related issues in these areas, the order of magnitude for the global market for cloud business consulting services is perhaps around $20-40 billion with the US market being a clear leader. However, the market for business consulting where cloud computing plays a central role is arguably smaller.

[26] A perfect market is a theoretical construct in economics that includes to, among other things, the free entry and exit of buyers and sellers, in addition to and perfect information for all transaction parties.
[27] Therefore, it should be noted, that the value chain might look very different from the perspective of e.g. a SaaS provider especially with respect to technical consulting services. It is also possible to decompose the value chain even further especially at its lower levels. Here we put more emphasis on higher value chain positions which are more relevant from the perspective of the EASI CLOUDS project.
[28] Based on Consultancy.uk's summary of various analyst reports. Available at: http://www.consultancy.uk/consulting-industry/global-consulting-market
[29] Ibid, and https://www.gartner.com/doc/2733920/market-share-analysis-consulting-services

[30] Source: http://www.consultancy.uk/consulting-industry/global-consulting-market
[31] Sometimes IT is also considered to be a segment of management consulting, however here we place it under IT consulting.

Significant players in the management consulting market include likes of McKinsey, Boston Consulting Group, Bain & Company ('the big three'), Accenture, and Strategy& (owned by PwC, formerly Booz & Company). Companies like Deloitte, PricewaterhouseCoopers, Ernest & Young and KPMG have significant management consulting operations despite being better known for their auditing and accounting services. Many firms that are better known from technology consulting also provide business consulting services, for example IBM, Microsoft, Atos, Thales Group, and Bull. The distinction between business consulting and IT consulting is naturally vague in many situations due to their close relatedness.

Cloud IT consulting services aim to inform managers on how to exploit cloud technology for business purposes. IT consulting can also include technical outsourcing services, such as custom software development, system integration, deployment and management, and vendor selection. The customers of cloud IT consulting services include both technical and non-technical managers.

Based on Forrester's market decomposition[32], we estimate that the global IT consulting market is roughly $400Bn. The subsegment of this market that addresses cloud-specific issues is often called cloud professional services. IDC estimates the size of this market to be $9.6 Bn in 2013 with CAGR of 24.8%[33]. The growth rate of this service category is hence about 5 times greater than what Forrester estimated for the IT market in Europe. The reader should however note that considering the broad adoption of cloud computing in IT, IT consulting services that have nothing at all to do with cloud computing are rare.

IDC views IBM and Accenture to be the leading cloud professional services firms. Major players include PwC, Infosys, Fujitsu, CSC, Microsoft, Dimension Data, Wipro, Cisco, and HP. In addition to PwC, Capgemini is the only European company in IDC's analysis of the top 13 vendors, which the firm categorizes as a 'contender' in terms of its capabilities and strategy. While the cloud professional services segment may not capture all essential parts of IT consulting that are related to cloud computing, the market is clearly US-dominated.

[32] Source: http://www.cmswire.com/cms/information-management/forrester-report-brighter-days-coming-for-tech-spending-018989.php. Author's calculations include 'Systems integration project work' and 'Custom-built software by contractors and consultants'.
[33] Source: http://planetic.es/sites/default/planeticfiles/content-files/private/IDC%20MarketScape.pdf

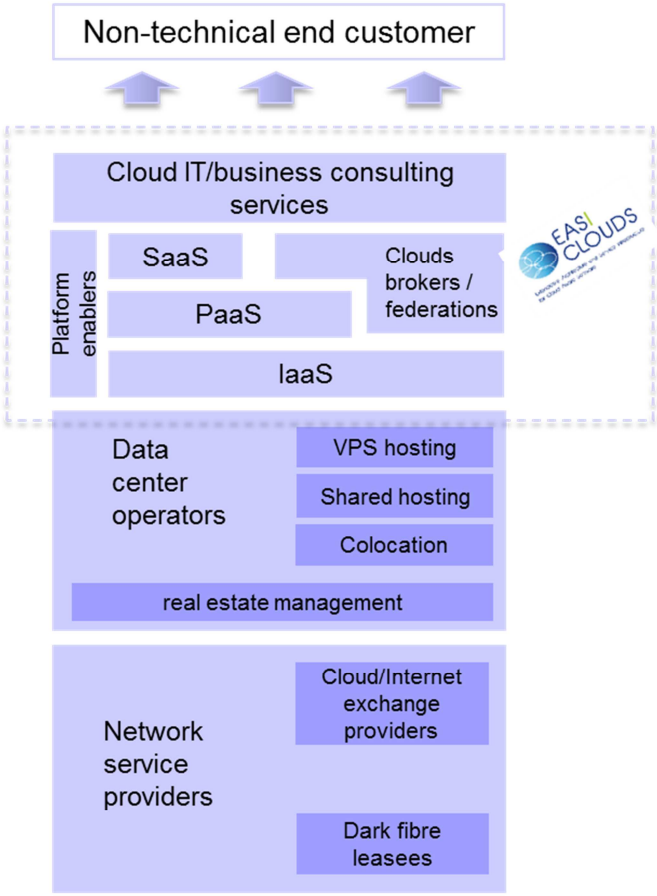


Figure 4: A simplified cloud value chain from a non-technical cloud consumer perspective with the focus of the EASI CLOUDS project highlighted.

Cloud brokerage. A cloud broker is an entity that manages the use, performance, and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers[34]. We provide a deeper overview into the cloud brokerage definitions and market in sections 3.6.1 and 3.6.3., and here we briefly summarize the market in the context of the broader cloud value chain.

Here we consider that cloud brokers to operate on IaaS and PaaS services, and provide services in two main categories. In service intermediation, a cloud broker enhances a given service by improving some specific capability and providing value-added services to cloud consumers. In service aggregation/arbitrage, a cloud broker combines and integrates multiple varying services into one or more new services.

In sections 3.6.1 and 3.6.3, we conclude that the market size estimates for cloud brokerage (from $1.6Bn currently up to $100Bn already in 2015) vary significantly mostly due to variations in definitions. If other value-added consulting services are excluded, the cloud brokerage market can also be sized by reviewing the market of public PaaS and IaaS markets. If, for example, we optimistically assume that a broker collects a 5-10% commission on 50% of all IaaS and PaaS transactions, the size of the brokerage market would be in the range of $500- 1 000 M (see

[34] Source: NIST (2011), URL: http://www.nist.gov/itl/cloud/upload/SP_500_293_volumeII.pdf

section 3.2 for figures on the IaaS and PaaS markets)[35]. This approach would also imply that after an initial growth period, the growth of the cloud brokerage market would converge on the growth rate of the public cloud market (primarily IaaS and PaaS), and that the same geographic distribution of revenue seen in the public cloud market would also reflect on the cloud brokerage market. However, if other forms of cloud-related consulting are included, the brokerage market looks significantly larger, and geographic differences (e.g. between Europe and the US) will likely be smaller.

Barriers of entry into cloud brokerage can be low when we consider the case of a human-delivered professional service. In essence, any IT service provider (e.g. telcos and IT consulting firms) can enter the cloud brokerage market almost unavoidably through customer projects that relate to cloud deployments. The situation is different for companies specializing in brokerage that deploy automated platforms. In their case, up-front investments into technology and marketing are required, and economies of scale will ultimately dominate especially less differentiated markets[36]. Cloud brokers with high volumes can also gain bargaining power over cloud suppliers and gain higher margins. Currently numerous companies are entering the cloud brokerage market[37].

Cloud Federation is the possibility for a cloud consumer to send a cloud request to multiple cloud providers as if they were a single cloud provider.[38] Cloud federation ('intercloud', 'cloud of clouds') enables cloud service providers to 'pool' together their data centre resources with the aim of being able to jointly offer more comprehensive and especially more flexible cloud resources to their customers. In this section, we briefly review the concept and provider a deeper market overview in sections 3.6.1 and 3.6.3.

Based on our review, London-based OnApp is currently the only significant commercial actor that operates a cloud federation (OnApp CDN and cloud storage). The company provides a software solution that enables cloud service providers to sell their excess cloud resources or obtain additional capacity from other users of the platform. The federation currently spans 170 locations in 113 cities across 43 countries[39]. The company also operates Cloud.net, which is a marketplace for resources in the federation.

Due to its nascence, it is difficult to estimate the size of the cloud federation market and how it will develop[40]. However, we expect that the number of "horizontal" cloud federations, i.e. federations that seek to compete directly with players like Amazon and Microsoft, will remain very limited due to strong network externalities[41]. However, it is likely that the market could support a higher number of "vertical" federations that address the special needs of certain industries. Potential entrants into cloud federation include other technology enablers (e.g. OnApp) and cloud integration service providers. In addition, small CSPs and public sector

[35] An alternative way to size that market would be to look at the total revenue involved in brokerage. In this case, however, we would need to assume that the broker is fully responsible for billing all cloud services from their customers. We believe that this approach would give the market size a misinformative upward bias.
[36] We see e.g. flight search engines as relatively similar business segment, where competition is primarily based on price and only a handful of players can exist on the market due to low margins.
[37] A useful list of cloud service brokerage companies is available at: http://talkincloud.com/cloud-services-broker/cloud-services-brokerage-company-list-and-faq
[38] This is a common definition adopted by the EASI CLOUDS project consortium.
[39] Source: http://onapp.com/federation/
[40] Especially, OnApp is a private company and its financial statements are not available.
[41] This is a similar case for airline alliances: having a very high number of them would defeat the benefits to member airlines. In other words, all things equal, a CSP gains more value by joining a larger federation than a smaller one.

entities have the incentive to form federations. We also see that there is also an internal latent market for federations in large corporations seeking to improve the efficiency of their distributed IT resources.

SaaS (software-as-a-service)[42] market can be segmented most clearly into enterprise and consumer markets. Like in the case of the software market as a whole, the consumer SaaS market represents a small fraction of the total market. The most important enterprise SaaS segments include CRM (customer relationship management), ERP (enterprise resource planning), and SCM (supply chain management). Gartner has forecast that the enterprise SaaS market in Western Europe in 2014 will be $4.2Bn, which represents less than a quarter of the global market of approximately $19Bn. It is also less than half of the US market[43].

SaaS is broadly considered the largest segment in public cloud computing in terms of growth and size and also the most differentiated one. PwC maintains a list of top companies in terms of SaaS revenue[44]. The leading firms in their listing include Salesforce.com ($2,7Bn), Microsoft ($1,4Bn), Intuit ($1,2Bn) ADP ($1,2Bn), SAP ($1,1Bn), Oracle ($1,0Bn), and Cisco ($0,8Bn). In addition to SAP, DATEV is the only company to make PwC's top 20 list from Europe with estimated $0.4Bn SaaS revenue.

A special category of SaaS is *SaaS aggregators* that create a value added service by combining a set of existing external SaaS offerings[45]. The set of services being aggregated is mostly fixed, and the number of possible services is low. SaaS aggregators can for example give users better control of their data, contracts, and billing that is spread out over several SaaS providers especially in enterprise markets (e.g. CloudConnect, Sigma Systems). On the consumer side, F-Secure's Younited service provides a common data management interface for many cloud storage and social media platforms in addition to cloud storage services hosted by F-Secure.

PaaS (Platform-as-a-Service)[46] market size estimates range from $1.6Bn (Gartner) to $4.4Bn (Forrester). Gartner estimates market growth to be approximately 25% in the next few years. Leading companies in PaaS include Amazon (e.g. elastic beanstalk), Salesforce (force.com), Microsoft (Azure), IBM (SmartCloud), Google (AppEngine), Redhat (OpenShift), Pivotal Software (e.g. CloudFoundry), CloudBees, and EngineYard. While the PaaS market is more differentiated than the IaaS market, its price dynamics have come to increasingly resemble those of the IaaS market.

[42] NIST (2001) defines SaaS as *"the capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings."*

[43] Source: http://softwarestrategiesblog.com/category/idc/

[44] Source: http://www.pwc.com/gx/en/technology/publications/global-software-100-leaders/saas-trends.jhtml

[45] In some cases, this may be considered a part of cloud brokerage. However, due the differentiated nature of SaaS, we distinguish between these two value chain positions.

[46] NIST (2011) defines PaaS as "the capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment."

IaaS (Infrastructure-as-a-Service)[47] market size estimates range from $5,6Bn (Forrester) to $9Bn (Gartner). Gartner places IaaS's growth at over 40% in the upcoming years.

In IaaS/PaaS it has been estimated that Amazon is the clear leader by having approximately one quarter market share, which is slightly more the three following competitors: IBM, Microsoft and Google[48]. The market is characterisable by its intense and accelerating price competition where double-digit price drops have been common recently. This has caused for example RackSpace to withdraw from the market, while companies like DigitalOcean, ProfitBricks and CloudSigma are trying to differentiate on usability particularly in SMB segments[49]. However, the declines in prices in IaaS should also be viewed in the context of decreasing hardware costs, which mostly follow Moore's law. In addition, economies of scale have enabled high margins for the leading players[50], meaning that there has been a high starting level for price-cutting. However, smaller cloud providers do not have these high margins, meaning that a shakeout is inevitable. Moving into value-added cloud brokerage services provides one viable option for these firms, as the costs of outsourcing IaaS supply becomes more profitable than managing data centres internally.

On the other hand, while IaaS is clearly a volume business, but its applicability is also clearly limited e.g. in several governmental sectors and also in many enterprise contexts due to data security and control issues. In essence, the IaaS market does not yet effectively serve all market needs, and we see more potential for vertical offerings in terms of region and industry (Figure 5).

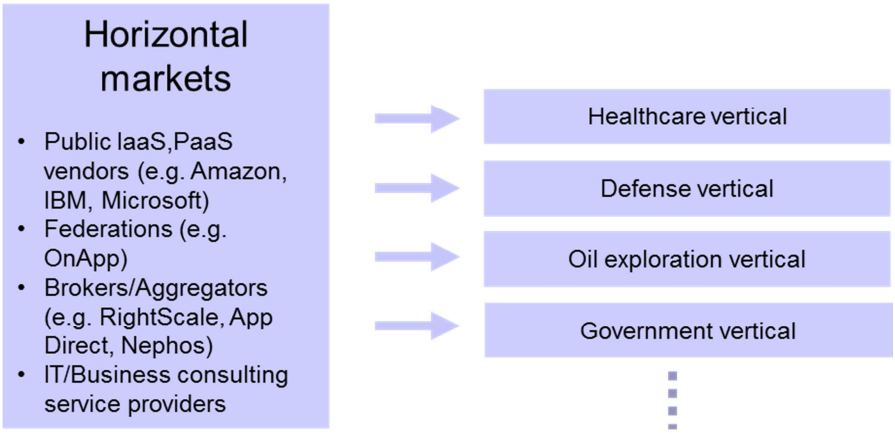


Figure 5: We expect that future cloud federations and brokers will increasingly focus on vertical markets as competition continues to intensify on horizontal markets despite efforts to focus on particular market segments.

Platform enablers are complementary software services that facilitate the development and provisioning of IaaS, PaaS and SaaS services. IaaS(/Paas) enablers include proprietary and open-source cloud computing software orchestration/virtualization platforms like OpenStack, vCloud, Hyper-V, Xen and Eucalyptus. PaaS enablers for example include e.g. proprietary infrastructure

[47] NIST (2011) defines IaaS as "the capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls)".
[48] Source: https://www.srgresearch.com/articles/microsoft-and-ibm-chase-amazon-while-google-falls-pace
[49] Source: http://www.forbes.com/sites/mikekavis/2014/08/08/how-niche-cloud-providers-compete-with-aws-google-and-microsoft/
[50] Source: http://venturebeat.com/2013/09/05/amazons-mountain-of-margin-in-cloud-services-over-80-profit/

Google App Engine and Azure platform software, and AppScale; and configuration management/orchestration platforms like Chef and Puppet. Platform enablers for SaaS form a diverse highly diverse group. Examples range from payment solutions (e.g. Avangate, Orga) to various broader ecommerce frameworks etc. and common APIs used in mashups (e.g. Goolge maps, Facebook comments).

The EASI CLOUDS project is primarily interested in the development and integration of platform enablers related to brokerage and federation. There are also various technology enablers lower in the cloud value chain (e.g. SDN), but given the focus on the EASI clouds project, this report does not examine them in detail. Sizing the market for platform enablers in this context is challenging because the revenue they create is predominantly realized in other parts of the value chain, of market segments are too emergent for existing analyses to cover them. For example, OSS is monetized by either selling a services that the OSS software enables (e.g. IaaS) or selling a diverse range of related consulting services. Direct licensing revenue is also only partially available. As individual exceptions from the virtualization market, VMware's license revenues are approximately $2.3Bn which is less than half of its total revenue[51]. Citrix, which also focuses on virtualization, reported $891M license revenues for 2013[52].

Data centre operators (and related) primarily manage (and own) data centres. Operating data centres is commonly internalized by IaaS providers (e.g. Amazon, Microsoft, Google, Rackspace etc.), and telcos and IT service firms represent a major groups that are strong players in this area in addition to several specialized 'carrier-neutral' firms (e.g. Telecity, Centurylink, Interxion, Zenium, Equinix).

While data centre operations and development are hotbeds of innovation both in terms of technology and business models[53] (e.g. SDN, SDDC, bare-metal clouds, total hardware solution providers etc.), we review this value chain position in less detail, because data centre operators are not core to the EASI CLOUDS project. Estimating a market size for data centre operators is difficult as data centre assets are typically monetized completely of partially by offering higher-level services in the cloud value chain. Colocation services form an exception, and Research and Markets estimates this market to be $26Bn with expected 11% CAGR for the upcoming years[54].

A related value chain position is *data centre real estate services* that includes providing data centre facilities to their customers, but do not manage the hardware inside the datacentres. Verizon Terremark is an example of a company that has its roots in real estate, but has gradually evolved into operating data centres. Digital Reality Trust , Dupont Fabros, CyrusOne, and CoreSite Reality represent major data centre real estate investment trusts that rent data centres to CSPs that prefer not to get involved in real estate ownership.

Network service providers (e.g. telcos, ISPs) provide various data communications services to their customers including CSPs. Gartner values this telecom services market in 2013 at $1600Bn in 2013 with expected growth of 2.1% for 2014 and 3.7% for the following year[55]. As special

[51] Source: http://ir.vmware.com/secfiling.cfm?filingID=1124610-14-8&CIK=1124610
[52] Souce: http://www.citrix.com/content/dam/citrix/en_us/documents/news/citrix-reports-fourth-quarter-and-fiscal-year-financial-results-2013.pdf
[53] Data Center Knowledge (http://www.datacenterknowledge.com/) is one of many news sites following recent developments.
[54] Source: http://www.reuters.com/article/2013/12/12/research-and-markets-idUSnBw126064a+100+BSW20131212
[55] Source: http://www.channelpostmea.com/2014/07/07/gartner-says-worldwide-it-spending-on-pace-to-grow-2-1-percent-in-2014/

segment of network service providers are *virtual network service providers* that do not own the necessary communications infrastructure, but rent of lease it from network service providers. An important function related to network service providers is *network exchanges* that interconnect different networks. This gives CSPs the ability to effectively transfer data between data centres and customers, which is also critical for brokerage or federation-based offerings. Equinix is an example of a company that both operates data centres and provides a vast range of interconnection capabilities.

In addition to telcos, *dark fibre lessors* own physical installed communications cables, but do not provide other communications infrastructure needed to transfer data over the cables. Instead, they sell rights to use the cables to network operators. Typical dark fibre lessors include telcos leasing fibre to other telcos (due to competitive regulation), and cities and municipalities. Data communications infrastructure is a valuable resource with limited supply that puts boundaries on entry opportunities in the otherwise largely fluid public cloud market. Specifically, the availability of communications infrastructure is an important factor when considering the viability of cloud federations, as information needs to flow effectively between the members of the federation and the customers of the federation.

3.4 EASI-CLOUDS partners and the cloud value chain

In this summary section, we wish to highlight that the business opportunities that the EASI-CLOUDS project touch upon are not only directly related to cloud brokerage and federation; technologies and knowledge that can be used to build brokerage and federation functionalities can also be applied in other contexts as well. However most importantly, the value of brokerage and federation is often realized on higher levels of the value chain, e.g. in SaaS or consulting levels.

In order to map the areas where the EASI-CLOUDS project has aided partner organizations on the cloud market, we conducted an internal survey among the project partners. The responses are summarized in Table 1 along with a summary of market estimates from the review in section 3.3. EASI-CLOUDS industrial partners are generally well-represented on all levels of the cloud value chain, and hence we list only new developments. The table highlights that the EASI-CLOUDS project has helped project partners to enter valuable markets in terms of growth and size, or enhance their current positions in them.

Table 1: Summary of markets along the cloud value chain and the impact of EASI-CLOUDS on industrial partners' offerings.

Partner	Market size estimates (Bn USD)	Growth	Examples of partners whose existing position was enhanced by EASI-CLOUDS	Examples of partners where EASI-CLOUDS enabled new entries
Cloud-related business consulting services	20-40	>10%	Gearshift	Orga
Cloud IT consulting services	9.6	24.80%	Leonidas	Orga
Cloud brokers / federations	< 1	>50%	Atos, Bull	Materna
Platform enablers (e.g. cloud billing)	n/a	n/a	Bull	Materna, Orga
SaaS	19-47	20%	F-Secure, Kolor	Orga, Atos
PaaS	1.6-4.4	25%	Atos	Materna, Thales
IaaS	5.6-9	40%	Thales	Materna
Data centre operators (and related)	> 26	11%		
Network service providers (and related)	1600	2.1%	Thales	

3.5 Future trends in the cloud computing market

Apart from the forecasted growth rates of different cloud computing segments, industry analysts have identified several trends that are likely to impact the market of cloud computing. In the following, we provide an overview of these trends[56].

Increasing awareness of information security issues

Even prior to the NSA revelations of Edward Snowden in June 2013, there were privacy concerns relating to the US Patriot Act and the use of US-based cloud service providers in Europe. Yet, the Snowden revelations raised these concerns to a completely new level. On the other hand, industry sources have pointed out that legal guards on data privacy are not better in the EU than the US[57], and it now appears that the US is taking the lead in making government-based data request more regulated and transparent. The EU is also pushing ahead with a major overhaul to its Data Protection Directive[58]. It also appears that US-based companies have

[56] The way of organizing these trends does not indicate their degree of importance/ relevance.
[57] Source: http://www.continuitycentral.com/news06514.html.
[58] Source : http://www.europarl.europa.eu/news/fi/news-room/content/20130502BKG07917/html/QA-on-EU-data-protection-reform

stepped up efforts to build data centres in Europe[59]. European Telcos have also launched initiatives to keep customer data within national borders[60].

Right in the wake of the incident, it was estimated that the US cloud computing industry will lose about $22Bn to $35Bn of revenue during the next three years due to the Snowden revelations[61]. Considering that the cloud market is rapidly growing, losing market share may have very long-term implications. It is still too early to assess the net effect of these trends on the cloud market. The Snowden revelations will be remembered in history as a game changer that returned at least a healthy level of cautiousness to cloud services, which was perhaps temporarily suppressed by technological optimism. While they may not significantly slow the development of cloud computing, they certainly have changed how decision-makers view cloud security issues.

The importance of hybrid cloud computing will increase[62]:
Hybrid cloud computing environments are becoming more and more important due to their higher flexibility, which is largely needed to meet the changing business demands. This trend has been raised before the Snowden revelations and we assume that the public part in the concept of hybrid cloud computing will decrease, especially in Europe. This trend has been verified by the market figures that have been provided by several analysts.

Formal decision frameworks are needed for cloud investment optimization[63]:
This trend addresses the important aspect of a transparent value creation from the perspective of the cloud consuming company. Cloud computing dominates the discussions with its ever expressed arguments of cost reductions and higher flexibility compared to traditional IT concepts. More and more companies are mistrusting these standard arguments and therefore ask for objective proofs. Objective and formal decision frameworks will be needed enabling companies to evaluate and compare different cloud computing offerings in terms of their benefits (e.g., lower costs and risks, higher flexibility) and challenges (e.g., security, lack of transparency). These will facilitate the decision for cloud computing investments. With respect to new concepts like cloud federation and cloud brokerage these formal decision frameworks have to be extended regarding different perspectives:

- From the perspective of cloud consumers: A decision framework should be able to reveal the benefits a cloud consumer might be able to experience when using the offering of a federating cloud provider. The offering of cloud services via a brokering platform will result in some parts different benefits for the cloud consumer.
- From the perspective of cloud providers: A decision framework should be able to support setting up of a federation and help them provision their offerings via an independent brokering platform. The costs for setting up the federation or for using the cloud brokering platform as well as the effect on the utilization rate of their cloud services are for instance important criteria among others.

Applications have to be developed with respect to cloud-centric design principles[64]:
In order to exploit the full potential of cloud computing, applications should not just migrate to the cloud, they need to be designed with respect to the special characteristics, opportunities and

[59] Source : http://blogs.wsj.com/cio/2014/06/05/snowden-effect-clouds-u-s-it-one-year-later/
[60] Source: http://www.techweekeurope.co.uk/comment/european-telcos-protect-customers-nsa-134843
[61] Source: http://www2.itif.org/2013-cloud-computing-costs.pdf.
[62] Source: http://www.gartner.com/newsroom/id/1971515.
[63] Source: http://www.gartner.com/newsroom/id/1971515.
[64] Source: http://www.gartner.com/newsroom/id/1971515.

limitations of cloud computing in mind[65]. Bearing in mind a federation as well as the brokerage approach, additional requirements might have to be taken into account when designing cloud based applications.

Cloud computing will evolve from a one-to-one relationship to a one-to-many ecosystem[66]:
Particularly for small and midsized enterprises cloud federation will become an elementary aspect of their strategy, where cloud providers, cloud insurers, broker services, and other cloud organizations will enjoy and especially offer combined operational and financial benefits of cloud.

Cloud brokerage as door opener for eased cloud consumption[67]:
The cloud computing adoption is increasing quickly. As a result the need for special assistance for using cloud computing offerings is also rising. Intermediaries like cloud service brokers (CSB) are more and more needed to bring cloud providers and cloud consumers together or at least guide the latter during their decision phase. It is expected that this trend will accelerate and more and more CSB will enter the market.

Software-defined datacentre are becoming more important[68]
As a consequence of the increased relevance of private and hybrid cloud computing software-defined datacentre are increasing in relevance. In a software-defined datacentre all elements of the infrastructure network, storage, CPU and security) have been virtualized and will be provided as service. Usage, provisioning, configuration and operation are completely separated from the hardware level and will be realized via software. Integral to this trend are software-defined storage and networks, as well as compute virtualization[69]. Software-defined datacentre enable cloud provider to provide cloud services much faster and cost efficient[70].

Cloud orchestration and multi-cloud management solutions are increasing in relevance
Due to a study by Technology Business Research Inc. (TBR) 70% of the companies are looking forward to adopt cloud orchestration services[71]. Main arguments driving the adoption are the additional workload, the general trend in the direction of hybrid clouds, the increased volume of purchased cloud services and many cloud services are not providing the promised efficiency. Experton group is mentioning that more and more cloud management software is going in the direction of multi-clouds orchestration[72].

[65] Here somehow are the same principles valid like for 3 dimensional (3D) movies that have entered worldwide cinemas. Every cinema enthusiastic persons would say that movies that are converted into 3D after the image capturing process are not as good as movies that are directly captured in 3D and therefore provide a much better 3 dimensional experience for the end user.
[66] Source: http://midsizeinsider.com/en-us/article/cloud-computing-federation-is-the-futur.
[67] Source: http://www.gartner.com/newsroom/id/1971515.
[68] Source: http://www.idc.com/getdoc.jsp?containerId=IDC_P10884
[69] Source: http://www.tecchannel.de/server/cloud_computing/2062229/so_klappt_der_aufbau_eines_software_defined_data_center/index.html#
[70] Source: http://www.tecchannel.de/server/cloud_computing/2062229/so_klappt_der_aufbau_eines_software_defined_data_center/index.html#
[71] Source: http://www.prweb.com/releases/2014/03/prweb11663026.htm
[72] Source: http://blog.experton-group.de/2014/10/01/cloud-vendor-benchmark-2014-cloud-management-orchestration/

Cloud computing landscape is changing at pace[73]

Cloud computing market is characterized by high competition and a high mergers and acquisition dynamic. Therefore, it is important for cloud consumer to choose their cloud provider wisely. This trend indicates that there is a high need for cloud consumer to adopt very flexible cloud management solutions (see previous trend) that help cloud consumer to reduce their business risk and flexibly adapt to new circumstances.

Recent M&A activities have gone through the press like Cisco's acquisition of Metacloud, HP's acquisition of Eucalyptus, IBM's acquisition of SoftLayer, Atos' acquisition of Bull, CenturyLink's acquisition of Savvis' and Verizon's acquisition of Terremark[74].

3.6 Market insight into cloud federation and cloud brokerage

Besides the omnipresent security aspect of cloud computing, interoperability of clouds has been identified by experts as one major driver for the success of cloud computing. The potential of interlinking clouds of various cloud providers for different purposes offers many advantages for cloud providers and cloud consumers. One example is the potential for cloud providers to sell their unused cloud capacity to other cloud providers that have a shortage of could capacity. Due to this development the terms "cloud federation" and "cloud brokerage" have entered the cloud computing discussion. Before going into details on the market figures with respect to these types of services, definitions will be given, which will be the basis for our further discussions.

3.6.1 Definition of cloud federation and cloud brokerage

Cloud federation and cloud brokerage have both been discussed and analysed within many different publications (research papers as well as commercial studies). Varies definitions are available. Based on an analysis of different definitions we have provided the following definition for cloud federation within the previous deliverable (D1.3)

> ***Cloud federation*** *is the possibility for a cloud consumer to send a cloud request to multiple cloud providers as if they were a single cloud provider.*[75]

Other terms used in the context of federation are "cloud of clouds" and "intercloud" Especially intercloud is becoming more and more relevance since Cisco's announcement. Nevertheless they have the same meaning.

For cloud brokerage we agree with the following definition.

> *A* ***cloud broker*** *is an entity that manages the use, performance and delivery of cloud services, and negotiates relationships between cloud providers and cloud consumers*[76].

From this perspective, cloud federation cannot exist without at least some members of the federation somehow carrying out the technical function of a broker, possibly jointly or individually.

[73] Source: http://blog.experton-group.de/2014/10/01/cloud-vendor-benchmark-2014-cloud-management-orchestration/

[74] Source: http://www.networkworld.com/article/2684801/cloud-computing/what-is-metacloud-and-why-did-cisco-buy-it.html

[75] This definition has been developed by the EASI-CLOUDS consortium.

[76] Source: http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf.

In this report it is stressed that both cloud federation and cloud brokerage have slightly different meanings depending on whether they are viewed from a business model (or organizational) perspective or a technical perspective. The contrasting view emerges from the business model perspective, whereas from a technical perspective, the ability to broker is one necessary requirement of federation. In the following section, we look a bit deeper into the business model perspective.

3.6.2 Different ways of organizing federation from a business perspective

From the technical perspective, the central act of simplifying transactions between a multitude of cloud consumers and cloud providers is cloud federation, and cloud brokerage is one necessary technological capability of accomplish this. While we divorce "organizing" from the concepts of federation and brokerage, it remains highly relevant in different ways of doing business in the cloud.

Depending on how the activities relating to federation are divided between different organizations or actions, a variety of business models may emerge. One way of categorizing these business models is to view them more or less as "broker-driven" or more or less "federation-driven".

In **federation-driven business models** there is deeper collaboration between the involved cloud suppliers (that share cloud resources and hence form the federation). For example, members of a cloud federation may sign a joint federation-level-agreement (FLA) instead of bilaterally signing a multitude of different contracts between the cloud suppliers in the federation. The FLA generally creates a longer-term and more reciprocal relationship between its members than could be expected from a purely free market transaction perspective. The technology that the cloud federation uses internally to share resources can vary between peer-to-peer and centralized approaches.[77]

In what we call **broker-driven business models** there are no constraints on how the cloud broker communicates with each separate cloud provider[78], or whether there are special contractual relationships between the cloud broker and any of the cloud suppliers. Notably, also in broker-driven business models, no assumptions are made about the ownership or control of the entity carrying out the brokering activities. It is hence possible for a group of cloud providers to set up a common (external) cloud broker in order to participate in the cloud market more efficiently, or the broker may be a completely separate business entity from all of the cloud suppliers[79] [80].
OnApp, the pioneering cloud federation, is mostly a broker-driven business model: The company is the central coordinator of the federation through providing cloud orchestration platform that its users to federate their resources.

[77] One example of a federation-driven business model from outside cloud comptuting are alliances between different airlines (e.g., Star Alliance). Within these alliances all participating airlines share their resources, flights between different destinations, which can be booked via the reservation platform of each alliance member. A prerequisite for this is the signing of a special contract which clarifies the terms and conditions of the alliance.
[78] If there is a common standard in use in how to technically send cloud requests to cloud suppliers, the form of cloud brokerage may be called "non-cooperative cloud federation".
[79] To compare our terminology with some external sources, we understand Gartner's "cloud service brokerage" as federation that emphasizes a kind of broker-driven business model.
[80] An example from outside cloud computing would be the stock exchanges. Stock exchanges themselves may be publically traded companies, i.e. the firms that are being traded on the stock exchange may be joint owners of the stock exchange themselves.

3.6.3 Market figures on cloud federation and cloud brokerage

Bearing the definitions of cloud federation and cloud brokerage in mind, several reports were reviewed in order to inform the readers about the financial dimension of cloud federation and cloud brokerage that might be realized in the near future.

Over the years the cloud service brokerage (CSB) market, which comprises the cloud service brokerage and enablement market, has evolved. Cloud brokerage enablement refers to integration platforms which enable other companies to become cloud services brokers. Both markets have been described and segmented separately. The market is structured by the two types[81]:

(1) **Internal and external cloud brokerage enablement**, which is further split into telecom service providers, system integrators and independent service vendors (ISVs), resellers and distributors, hosting and cloud providers. All the named sub-segments are further segmented by geographies comprising North America (NA), Europe and Middle East Africa (EMEA), Asia Pacific (APAC) and Latin America (LA).
(2) The other market, the **cloud brokerage** market, consists of market players who use the enablement platforms as brokers and serve businesses of all sizes regarding their cloud-based needs. This market is structured by type of service consumers. The cloud brokerage market differentiates between small and medium businesses (SMB) and enterprises. The market is also segmented by geographies comprising North America (NA), Europe and Middle East Africa (EMEA), Asia Pacific (APAC) and Latin America (LA).

The market research company MarketsandMarkets expects in their report from March 2013[82] that the global cloud service brokerage market is going to expand from $1.57bn in 2013 to $10.5bn by 2018. This represents a compound annual growth rate (CAGR) of 46.2% from 2013 to 2018. The report forecast the cloud brokerage enablement market to grow at a CAGR of 55.3% from $225.42M in 2013 to $2.03Bn by 2018. Within this reports, they have identified 46 companies that are active in the market of cloud brokerage as cloud brokers or at least as enablers[83].

Gartner expects the cloud service brokerage market to be the fastest growing segment in the overall cloud computing market and to be worth over $100Bn by 2015[84]. Darryl Plummer, Chief Analyst of Gartner, predicts a hundred billion dollar opportunity and that the market for cloud service brokerage will soon be highly fragmented by hundreds of providers. According to Plummer[85],

> *"by 2012, CSBs will represent the single-largest category of growth in cloud computing, moving from a sub-$1 billion market in 2010 to a composite market counted in the hundreds of billions of dollars. By 2013, the CSB vendor landscape will have grown from dozens to hundreds of providers."*

[81] Source: http://www.researchandmarkets.com/research/qk53dw/cloud_brokerage.
[82] Source: http://www.marketsandmarkets.com/PressReleases/cloud-brokerage.asp.
[83] Source: http://www.marketsandmarkets.com/Market-Reports/cloud-brokerage-market-771.html.
[84] Source: http://www.nbtequitiesresearch.com/report/cloud-brokers-make-the-cloud-fit-for-enterprise-requirementsmakes-verecloud-interesting.
[85] Source: http://de.slideshare.net/stevecrawf99/cloud-services-brokerages-evaluating-the-business-case.

So far, only two reports are available providing dedicated market figures for the cloud service brokerage market. Other sources mentioning market figures always reference these two reports provided by Gartner and MarketsandMarkets. This unavailability of additional market figures indicates that the market for cloud brokerage is still in its youth. This view is supported by Gartner's hype cycle on cloud computing which describes the concept of cloud service brokerage still as an emerging concept/ technology[86].

Nevertheless, the figures also indicate that there is still a high degree of uncertainty regarding the overall market volume. MarketsandMarkets predicts a market volume for cloud brokerage of $10.5bn by 2018, whereas Gartner forecasts that cloud brokerage services will reach a volume of more than $100bn until 2015. This is ten times more than what MarketsandMarkets predicts (although the years cannot be directly compared). In addition, comparing especially Gartner's figures with the general figures for cloud computing, it can easily been seen that in 2015 the forecast for cloud brokerage over-exceeds the predication for the general cloud computing market. This might be the result of a general (partial) overlap of both market considerations or due to different underlying assumptions for both markets.

Dedicated market figures on cloud federation are not available. From our perspective, the reasons for this situation are manifold:

- Direct offerings following the concept of cloud federation are not present at the market.
- In order to be able to estimate the market potential for cloud federation, it is necessary to have more information about the utilization rates of cloud providers. This would enable drawing an estimate on the excess capacity that CSPs might be willing to sell on the market by participating in federations. Utilization rates are however trade secrets that CSP are usually unwilling to reveal, which means that reliable estimates are also not available.
- The terminology of cloud brokerage is more common in the cloud computing market than cloud federation. As mentioned in our definitions section the concept of cloud federation relies on at least some members of the federation carrying out the technical function of a broker. Therefore, we can assume that cloud federation is already included in the market figures of cloud brokerage.

As federation is about the efficient combination of several clouds/ cloud provider the management/ orchestration of such multi-clouds or cloud of clouds is an important element in this context as it helps cloud consumer to find their way through the manifold offerings of different providers and to integrate them efficiently in their respective business processes.[87] In this field of cloud management/ cloud orchestration there do exist a few market figures which can be used as an indicator for cloud federation at least. IDC for instance mentions that the cloud management system market reached a size of $1.8 billion in 2013 and will grow up to $5.8 billion in 2018 which comprises a CAGR of 26.6 %[88]. Furthermore they say that most successful vendors have to offer cloud consumers full suite of automation, orchestration, monitoring as well as analytics optimized for managing heterogeneous hybrid cloud environments. There will be several innovations like real-time cloud service brokering and analytics which help customers to improve their application portability[89].

[86] Source: http://clouduser.de/news/gartner-veroffentlicht-cloud-computing-hype-cycle-2012-14056.
[87] Source: http://searchcloudcomputing.techtarget.com/news/2240188111/Using-multi-cloud-management-software-to-juggle-cloud-providers
[88] Source: http://www.idc.com/getdoc.jsp?containerId=247607
[89] Source: https://www.vmware.com/files/pdf/management/idc-cloudsystems-mgmt-vendor-shares-copy.pdf

3.6.4 Key aspects in brokerage and federation

As cloud federation and cloud brokerage are newer concepts we will summarize different experts' view in a first step.

Cloud brokerage		
Author / Expert	**Key aspects**	**Market growth assessment**
Lauren Ellis Sep. 2014	- "Cloud Service Brokers Emerge As Cloud Computing Skyrockets" (Quote of Lauren Ellis) - The main basis for the value a Cloud Broker can provide is its huge cloud computing knowledge and market experience. He can help companies to set up and implement cloud infrastructure and to customize solutions efficiently.	positive
Chris Preimesberger [90] May 2014	- Cloud consumers have a high demand for solutions helping them to efficiently manage on-premises systems, private clouds and multiple public cloud environments, as those increase complexity. - The mention 10 reasons why they believe that the cloud-service brokerage market will grow significantly. o Better (Single) interface to several offerings; Ease of use o Finding new services, support and troubleshooting, simplified deployment (Guidance) o Comparison shopping (increased transparency) o Lower costs due to negotiation power of the broker	positive
CFO Appservice[91] May 2013	- Trend at large enterprises: IT departments will take on more responsibility and adopt the role of cloud brokers - Trend at smaller enterprises: the role of cloud service brokers will rise	positive
David Morrison, Huawei's Global Director for Managed Services	The evolution of cloud service brokerage - CSB will help enterprises select, manage and coordinate the multiple services - CSB will become a premium service offering for sophisticated service providers - The aim of cloud brokerage is to help companies consume cloud-based business functionality and data more easily and effectively - CSB will mature quickly	positive

[90] Source: http://www.eweek.com/cloud/slideshows/10-reasons-cloud-service-brokerages-are-seeing-solid-growth.html

[91] Source: http://www3.cfo.com/appservices/article?pid=004c6607-a6d6-4c2c-8f05-cf8fd6cc5f0d.

Cloud & IDC[92] Sep. 2012		
Peter Leichsenring, Sales Director of Central Europe at Cordys[93] May 2012	- Cloud brokerage offers companies new possibilities - Cloud broker combines Software-as-a-Service with Infrastructure-as-a-Service to establish and host software - Solution of the broker can be supplement by advice on specific requirements of the customer - Companies at all sizes profit from the cost-saving cloud services	positive
Daryl Plummer; Gartner, Inc.[94] March 2012	<u>Aim of cloud service brokerage:</u> - Individual service for companies - Integration or aggregation of services to enhance security - Adding significant layers of value (i.e., capabilities) to the original cloud service offering <u>Reasons for cloud service brokerage:</u> - Valuable cloud services because of close collaboration with cloud providers - More experience working with multiple providers and many consumer scenarios - CSB provider can make it less expensive, easier, safer and more productive for companies to navigate, integrate, consume and extend cloud services	positive

Cloud federation		
Author / Expert	**Key aspects**	**Market Growth Assessment**
Dell[95] June 2014	- Cloud consumers prefer the interaction with one cloud provider from end to end - Today's reality is, that most cloud consumers have to interact with more than one cloud provider - The cloud market is still in its early stage, but we can be sure that their will take place a consolidation process which will make the use of cloud computing much more	positive

[92] Source: http://www.huawei.com/cl/static/HW-193390.pdf.
[93] Source: http://www.zdnet.de/41562523/der-aufstieg-der-cloud-broker/.
[94] Source: http://www.forbes.com/sites/gartnergroup/2012/03/22/cloud-services-brokerage-a-must-have-for-most-organizations/.
[95] Source: http://www.bitpipe.com/detail/RES/1401305624_399.html

	easier.	
Paul Burns[96] June 2014	- Cloud Federation is not a dream anymore, it has become reality (Cisco and HP are working excessively on federation and OnApp is already live with its federation). - Cloud Federation provides cloud consumers the chance to consume a set of cloud services from multiple providers via one channel. - Cloud Federation strengthen the market position of cloud providers sustainably.	positive
Marco Meinardi[97] May 2014	- Cloud Federation prevents cloud providers from differentiation. - They see 13 challenges in terms of cloud federation. - Especially the loss of revenue as well as the commoditization are seen very critical by the author.	negative
Beth Pariseau [98] July 2013	- The manifold cloud offerings force cloud consumers to use multi-cloud management software to jungle cloud providers	positive
Dragon Slayer and Marc Staimer[99] Feb. 2013	<u>Pros associated with federated clouds:</u> - Reduced on-site and local storage costs for vast amounts of passive data - Much faster on-site/local response times to the more active parts of the passive data - Enhanced disaster recovery for all the passive data moved to the public storage cloud - Shorter times to share data requiring geographic distribution - Ability to leverage multiple public cloud storage providers <u>Cons associated with federated clouds:</u> - Limited compatibility between cloud storage software providers and public storage cloud service providers - Management information and control between private cloud storage software and public storage clouds is typically limited - Works much smoother if the software is from the same vendor for both the private and public storage clouds	neutral

[96] Source: http://www.neovise.com/cloud-federation-dream-or-reality
[97] Source: http://www.flexiant.com/2014/05/02/federation-vs-differentiation-debate-rears-its-head-again/
[98] Source: http://searchcloudcomputing.techtarget.com/news/2240188111/Using-multi-cloud-management-software-to-juggle-cloud-providers
[99] Source: http://searchcloudstorage.techtarget.com/video/Federated-clouds-A-private-public-option-that-requires-some-DIY.

Michael Poulin[100] Feb. 2013	- Cloud federation forgets about the end-consumer and the contract conditions between the end-consumer and the cloud service provider - There is nothing wrong technically with cloud federation; but contractually or legally, there exists a serious problem - Cloud federation is far from conduction effective business in the clouds	negative
Scott Sanchez,[101] Jan 2013	- Users want cloud providers who offer their resources to them that are ready to buy - Users want to be able to obtain the cloud resources they need quickly from their "home" provider or broker (regardless who the seller might be)	positive
Intel[102] Oct. 2012	- Cloud computing services must become more federated and automated to help enterprise IT use them to deliver more for less - Therefore, companies need more flexible and responsive cloud computing services because of their limited IT budgets - If cloud services become more federated, it becomes easier for users to deploy the right applications on the right platforms - One major advantage of a federated cloud is that enterprises can select cloud services from different providers to host different workloads, rather than buying cloud services from a single supplier and hosting all their apps on them - Better federation, automation, standards and interoperability are crucial for cloud computing services to be successful and for users to get the most from them	positive
Ditlev Bredahl, CEO of OnApp[103] Sept. 2012	- Connection of local infrastructure providers to a global marketplace that allows each participant to buy and sell capacity on demand - Small service providers can offer a global service when their capacity in the data centre is small (additional source of revenue) - End users can choose a local provider and still receive access to as much local or global IT resources as they need without the pressure to manage multiple providers and invoices	positive

[100] Source: http://www.ebizq.net/blogs/service_oriented/2013/02/a_dead-end_of_the_cloud_federation_business_process.php.
[101] Source: http://www.scaleupcloud.com/2011/cloud-federation-is-coming/.
[102] Source: http://www.computerweekly.com/news/2240168915/intel-cloud-must-be-more-federated-and-automated.
[103] Source: http://www.datacenterknowledge.com/archives/2012/09/17/federation-is-the-future-of-the-cloud/.

John Joyner, Senior Architect at ClearPointe Feb. 2012	- He sees no activities among the largest public cloud providers like AWS and Rackspace to work on interoperability standards. - There is definitely a need for cloud federation - Cloud federation helps cloud providers to prevent outages from their services which provides cloud consumers more stability - Main value arguments of dedicated providers in the field of cloud federation are the increase of confidence and the risk reduction in cloud scenarios.	positive
IBM[104] May 2012	Partnering in the cloud and federated cloud - Cloud providers partnering with other providers to enhance their service and provide best-in-class solutions (provides an array of computing and communication capabilities) - The main aim of cloud partnering is the provisioning of capabilities - A more efficient and effective union is a federated cloud - Federated cloud: closer relationship between the provider than a simple partnering because the boundaries between the clouds are removed - Federated cloud can bring private, public, and other hybrid clouds together - Federated cloud is the organization and administration of multiple external and internal cloud computing services - Federated cloud is the most effective expression of the hybrid cloud	positive
Gugh Tonks[105] Oct. 2011	<u>Challenges of cloud federation:</u> - Two issues must be overcome: mutual mistrust, and technical discontinuity - Heterogeneity makes federation of cloud difficult <u>Advantages of heterogeneity:</u> - Increases flexibility and choice - Variation of cloud features and behaviours - Different range of performance levels - Pricing differentials - Competition and cooperation - Possibility of a rich cloud ecosystem	neutral

[104] Source: http://www.ibm.com/developerworks/cloud/library/cl-hybridcloud2./
[105] Source: http://blogs.citrix.com/2011/10/10/cloud-federation/.

3.7 Survey on leading cloud bloggers

A small survey conducted by Atos and Gearshift analysed the general awareness of cloud experts for cloud federation and cloud brokerage and their opinions in which terms these concepts are providing value to cloud consumers and cloud providers.

A group of cloud experts was targeted that either belong to the Top 100 cloud bloggers that have been mentioned and gathered by Vala Afshar or are otherwise active as cloud bloggers with a profound technical experience. These bloggers are leading cloud advocates and experts, that are actively sharing their views on social networks (Twitter, Facebook other blog[106][107]). The list consists of industry analysts, chief executives - including CEOs, CTOs, and CIOs, journalist, authors and keynote speakers, who are not tied to the EASI-CLOUDS project.

The questionnaire was compiled on the one hand of a few general questions to check their overall awareness for cloud federation and cloud brokerage and on the other hand of 38 statements, that the respondents were asked to rate the questions on a scale of 1 ("strongly disagree") to 5 ("strongly agree"). While the survey received a low number of respondents[108], the respondents represent a population with highly valuable insights on cloud computing.

The respondents generally support the benefits of cloud brokerage for cloud providers; Brokerage is seen to improve suppliers' access to markets, resource utilization, and to be a very interesting opportunity for cloud providers operating on various markets. While in general, cloud brokerage is seen to facilitate the use of cloud services (Figure 6), brokerage was generally not seen as a way to improve scalability of cloud services.

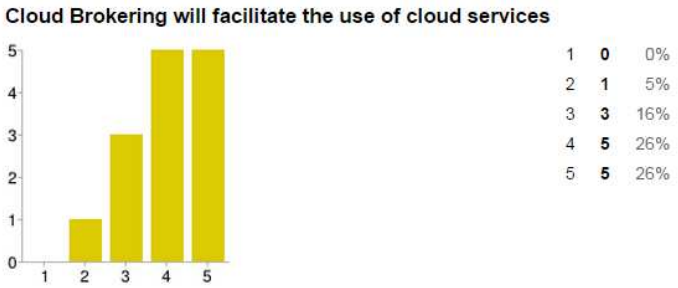


Figure 6: Histogram of responses (1=strongly disagree, 5=strongly agree)

Responses are more divided on cloud federation. However, respondents were somewhat inclined to believe that also cloud federation increases the profitability of cloud providers. In addition, data protection issues and other security topics were considered to be somewhat problematic for cloud federation (but not for brokerage)[109]. 37% of respondents were not familiar with the concepts of brokerage and federation which was somehow a small surprise for the authors (Figure 7).

[106] Source: http://www.cloudbloggers.de/
[107] http://clouduser.de/analysen/cloud-marktplaetze-versus-cloud-oekosysteme-wo-cios-am-besten-zum-cloud-shopping-gehen-24404
[108] In addition to 14 full responses, we received 5 partial responses. We used two-tailed t-tests to test if responses significantly deviated from the neutral option in the questionnaire (3 on the scale of 1 to 5). Reported findings are significant at the $p<.05$ level.
[109] These two results are significant only at the $p<0.1$ level

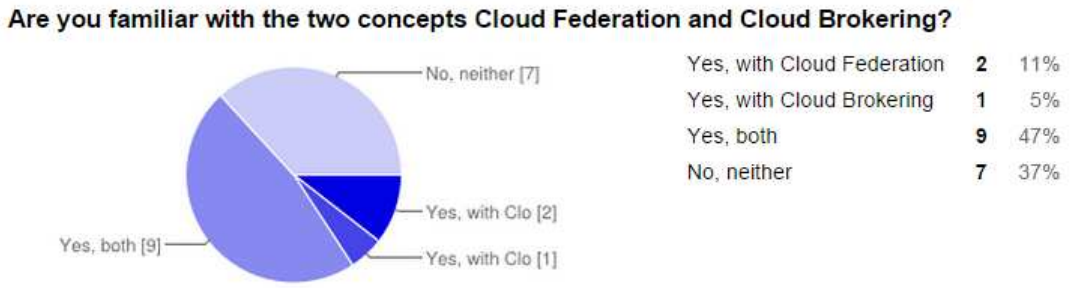


Figure 7: Respondent's familiarity with cloud federation and cloud brokerage.

Respondents also consider that there is generally little information available on cloud brokerage and especially on cloud federation (Figure 8), and that the technical maturity of especially cloud federation is low. This probably contributes the results in the form of incoherent opinions.

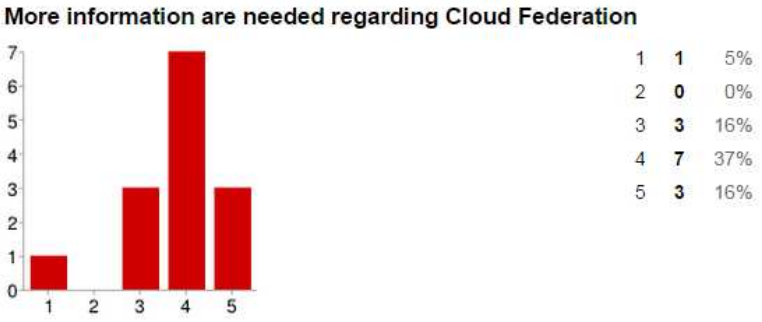


Figure 8: Histogram of responses (1=strongly disagree, 5=strongly agree)

The results of this study highlight that even among well-informed individuals, there is little consensus on matters related to cloud federation. While the respondents generally agree to the benefits of cloud brokerage, cloud federation is considered technically immature, which may lead to security concerns among respondents.

3.8 Survey on intentions to adopt cloud federation

A recent survey by SNU[110] conducted under the EASI-CLOUDS project in July 2014 examined what influences cloud experts' intentions to adopt cloud federation. The researchers find that these adoption intentions are driven by perceived risks and benefits. Especially, the perceived benefits of flexibility showed the strongest impact on intentions to cloud federation. All large and small cloud providers intend to benefit from economies of scale and resource scalability.

The study also finds that interoperability among providers is likely to reduce the risk perception for both larger and smaller providers it is also expected to increase the benefits of cloud federation for smaller providers. Larger cloud providers consider the market structure of their target market to reduce their risk of adoption. The respondents (N=36) consisted mostly of researchers (67%), in addition to cloud providers, consultants, and other cloud experts.

[110] Haile, N., Altmann, J. Modeling the Determinants of Cloud Federation. Working paper. Oct. 2014.

3.9 Interesting projects and initiatives

This section lists several interesting developments in the cloud space which are either the first-of-its-kinds, have a great announcement effect, results are used by other projects and initiatives or provide an interesting business model to organize the federation.

Intercloud initiative by Cisco. Cisco is currently in the phase of building the world's largest global Intercloud – a network of clouds – together with a set of partners. More than 20 additional partners have joined its Intercloud initiative, dramatically expanding its reach with 250 additional data centres across 50 countries[111]. Intercloud is being architected for the Internet of Everything, with a distributed network and security architecture designed for high-value application workloads, real-time analytics, "near infinite" scalability and full compliance with local data sovereignty laws. They say that they are the first-of-its-kind open Intercloud, which will feature APIs for rapid application development, will deliver a new enterprise-class portfolio of cloud IT services for businesses, service providers and resellers[112]. Intercloud will provide users control back as is therefore designed to deliver enterprise-class cloud IT services for businesses, service providers and resellers, with the ability to move application workloads between public, private and hybrid clouds and cloud providers.[113]

The following organizations have joined Cisco's intercloud initiative: Telstra; Allstream; Canopy; Ingram Micro Inc.; Logicalis Group; MicroStrategy, Inc.; OnX Managed Services; SunGard Availability Services; and Wipro Ltd[114]. In 2014 Cisco has acquired Metacloud to strengthen its intercloud initiative by enabling customers to easily build an open source-based OpenStack private cloud. [115]

HP – Helion Network[116]**.** Besides Cisco, with HP another key player in the IT market has unveiled plans for a federated ecosystem of service providers that will provide customers with an open market for hardware-agnostic cloud services. Their purpose is to give customers a better way to build open and secure hybrid IT environments. The federation is planned to be hardware agnostic. The program will also allow partners to resell solutions from other providers in the Helion Network.

OpenNebula is an open-source project and offers an extensible framework that can be modified to fit an enterprise individual cloud. This project develops a de-facto standard solution for building and managing virtualized enterprise data centres and private clouds. Supplementary to local infrastructure, OpenNebula can obtain resources from Amazon EC2 in order to reach high demands. In order to facilitate inter-cloud communication between different cloud service providers can be leveraged by adding APIs and plug-ins to the existing OpenNebula architecture. The OpenNebula framework is already used by more than 9 projects and/ or organizations[117].

[111] Source: http://us-cloud-new.ingrammicro.com/_layouts/CommerceServer/IM/ExternalHost.aspx?site=CloudTalk
[112] Source: http://newsroom.cisco.com/release/1373639
[113] Source: http://www.networkworld.com/article/2175477/cloud-computing/cisco-s-big-about-face-on-cloud-services.html
[114] Source: http://www.neovise.com/cloud-federation-dream-or-reality#
[115] Source: http://www.networkworld.com/article/2684801/cloud-computing/what-is-metacloud-and-why-did-cisco-buy-it.html
[116] Source: http://www.neovise.com/cloud-federation-dream-or-reality#
[117] Source: http://de.wikipedia.org/wiki/OpenNebula

Openstack is an IaaS initiative for creating and managing large groups of virtual private servers in a data centre. The NASA worked with Rackspace to develop OpenStack[118]. Since the start, more than 200 companies have joined the project, including Arista Networks, AT&T, AMD, Avaya, Canonical, Cisco, Dell, EMC, Ericsson, Go Daddy, Hewlett-Packard, IBM, Intel, Mellanox, Mirantis, NEC, NetApp, Nexenta, Oracle, PLUMgrid, Red Hat, SUSE Linux, VMware and Yahoo![119]

OpenStack supports interoperability between cloud services and allows businesses to build Amazon-like cloud services in their own data centres. Furthermore it provides extended functionalities to orchestrate multiple composite cloud applications using templates, through both an OpenStack-native REST API and a CloudFormation-compatible Query API.[120]

OpenStack is used in EASI-Clouds and furthermore in several orchestration and federation initiatives (see Cisco's intercloud initiative, HP's Helion Network). Furthermore many cloud providers are adopting Openstack in their cloud strategies as mentioned by Wikipedia[121].

OnApp can be considered the first commercial federation. The company is London-based and it offers a cloud orchestration platform that has the capability to federate resources between other useds of the platform. The company used the federated resources to first enter the CDN (content delivery network) market in 2011, and has since expanded into storage (2012). There CDN is based on 170 point of presence which makes them the largest federation in the world.[122] In early 2013, the company also started selling the federation's capacity to 3rd parties in a fashion that enables forming virtual cloud providers. Currently the company reports to have over 3000 customers in 87 countries, and has a staff of 140. In September 2014, the company acquired SolusVM, a cloud orchestration platform provider. Through the acquisition, the company can further increase the resources in its federation.

CometCloud[123] is an autonomic computing engine that allows the dynamic and on-demand federation of clouds. The engine also enables the deployment and execution of applications on these federated environments. End-users are enabled to aggregate heterogeneous and dynamic cloud infrastructures by the integration of autonomic cloud bursts and public/private clouds, i.e., dynamic scale out to clouds to address the dynamic workloads.

Conceptually, CometCloud is composed of a service layer, programming layer and infrastructure layer. The service layer provides a range of services to support autonomics at the programming and application level. The programming (e.g., master/worker/BOT) layer supports the dynamic addition or removal of master and/or worker nodes from any of the federated environments to enable on-demand scale out/in or up/down. The autonomic management services which are provided by CometCloud are driven by user-defined policies.

Deutsche Börse and **Zimory GmbH** founded the joint venture **Deutsche Börse Cloud Exchange AG** intended to create the first neutral, secure and transparent trading venue for cloud computing resources. The primary users will be companies, public sector agencies and also organizations such as research institutes that need additional storage and computing resources or

[118] Source: http://whatis.techtarget.com/definition/OpenStack
[119] Source: http://en.wikipedia.org/wiki/OpenStack
[120] Source: http://en.wikipedia.org/wiki/OpenStack#Orchestration_.28Heat.29
[121] Source: http://en.wikipedia.org/wiki/OpenStack
[122] Source: http://www.neovise.com/cloud-federation-dream-or-reality#
[123] Source: http://nsfcac.rutgers.edu/CometCloud/uff/

have excess capacity that they want to offer on the market. Deutsche Börse Cloud Exchange AG sets and monitors standards regarding the product offering, admission procedure, changes of provider and guaranteed purchased capacity. Clients are able to choose capacity providers and select the jurisdiction that applies to the outsourced data. Deutsche Börse Cloud Exchange AG offers outsourced storage capacity and computing power.[124]

CloudBroker GmbH[125]. CloudBroker is another interesting company in the field of cloud brokering. The results are based on the European Funded project CloudSME. Their solutions allow users to easily port, offer and use compute-intensive software on heterogeneous cloud infrastructures. They offer the CloudBroker Platform, a SaaS and PaaS web service for compute-intensive applications; an AppCentre, a web-based one-stop-shop for simulation software and services, and consulting services to support user on their way to use brokered cloud resources. They mention several references on their website.

3.10 Conclusion

From the perspective of the authors, there are mainly four key aspects that can be taken away from these different views:

- Cloud federation and cloud brokerage have become reality as the available solutions as well as the ongoing projects and initiatives are demonstrating.
- There exist different opinions with respect to the value proposition of both concepts which may result from different personal interests.
- Even cloud experts are using cloud federation and cloud brokerage together, which supports our point of view that these concepts cannot be considered separately. They belong more or less together and as mentioned in chapter 3.6.2 it is more a different way of organizing the cloud of clouds.
- We concur with Intel's interesting point in this context: At the end, federated cloud is about the users and their improved user experience in the context of an efficient use of cloud computing in their process.

We also highlight the following observations regarding cloud brokerage/federation in a broader context and the generally nascent nature of these markets and technologies:

- The positive opinion of different cloud experts towards cloud brokerage confirms Gartner's trend that *"Cloud Computing will evolve from a one-to-one relationship to a one-to-many ecosystem"*.
- Especially the argument of assisting companies in selecting the right cloud services and the argument of cost saving are important value adds of cloud brokerage.
- Furthermore, the experts see that cloud brokerage will be very interesting for small and medium-sized enterprises, whereas large companies in the field of cloud computing will themselves evolve towards a cloud broker.
- Most experts view the potential of cloud federation in a positive light but there is much more divergence, and even criticism than in the case of cloud brokerage:
    - Especially, the aspect of finding a contractual agreement between several cloud providers is a high hurdle. This hurdle becomes even higher the more cloud providers would like to participate in the federation.

[124] Source: http://www.itespresso.de/2013/07/02/deutsche-borse-cloud-exchange-geht-an-den-start/.
[125] Source: http://cloudbroker.com/solutions/

- In addition, it is doubted that cloud federation will enable an efficient business. Furthermore, one opinion really criticizes that cloud federation does prevent differentiation, which will result in a bad quality as well as commoditization of cloud services.
- Though many believe that cloud federation helps cloud providers to increase their utilization rates and improve revenues, there are also critics of this view..
- However, most experts agree that cloud federation helps to improve the efficiency of cloud resources, is an interesting option especially for smaller companies and leads to very strong form of cooperation.

4 Value architecture in cloud brokerage and federation

4.1 Value creation and value capture

When assessing business opportunities, it is important to distinguish between what it means to create value, and what it means to capture it, as oftentimes the latter is neglected at the expense of the former when developing novel technologies. However, both value creation and value capture are necessary requirements for any sustainable business, and this requirement passes down the supply chain as depicted in Figure 9.

Value creation is tied to the concept of willingness to pay, which refers to a specific quality of a new job, task, product or service as perceived by users in relation to their needs. The quality/ advantage highly depends on the reference situation to compare the new job, task, product or service against (relative advantage). This judgment is fundamentally subjective and individual-specific[126].

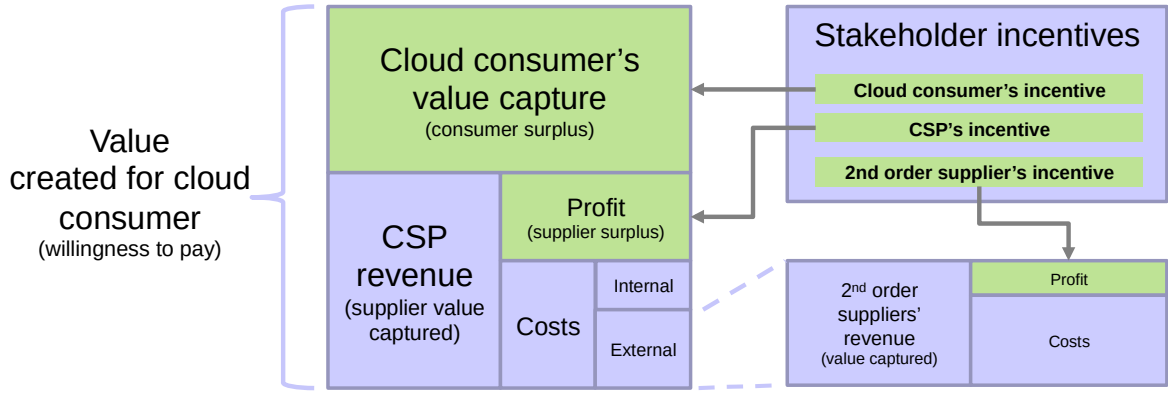


Figure 9: Value creation and value capture in a supply chain context.

For new creative technical solutions, appropriateness and novelty can be seen as highly important drivers of perceived value on the customer side. In order for buyers to perceive the novelty and appropriateness of a product or service, they must have specialized knowledge to assess the new solution against alternatives, and to understand how it can be used in their specific context. Furthermore, these evaluation processes are affected by social and cultural contexts, and not only by the technical and easily quantifiable attributes.[127]

A firm's ability to capture higher value is essentially about its ability to capture a greater share of the value it helps to create as revenue, and leave less of the value to customers as "consumer surplus". Supplier revenue (or exchange value) refers to the monetary amount paid by the user (or customer) to the seller. Value capture involves person level, firm level, and societal/industry level factors.[128] Regarding a firm's ability to capture value, factors that relate to the firm level,

[126] Lepak, David P., Ken G. Smith, and M. Susan Taylor. "Value Creation and Value Capture: A Multilevel Perspective." Academy of Management Review 32, no. 1 (January 1, 2007): 180–194.
[127] Amabile, T.M. 1996. Creativity in context (Update to The social psychology of creativity). Boulde, CO: Westview Press.
[128] Lepak, David P., Ken G. Smith, and M. Susan Taylor. "Value Creation and Value Capture: A Multilevel Perspective." Academy of Management Review 32, no. 1 (January 1, 2007): 180–194.

rather than the industry where the firm operates (or chooses to operate), appear to matter more on average[129].

The firm's value capture process is aided by the degree to which its resources are rare, inimitable, and non-substitutable[130]. A firm can also invest in difficult to imitate relationships with its business partners in order to create an advantage[131]. In essence, the firm should in a maintainable sense provide something unique that its rivals cannot, i.e., create a small 'monopoly' around its offering that is as sustainable as possible. The sustainability of any such competitive advantage has, however, been questioned, particularly in the case of industries with a high rate of technological innovations, meaning that if a firm desired to be successful in the long run, it needs to create a continuous stream of competitive advantages[132]. Yet, particularly in high technology industries, network externalities[133] often create "winner takes all" markets, where both the use value and the "stickiness" of an offering grows as the number of the offering's users grows. In addition to demand-side economies of scale, vast supply side economies of scale exist particularly in the case of software, as its costs of replication are extremely low. These phenomena can provide extremely high sustainability for a competitive advantage.

These firm-level concepts that shield firms from perfect competition also have their closely related counterparts at the industry/market level. For example, the bargaining power of suppliers and customers, internal rivalry, and the threats of new entrants and substitutes[134] are commonly used to assess the attractiveness of industries. Other factors also relate to firm survival. For example, the lack of legitimacy[135], e.g., for young or otherwise immature firms or for firms in novels markets, may hurt survival prospects.

Overall, in order for a firm to survive in the long run, it must be able to capture value at a higher rate than its cost level. Typically, the non-scalable elements of a business relate to human-provided services and using internal resources to develop sales channels. One of the key promises of the EASI-CLOUDS infrastructure in particular is to increase scalability and efficiency by removing several human-delivered process steps. Nonetheless, particularly innovation-related profits are eroded by imitation leading to commoditization in the long run, meaning that value constantly 'leaks' from firms to consumers and societies. In our assessment of the EASI-CLOUDS infrastructure, it can also be expected that most of its inherent value eventually propagates to society. Meanwhile, it is also feasible that a significant share of the new

[129] McGahan, A. M, and M. E Porter. "How Much Does Industry Matter, Really?" Strategy: Critical Perspectives on Business and Management 2, no. I997 (2002): 260.
Rumelt, Richard P. "How Much Does Industry Matter?" Strategic Management Journal 12, no. 3 (March 1, 1991): 167–185.
[130] Barney, Jay B. "Firm Resources and Sustained Competitive Advantage." Journal of Management 17, no. 1 (1991): 99-120
[131] Dyer, J. H., and H. Singh. "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage." Academy of Management Review 23, no. 4 (1998): 660–679.
[132] Eisenhardt, Kathleen M., and Jeffrey A. Martin. "Dynamic Capabilities: What Are They?" Strategic Management Journal 21, no. 10/11 (October 1, 2000): 1105–1121.
[133] Katz, Michael L., and Carl Shapiro. "Network Externalities, Competition, and Compatibility." The American Economic Review 75, no. 3 (June 1985): 424–440.
[134] Porter, M. E. Competitive Strategy: Techniques for Analyzing Industry and Competitors. Free Press New York, 1980.
[135] Freeman, John, Glenn R. Carroll, and Michael T. Hannan. "The Liability of Newness: Age Dependence in Organizational Death Rates." American Sociological Review 48, no. 5 (Oct. 1983): 692–710..

value created by novel cloud-based business models can also flow back to traditional CSPs. This, however, depends on their bargaining power within the new value networks.

In the following section, we proceed to decompose how value can be created and captured in relation to EASI-CLOUDS platform components. While the approach builds on the fundamental concepts of value creation and capture, it is necessary to occasionally blur the lines between these concepts for a practical analysis, because several elements that create value for one party influence how value is created and captured in others.

4.2 Examining value through value trees

When promoting new business ideas, solutions/ services or technologies the value contribution is the most vital element of a buyer's/ user's decision process. The decision for or against the adoption of a new solution is mainly derived from the relative advantage a user can experience compared to a reference solution. The higher the value contribution is, the more a customer is willed to pay and/ or the more customers can be addressed. This coherence has also been summarized by the diffusion theory, introduced by Rogers[136], which has been adapted by Hall[137] in a more practically way.

Especially Hall comes to the point that the value in general can be decomposed into quantitative and qualitative value statements as he is mentioning a financial dimension in addition to the benefit dimension. Quantitative value statements have a direct impact on the buyer's finances (e.g. realization of cost decreases and/ or increases in the buyer's own revenues). Qualitative value statements (like higher reputation) are difficult to measure. Nevertheless, they have indirect impact on the finances as it can be concluded that due to a higher reputation of the buyer the number of potential customers can be increased which can result in higher revenues at the end.

Based on this theoretical thoughts, the results of our market research on cloud computing in general but also cloud federation and cloud brokerage plus our results from our surveys, we will use the methodology of value trees to highlight the impact of cloud federation and cloud brokerage in general as well as the impact of our project results that have been developed by the different project partners.

As cloud federation and cloud brokerage should address special needs and challenges of cloud computing in general, we will use this as basis for our value tree and highlight the potential links. Depending on the perspective of a cloud provider or cloud consumer different value arguments come on the spot which are mainly derived from their expectations and challenges with respect to cloud computing.

Costs (Consumer/ Provider)
The decision for or against cloud computing is typically connected with a cost consideration. The lower the costs for planning, developing and using a solution/ service are, the more efficient a consumer can run his own business. In addition the lower the costs for planning, developing and operating a cloud service are from the perspective of the cloud provider, the more customers can

[136] Rogers, E. M. (1995): Diffusion of Innovations. 4. ed, New York.
[137] Hall, B. H. (2005): Innovation and Diffusion, in: Fagerberg, J./Mowery, D./Nelson, R. R. (Hrsg.), The Oxford Handbook of Innovation, Oxford, pp. 459-484.

be addressed. Considerations on the cost structure can be further broken down into the following sub criteria.

Time-to-market (Provider)
Time to market refers to the time a cloud provider needs to enter a new market (e.g., country) with a cloud service by setting up a distribution channel or a dedicated sales organization to address the new market. Improvements in the time to market have a direct effect on the costs of a cloud provider. Due to a higher degree of efficiency in its costs the cloud provider is able to come up with better prices for cloud consumers which can indirectly result in a larger customer base. Alternatively the cloud provider can use the cost savings to improve his internal margins.

Development (Consumer/ Provider)
The reduction of development costs is one important aspect of cloud computing especially in the context of platform as a service. Furthermore, the fast migration of existing legacy applications into the cloud is one field of interest in today's cloud computing activities. The faster and more efficient these development process can be conducted, the less costs have to be covered by the cloud providers as well as cloud consumers that want use such PaaS services. Furthermore, the number of available cloud services can be increased by efficiently migrating applications into the cloud which indirectly increases the provider's attractiveness for potential cloud consumers.

Hardware (Consumer/ Provider)
The efficient usage of hardware (e.g. server, storage, computing power …) is important to run cloud based applications as well as legacy applications cost efficient. The less hardware is needed, the less investments are needed.

Flexibility (Consumer/ Provider)
From both the perspectives of the consumer as well as the provider, flexibility is an important decision criterion for or against cloud computing. We highlight that flexibility is predominantly related to Opex as cloud-based offerings typically undergo constant change and improvement.

Economies of Scale (Provider)
Economies of scale refer to the decrease of marginal costs as volumes increase. The more activities, services, functions and/ or hardware can be shared between cloud providers, the more cost savings can be realized.

Automation (Consumer/ Provider)
The automation of tasks by the provision or as well by the use of cloud services results in the reduction of manual labor from repetitive tasks for the cloud consumer as well as the cloud provider.

Revenue (Provider)
As the decision for or against cloud computing is on the one hand side connected to the impact on the cost structure, a decision can also be derived based on the impact on the cloud provider's revenue structure. The higher the revenue based on the provision of cloud services is, the more profit a cloud provider can make. The revenue consideration is divided into the following sub criteria.

Utilization (Provider)
Utilization describes the utilization of the underlying hardware infrastructure. If the cloud provider is able to improve the utilization of its hardware by selling more cloud services, he is able to improve its revenues. Furthermore, he becomes able to reduce prices which can indirectly result in a higher attractiveness for cloud consumers and as a consequence in a larger customer base.

Customer Retention (Provider)
The time a cloud consumer stays with a cloud provider is highly dependent on the type of service and the amount of services the cloud provider offers. The more robust the customer retention is, the longer revenues can be created with the customer. This gives the cloud provider more planning stability. Trust, security, and ease of use are important customer criteria that can help to improve customer retention sustainably.

Customer base (Provider)
From the perspective of a cloud provider it is important to address a large customer base with its services. The more customers can be addressed e.g. via a single sales channel, the more revenues can be achieved. In addition, there is a direct connection to the qualitative value statements (Security, Control of Data, Vendor lock-in, Ease of use, Assistance, Quality of Service, Completeness and Trialability). If a cloud provider is able to address a few or at the end all of these qualitative value statements, the attractiveness for cloud consumers can be increased which can result in a larger customer base and, therefore, in higher revenues.

Available cloud services (Provider)
The more cloud services are available at one cloud provider or in one dedicated sales channel (e.g. a certain marketplace), the more customers can be addressed and the more revenues can be created from the perspective of the cloud provider. A critical mass of cloud services is thus needed for a cloud provider to become interesting for potential customers. From the point of the cloud consumers, they become able to save time for searching and identifying the right cloud services.

Missing opportunities (Provider)
The possibility to address cloud opportunities does mainly depend on the market presence of the cloud provider and its ability to flexibly react to customer demands (e.g., SLA negotiation). The more cloud opportunities can be addressed by the cloud provider, the higher the revenue is at the end.

Security (Consumer)
Security in the context of cloud computing has not just been around since Snowden's revelations. It has been there before but has received a higher relevance from these developments. It is the top requirement cloud consumers bring to the table when considering cloud services for their businesses. If cloud providers are able to guarantee cloud consumers that their information are 100 percent secure, then more cloud consumer would decide to use cloud computing in their business context which will, in turn, result in higher revenues for the cloud provider.

Control of Data (Consumer)
Besides security, the control of their data is also an important requirement for potential cloud consumers. Cloud consumers want to decide where the data can be stored, the want to know where their data are (transparency) and also what happens to their data. This is a very important

criterion for customers for deciding whether they will adopt cloud computing technologies or not. If it is ensured that the power of control stays with the cloud consumer, more customers will use cloud computing which will indirectly increase revenues of the cloud providers.

Vendor lock-in (Consumer)
Vendor lock-in is an important aspect as was shown by the market analysis and the surveys. Most consumer fear to be tied to one cloud provider as this would mean a higher business risk for them. It can be concluded that vendor lock-in has an indirect effect on the customer base of a cloud provider. If the vendor lock-in can be reduced or even prevented, more companies would decide to become cloud consumers which would result in higher revenues for the respective cloud provider.

Ease of use (Consumer)
The market analysis has revealed that due to the high number of cloud services on the market cloud consumers are increasingly searching for solutions/ platforms to easily use and combine different cloud services and integrate them efficiently in their daily business routine. As a consequence, from the perspective of a cloud consumer, it can be concluded that the internal process efficiency increases when the usage of cloud services is facilitated. Furthermore, from the perspective of the cloud provider, the customer base can be indirectly increased.

Assistance (Consumer/ Provider)
The market analysis has shown that manifold cloud services are already available at the market or are just about to enter the market. For cloud consumer it has become a tough and long decision process to identify the right cloud services that fit to their requirements. In addition, it is also important for potential cloud consumers that the respective cloud services can be perfectly integrated into their business processes in order to leverage their full potential. Therefore, we can conclude that the more assistance will be provided, the more consumers will use cloud computing in the end. Furthermore, assistance is also an important aspect for cloud providers, in order to become more efficient (e.g., by using cloud federation).

Quality of Service (QoS) (Consumer)
Cloud consumers, especially in a business context, require stable cloud services with strong and reliable service level agreements. By procuring a combination of cloud resources from multiple sources, the cloud consumer may obtain better quality of service that it may also be able to transfer to its (possible) customers. For example, availability can be improved by offering capabilities that automatically switch between different cloud service providers in case of a technical failure. The higher the stability of the available cloud services is, the lower is the business risk and the higher the attractiveness for cloud consumers. From the perspective of the cloud provider, this will also indirectly result in a higher customer satisfaction, improved customer retention and a larger customer base.

Completeness (Consumer)
Completeness refers to the value that the breadth/ variety of a cloud service provider's offering brings to its cloud consumers. While a consumer may be able to obtain the services it needs from many cloud suppliers, consumers prefer one stop shopping where they can get all desired cloud services without long search and negotiation efforts.

Trialability (Consumer)
Trialability means the possibility to test cloud services without being tied to a cloud provider or a long term contract. Abiding to the motto "You buy what you can try" potential cloud consumers

want to test the cloud services prior to a full integration into their business processes. Therefore, if the cloud providers offer test possibilities to potential users, they are probably able to attract more cloud consumers for their offerings which will result in higher revenues.

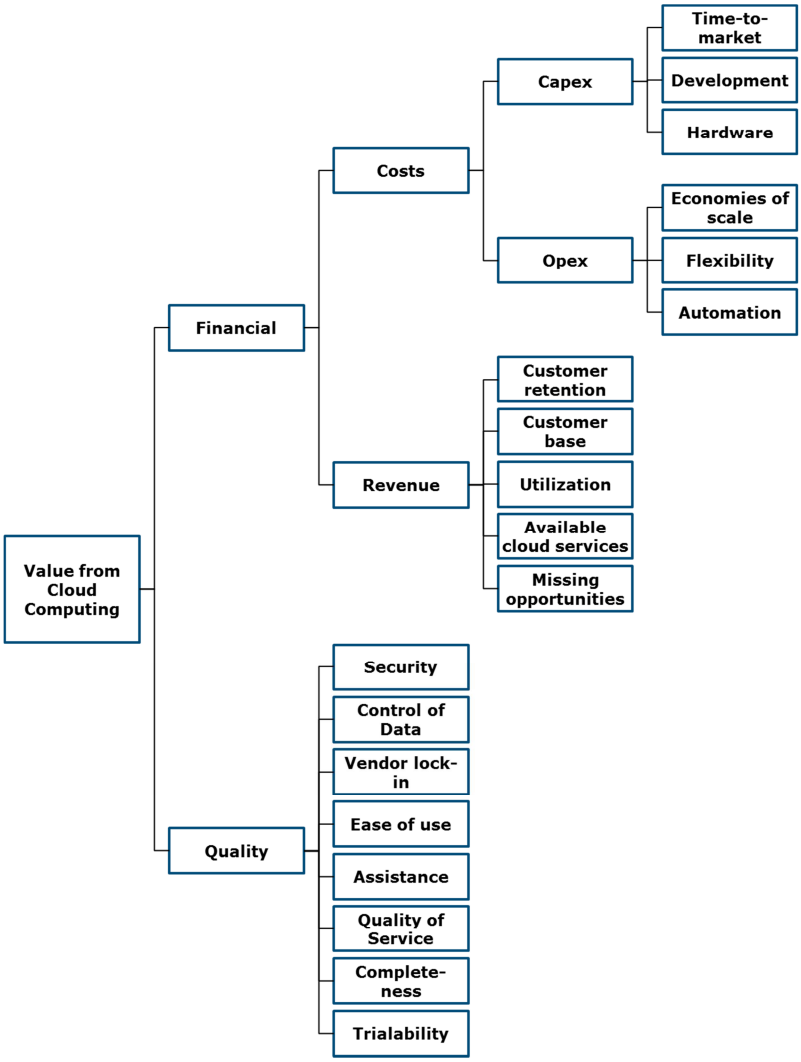


Figure 10: Summary of value components (i.e., the value tree) in cloud brokerage/federation.

4.3 Value tree for cloud federation/ cloud brokerage

In the following, we will indicate the value statements where cloud federation and cloud brokerage provide value by highlighting each value statement by color:

- cloud federation (red)
- cloud brokerage (green)

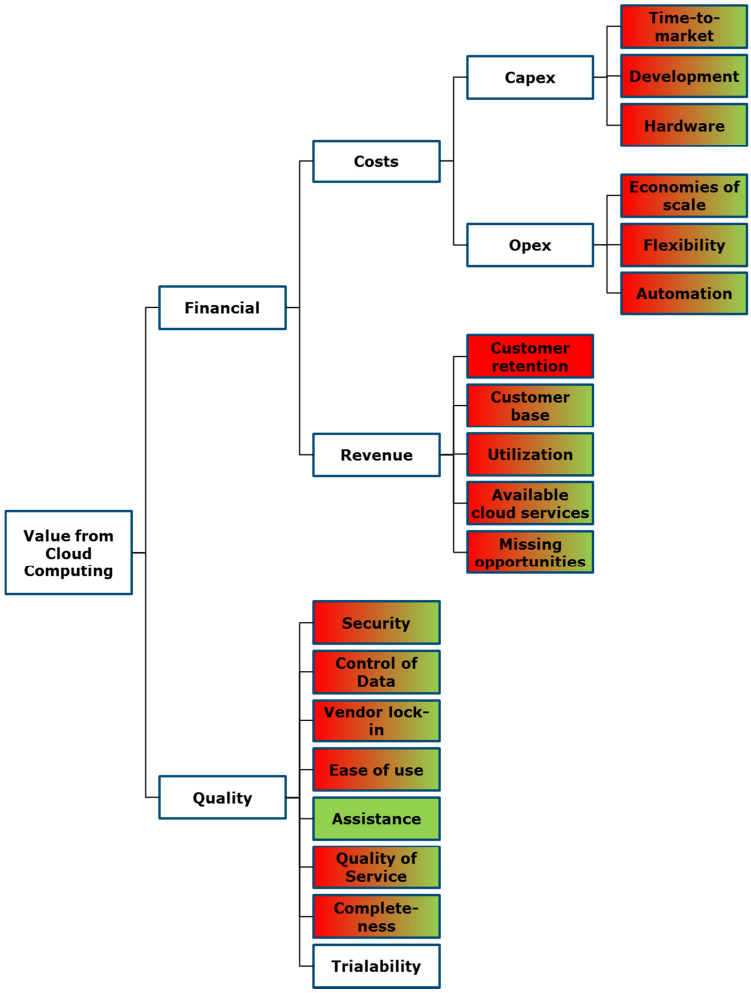


Figure 11: Comparison of value creation between brokerage and federation.

Cloud federation and cloud brokerage both have a positive influence on the value statements of cloud computing. The depth of the impact mainly depends on the way federation/ brokerage are a) organized and b) integrated in the stakeholder processes. In general, the authors derive at the conclusion that an impact can be determined with respect to both the financial consequences of cloud computing as well as the qualitative value statements.

On the **costs side**, cloud federation as well as cloud brokerage help cloud providers to optimize their Capex and also Opex centric cost structure. Cloud federation and cloud brokerage help cloud providers to enter new markets faster without the need to establish new market and organizational structures beforehand. Distribution and sales channels can commonly be used. From the authors point of view, the effect of cloud brokerage is higher as federation seems to be limited compared to brokerage as this depends on the market presence of the federation partners. With respect to development costs a positive effect can also be concluded. Cloud federation helps cloud providers to streamline their development activities by using a shared development environment. Different cloud service elements can be shared between the federating cloud partners (e.g., billing). Cloud brokerage also helps cloud providers to streamline their development activities by providing them with the capabilities to flexibly incorporate public cloud resources into their development processes which are cheaper. Furthermore, dedicated services (once developed) can be reused by others (e.g., billing). Finally, cloud federation and cloud brokerage both help to minimize the need for hardware resources due to the possibility to share hardware for dedicated activities. The possibility to share infrastructures and the provision

of flexible and automated services (e.g. billing, marketing, promotion, maintenance …) help cloud providers to reduce operational costs as well. In conclusion, due to a streamlined cost side, cloud providers are able to come up with better prices for potential cloud consumers which increase their attractiveness.

Besides, from the perspective of the cloud providers a positive effect with respect to the **revenue side** can also be achieved by cloud federation and cloud brokerage. Customer retention can be improved by cloud federation as the cloud provider is able to increase its offering together with the federating cloud providers but still maintains the customer contact. In contrast, cloud brokerage can result in a decrease of customer retention as the customer interface would be managed by a third party (broker). The customer base can be increased as customers of potential federation partners can also access the cloud offerings of the federation partners. Thus, cloud federation makes more cloud services accessible and cloud providers can act as resellers of these cloud services.
Cloud brokerage, on the other hand, can make a large pool of cloud services available to cloud consumers. But as the customer relationship is maintained by the cloud broker there is no guarantee that this will result in higher revenues for a cloud provider. There might be an indirect effect, though, in the form that the available cloud services reach a critical mass which increases the attractiveness of the overall brokerage network for cloud consumers. This, in turn, might increase the chance that a cloud provider's offering can reach more customer attention at the end. Due to the promotional activities of a cloud broker the cloud offerings can be made aware on several markets which might result in an improved customer base. This would also result in a higher utilization of the cloud services (incl. underlying infrastructure) for the respective cloud provider. Also, special promotions can be highlighted by cloud brokerage. In terms of cloud federation, utilization can be improved by selling unused capacities to partners. Furthermore, the hardware structure can be streamlined by divesting mainly unused hardware infrastructure and furthermore sharing hardware (e.g., for testing and/ or for development activities).

Cloud federation and cloud brokerage also support **qualitative value statements** which are important decision criteria for cloud consumers and can thus result in higher revenues from the perspective of the cloud providers. Cloud federation addresses one elementary pain point of cloud consumers, namely security. Since Snowden's revelations each company (especially in Europe) is looking for cloud solutions that can guarantee to keep the data in Europe. Cloud brokerage also supports the security needs of cloud consumers as cloud providers are forced to describe their cloud services in detail. Thus, cloud consumers can easily check which cloud services are meeting their security requirements and which do not. Vendor lock-in can be decreased as both cloud federation as well as cloud brokerage make cloud offerings of different cloud providers available to cloud consumers. By using a portal in the frontend it also becomes possible for cloud consumers to easily identify, buy, consume and use the cloud services of their choice. With specific guidance functionalities cloud brokers also address an additional highly relevant requirement of cloud consumers. Cloud federation and cloud brokerage also enable an extended cloud offering which addresses all needs of the cloud consumers. Cloud consumers can save time as they are not in the need to approach several cloud providers for satisfying their needs.

4.4 Value trees for EASI-CLOUDS platform components

Besides the general perspective described in the section above, we will subsequently highlight the value of the most important solution components that have newly been developed in the EASI-CLOUDS project. These components on the one hand enable/ support cloud federation

and brokerage while on the other hand also having a direct impact on the various cloud computing needs and challenges. The solution components we are covering in this deliverable are:

- **EASI-CLOUDS portal** as a marketplace for presenting dedicated cloud offerings as well as for selecting the right cloud offerings.
- **Billing as a Service** to flexibly provide the possibility for cloud providers to bill their cloud services on a pay per use basis.
- **Resource Manager** to enable a dynamical forward planning of the cloud jobs to be executed.
- **Context Store** to gather the relevant data from the respective cloud services to feed other services (e.g., resource manager, billing) with these data.
- **SLA Manager** to flexibly negotiate SLAs between the cloud provider and the cloud consumer.
- **Accords Platform** as central element to enable pure federation of cloud infrastructure resources.
- **Toolbox** to make legacy applications cloud ready without long recoding activities.

Detailed descriptions will not be provided at this point as these components have been described in detail in the technical deliverables.

4.4.1 EASI-CLOUDS portal

The EASI-CLOUDS portal enables cloud providers to offer and present their cloud offerings to a large customer base. Thus, cloud consumers can experience one stop shopping and easily identify the right cloud services matching their individual requirements.

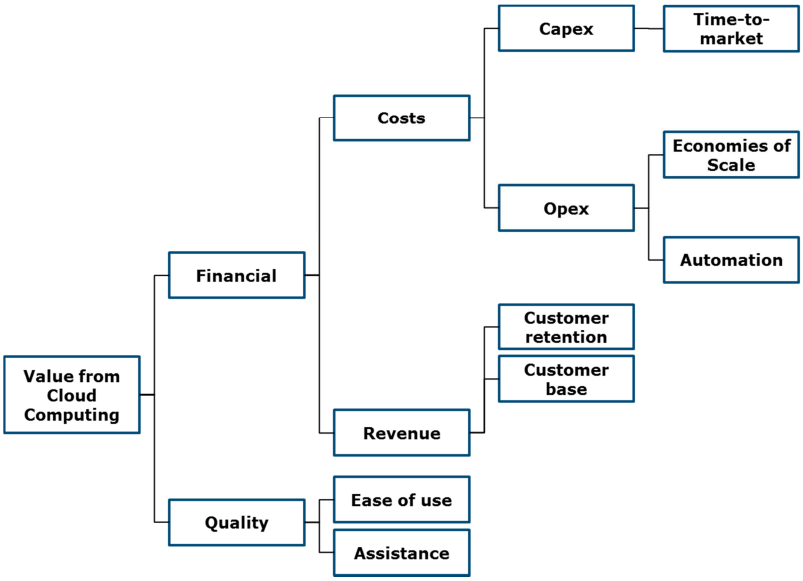


Figure 12: Value tree of the EASI-CLOUDS portal component.

On the **cost side**, the EASI-CLOUDS portal will help cloud providers to improve the time to market as they can easily use the portal to promote their cloud services on different markets without building up a dedicated sales organization. Due to the sharing of the EASI-CLOUDS portal with other cloud providers the operational costs can be decreased by sharing maintenance costs, for instance, resulting in economies of scale. Dedicated services like billing or a helpdesk can also be shared among the cloud providers. Due to the possibility of automating dedicated

process steps like the booking of a cloud service, an additional optimization of the cost structure becomes possible.

In terms of **revenues** the cloud provider can increase its returns with the help of the portal as it helps the cloud provider to easily attract new customers which increases its customer base. Furthermore, the portal helps to easily maintain the customer contact which results in a stronger customer retention as long as the experiences for the cloud consumer are positive.

From the **qualitative side**, the portal helps cloud consumers to easily identify, buy, consume and use the cloud services of their choice by providing special guidance and search functionalities. The shopping experience for cloud consumers increases which, again, has a positive effect on the customer base and as a consequence on the revenues of the cloud provider.

Value flow
The EASI-CLOUDS portal acts as mediator between the cloud provider and the cloud consumer. Depending on the business model, there are three main possibilities for the value flow:

- The EASI-CLOUDS portal might be like an App Store for one single cloud provider to promote its cloud services to its customer base. Besides the promotional aspect, booking and billing procedures as well as other services can be offered/ managed via the portal. As the detailed set-up of the enterprise centric portal depends on the cloud provider's individual requirements, the cloud provider has to pay a one-time fee for making the portal useable in its business context.
- The EASI-CLOUDS portal might only be a standardized shared promotion/ marketing channel for several cloud providers like a shopping window for cloud consumers. Contractual aspects when ordering a cloud service still have to be handled between the respective cloud provider and the cloud consumer. In this case a monthly fee for using the portal seems to be the most appropriate way to organize the payment process between the provider of the portal and the cloud provider.
- The EASI-CLOUDS portal might provide additional functionalities like the handling of the billing process between the cloud consumer and the cloud provider. In this case, the provider of the portal is distributing the incoming money from the cloud consumers to the respective cloud providers. For this service the portal provider can either charge the cloud provider a fee based on the ordered volume (less risk from the perspective of the cloud provider) or can still make use of a constant monthly fee.

From a strategic point of view the costs for establishing a portal to promote the cloud services have to be over-exceeded by the revenues through additional cloud consumers. This principle is valid for all three possibilities to organize the value flow.

4.4.2 Billing as a Service

Billing as a Service can either be understood as a dedicated SaaS service that can be used to bill any activity or it can be used to bill dedicated cloud services more efficiently and in real-time which give consumer more control over their cloud services in use.

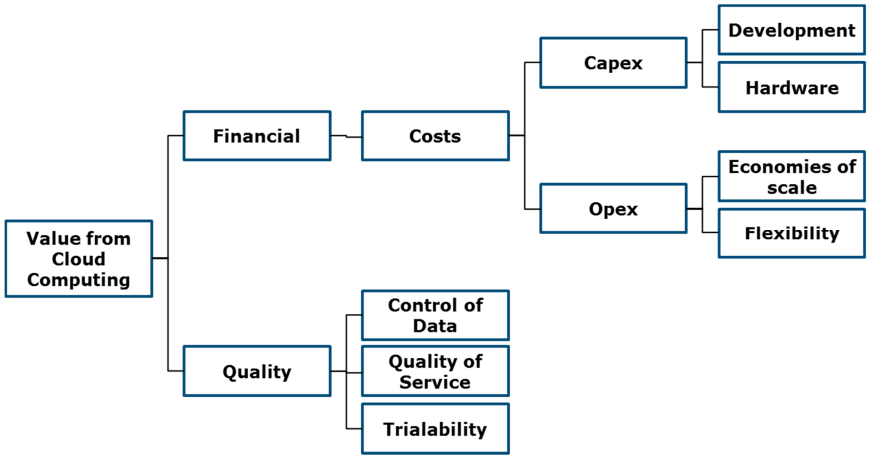


Figure 13: Value tree of the Billing-as-a-Service component.

Billing as a Service has no impact on the revenues but on the **costs**. It enables cloud providers to reduce their development costs as they do not have to build or buy a complete billing solution. Investments in hardware are not necessary. Economies of scale are possible as the billing service can be shared between many different cloud providers. The usage based pricing gives the provider a high degree of flexibility. Thus, they will not experience any cost risk in this respect.

In terms of the **qualitative aspects**, billing as a service offers cloud consumer more control and increases the quality of the purchased service, as billing as a service enables real-time billing. The customer receives full cost transparency. As it is available on an "as a Service"-basis all potential users of such a service (cloud providers as well as other service providers) become able to test the service instead of buying a complete solution without checking its performance and strategic fit.

Value flow

Billing as a Service has to be purchased by the company that is in need of a billing service. The payment will be done on a usage base which eventually consists of a performance based component.

4.4.3 Resource Manager

The resource manager enables an improved and especially dynamic planning of the jobs a cloud service has to process.

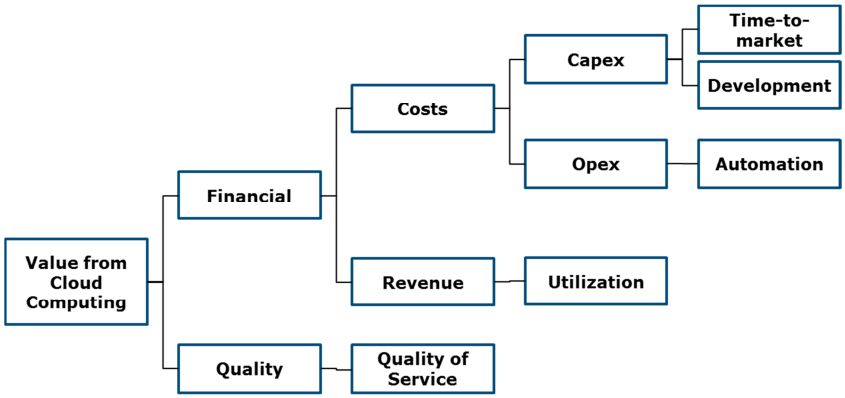


Figure 14: Value tree of the resource manager component.

By using the resource manager, cloud providers become able to reduce their fix **costs** when developing a new cloud service or when bringing a new cloud service to the market. Instead of developing a resource manager functionality for each cloud service on their own, they just have to integrate the standardized resource manager in their offerings. Furthermore, development costs can be shared with other cloud providers who also use the resource manager. On the operational side, the resource manager reduces manual planning work as the planning is done fully automated.

Additionally, a positive effect on the **revenue** is possible as the resource manager supports a better planning of the available cloud services in terms of their utilization.

The resource manager also improves the **quality** of the cloud services as it provides cloud consumers full transparency about the current planning status of their cloud jobs.

Value flow
As cloud providers who are looking forward to improving the quality of their services by enabling an efficient planning of their cloud jobs and to reduce costs, they are the target customers for the resource manager offering. The component can either be used free of charge (in case of open source) or on fix price basis which has to be paid once by the cloud provider.

4.4.4 Context Store

The context store as a separate component does not make much sense as it mainly feeds other services with information. The context store is an important feature for billing and planning a cloud service. In this case, the context store gathers the relevant information from the respective cloud services in real-time and provides these data to a billing service (e.g., the Billing as a Service component) or a service for planning cloud resources (e.g., the Resource Manager component). Without this information other EASI-CLOUDS components like the resource manager or the Billing as a Service component would not be able to run properly.

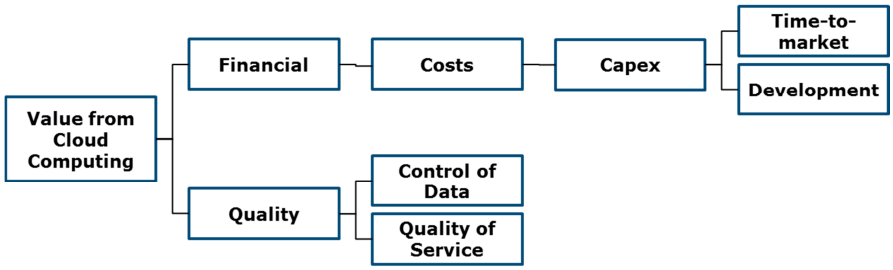


Figure 15: Value tree of the context store component.

The context store developed in the EASI-CLOUDS project provides two main values. On the one hand, it helps cloud providers to reduce their investments costs when developing a new cloud service or when bringing a new cloud service to the market. Instead of developing the context manager or another service (with similar functionalities) on its own, a cloud provider can just use the context manager and integrate it with its cloud service. Thus, time to market improves and development **costs** can be decreased.

On the other hand the **quality** of service can be improved. The context store feeds the billing as well as the planning service with the relevant data in real-time. This provides cloud consumers with more transparency and as a consequence more control over their consumed cloud services.

Value flow
Cloud providers who are looking forward to improving the quality of their services and to reduce costs are the target customers for the context store. The component can either be used free of charge (in case of open source) or on fix price basis which has to be paid once by the cloud provider.

4.4.5 SLA Manager

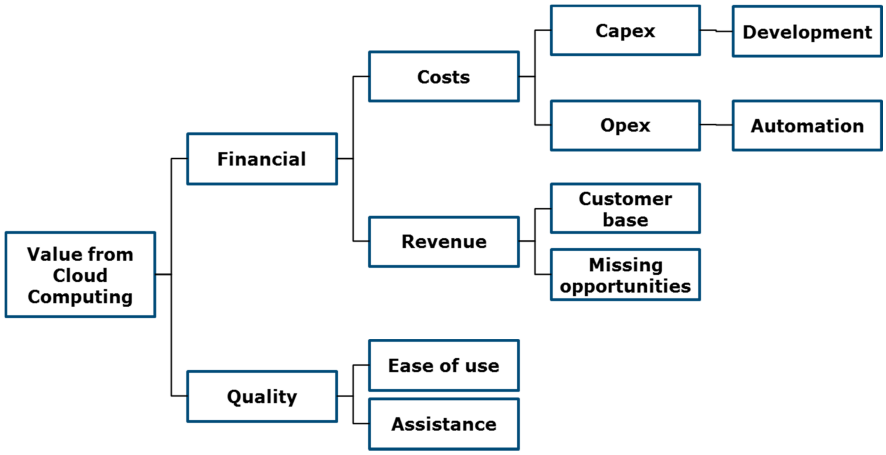


Figure 16: Value tree of the SLA manager component.

As the SLA manager is already available, cloud providers do not need to develop this functionality again on their own. These **costs** can be shared with many other cloud providers depending on the business model of the technology provider. In terms of **revenues** the SLA managers supports cloud providers in increasing their customer base and in reducing the number of missed opportunities as it increases the chance that cloud providers and cloud consumers can finally agree on SLAs which both sides can accept.

In addition, the SLA manager makes the use of cloud services much easier **(qualitative value statement)** as it automatically negotiates the SLAs between the cloud consumer and the provider. The need for interaction with the cloud consumer is reduced to a minimum.

Value flow
This functionality should be used at the point of sale of a cloud service. Thus, it makes sense to integrate the SLA manager in the EASI-CLOUDS portal or another cloud service platform. Therefore, the component can either be used free of charge (in case of open source) or on fix price basis which has to be paid once by the cloud provider.

4.4.6 Accords Platform

The accords platform is enabling federation. Therefore, the value arguments that have been described in general in Chapter 4.1 are also valid for the accords platform.

Value flow
From the perspective of the authors, the accords platform represents a pure technology/ solution enabling federation. Cloud providers can use this platform to organize their federation. As compensation a one-time fee has to be paid.

4.4.7 Toolbox

The toolbox helps potential cloud providers and cloud consumers to make their legacy applications cloud ready without long recoding activities.

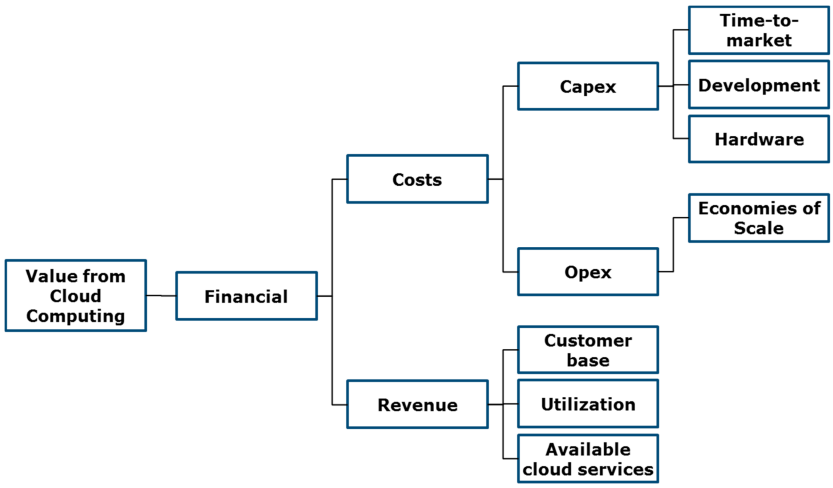


Figure 17: Value tree of the toolbox component.

On the **cost side** the toolbox will help future cloud providers to reduce their time to market by making the development process more efficient. Instead of long recoding projects, the toolbox supports a faster transformation as it provides efficient tools to turn a non-cloud ready application into a cloud service. As a consequence, the development costs are reduced and the hardware can be divested. Even potential cloud consumers with a landscape of different legacy applications will be enabled to transform this internal IT landscape to become cloud ready which supports them in reducing their costs and to efficiently use their existing hardware.

In terms of **revenues**, cloud service providers will become able to differentiate themselves from the competition as they now might provide their services based on different business models (cloud based BM vs. traditional BM) which would increase their potential customers base. This would also help to increase the utilization of the cloud provider. Furthermore, companies that are not in the IT service business become able to somehow transform into a cloud service provider by turning their core legacy applications into cloud services which they can either sell internally or to external companies (e.g., companies they are partnering with). By using the toolbox component, the overall number of available cloud services on the market can increase. This can help to achieve a critical mass of cloud offerings. Thus, a dynamical process can occur which might attract potential cloud consumer to increasingly use more cloud services. This will result in higher revenues for the cloud providers.

This kind of functionality that the toolbox component provides should be and is already included in PaaS offerings. Canopy, the Atos Cloud Company, is already offering similar features within its PaaS offering Canopy Compose. IBM and Microsoft as well as other smaller PaaS providers are also offering such features within their PaaS offerings.

Value flow

As the toolbox component does only make sense in the combination with a PaaS offering, the value flow is mainly inspired by traditional PaaS business models. As a consequence, the

availability of the toolbox feature would mean a surplus on the usage based fee a user (cloud provider or cloud consumer) has to pay per month and per user (e.g., developer). From a strategic point of view, the costs for using the toolbox component make sense for companies that are really interested to transform their services into cloud services. The cost savings realized by the usage of the component should cover the costs for the toolbox.

5 Analysis of business models related to cloud brokerage and federation

5.1 Introduction

In this section we take a deeper and forward-looking view into the business model that may be used in the brokerage and federation contexts. On the business model side we can outline two main models – cloud brokering and cloud federation – that are in fact complementary. The federation-driven approach involves tighter collaboration between its member CSPs in order to satisfy customer needs, which is outlined in a contract between the CSPs – the FLA. The broker-driven models do not require the CSPs whose services the customers use to be in any kind of formal relationship with each other, and emphasize the independence of the broker from the CSPs that provide resources. These two main business model categories may be combined in various ways, which forms the guiding principle of this section.

Well-functioning markets of any kind require that the goods or services are comparable with each other in order to facilitate effective transactions. In the technology domain, standardization plays an important role in this and is also a key driver for efficient cloud computing markets. The most common 'good' that is being traded in both cloud federation and cloud brokering IaaS markets is a virtual machine (VM). A VM can be objectively described, for instance in terms of computing capacity and memory[138]. As the complexity of the software stack that runs on a VM grows, so does the difficulty of identifying (de facto) standard metrics. At the SaaS level, the diversity of different APIs grows, the set of standards, in a de facto sense, forms the closest representative of a 'standard'. Hence in the SaaS domain, one can argue that due to the lack of multiple suppliers for each individual API, an effective cloud market cannot exist. In conclusion, standardization at the IaaS, PaaS and SaaS level are requirements for any broker-based business model to exist on the respective level of the stack.

As the degree of standardization increases, it is worthwhile to note that cloud business is volume business characterized by economies of scale. Hence, the trend toward higher standardization will make the market more difficult for smaller businesses to enter and survive in. This drives not only consolidation, but also pushes smaller cloud service providers and brokers to vertical integration into services and forming various partnerships (possibly federations).

While some degree of standardization at the IaaS level is necessary for basic cloud resource markets to emerge, the full complexity of cloud resources requires complex SLAs. While matching supply and demand in the SLA space can be conducted by human means, automation has obvious benefits when the frequency of transacting increases, and when the cloud resources in question move away from IaaS to SaaS. Automating SLA management (which includes matching supply and demand dynamically based on changing price and quality information), billing and monitoring effectively enable transacting quicker and using more differentiated cloud resources – whether this is done within a federation or outside of it.

At the business model level, human-based SLA management can make it possible to broker cloud resources in a low level of granularity, which involves longer-term contracts, more resources, and less flexibility in changing suppliers in case the SLA becomes suboptimal during

[138] In the case of cloud storage, customer-facing VMs are not necessarily required. Also smaller granularity assets (e.g. www.docker.com) can be exchanged.

the contract term. Automated SLA management, however, makes it possible for smaller (and more resource-constrained) firms to act as brokers, and enable a more efficient cloud computing market for both suppliers and consumers. The emergent property of higher frequency transacting is that suboptimal resources (e.g., temporarily inoperable, incompetitively priced) can be substituted quicker, leading to an improved customer-facing SLA. This in effect makes the shared cloud resource pool 'more than the sum of its parts', which can enable the suppliers also to defend or perhaps even increase their prices.

5.2 Exploiting opportunities: Emerging and hypothetical business models

5.2.1 Managed federation model

The managed federation model can be divided into self-managed and externally managed cases: A self-managed federation as a federation that is in total hand of the federating cloud providers. In this case no activities are outsourced to a third party. In the context of an externally managed federation a third party is taking over more and more responsibilities from the cloud service providers depending on the level of integration to be achieved. At the end a third party can be in full control of the federation and the cloud providers are only supplier of their cloud resources.

5.2.1.1 Self-managed federation

Cooperative business model

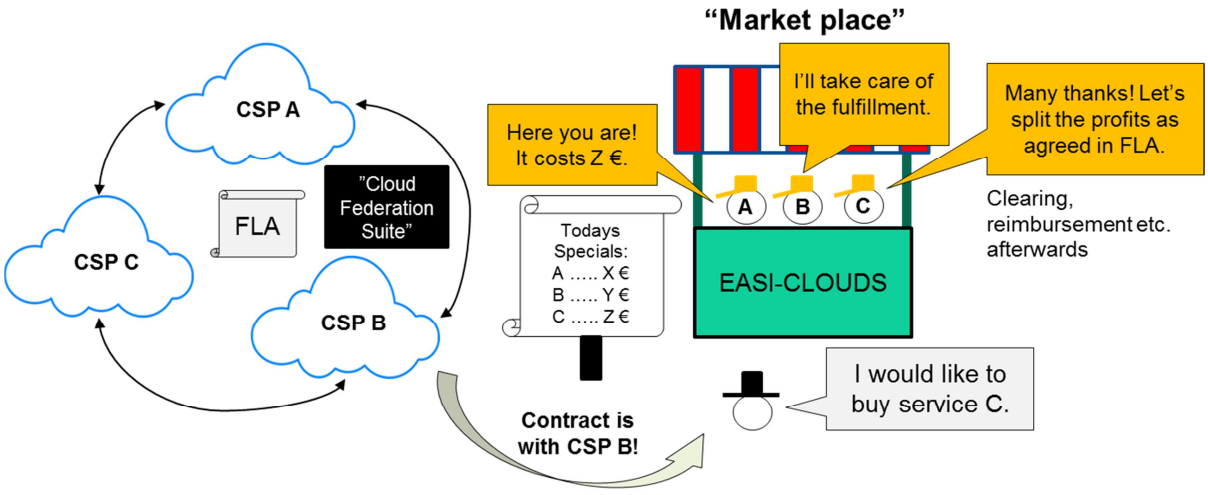


Figure 18: Overview of the cooperative business model

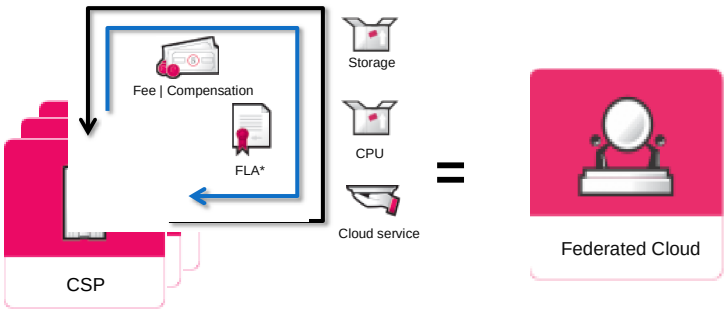
Overview

In the cooperative model (Figure 18), a group of CSPs federate cloud resources, and establish joint customer-facing marketing capabilities that seek to package offerings according to cloud consumers' needs, dividing the tasks of fulfilment and revenue sharing between CSPs. This approach creates synergies in marketing compared to each CSP doing marketing separately. However, the SLA remains between the cloud consumer and the CSP, and each CSP maintains its own brand identity. The operation and maintenance of the common marketing interface (e.g. common sales portal) is done by one of the cloud service providers. This model may be feasible

for cloud providers that are operating under one common enterprise. However, we are not aware of any such businesses currently in existence.

Value net description

When the internal revenue distribution and resource commitments are abstracted away, the cooperative business model practically resembles that of a normal CSP. The only exception is that the customer-facing marketing function replaces the marketing function of a single CSP.



* FLA = Federation Level Agreement

Figure 19: Notation depicting a federated cloud

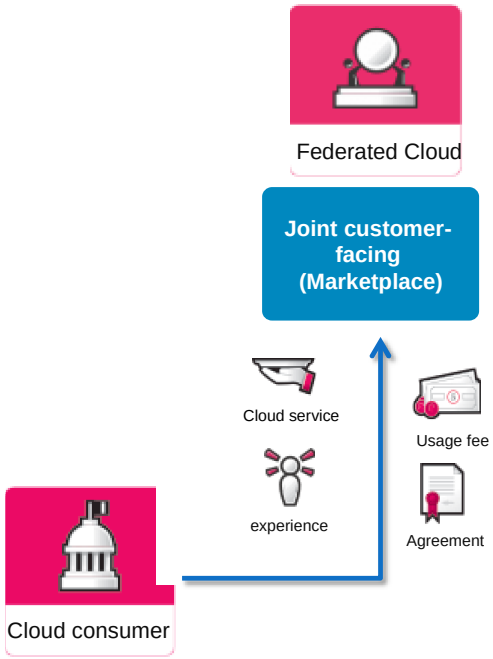


Figure 20: Value net of the cooperative business model

Value considerations

We highlight the following value considerations from the perspective of the cloud consumer:

- Access to a broader cloud offering, e.g. in terms of geography.
- Reduction of transaction costs as negotiation is outsourced to the federation (and particularly the marketing function). This involves reduced efforts for identifying and selecting the right cloud offerings matching the requirements
- Higher Quality of Service by aggregating CSPs' resources
- A higher variety of service providers to choose from.

From the perspective of the cloud provider:

- Access to broader markets, though limited marketing capabilities of the federation partners may be an issue.
- Relatively reduced costs in marketing due to a joint market interface.
- Reduced CapEx and OpEx when building a global service network
- Protection against competitors as cloud providers can decide with whom they want to federate their cloud resources (e.g. compared to brokerage). This can for instance enable differentiation within an industry vertical and create lock-in.
- Possibility to improve the internal efficiency of cloud resources (e.g. utilization).
- All things equal, joining a larger federation provides more value to CSPs than joining a small one. Hence, the number of viable federations on a specific market may be very limited.

5.2.1.2 Externally managed federation

Cooperative business model with 3rd party promotion

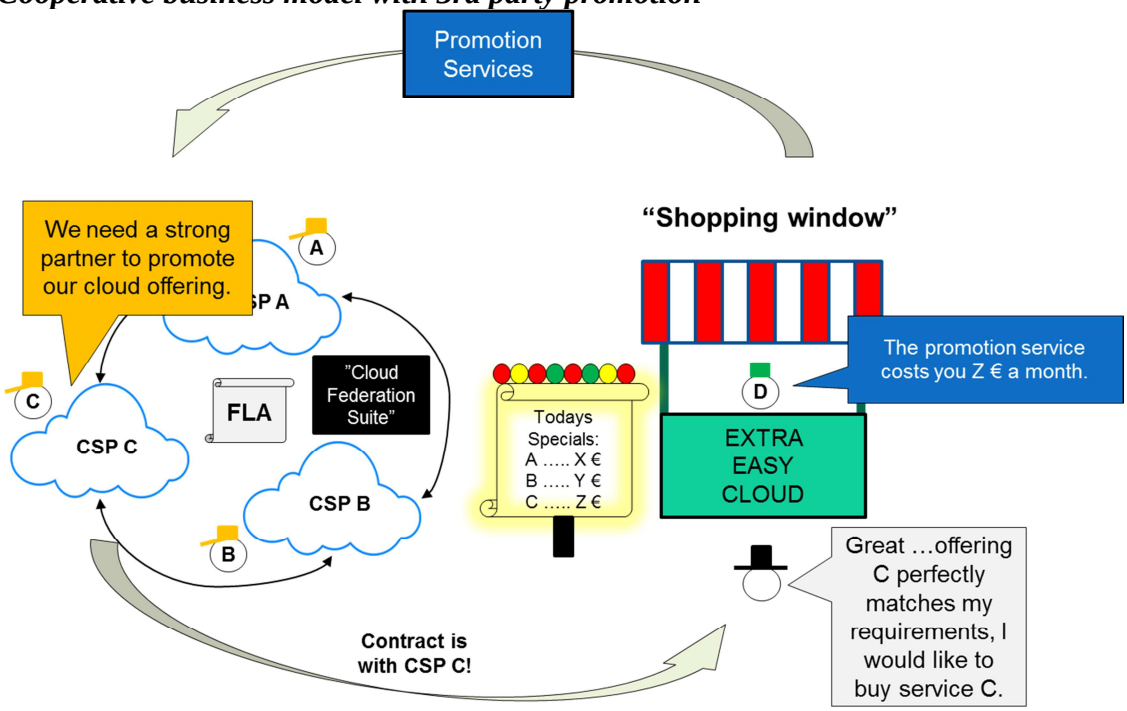


Figure 21: Overview of the cooperative business model with 3rd party promotion

Overview

The cooperative model can also be carried out by involving a 3rd party entity to do promotion and the matchmaking between cloud providers and cloud consumers by establishing a marketplace (Figure 21). This marketplace offers only the functionality of a shopping window. This model may be used to create service partner networks to increase the marketing reach of cloud service providers. This approach may be viable, if the CSPs themselves have limited marketing capabilities possibly due to their small size or if they jointly have poor reach in a particular foreign market.

However like in the case of the cooperative model (5.2.1.1), we are not aware of any such businesses currently in existence. However, the operating model of OnApp can be seen as an extension of this model (see "*Cooperative business model with 3rd party one stop shop*

“ under 5.2.1.2).

Value net description

The value net is in parts similar to that of the cooperative model, but a new intermediary is added between the cloud consumer and the federation. A contractual relationship exists between the cloud provider and the cloud broker as well as the cloud provider and the cloud consumer. The relationship between the cloud providers/ cloud federations and the cloud broker may or may not be exclusive. By following this business model, the cloud consumer can easily search for cloud offerings matching the requirements.

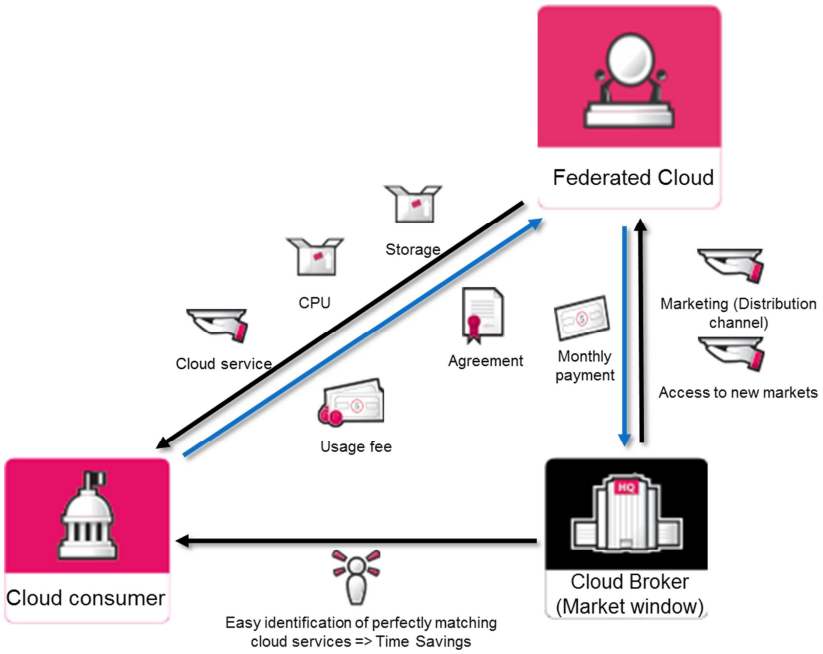


Figure 22: Value net of the cooperative business model with 3rd party promotion

Value considerations

From the perspective of the cloud consumer, we highlight the following value considerations:

- Access to a broader cloud offering due to a better marketing reach provided by the 3rd party (otherwise similar to 5.2.1.1)
- Improved quality of service and the potential of cost savings due to more transparency and the possibility to benchmark different offerings
- Assistance by the identification of the right cloud offerings

From the perspective of the cloud provider:

- 3rd party reduces business risks in marketing
- Increased cost efficiency, since no large initial marketing investments have to made
- Possibility to use standard marketplace services which are cheaper than individual marketplace services.
- Possibility to address niche cloud consumers that the 3rd party marketing entity focuses on.
- Reduced time to market, when standard marketplace services can be used
- Increased customer base, due to the promotion activities as well as the market access of the cloud broker
- Flexible pricing models (Depending on the pricing model the margins for each transaction are reduced from the CPSs’ perspective by sales commissions, a limitation

that needs to be countered by higher scalability and economies of scale through larger sales volumes)
- Otherwise similar to 5.2.1.1

Cooperative business model with 3rd party one stop shop

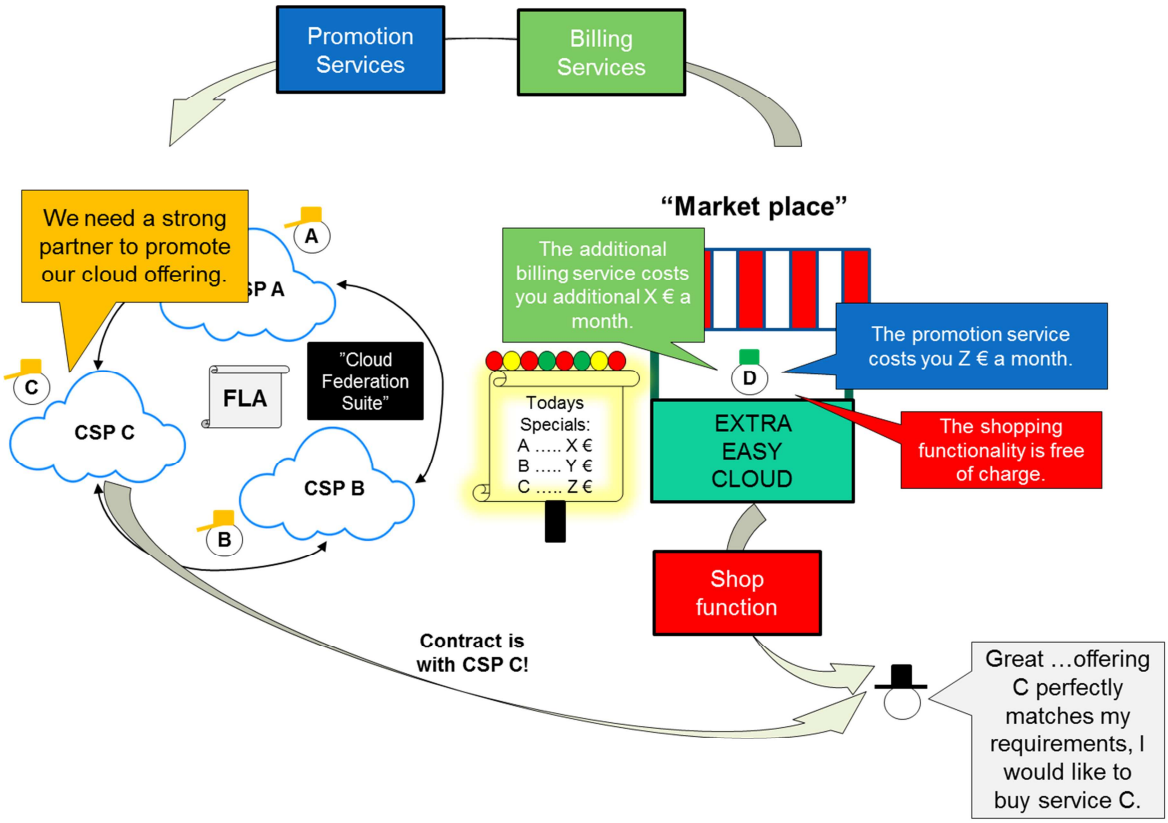


Figure 23: Overview of the cooperative business model with 3rd party one stop shop.

Overview

In addition to the cooperative business model with 3rd party promotion the operator of the marketplace (cloud broker) does provide additional services to the cloud provider. Instead of pure matchmaking and promotion activities, the broker is taking care of the billing process and possibly other value-added services. The contract and service levels are still negotiated between the provider and the consumer. This model is interesting for all cloud providers that have only limited capabilities to offer a broad range of additional services to various customers.

A federation that closely resembles this model is the federation powered by OnApp[139]. OnApp offers a cloud orchestration platform that enables federation among the CSPs that use the platform via an internal marketplace. Hence, we can consider that OnApp itself acts as a value-added 3rd party, which also to a great extent coordinates the federation. OnApp also provides tools for 3rd parties to create virtual clouds using the federation's resources. These 3rd parties can then sell the resources of the cloud to different customers in a similar sense that OnApp does.

Value net description

[139] http://onapp.com/

The value net is similar to that of the cooperative business model with 3rd party promotion. Changes are the additional services (e.g. billing) that are offered for cloud providers and the money flow, which is going from the cloud consumer, via the cloud broker to the cloud provider. By following this business model, the cloud consumer is able to book the cloud services through this marketplace. The financial processing will be handled via the marketplace operator who will redistribute the incoming money. As compensation the cloud providers have to pay a higher fee for this service than in the pure promotion case.

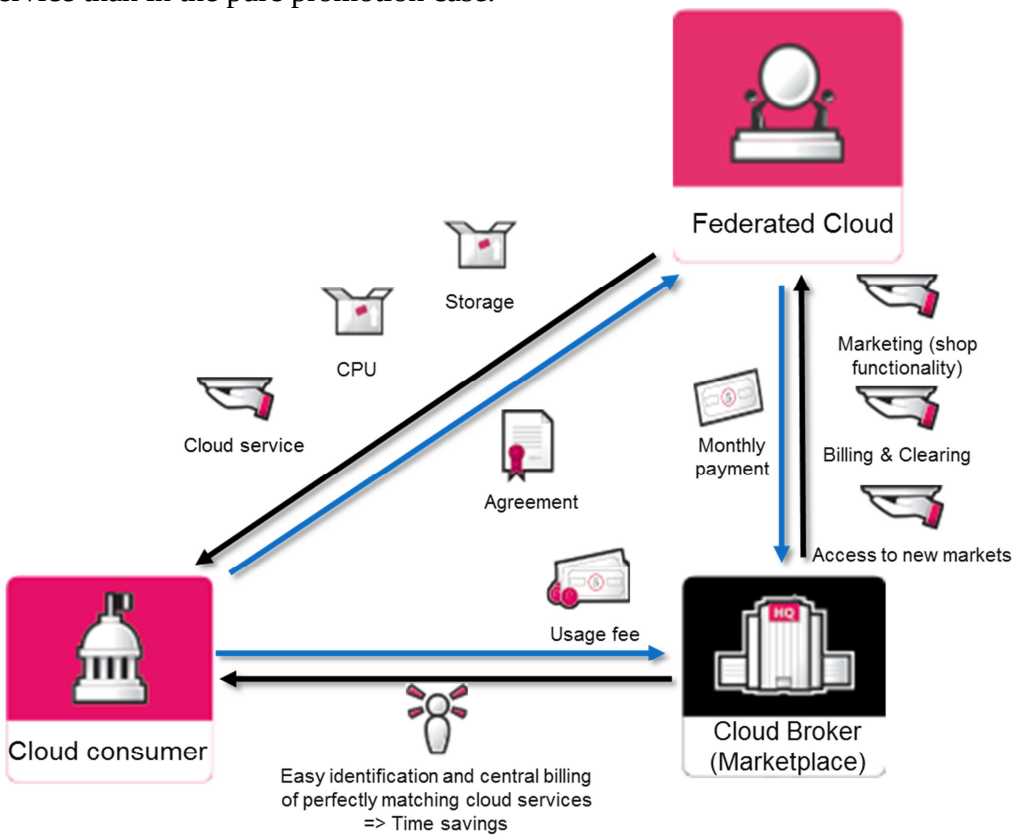


Figure 24: Value net of the cooperative business model with 3rd party one stop shop

Value considerations

In addition to the already mentioned value statements for the cooperative business model with 3rd party sales & promotion cloud consumers can experience reduced transaction efforts has the billing process is centrally managed by the operator of the market place (cloud broker). In addition the process to identify, negotiate, buy and consume cloud services will be facilitated. Further advantages might be a larger (complete) cloud service offering a cloud consumer can access. This does depend on the cloud providers, cloud federation networks that are providing their cloud.

Moreover, the provider side is relieved of the effort to develop and support technology to enable the federation. This in turn, can result in lower capex and shorter time-to-market. For example, OnApp provides the cloud orchestration platform that supports federation and support for the platform. Hence, the threshold of joining a federation is made lower, and the cloud providers can focus on their core processes/ offerings which save internal process efforts.

Crowdbuyer business model

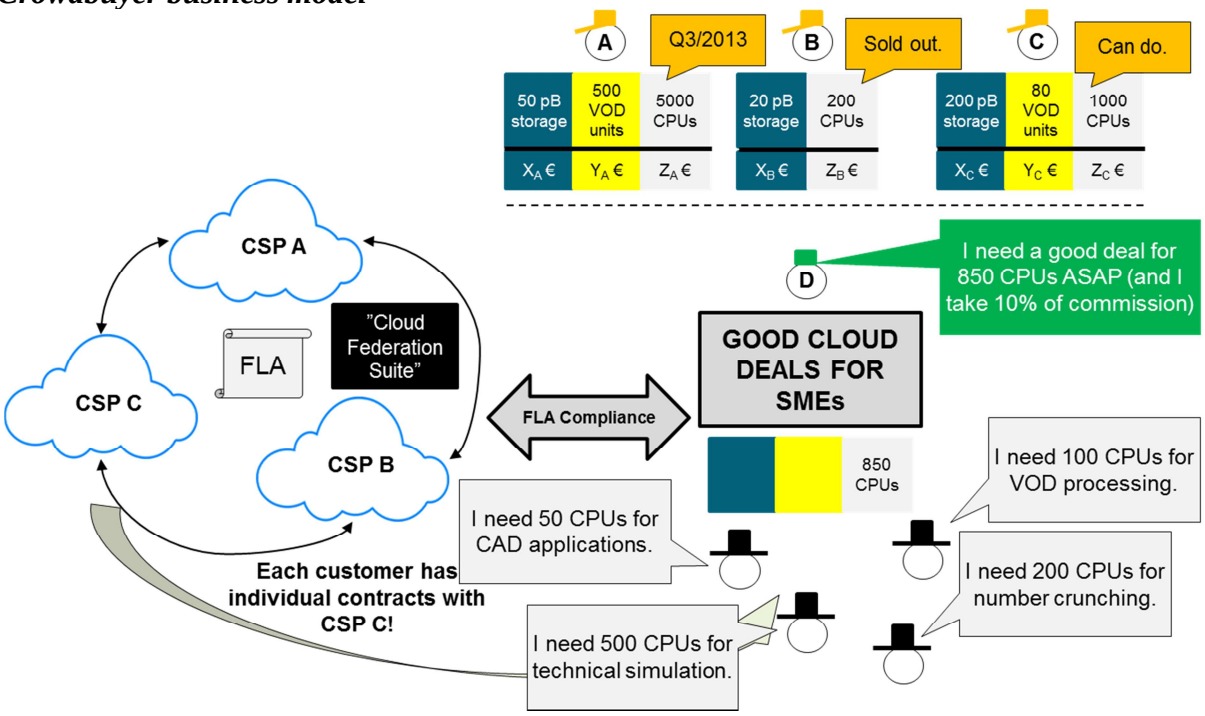


Figure 25: Overview of the crowdbuyer model

Overview

The crowdbuyer business model is inspired by the electricity market and in general an extension of the cooperative business model with 3rd party one stop shop. It includes an intermediary (D) that collects orders from separate cloud consumers, pools them into one offer, and finds the best possible federation (or CSPs) to fulfill the pooled order (Figure 25). A pooling of resources would make sense as there are still several cloud offering on the market with a minimum purchase clause in their terms and conditions. Especially small and medium sized enterprises struggle to reach these minimum borders. Besides the pooling the crowdbuyer is responsible for the promotion and the offering of a shop functionality.

This model inherently moves bargaining power more into the hands of the cloud consumers and away from the supply side, resulting in less revenue captured by CSPs and more by cloud consumers (and possibly the crowdbuyer itself). On the other hand, this may bring new demand to the market though lower unit prices. Therefore, this model can be used by cloud federation networks/ cloud providers to distribute their final 10 to 20 percent of their cloud capacities to potential consumers in order to cover potential fix costs.

We are currently unaware of a cloud crowdbuyer that would operate purely on the above business logic. Slicify[140] however demonstrates the logic in a limited sense through reselling the computing capacity of household computers. We can expect that the individual sources of cloud resources (household personal computers) are much smaller is much than the buyers (not just households, but also businesses). In this respect, it is at least partially the case, that in order to meet a larger order, the company needs to pool many suppliers that meet the pricing requests of the buyer.

Value net description

[140] Source: https://secure.slicify.com/

This business model introduces the crowdbuyer as intermediary that is not only matching individual ask and bid prices, it aggregates several customer bids, and attempts to bring down the price offered by CSPs (Figure 26). The crowdbuyer maintains an UI (e.g. marketplace), which the cloud consumers use to specify their needs. Once ask and bid prices match on the market regarding the pooled order, transactions are taken to the level of individual cloud consumers and the crowdbuyer where the cloud resources are divided between the cloud consumers in proportion to their payment shares. The financial processing will be handled via the crowdbuyer who will redistribute the incoming money. The payment of the crowdbuyer is done on a commission basis.

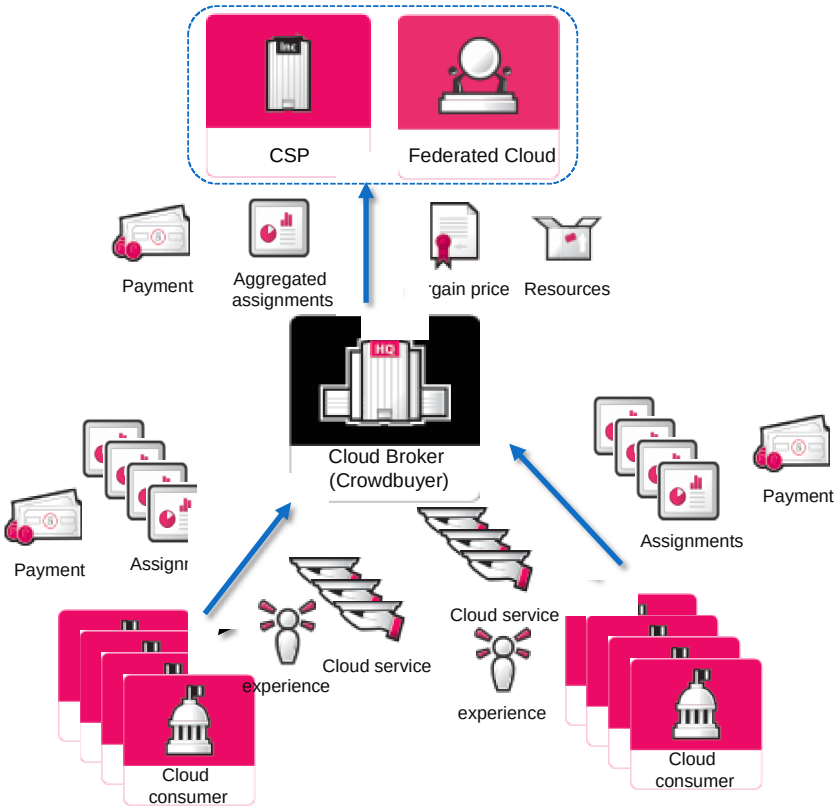


Figure 26: Value net of the crowdbuyer business model

Value considerations

This business model is closely related to the cloud exchange model, however with important differences. First, the volume of transactions will likely be much smaller. This results in a penalty to some cloud consumers on efficiency and completeness of the offering. From the consumer perspective, we highlight the following matters:

- Lower prices due to higher bargaining power
- Less differentiated services, as the service strongly depends what orders are pooled (Furthermore a pooling does only make sense for highly standardized services)Lower level of support, as suppliers may be smaller and more fragmented.
- Lower QoS compared to e.g. federation, as the cloud offerings are not integrated.

From the cloud provider perspective:

- Provides a channel to sell to customers that might otherwise be too small to be efficiently reached.
- Improves efficiency of serving smaller customers once they have purchased services.
- On the other hand, moves bargaining power into the hands of customers, which might hurt margins.

- The main differentiation point is price, and possibilities to create lock-in effects are modest.

From the perspective of the crowdbuyer intermediary, the expandability of the model may also be limited. This is because CSPs may be disincentivised to sell their resources through a crowdbuyer, because the increased bargaining power of cloud consumers would limit their margins. Since these operations would have limited size, network effects would not shield them from competition in the same ways as cloud exchanges.

Wholesaler business model

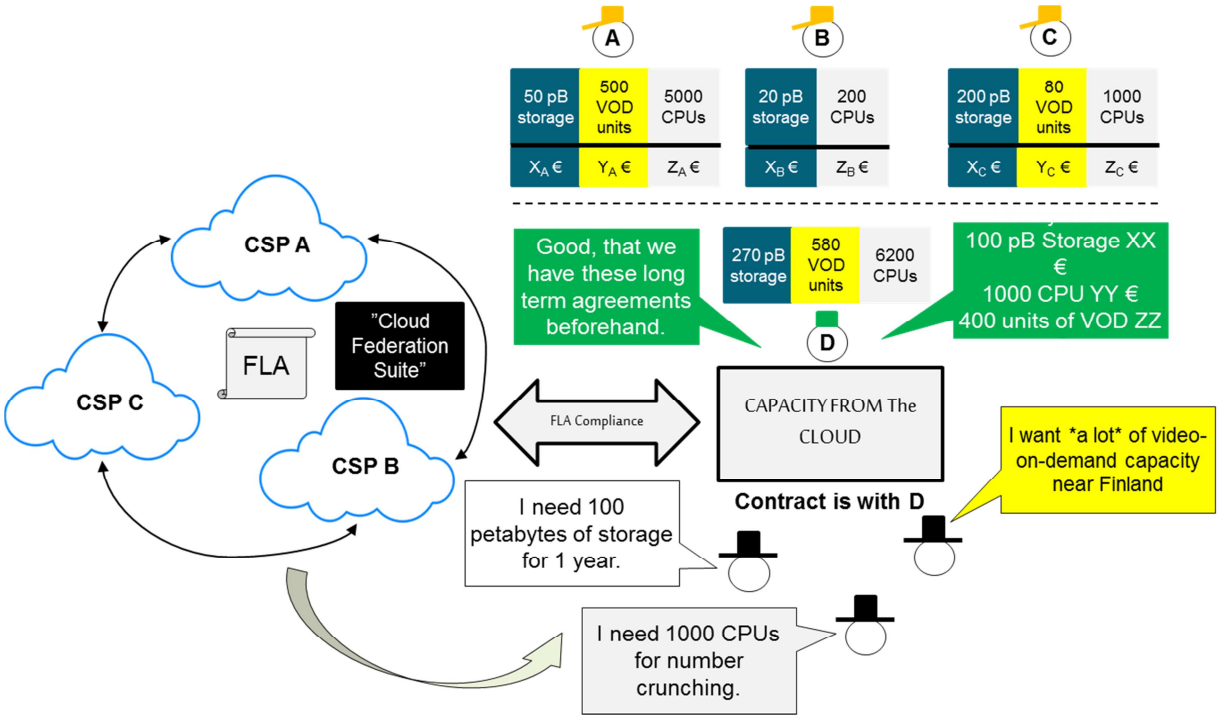


Figure 27: Overview of the wholesaler business model

Overview

The wholesaler approach is closely related to the 3rd party cooperative model, and emphasizes long-term SLAs and large individual transactions with could resources. This model is best for large bulk transactions, and de-emphasizes dynamic features (like arbitrage) and value-added services. A third party wholesaler (broker) makes contracts with CSPs and cloud consumers.
From the perspective of the cloud consumer, the wholesaler acts like a CSP.

This business model does not require sophisticated technological capacity from the broker entity due to the high granularity of the transactions. Hence, it is easy for IT service companies to enter the cloud market in the role of a wholesaler. This business model is interesting for IT companies that do not have own cloud capacities but have a strong market position/ customer base. From their point of view cloud would be a strategic, complementary enhancement of their portfolio.

Greencloud[141] is an example of a firm that offers "white label" IaaS services, and hence acts as a wholesaler of cloud services to CSPs and other businesses. The company itself does not have a end-customer facing marketing function. However, the firm itself owns data centres and it apparently does not source cloud resources from other companies. NTT also offers its IaaS

[141] Source: http://gogreencloud.com/whitelabelpartner/

resources through a wholesale model[142]. Arguably, other telcos can operate through this model, though information is not readily publicly available. OnApp is also active in this space, as it sells resources from its federation as 'white label' virtual cloud resources to 3rd parties.

We are currently unaware of a firm that would predominantly focus on the wholesale function without owning data centre resources themselves. Instead, what we generally see is that companies that somehow distribute and aggregate cloud resources of other companies also offer value-added services or do not focus on large-granularity / high volume transactions in resources.

Value net description

The wholesaler acts in the customer-facing role and obtains commissions for transactions as it invoices cloud consumers and respectively compensates CSPs (or federations) based on what resources they sell. The wholesaler maintains a UI, which the cloud consumers use to specify their needs, to browse available resources, and to make transactions (Figure 28).

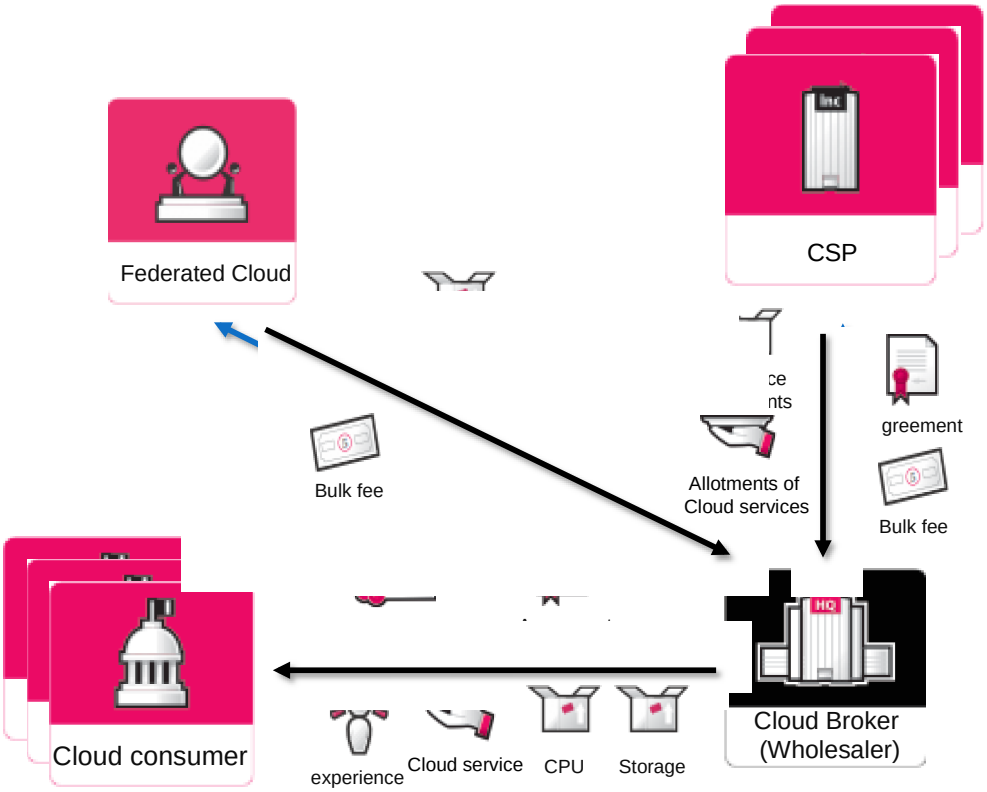


Figure 28: The value net of the wholesaler business model

Value considerations

We highlight the following matter from the perspective of the cloud consumer:

- A wholesaler can offer a large breadth of cloud resources, enabling it to have a highly price-competitive offering that boosts the cloud consumer's efficiency.
- However, as there is no aggregation or dynamic cloud resource management, it falls short of QoS when comparing to the cooperative models. On the other hand, the consumer avoids paying for these properties.

[142] Source: http://www.businesscloudnews.com/2014/07/28/ntt-com-to-wholesale-iaas-through-pldt/

- Also, the cloud resources are transacted in large batches, which also limit the completeness of the offering from the perspective of cloud consumers with limited resource needs.

Perspective of cloud provider:

- Regarding value capture, the wholesaler model is highly scalable and internally efficient. However, it is also extremely easy to copy, which opens the door for new entrants to drive down margins.
- By providing cloud resources for wholesale, the company also avoids investment into marketing. This can be a viable choice for cloud providers that wish to focus on operational efficiency.

Cloud aggregator and broker business model

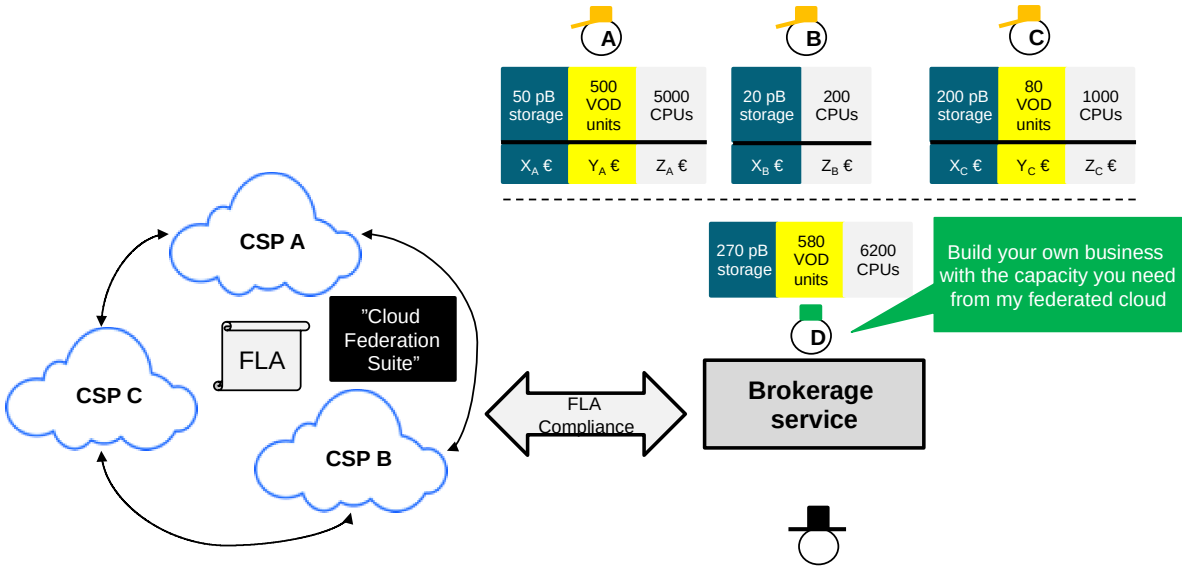


Figure 29: Overview of the capacity aggregator and broker business model

Overview

The cloud aggregator and broker business model (Figure 29) includes an entity (D) that manages a PaaS/SaaS platform that brokers or aggregates IaaS resources from CSPs. The customers of entity D are SaaS businesses that build their business using the capabilities offered by D. This business model refers to what is commonly understood as cloud infrastructure brokerage in the upstream value chain. The business model may lean more or less between the use of technological assets and human assets.

There are currently tens if not hundreds of cloud broker startups on the market[143], which include likes of ComputeNext, Nephos Technologies, and Cloud Sherpas. Cloud aggregators like Cloud More and BlueWolf on the other hand create services that aggregate different cloud services in order to create a new service. Furthermore, all major IT service companies to some extent act as cloud brokers in situations where they need to advise their customers on cloud deployment matters.

Value net description

[143] For a useful list, see http://talkincloud.com/cloud-services-broker/cloud-services-brokerage-company-list-and-faq.

The cloud aggregator/broker can have frame agreements with several CSPs to resell their cloud offerings, and possibly receive discounts from them if volumes are significant. The aggregator/broker can either (i) be a simple intermediary that takes a commission out of transactions between CSPs and SaaS providers or (ii) offer an additional value-added service for aggregating the cloud offering (Figure 30).

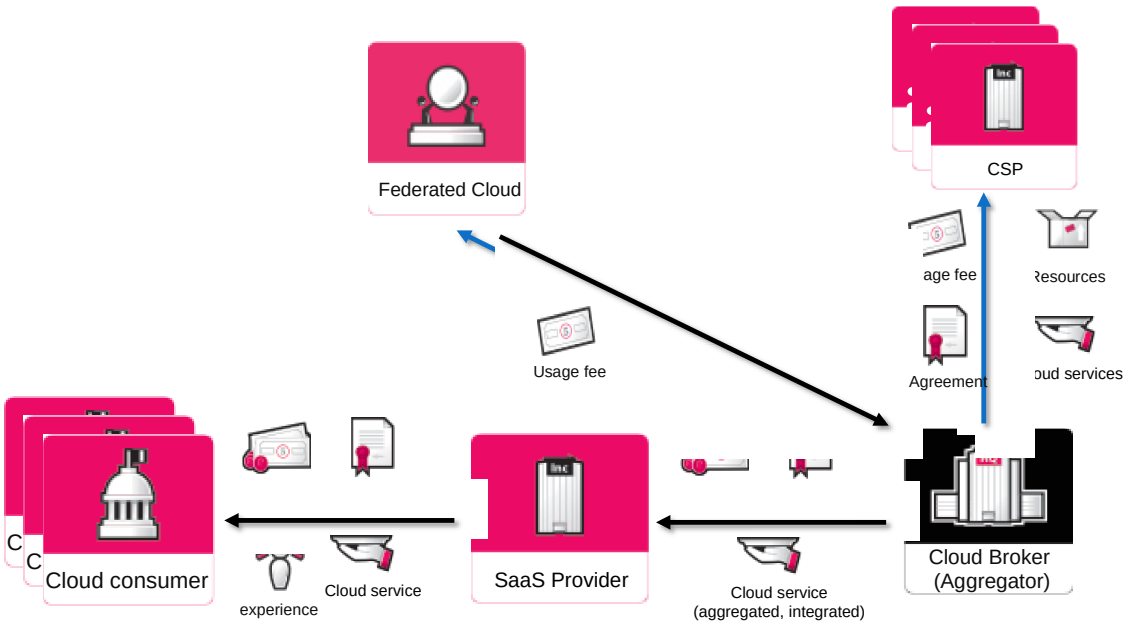


Figure 30: Value net of the capacity aggregator and broker business model

Value considerations

As opposed to the cooperative models, the aggregator/broker employs a looser type of organizational coupling between the CSPs whose resources are being applied. Similar to other models, the cloud aggregator/broker provides completeness to its offering by using the resources of other CSPs. Depending on the technical capabilities of the aggregator/ broker, it may or may not be able to create a QoS for its customers (i.e., the SaaS providers) that is "more than the sum of its parts" by employing dynamic switching of resources in case of technical failures by a given CSP.

From the cloud consumer perspective we highlight:

- Offers similar benefits as the cooperative business models.
- However unless the broker sells cloud resources not only from leading and established players, QoS may be lower.
- Due to looser coupling, consumers may have access to a more up-to-date variety of CSP services.

From the cloud provider perspective:

- Broader market reach compared to federations, as it is easier to sell through many brokers.
- Setting up relations with brokers is highly efficient, or may not involve any effort at all.
- Using brokers as channels however does not aid in differentiation in the same sense as a federation.

We also highlight that aggregator/broker models are easy to imitate compared to cooperatives, increasing the risk of new entrants. Unless exclusive CSP contracts are in place, one

aggregator/broker business can easily offer what another aggregator/broker business is offering. The success of the cooperative model depends largely on its ability to deliver superior QoS and completeness to the customer (i.e., the cloud consumer or the SaaS provider) compared to the aggregator/ broker model, and related models like the exchange, wholesaler, and crowdbuyer models.

Cloud exchange business model

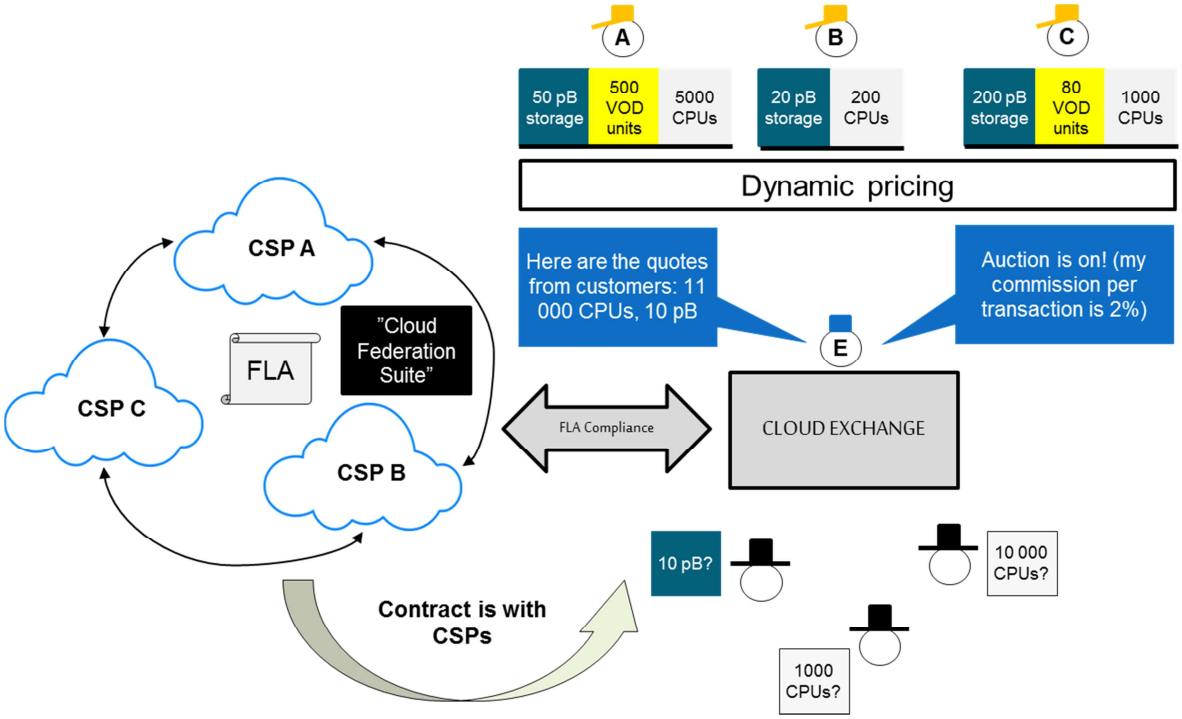


Figure 31: Overview of the cloud exchange business model

Overview

The cloud exchange model (Figure 31) refers to a broker model that has come to resemble a stock exchange, i.e. both the supply and demand side offers vary constantly in price, and there are multiple actors on the supply and demand side. The exchange is operated by a third party whose business model relies on transaction commissions. There is neither clear dominance in price formation on the supply nor the demand side of the market. In order to operate, the cloud exchange requires a very high degree of standardization compared to the other cloud business models. This may ultimately limit the scope of offerings among these businesses.

The cloud exchange concept is rather new, and Deutche Börse is acting as the pioneer by offering its cloud exchange service to beta testers[144]. The concept should not be mixed with network-level exchanges, that seek to enhance data flows between data centres and networks.

Value net description

The cloud exchange model effectively combines a broker and an exchange function. The novel exchange component matches ask and bid prices, while the broker element enforces the price and service levels from CSPs (and federations) (Figure 32). The broker component constantly

[144] Source: http://www.dbcloudexchange.com/en/

receives updates on prices and available resources from CSPs (and federations), and this data are also constantly available to all potentially transacting parties. This for example departs from the broker/aggregator model, where sellers cannot directly observe the bids the buyers are making.

Once the exchange matches an ask and bid price, the exchange collects a fee from the cloud consumers and passes it to the winning CSP (or federation) after taking its commission. At the point of transaction, an agreement is formed between the CSP and the cloud consumer, and the exchange has no role in the technical details of consuming the cloud service.

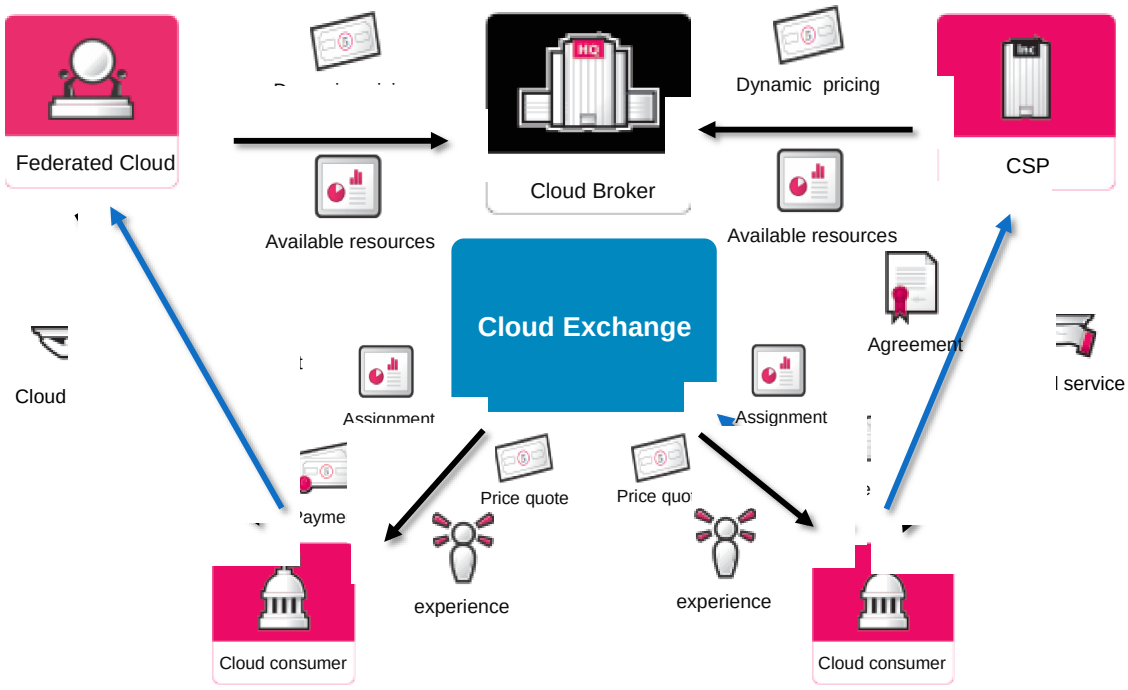


Figure 32: Value net of the cloud exchange business model

Value considerations

The cloud exchange model offers cloud consumers a very high variety of cloud resources, and enables highly liquid cloud markets bringing efficiency benefits to customers. However, the lack of human-delivered consulting services limits completeness of the offering. In addition, as no aggregation services are offered, the cloud services purchased are not more than the sum of their parts.

From the cloud consumer's perspective we highlight the following value elements:

- Most efficient price formation leading to lower costs
- Broad variety of services lowers search costs
- Little or no additional value-added services, which will likely need to be purchased from elsewhere.

From the cloud service provider's perspective:

- Access to board markets to e.g. offload excess capacity.
- Intensified price competition, less opportunities to differentiate.
- However, providers can still maintain their brand identities, and not be treated as white label providers.

Technically speaking, the cloud exchange model is easy to copy and expand while keeping internal costs low. However, as with stock exchanges, there are extremely high network effects, meaning that only a highly limited number of firms would be able to survive in this market.

5.3 Additional business opportunities in federation and brokerage adoption

The possibility to federate and/or flexibly broker cloud resources is directly connected to the depths of the undertaken value creation process, which can in a consequence result in different scopes of a federation (from lightweight federation to fully integrated federation). Based on the scoping of the federation different business models are possible. These will vary in their relevance when assigning them to the different phases of the federation lifecycle.

The lifecycle phases, proposed by the authors, are mainly inspired by the traditional lifecycle of IT projects (Figure 33). The following figure provides an overview of Cloud Federation lifecycle and main activities to be performed in each phase.

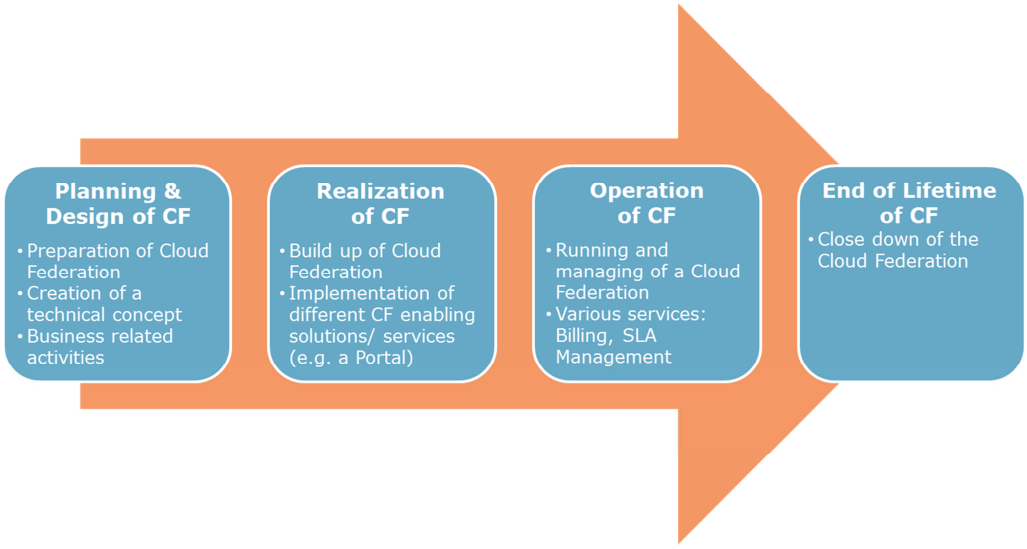


Figure 33: Lifecycle model of a cloud federation.

With respect to these phases various activities have to be performed by the involved stakeholders, which will be summarized in the following:

- **Planning and design of Cloud Federation** are mainly comprised of conceptual activities related to relevant business[145] and technical[146] aspects. In this phase experts with in-depth knowledge on cloud computing, federation as well as the general market, are required.
- **Realization of Cloud Federation** encompasses building up the cloud federation, implementation of the different services and solution components (e.g. the platform), thus, cloud providers become able to federate and flexibly interchange their cloud resources. In this phase experts/ companies are needed that have a profound knowledge of cloud as well as federation enabling technologies and/ or have ready solution components in their portfolio.

[145] E.g. stakeholders to be involved, customers to be addressed, analysis of the federation fit of cloud providers, market access, business model, timeline, focus/ depths of federation, exit strategy
[146] E.g. requirements, technical solution components, architecture.

- **Operation of Cloud Federation** means the operation of the technical infrastructure and the execution of the contractual aspects by providing additional services. Various ways of conducting this operational phase are possible, depending on the readiness to risk acceptance. In addition, a constant optimization of the federation is required in a business relevant ways (e.g. cost reduction, enhancing the offering, address new customers; exchange of cloud providers) as well as technological relevant ways (e.g. implementation of new service functionalities).
- **End of Lifetime of Cloud Federation** means the close down of the federation between the different providers in the case a federation is for instance not profitable anymore. Therefore various criteria have to be defined to identify this time point.

Depending on the phases the authors see four generic business models that address customer needs in one or more phases of the total federation lifecycle. These are summarized in Figure 34.

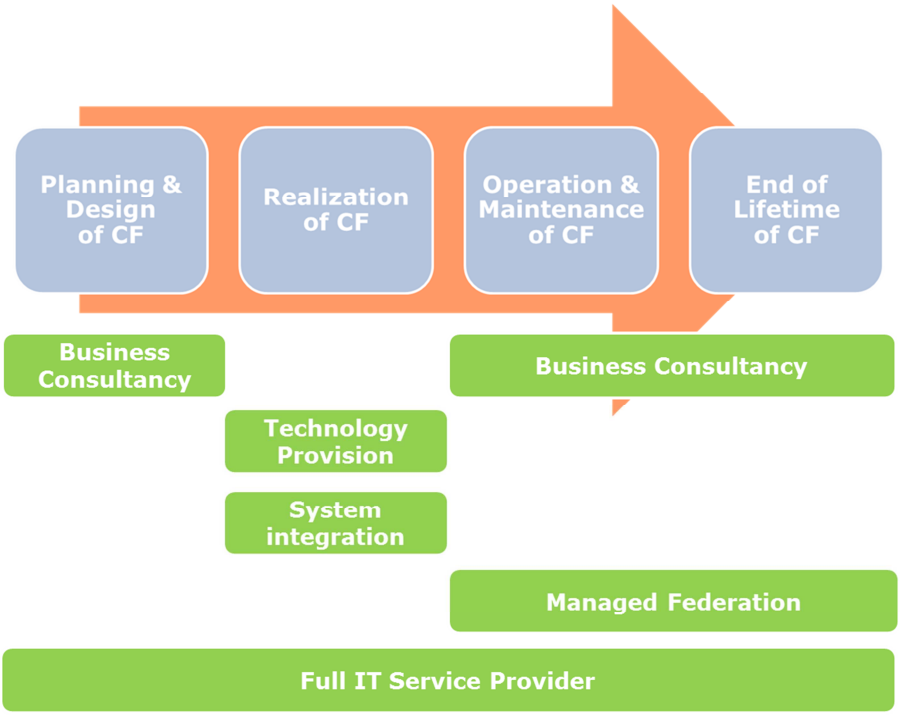


Figure 34: Summary of relationships between business models and the federation lifecycle.

The "**Business Consultancy Service"** model is mainly relevant in the planning & design phase, the operational phase of a cloud federation and in addition at the end of a cloud federation's lifetime. This form of business consultancy can be offered in different direction. Business consultancy services can be offered for single cloud providers (see Figure 35), a cloud federation, cloud consumers and IT companies, including to:

- Cloud providers that are interested to form or participate in a cloud federation, optimize their federation involvement or step back from the federation, are in the need of guidance when defining their federation strategy and the scope of the federation, identifying of potential federation partners or an appropriate cloud federation network that is already active. Furthermore, cloud providers are in the need, to check the performance/ the outcome of their federation involvement.
- Cloud federation consortium can use business consultancy services to optimize the performance of their federation and actively promote their federation to cloud consumers.

- Cloud consumers might be able use business consultancy services to identify the right cloud offering or federation network meeting their business requirements.
- IT companies have different interests depending on their portfolio offerings
    - IT companies providing federation technologies and solutions can use business consultancy services for the promotion of their portfolio to cloud providers looking forward to establish a federation or other IT companies that want to become a federator/ broker. Furthermore, new strategic directions in order to adapt and enhance their portfolio might be in their field of interests.
    - IT companies planning to become a cloud federator/ cloud broker could need an advisor when defining a strategy (e.g. scope of the offering, Market entry, customers, partners …) and bringing their offering to the market. In addition promotion of their federation offering can also be covered by a business consultancy service.

The consulting company can take an active role, which is present on the market, or a passive role, by working from the background.

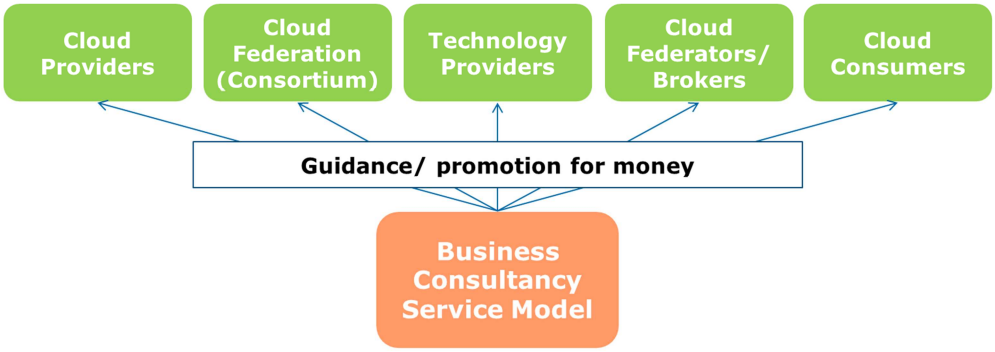


Figure 35: Potential customers for business consultancy services relating to cloud federation.

The "**Technology Provision"** model is only relevant in the realization phase. It addresses cloud providers to establish their own federation network or IT companies to establish their own federation offering by providing them with the relevant technologies and solutions. Furthermore IT companies with the purpose to become a cloud federator/ cloud broker can be provided with the relevant technologies and solutions as well. The final integration work is either done by the cloud providers/ IT companies themselves or a third party company (system integrator). In the case a system integrator is doing the implementation a partnership/ reseller contract could be worked out between a technology provider and the system integrator. This business model is interlinked with the business consultancy model, as these companies have to know the relevant offerings in order to provide advises.

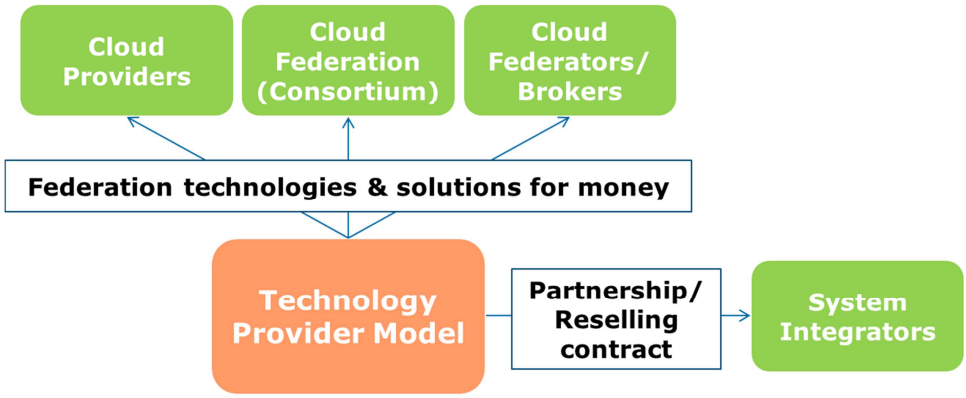


Figure 36: Potential customers for technology provision relating to cloud federation.

The **"System Integration"** model is also addressing the needs of the realization phase. Instead the pure provision of technology components and solutions to create a cloud federation, the system integrator is realizing the cloud federation by combining the various solution elements provided by technology providers. Furthermore, the system integrator can help cloud consumer to integrate the cloud federation including the cloud offerings provided by various cloud provider into their relevant business processes.

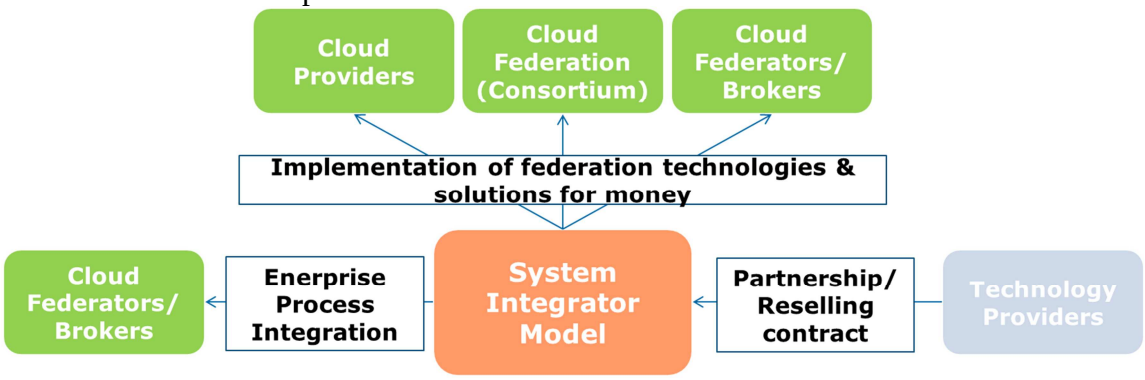


Figure 37: Potential customers for system integrators relating to cloud federation.

The **"Managed Federation"** model is mainly relevant in the operational phase of a cloud federation. It is all about the operation of the technical infrastructure, the federation/ brokerage portal and the execution of the contractual aspects by providing additional services. Depending of the scope of a federation (lightweight federation with no integrated offerings to fully integrated federation) the managed federation model can differentiate various business models. In case of a lightweight federation with no integrated offerings the managed federation model could just come up with a portal where cloud providers can highlight/ describe their offerings and potential cloud consumers can search for those offerings. In this case the provider of the managed federation is just acting as a matchmaker. An extension of this model would be the offering of shop functionalities. Managed federation provider in this case acts as single point of contact to the cloud consumer and maintains the financial contract. In the variant of a fully integrated federation the managed federation provider would take over all liabilities.

The "**Full IT Service Provider"** model covers the complete lifecycle by accompanying cloud providers on their roadmap to set up and run a cloud federation. There exist two main service delivery concepts for the "full it service provider" model. On the one hand cloud federation can be offered highly exclusive to the handful of cloud providers that want to federate their offering. In this case individual adaptions are possible based on the providers' requirements. On the other hand cloud federation can be offered as standardized service with no adaption possibilities for the participating cloud providers.

Based on this more or less generic business models detailed business model descriptions including different variants are provided in the next chapter.

5.3.1 Business consultancy services model

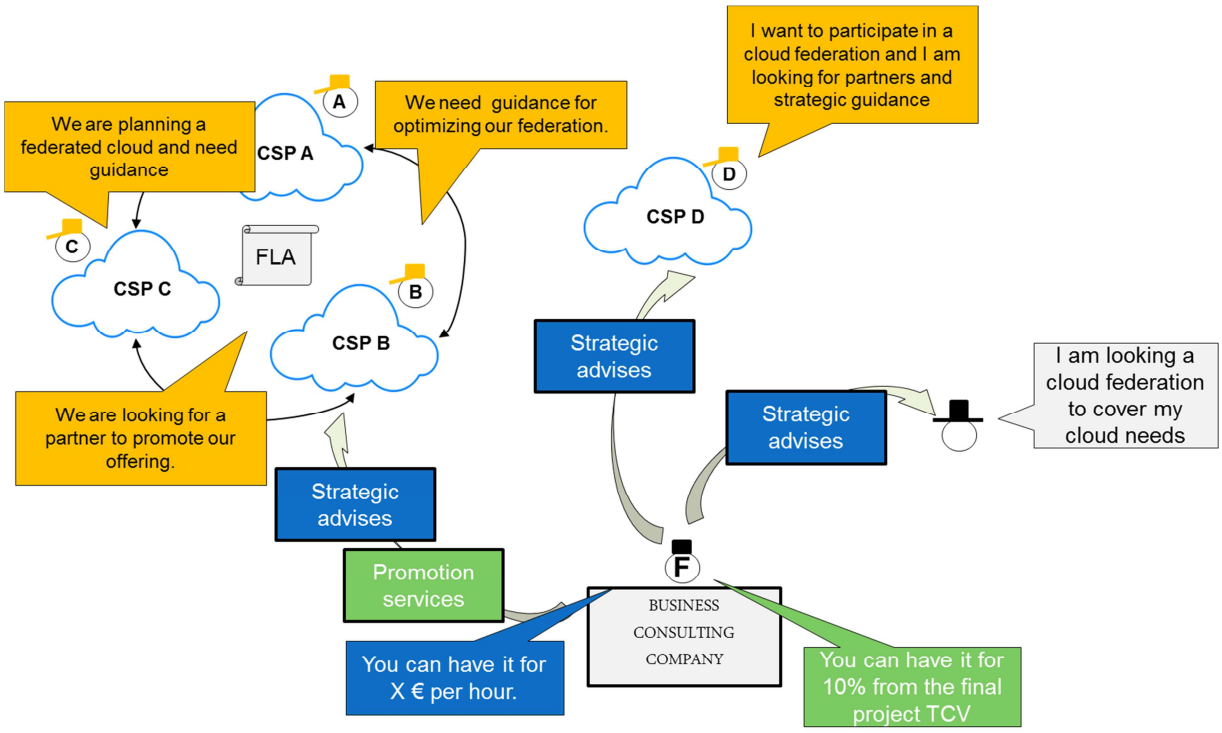


Figure 38: Overview of the business consultancy service model.

General Overview

Based on their accumulated knowledge about the cloud computing market, including relevant market structures, developments in the cloud computing market, and the cloud consumer demands, business consulting companies can provide non-technical guidance to all relevant stakeholder groups in the field that are somehow involved in the cloud federation value chain (Figure 38). Furthermore, they are also able to promote various cloud federation offerings due to their large customer network. Their knowledge and expertise as well as their customer network are their key to success, which they are able to monetize. The most IT service providers (e.g. IBM, Accenture, HP, Capgemini, T-Systems and Atos) but also smaller companies that have specialized themselves in the direction of cloud federation/ cloud brokerage can provide or are already providing such consultancy services.

Based on the knowledge gained in the EASI-Clouds project most project partners can be active on the market for cloud federation and cloud brokerage as provider of business consultancy services.

Business consultancy services for cloud consumers

Overview

Business consultancy services can help explore the business cases where the cloud resources (including federations) would be used, and help identify means to obtain other critical resources. Moreover, business consultancy services for cloud consumers encompass the identification of the right cloud providers and cloud federation offerings that more optimally match their business requirements.

Value net description

As exchange for the consulting service the cloud consumer pays money on a T&M or fix-price basis. The value model (Figure 39) describes the main value exchanges between the involved stakeholders.

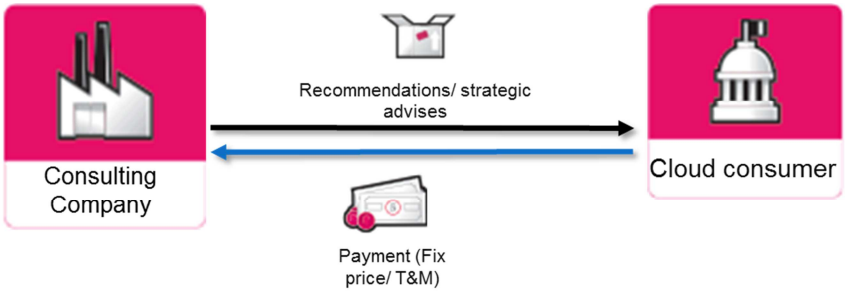


Figure 39: Value net of cloud business consultancy for cloud consumers.

Value considerations

From the perspective of the cloud consumer the following value can be created:

- New external perspectives brought to the attention of managers.
- Shortened identification process due to the knowledge of the cloud computing market provided by the consultants (providers and federation with the right offering can be identified faster than earlier)
- Possibility to consume the right cloud federation offerings that more accurately match their requirements.
- Decreased possibility of poor business decisions and missed opportunities

Business consultancy services for cloud providers

Overview

Business consultancy services for cloud providers consists of strategically advising cloud providers on their way to use cloud federation/ cloud brokerage for enhancing their cloud businesses, to find the right partners and technology providers particularly in areas of vertical integration. More importantly, business consultants may help to map the needs of the end customer, which should be comprehensively understood to justify investments into federation.

Value net description

As exchange for the consulting service the cloud provider pays money on a T&M or fix-price basis. The value model (Figure 40) describes the main value exchanges between the involved stakeholders.

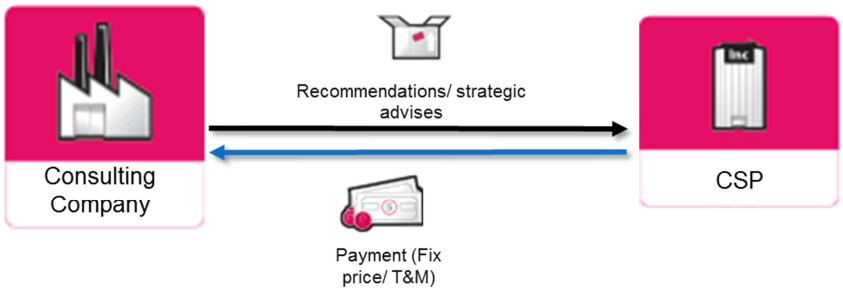


Figure 40: Value net of business consultancy for cloud providers.

Value considerations

From the perspective of the cloud provider the following value can be created:

- Shortened time to market when a valid business case for entry into a federation exists.

- Decreased possibility of poor business decisions (prevention of misinvestments or missing opportunities), possibly resulting from a poor understanding of end-customer needs.

Business consultancy services for cloud federation networks

Overview

These services encompass consulting cloud federation networks on their way to optimize their cooperation, to find the new cloud provider as federation partners and to promote their offerings actively among cloud consumers (e.g. that belong to the customer base of the consulting company).

Value net description

As exchange for the consulting service the cloud federation network pays money on a T&M or fix-price basis. Promotion can be done either on a T&M/ fix-price basis or on a provision basis (success oriented). The value model describes the main value exchanges between the involved stakeholders.

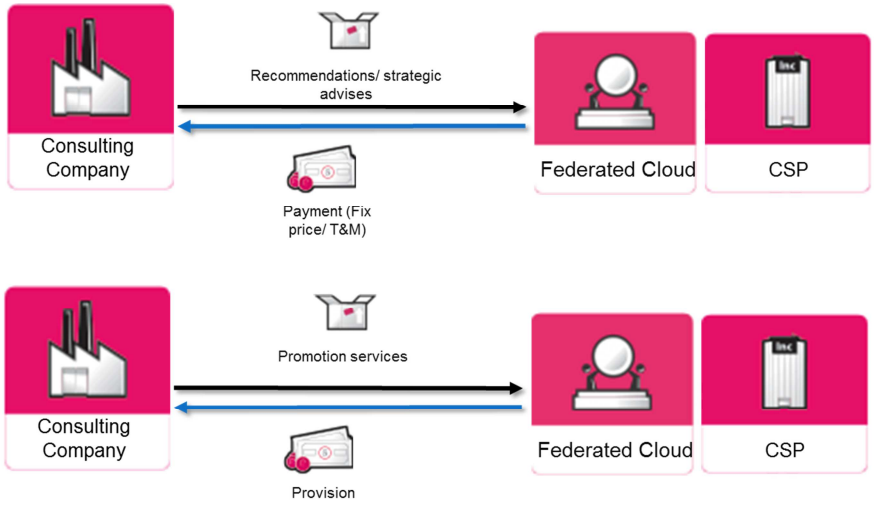


Figure 41: Value net for business consultancy services for cloud federation networks

Value considerations

From the perspective of the cloud federation network the following value can be created:

- Better longer-term strategic coordination between federation partners, particularly in areas of resource investment and marketing.
- Cost reductions due to constant optimization of the federation
- Increased customer base due to improved go-to-market plans
- Reduction of missed opportunities an misinvestments

Business consultancy services for technology providers

Overview

Business Consultancy Services for technology providers consist of advising them on their way to strategically establish and enhance their offered solutions based on market demands and to promote their offerings actively among cloud providers and cloud federation networks (e.g. that belong to the customer base of the consulting company).

Value net description

As exchange for the consulting the technology provider pays money on a T&M or fix-price basis. Promotion can be done either on a T&M/ fix-price basis or on a provision basis (success-oriented). The value model (**Figure 42**) describes the main value exchanges between the involved stakeholders.

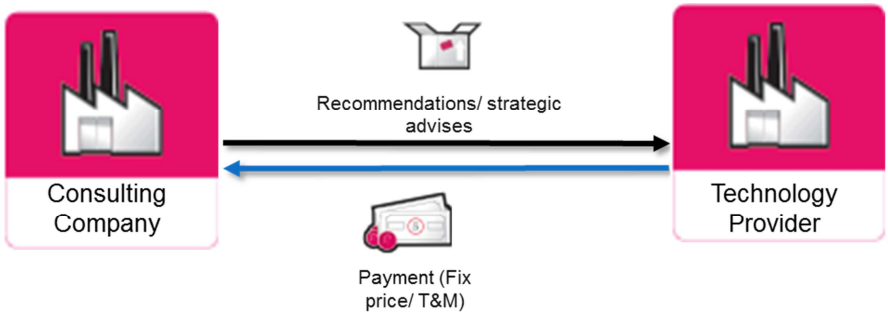


Figure 42: Value net for business consultancy services for technology providers

Value considerations

From the perspective of the technology provider the following value can be created:

- External view when identifying customer needs and mapping the competitor landscape
- Improvements in go-to-market plans and product management.
- Identification of funding sources for product development
- Consultancy services for business exits.
- Decreased possibility of wrong decisions (prevention of misinvestments and missing opportunities)

5.3.2 *Technology Provider model*

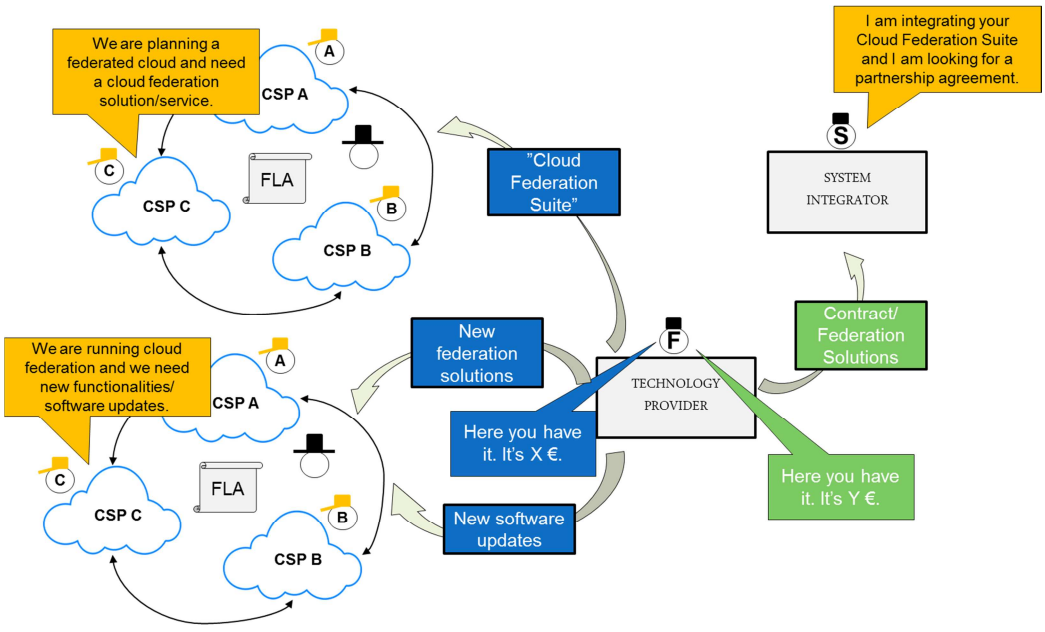


Figure 43: Overview of the technology enabler/service provider business model

General overview

Based on their accumulated technological knowledge, their innovation capabilities and their footprint on the cloud computing market, technology providers can provide the relevant solutions to build up a federation as well as to constantly enhance a federation to all relevant stakeholder groups in the field that are somehow involved in the cloud federation value chain. Their technological expertise and their innovation capabilities are their key to success which they are able to monetize.

Examples of these business models include Eucalyptus Systems that markets the Eucalyptus platform (open source) and VMWare (owned by EMC) with its proprietary solution. There are also many cases where CSPs jointly develop enabling software platforms, such as in the case of OpenStack. In addition to cloud orchestration platforms, there is a broad range of software platforms that are relevant, for example platforms that can be used to build federations and conduct brokerage (e.g. OnApp. Gravitant, CompatibleOne).

Based on the components developed in the EASI-Clouds project most project partners can be active on the market for cloud federation and cloud brokerage as technology provider.

Technology Provider for cloud providers

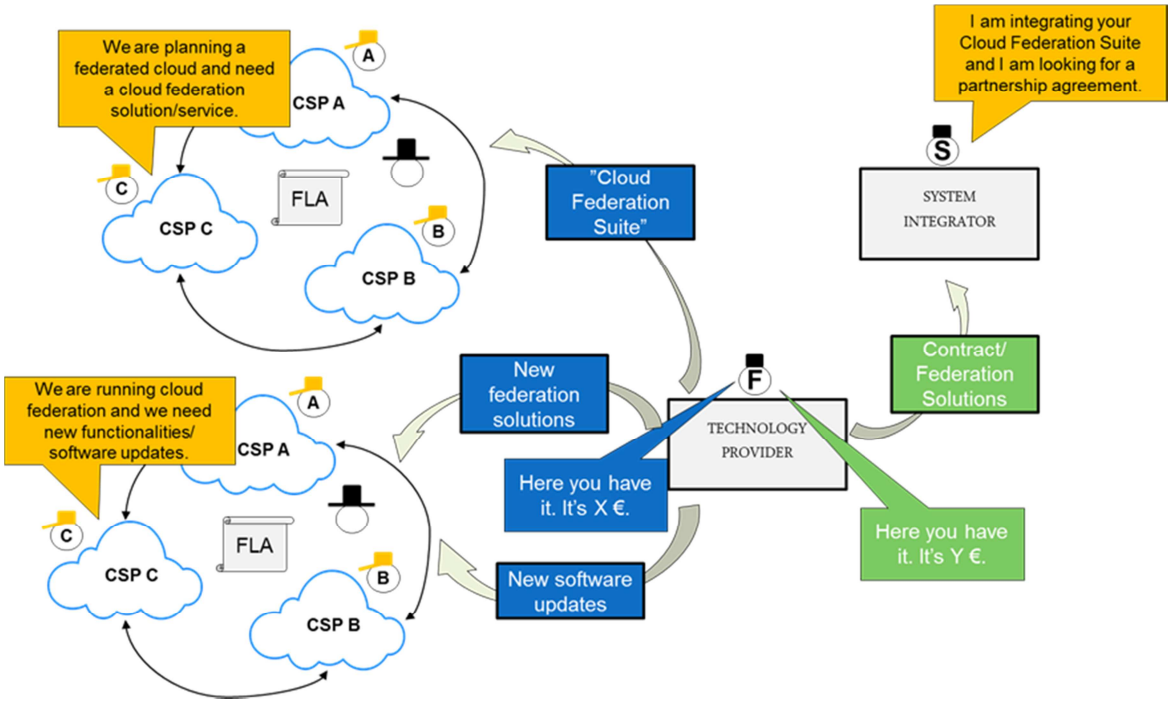


Figure 44: Overview of the technology enabler/service provider business model for cloud providers.

Overview

The technology providers create and/or distribute software that is required by CSPs to provide any kind of cloud offering involving more than one cloud (incl. cloud federation, cloud brokerage). Prime examples of software platforms in this area are cloud orchestration platforms, which are also relevant when system integrators are involved.

Value net description

The general business operates like traditional solution businesses where a solution provider sells a solution to another company. The following value model describes the main value exchanges between the involved stakeholders.

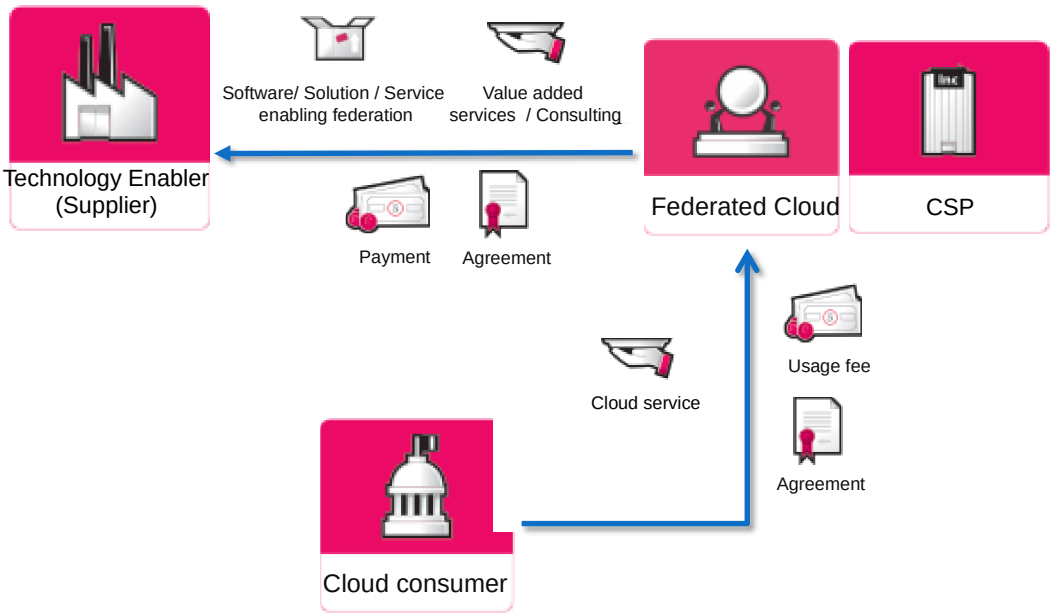


Figure 45: Value net description of the technology enabler/service provider business model in the context of cloud providers.

Value considerations

From the perspective of a cloud provider the following value can be created:

- Lower risks of investing in wrong development activities.
- Faster time to market when using existing federation solutions.
- Possibility
  - to federate and to improve the efficiency of their cloud resources,
  - to reduce the investment costs in infrastructure and
  - to gain additional revenues as overcapacities can be sold to cloud consumers via federation partners.

Technology Provider for cloud federation networks

Overview

Technology Provider distributes its developed solution and software to already running cloud federation networks in order to enhance the function range and to constantly optimize the federation and its performance. This includes also updates of software components. Implementation is executed by the federation networks itself. While federation is a highly novel area in cloud computing and related software ecosystems are yet to form, we consider that many existing cloud-related software solutions can be applied to this context, for example in the security space.

Value net description

As exchange for the provided solution and software elements as well as the updates the cloud federation network pays money on a fix-price basis. The value model describes the main value exchanges between the involved stakeholders.

Value considerations

From the perspective of the cloud federation network the following value can be created:

- Enhancement of the function range
- Higher attractiveness for cloud consumers
- Optimization of internal processes due to improved functions

Technology Provider for system integrators

Overview

Technology Provider distributes its developed solution and software that is required by cloud providers to federate or cloud federators/ brokers to system integrators that take care of the implementation. VMware is a good example for this business model, as they cooperate with most of the large system integration companies like IBM, Accenture and Atos. Other cloud orchestration platform providers are also notable examples.

Value net description

The value net description is based on a partnership/ reseller contract between the technology provider and the system integrator which means solutions and software against money. The value model describes the main value exchanges between the involved stakeholders.

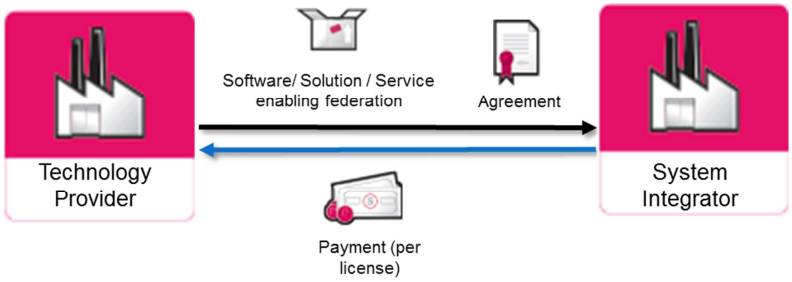


Figure 46: Value net description of the technology enabler/service provider business model in the context of system integrators.

Value considerations

From the perspective of the system integrator the following value can be created:

- Faster time-to-market for customers can be offered, as existing tools reduce integration work.
- Lower up-front investments as technology investments can be externalized and/or amortized over a longer time.
- Lower risks of misinvestments into poorly suited technologies

The benefit for the technology provider is that large system integrators, with a good customer base, are a good distribution channel.

5.3.3 System Integrator model

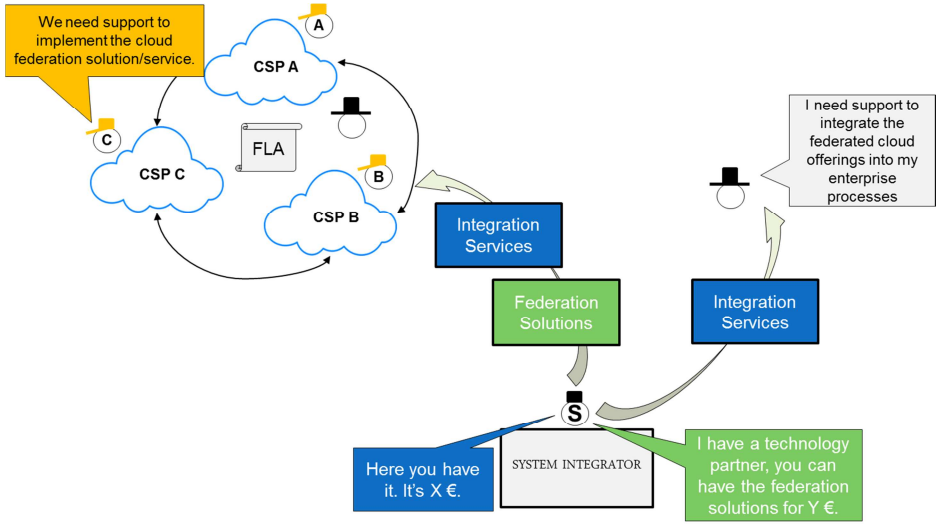


Figure 47: Overview of the system integrator model.

General overview
Based on their technological knowledge and partnership with the relevant technology providers and their understanding of the relevant business processes either of the cloud providers as well as the cloud consumer system integrator can perfectly and efficiently implement the provided federation solutions and adapt them with respect to individual requirements.

Their technological and integration expertise as well as their understanding of the business processes are their key to success which they are able to monetize. The most IT service providers with system integration capabilities (e.g. IBM, Accenture, HP, T-Systems, Cap Gemini and Atos) can provide or are already providing such integration services.

System Integration for Cloud Consumers

Overview
Based on their deep knowledge about the cloud computing market, the technology expertise and an understanding of the cloud consumers business processes system integrator can support cloud consumers by integrating the cloud federation offering including the different cloud services into their business processes. The most IT service providers that are operating as system integrator (e.g. IBM, Accenture, HP, T-Systems and Atos) can offer or are already offering such business process integration.

Value net description
As exchange for the integration activities the cloud consumer pays money on a T&M or fix-price basis. The value model describes the main value exchanges between the involved stakeholders.

Value considerations
From the perspective of the cloud consumer the following value can be created:
- Fewer gaps between cloud services and business processes
- Higher efficiency
- Reduced costs (for federation solutions)
- Possibility to use federation
- Possibility to gain more control over own data

System Integration for Cloud Providers

Overview
Based on their deep knowledge about the cloud computing market, the technology expertise and a profound understanding of the cloud providers' strategy system integrator can support cloud providers by implementing their cloud federation. The most IT service providers that are operating as system integrator (e.g. IBM, Accenture, HP, T-Systems and Atos) can offer or are already offering such business process integration.

Value net description
As exchange for the integration and implementation activities the cloud provider pays money on a T&M or fix-price basis. The system integrator might be able to provide special discounts for the cloud provider due to a partnership with adequate technology providers. The value model describes the main value exchanges between the involved stakeholders.

Value considerations

From the perspective of the cloud providers the following value can be created:

- Faster time to market
- Reduced costs (for federation solutions)
- Possibility to use federation solutions to optimize their efficiency

5.3.4 Full IT Service Provider model

General Overview
The Full IT Service Provider model is a combination of all previous models that have been introduced already (see sections 5.3.1, 5.3.2, and 5.3.3). Especially IT service providers with a strong market presence that do have deep cloud computing knowledge and expertise, business process know-how, system integration and operation capabilities and strong technology partnerships are able to offer. The most IT service providers (e.g. IBM, Accenture, HP, T-Systems and Atos) with a strong market presence can or are already offering the full service.

The "**Full IT Service Provider"** model covers the complete lifecycle by accompanying cloud providers on their roadmap to set up and run a cloud federation. There exist two main service delivery concepts for the "full it service provider" model. On the one hand cloud federation can be offered highly exclusive to the handful of cloud providers that want to federate their offering. In this case individual adaptions are possible based on the providers' requirements. On the other hand cloud federation can be offered as standardized service with no adaption possibilities for the participating cloud providers.

6 Assessment of project demonstrators from a business perspective

6.1 Freesurfer

The German demonstrator is about the flexible use of cloud resources to perform a cloud based image analysis to measure the cortical thickness within a patient's brain scan and to be able to come up with results much quicker.

The EASI-Clouds portal and the incorporated functions to automate the processes are the centerpiece of the demonstrator. Cloud providers of medical post processing services are able to provide their service to external cloud consumers like hospitals and radiology departments.
The main values to be demonstrated by the demonstrator are to functionalities to automate the overall process from the planning via the provision to the final billing of the cloud service which saves a lot of time and money from the perspective of the providers. Furthermore cloud consumers like hospitals and doctors have the chance to experience a facilitated use of cloud service, more control over their data as well as transparency among others.

Therefore, the German demonstrator is a good example of the business model cooperative or cooperative third party. Both have been described in chapters… properly. At the end it is more a choice if cloud providers would like to do the brokering and the management on their own or buy these competences (incl. solutions) from external third parties.

At the moment, the demonstrator only offers one post processing algorithm with Freesurfer. In order to address a larger group of radiology departments the number of available medical imaging services for post processing procedures has to be increased.

Currently, in the area of cloud based post-processing, first offerings are available. The Freesurfer method to measure the cortical thickness of a brain can, for instance, can be used in combination with Amazon's Elastic Compute Cloud (EC2)[147]. In addition, further methods for the post-processing of medical images are offered on a cloud basis:

- Eleks, for instance, helps medical device manufacturers to reduce patient assessment time by accelerating Magnetic Resonance Imaging (MRI) scanner post-processing software with CUDA™[148].
- NITRC offers a service called Computational Environment, an on-demand, cloud based computational virtual machine pre-installed with popular NITRC neuro-imaging tools. The Freesurfer method is also integrated in this environment[149].
- Cerebralvol was offering Freesurfer on a cloud basis, but their offering is not active anymore. We assume that the main reason might be the pure focus on Freesurfer instead of additional post-processing algorithms / methods.

In the field of reconstruction of medical images, to our knowledge, there is no cloud offering available so far. In terms of market size this would be more attractive as the use of reconstruction measures is excessive as the figures for the MRI and CT usage in Europe are indicating. The problem at this point would be that the reconstruction algorithms are in the hand of providers

[147] Source: https://surfer.nmr.mgh.harvard.edu/fswiki/AmazonCloud.
[148] Source: http://www.eleks.com/software-development/industries/healthcare.
[149] Source: http://www.nitrc.org/forum/forum.php?forum_id=3664.

like Siemens who are producing and selling imaging devices like MRI or CT. Without their involvement an extension of the EASI-Clouds approach towards reconstruction is hardly possible.

First discussions with Siemens have also revealed that there is only little interest as the market for selling reconstruction workstations is highly profitable for them. Furthermore an additional approval by the FDA has to be gained when there are changes to the reconstruction workflow. This would be the second hurdle to overcome.

As long as only post processing is addressed the demonstrator/ portal will be play a niche role.

Further exploitation possibilities
Based on the know-how EASI-Clouds partners have developed during the project time, the following business models are appropriate for the partners to enter the market:

- Business Consultancy:
    - Supporting providers to migrate their legacy applications for medical imaging into cloud services (Value: Improved time to market and reduced development costs)
    - Consulting of radiology departments and hospitals to identify the right offering with respect to their needs
- Technology provider:
    - Provision of dedicated EASI-Clouds components (EASI-Clouds portal; Billing as a Service ,,,) to potential customers that are looking forward to establish an efficient distribution channel for their
- System Integrator:
    - Provision of integration capabilities for providers of cloud based post processing services as well as potential cloud consumers (radiology departments, hospitals)
- Managed Federation
    - Provision of the EASI-Clouds portal based on the third party cooperating model

6.2 GPES

The GPES demonstrator has been built by Korean partners ETRI and Innogrid. The purpose of the demonstrator is to measure the performance of game servers in communicating with simulated players (GPES agents), and recommend changes to the server deployments. Prior approaches use in-lab simulations or on-site field testing. These approaches however have severe limitations: the former can be inaccurate compared to a real-life setting, whereas the latter involves high costs related to for instance the test engineer's travel costs.

The domain of the demonstrator is quite similar to content delivery networks, however with important differences. Like for a CDN provider, the developer of a game server network is interested in delivering a fluid user experience to its end-users, despite that a game server contains more complex interactive functionality with end-users than a typical CDN point. However for this reason, game developers can rely less on established game server networks as a video streaming service might rely on existing CDNs. The GPES demonstrator hence lowers the costs and time-to-market for game developers by making the process of finding and maintaining a suitable configuration of IaaS providers more efficient. From the CSP perspective, the solution may extend their markets by offering a new distribution channel to higher-margin dedicated servers that may be needed to maintain low latencies in the gaming experience. Within the multi

billion-dollar industry, the solution may be highly attractive for small game studios, that simply lack the resources to do their own field testing, or would need to resort to expensive outsourcing solutions.

The GPES demonstrator is essentially a special kind of cloud orchestration/brokerage platform, wrapped in to a SaaS interface. The solution also serves a lucrative and growing market: online gaming. It could use the brokerage/aggregator business model, and collect usage-based fees for its services. This kind of business however lacks a source of reoccurring revenue, so for example additional technology consulting services might be bundled.

The platform itself is agnostic to where it sources its cloud services from as long as the services provide sufficient reach. Hence, the service could potentially be fuelled by individual IaaS providers, other brokers or federations. Further down the road, the concept could be extended to constantly collect data on IaaS providers, so that customers can be informed about potentially suitable game server location prior to any simulations. The concept could also assume a greater role in game server placement by building an exclusive database of IaaS supplier performance. Based on this data, deployment bundles could be sold to customers for a greater margin compared to making the performance testing data fully visible to consumers, and letting them interact directly with IaaS providers. This approach would also enable constant customer invoicing. Overall, the concept demonstrates how cloud brokerage can be used to create a differentiated offering within a market that is seemingly commoditized.

6.3 Cloud-based collaborative IDE (MIDEaaS)

This demonstrator has been developed with the lead of the Tampere University of Technology. The demonstrator offers a cloud-based collaborative integrated software development environment (IDE). Using the IDE, many software developers can simultaneously edit the source code files is a similar fashion as documents can be jointly edited e.g. in Google Docs. This functionality is provided by the pre-existing MIDEaaS platform.

This EASI-CLOUDS demonstrator however adds new features to the mix by enabling users to select where their data is stored and deployed. Enabling this functionality on the SaaS level utilizes Accords and CompatibleOne to set up required cloud infrastructure (IaaS/PaaS). Once configured by the user, the source code and integrated binaries are stored/run in a desired location. By giving the user better control of the cloud resources, the user can receive at least two types of benefits. First, the tool could be used in various environments where the data storage location is of high importance. These can include certain verticals (e.g. defence), but also corporate environments where data security is emphasized. With suitable configurations, users can be assured that the data stays within a given organization or country, but also the benefits of SaaS can be gained as opposed to managing desktop software. Second, integrating the could resource selection function with the IDE can make it easier for software developers to run various tests on different hardware, and scale up the environment with less effort as the complexity of the developed system increases.

Regarding the business models for the demonstrator, a promising avenue would be the aim for a commission on the cloud resources being used. The user could for example buy “credits” from the new business, which the user would in turn use to pay for the cloud services used to store data and run the integration environment. This kind of turn-key solution could be received

positively by software developers. Furthermore, in order to target the verticals where the solution would bring high value to users, system integration services probably need to be bundled with the offering so that the system can be installed inside VPNs and the brokerage function can be configured for internal environments.

7 Conclusion

The cloud market is being shaped by several major forces. First, the market is growing rapidly due to a fundamental demand for the value it creates despite increasing privacy awareness and technological immaturity in some areas. Furthermore, the 'reality of the ground' is often somewhat different than in the stylized world of analyst reports: Many business managers are indeed highly confused about cloud computing as a phenomenon. While they are often reluctant to reveal their lack of knowledge, they also feel great pressure to take at least some action to join the cloud revolution with their peers, who they may assume are better informed. Especially the enormous amount of different cloud services that have to fit perfectly into the consumers' business processes will push the adoption of solutions that enable consumers to efficiently use dedicated services (like cloud management and cloud orchestration services). However, as cloud brokerage and federation are not well known concepts even among cloud experts, it is clear that there is a long way to go until they hit mainstream. Taken together, the asymmetry of knowledge between leading technology developers and customers is likely to be a stronger impediment to the growth of cloud computing than the NSA revelations and the slowing macroeconomic growth are combined.

Second, transaction costs (broadly defined) are reduced due to technological advances including standardization (either formal of de facto). This enables smaller new entities to exist in the cloud value chain, and new configurations in the value chain to form. This development, for instance, enables smaller cloud providers to find markets for their excess capacity, and larger players to expand their offering by transacting with smaller (independent) and differentiated cloud service providers. The EASI-CLOUDS project positions itself as a development in this area.

On the other hand, cloud infrastructure business is characterized by high economies of scale. Waves of consolidation and market exits are likely as price competition intensifies. How things will turn out for smaller players depends their ability to differentiate and create value. Investing into consultancy services is perhaps the most viable approach to create and capture new value under this setting in addition to developing SaaS offerings. The EASI-CLOUDS infrastructure also enhances the feasibility of forming resource-sharing partnerships or cooperatives with other cloud service providers, which may also improve cost-competitiveness and also differentiation ultimately at the SaaS level. A key element of the EASI-CLOUDS infrastructure is its ability to dynamically manage cloud resources, which, ceteris paribus, enables offering a higher quality SLAs for consumers.

The sustainability of this kind of cooperative federation arrangement is however nontrivial, and is a matter of economic utility to the various players involved. Each firm in the cooperation needs to compare the utility of participating in a federation to its opportunity costs. OnApp has clearly found a model where the cost of participation in a federation can be minimized: it is offered as a bundled feature in their cloud orchestration platform. For small cloud providers, a cooperation arrangement with other firms with roughly equal financial resources and complementary offerings may be feasible, as any member of the cooperation would lack the resources to obtain exclusive access to a significant share of the other member's resources. On the other hand, if market uncertainty (demand volatility) is high, any single player (with possibly greater financial resources) would be less willing to make fixed investments to obtain exclusive access to the resources of any of the players. These factors reduce the opportunity costs of participating in a federation.

If a large player is involved, the setting is different. The large firm may see higher risks and costs in collaborating with smaller players compared to expanding its own cloud resources (for example, through building new capacity or acquiring competitors) and retaining full control on their management and development over time. In this case federation (from more of a technical standpoint) might be undertaken within a single large corporation, and the EASI-CLOUDS infrastructure could be used to balance internal load and manage accounting. Regarding the improved efficiency and efficacy of using cloud resources, the result may be the same irrespective of how organizational borders and ownership relationships are drawn.

Cloud federations (organized as cooperations between firms or under the control of a single firm) may, on the other hand, provide value to third parties (and their customers) that broker or aggregate a broader range of cloud resources. These broker and aggregator entities may either exist independently, or the entities running federations (e.g., cloud service providers or business units in a large corporation) may also internalize them. Due to its modular nature, the EASI-CLOUDS infrastructure may also aid various cloud businesses without the involvement of any federation, and it may lead to new business consultancy and IT services opportunities for firms specializing in the EASI-CLOUDS infrastructure. The value tree analysis as also revealed that EASI-CLOUDS in total as well as each single component provides significant value to the cloud computing market.

We have observed that the market for cloud computing in general but also cloud federation and cloud brokerage is highly dynamic. Nevertheless, based on the experiences from the airline market we think there will be only a handful of federations available which do compete in the same size like OnApp. Especially the demand for more differentiation will force cloud providers to follow up different ways or at least closer approaches like a smaller federation with a few strategic partners from their individual value chain (e.g. to share infrastructures or data).

We also believe that brokerage and federation will play an important role in future developments in cloud computing. With respect to the sharing of data, with ‘data analytics’ a new hype topic has entered the market which is also known under big data or smart data. The purpose of data analytics is to build analytics services on the top of the data in order to gain valuable business information from the data. The data is stored in large data platforms which are running in the cloud due to the excessive demand for computing and storage resources. As the data is often used by more than one company within the value chain the common use of one data platform and the sharing of data across enterprise boarders is an interesting use case in the context of cloud federation. Advantages for providers of cloud based analytics services as well as consumers in this context are reduced costs, the prevention of information gaps and the increase of the efficiency from end-to-end. We believe that federation will play an important role for data analytics as well as other developments on cloud computing yet to be seen.

8 Appendix: Summary of key terms

Term	Definition	Examples
Cloud-related business	All business activity that involves a service that is part of the *cloud value chain* (e.g. cloud-based consulting, manufacturing hardware used in data centres)	Cloud consulting services, Amazon S3, manufacture of components to be used in data centres
Cloud business	All *cloud-related business* activity conducted by firms that have an internal cloud service capability.	Cloud consulting, Amazon EC2/S3, Azure
Cloud value chain	The full set of businesses that are required to create *cloud-based services.* Elements of the value chain include hardware manufactures and integrators, data centre operators, IaaS/PaaS and SaaS providers, and ICT service providers	Dropbox service uses Amazon's S3 storage service. Amazon, on the other relies of various IT component manufacturers in its data centres. The "Dropbox value chain" includes (at least) these activities
Cloud-based service	A service that has an IaaS, PaaS or SaaS component, and possibly additional human-delivered services.	
Cloud service capability	A firm with a "cloud capability" can offer a cloud-based service without completely relying on other firms' capabilities.	
Cloud broker	A cloud broker is an entity that manages the use, performance and delivery of cloud services, and negotiates relationships between cloud providers and cloud consumers[150].	Virtually all major IT service companies in Europe; Cloud Compare, ComputeNext
Cloud brokerage	The action required for a cloud consumer to obtain cloud services through a cloud broker.	
Cloud federation	Cloud federation is the possibility for a cloud consumer to send a cloud request to multiple cloud providers as if they were a single cloud provider.[151]	OnApp

[150] Source: http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf.
[151] Definition developed in the EASI-CLOUDS consortium.

Cloud aggregation [152]	A cloud aggregator is a type of cloud broker that packages and integrates multiple cloud computing services into one or more composite services.	Ingram Micro Cloud, F-Secure (Younited)
Cloud provider	A person, organization, or entity responsible for making a service available to interested parties. [153]	Amazon, IBM, Microsoft
Cloud consumer	A person or organization that maintains a business relationship with, and uses service from, Cloud Providers. [154]	
Cloud (brokering) enablement	Solutions, offerings needed to make cloud brokering possible.	Gravitant (CloudMatrix)

[152] Source: http://searchcloudprovider.techtarget.com/definition/cloud-aggregator.
[153] Source: http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf.
[154] ibid

9 Appendix: Cloud company overview

In the following, we provide a summary list of companies reviewed in this report with an emphasis on emerging concepts and startups.

Amazon

Offering	This leading e-commerce company is also a dominant cloud company particularly in IaaS and PaaS. As a very versatile offering portfolio in these areas, including EC2, S3, Glacier, EBS, and Redshift.
Partnering	Central player in partnership networks with numerous partners.

Appdirect

Offering	Cloud service marketplace and management platform.
Partnering	Deutsche Telekom, Comcast.

Appirio

Offering	Appirio offers cloud broker technology to help enterprises unleash information from SaaS silos, solving a growing problem faced by enterprises who are moving multiple applications to the cloud. Appirio CloudWorks enables companies to build solutions that connect SaaS applications from leaders like Google, salesforce.com, Workday and their ecosystem partners.
Partnering	• **Strategic:** Workday, Amazon, Salesforce, Cornerstone, Google • **Solution:** AppExtremes, Apple Consultants, Box, Cast Iron Systems, Docusign, Adobe Echosign, Hitterbit, Marketo, Okta

BlueWolf

Offering	Provides cloud aggregation and consulting services.
Partnering	Salesforce, Apttus, Avalara, BigMachines, birst, box, Bunchball, Cirrus Insight, Cloud Extend, Cloud 9, Clicktools, Dell Boomi, demandbase, DocuSign, EchoSign, Eloqua, ExactTarget, FinancialForce, Five9, GoodData, Jitterbit, marketo, Okta, Ping Identity, PivotLink, ReadyTalk, ShoreTelSky, Silverpop, Veeva systems, Xactly Corporation, Zuora

Canopy (The Atos cloud company)

Offering	Canopy Compose, a PaaS service to migrate legacy applications into the cloud. The PaaS service includes a cloud brokering service to incorporate various cloud infrastructures (public, private) or even dedicated data centers. Helix Nebula, an IaaS offering enabling high performance computing. They offering includes a brokering functionality to flexible integrate additional infrastructure resources.
Partnering	EMC, VMware and Cisco

Cisco

Offering	A pioneering player in the cloud space, that seeks to expand to higher positions in the value chain. Known e.g. for the Intercloud initiative and Cloud Fabric platform.
Partnering	Central player in partnership networks with numerous partners

Cloud Compare

Offering	Brokerage and consultancy services (They describe their position as an independent middle-man that is not tied to one particular Cloud vendor.)
Partnering	n/a

CloudMore

Offering	Offerrs cloud services aggregation through partners, and it seeks to provide a unified user experience.
Partnering	IBM, Microsoft, VMWare

CloudSelect

Offering	CloudSelect is the largest Cloud Service Broker in Asia. They are offering a platform which is already offering more than 100 cloud services of different cloud service providers. Their platform is integrating public, private as well as hybrid IaaS providers. In addition they are also providing managed and professional services.

Partnering	AWS, Microsoft, Cisco and VMware

CompatibleOne

Offering	Open source cloud broker that has broad interoperability with different CSPs, and can take into account various SLA needs.
Partnering	E.g. Bull, ComputeNext, Intel, OnApp, Prologue, Thales

Comcast Upware

Offering	An online marketplace for business-class applications and a SaaS aggregator
partnering	n/a

ComputeNext (Gartner: Cool Vendor 2013)

Offering	Offers a cloud services brokerage marketplace, Multi-cloud usage and a single payment gateway to control costs, E-commerce to compare pricing and benchmark performance
Partnering	Cloud Sigma, GoGrid, HP Cloud, Joyent, Luna Cloud, Arsys, Internap, Hegerys, Servercentral, Rackscale, enovance, Yenere, Harmonic, Bit refinery, Cloudcentral, exoscale, CACloud.com, Netplan, CLOUDA, UpCloud

Cordys

Offering	Cordys offers one of the first Cloud Service Brokerage platforms in cooperation with Nephos Technologies in order to enable organizations to transform their business with federated, aggregated cloud services.
Partnering	• **Cloud Brokerage Services:** Nephos Technologies • **Global stratigic alliances**: Argility, Atos, Capgemini, Cognizant, CSC, Fujitsu, • **Technology:** Aquima, EZY-Tech, Innovatec, Italtel, Itway, Malaxo Solutions, Revevol, Simbus, Soroc

Gravitant (Gartner Cool Vendor 2013)

Offering	Delivers a transformational Cloud Services Brokerage & Management platform enabling enterprises to optimize cloud consumption across public, private and hybrid clouds
Partnering	Amazon Web Services, General Dynamics, GoGrid Partner, Greeen Pages, Hitachi Consulting, NJVC, Oracle, SAVVIS, Terremark

GreenCloud

Offering	White label IaaS provider. One among many. The company focuses only on providing IaaS, and intentionally keeps away from branding. These kinds of resources could potentially be resold by broker firms with a wholesale orientation.
Partnering	Customers include Statsmayer, Enterprise Technologies, Virtual Image Technology

Hewlett-Packard

Offering	This Sillicon Valley pioneer is initiating the Helion project, which would allow cloud resource federation among members of the federation. Recently acquired Eucalyptus.
Partnering	Has a broad cloud ecosystem partnership program.

IBM

Offering	This traditional IT service company is also a leading IaaS and PaaS provider through its SmartCloud offering. Recently acquired the cloud infrastructure platform provider SoftLayer.
Partnering	Central player in partnership networks with numerous partners

InfoSys cloud ecosystem

Offering	The Infosys Cloud Ecosystem Hub is the first solution that helps enterprises build and manage a unified hybrid cloud environment.
Partnering	AWS, CA Technologies, HP, Hitachi, IBM, Microsoft, Novell, Oracle, Salesfore, VMware

Ingram Micro Cloud

Offering	Cloud services marketplace
Partnering	Fujitsu, VM Ware, Microsoft, IBM, box, Amazon

Jamcracker

Offering	The Jamcracker Services Delivery Network (JSDN) enables organizations to become Cloud Services Brokerages. It consists of following elements: • Jamcracker Platform: Automates all CSB workflow functions. • Cloud Services Catalog: Pre-integrated 3rd party services and tools/APIs for on-boarding new offerings. • Managed Services: To accelerate different deployment and operations needs for on-premise and hosted CSBs.

Partnering	• **Technology:** VM Ware, IBM, BMC software, Openstack, Juniper networks, Dell boomi, Intel • **System integrators:** CGI Federal, CommVerGe Solutions, TATA, Mindtree, KGS, IBM, Wipro

Jitterbit

Offering	Enables organizations to replicate, cleanse and synchronize their cloud-based data seamlessly and securely with their on-premise enterprise applications and systems
Partnering	• **System Integrators**: Appirio, bluewolf, Jelecos, etherios, CRM, Eustace, ForeFront, ModelMetrics, Genius4you, ExponentPartners • **Resellers**: Avandel Technesis, xRM, Emotive, Lanyon, Autodesk,Carahsoft, JobScience • **ISV & Technology:** Amazon, Intel, Microsoft, SAP, Oracle, RedHat, SalesforceNetSuite

Layer 7

Offering	The Layer 7 CloudSpan CloudConnect gateway is an on-premise solution to the cloud integration challenge, delivering security, identity, visibility and application integration in a single device.
Partnering	• Deutsche Telekom, Eucalyptus, HP ArcSight, Oracle, Oracle Sun Microsystems, Sofware AG, Ciscio, Novell, F% Red Hat JBoss, HP, VMWare, Amazon Web Services, Solace Systems, Thales, Progress Software, Imperva, Tibco, Computer Associates, AmberPoint, Microsoft, RSA, IBM Tivoli, IBM Webshere

Microsoft

Offering	Known best for its Windows and Office offerings, the company has moved strongly into cloud services. Particularly known for the Azure PaaS platform in addition to the SaaS versions of its many desktop product lines
Partnering	Central player in partnership networks with numerous partners

Mulesoft

Offering	Channel Program for System Integrators and Cloud Services Brokerage
Partnering	SAP, Cisco, Accenture, Amazon, box, Salesforce, Capgemini, LIFERAY, Logica, Clarizen

Nephos Technologies

Offering	Nephos Technologies provides consultancy, management and technology services to organisations seeking to develop, implement and optimise their cloud strategy
Partnering	• **Technology:** TwinStrata, Unitrends, Porticor, Cleversafe, ScaleArc, Nexenta, Appzero, CohesiveFT, Ctera, Cordys, Enstratius • **Cloud:** Rackspace, Savvis GoGrid, Google, CloudSigma, IBM, OpSource, Joyent, Amaton Web Service, Cloud 4, HP, Terremark, Windows Azure

OnApp

Offering	Provides a cloud orchestration platform, that is also used to federate resources. OnApp's CDN cloud is the first commercial federation.
Partnering	Superb Internet, SparkCloud, CAF, KungFuCloud

RackSpace

Offering	Traditional managed hosting service provider. Recently withdrew from IaaS. Key player in the OpenStack OSS project.
Partnering	The company has a verastile partnership program, but does not disclose its partner network.

RightScale

Offering	RightScale is a technology enabler that has e.g. created a customer-facing API that is cloud-vendor neutral, and can be used to automate, aggregate, and federate public clouds.
Partnering	Customers include EA, Pearson, Coty, IHG

SaaSMax

Offering	An online SaaS application marketplace for channel partners
partnering	n/a

Slicify

Offering	Sells capacity of household computers to any kinds of customers
Partnering	Oracle VirtualBox, Microsoft

Spot Cloud

Offering	A beta cloud exchange provided the functionality to buy and sell capacity based on price, location and quality.
Partnering	Virtusstream.com

Zimory

Offering	Zimory provides cloud infrastructure management software for service providers, enterprises and cloud brokers.
Partnering	Partnered with Deutche Börse to start a cloud exchange.