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Cloud Computing Value Chains: Understanding Businesses and Value Creation in the Cloud

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Abstract. Based on the promising developments in Cloud Computing technologies in recent years, commercial computing resource services (e.g. Amazon EC2) or software-as-a-service offerings (e.g. Salesforce.com) came into existence. However, the relatively weak business exploitation, participation, and adoption of other Cloud Computing services remain the main challenges. The vague value structures seem to be hindering business adoption and the creation of sustainable business models around its technology. Using an extensive analyze of existing Cloud business models, Cloud services, stakeholder relations, market configurations and value structures, this Chapter develops a reference model for value chains in the Cloud. Although this model is theoretically based on porter's value chain theory, the proposed Cloud value chain model is upgraded to fit the diversity of business service scenarios in the Cloud computing markets. Using this model, different service scenarios are explained. Our findings suggest new services, business opportunities, and policy practices for realizing more adoption and value creation paths in the Cloud.

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1. Introduction

The IT market is evolving quickly, driven by the increasing need for costs cuts and more agile and effective business processes. Cloud computing emerged as a promising computing model for providing utility-based, on-demand IT infrastructure services for anyone, anywhere and anytime [1, 2].

The developments realized in the past few years in computing techniques, especially in Grid computing, enabled the emergence of numerous computing models: Utility computing, ubiquitous computing, cyber-infrastructure, e-science, e-infrastructure and, above all, Cloud computing. Although many believe that these Cloud-based technologies hold the potential to revolutionize the Internet [3], actual adoption of Cloud computing services in industry and business is still way under expectations. It seems that the transition from classical enterprise IT models to Cloud-based computing is still the biggest challenge in businesses and industry, despite all the advancements that supported this transition.

Complexity in existing value structures and modes for attaining cost efficiency practices are main shortcomings in the Cloud. These problems are believed to be the chief factors in contributing to the weak business and industry deployment, low adoption, and missing sustainability.

Understanding the structure of the Cloud and its potential value creation schemes is challenging due to the diversity in requirements, inherited technical complexity, and unstructured service schemes. This complexity made the provisioning and utilization of many Cloud technologies and services a very difficult task to anticipate, especially by non-IT businesses. For example, the deployment of services, composition of services, and troubleshooting of many Cloud services needs special preparations even for IT experts. In addition to this, top management officers in enterprises or governments need to understand how costs are accumulated and how value is added without going into deep technical details of deployment or provisioning. Therefore, clarifying the value structure and corresponding primary and support activities in the Cloud value chains would help both, the business and the Cloud community, in accelerating adoption and creating more value.

Following the line of argument, this paper aims at addressing the following questions:

- What is the value structure in the Cloud market? What are the "primary and support" service? What activities that contribute to value creation in the Cloud?
- How do money and knowledge flow between stakeholders? And how can we minimize cost, maximize profit, and increase return on investment for Cloud stakeholders (providers and consumers)?

In order to tackle these questions, this research uses a case study analysis. Cases were reviewed and analyzed from available Grid and Cloud market services, projects, tools, applications, business models, and technologies. Based on the value chain theory, this analysis is used to create a reference model for Cloud value chains.

From the provider's perspective, the proposed Cloud value chain model helps Cloud Service Providers (CSP) to realize where they stand in the Cloud market and how they relate to other CSP. It particular, it helps CSP to identify their needs, anticipate potential alliances and create new service provisioning scenarios. This would also facilitate new entrants understanding of potential markets, formulate their value model based on market needs and fully utilize existing services. From the consumer's perspective, consumers will be able to identify the different potential costs for using and customizing the Cloud based on their business needs, and foresee diverse service scenarios from a strategic point of view.

To ensure the integrity of the model, the Cloud value chain reference model is later validated against hypothetical business scenarios. The validation also considers the value creation process and the flows of money and knowledge between the different stakeholders in the Cloud. As a result, a clear differentiation between main and support activities has been achieved, highlighting potential costs and opportunities in the Cloud.

The remainder of this chapter is organized as follows: In the next section, we review the literature on value chains and present the state-of-the-art in Cloud value chains. Section 4 describes the Cloud value chain reference model while Section 5 provides the business scenarios. Section 6 draws policy recommendations and Section 7 concludes this work.

2. Literature review

2.1 Porter value chain

The value chain was first described by Michael Porter in [4]. According to Porter, the value chain is a "system of independent activities, which are connected by linkages. Linkages exist if the way, in which one activity is performed, affects the cost or effectiveness of other activities". Linkages illustrate how a single activity affects other activities, thus serving as an important source of competitive advantage and value adding [5]. The value chain classifies activities into primary activities and support activities. Products (i.e. services) should pass all activities of the chain sequentially and, at each activity, the service gains some value and the chain of activities gives the product more added value than the sum of all single activities [6].

2.2 Upgrading the value chain

In the Internet era, value chains bear more advanced networking capabilities, adaptability to external changes, accessibility to virtual company structures, and more dynamic management capabilities [7]. In fact, many industries' value creation processes are dynamic, flexible, non-linear and multi-dimensional, crossing horizontal and vertical (inter- and intra-) industry domains. Porter's original value chain is believed to be linear and fixed [8–10]. Consequently, Value Networks [8] emerged to provide a platform for modeling non-linear complex set of social and technical resources, working together via relationships.

In those value networks, value is created through the exchange of resources via relationships between roles. Although value networks represent a new approach to describe tangible and intangible value creation processes [6, 8], value networks modeling becomes complex, since the structure grows exponentially. This leads in many cases to many difficulties in foreseeing economic competitiveness, new opportunities, or anticipating costs.

A more advanced concept, known as "value grid" (the grid is not to be confused with Grid Computing), has been introduced in [9]. This model allows expressing innovation strategies and coordinated operations in multidimensional, grid-like value creation schemes. In fact, the "value grid" extends the concept of value chains. In a value grid, the vertical dimension describes multiple tiers from primary inputs (raw materials) to end users. The horizontal dimension describes opportunities at the same tier across parallel value chains; and the diagonal dimension describes opportunities for integrating value chains [9]. This gives the value creation model an evolving structure, where the flow of knowledge and intangible benefits can take place between any number of stakeholders anywhere and anytime. At the same time, it maintains an organized and systematic structure.

In general, whatever representation for value creation is being used, value chain models should allow all stakeholders to explore the diverse scenarios for generating value and to find their unique added value, guaranteeing their competitiveness, the maximum return on their investment, and their economic sustainability.

2.3 State-of-the-art: Cloud value chains

A number of projects studied different aspects of value chains in the "information technology industry". Most recently, the "BEinGRID" project developed a Generic Grid Computing Value Chain and a corresponding value network model based on the analysis of industry case studies [10, 11]. In their classical Generic Grid Value Chain, different Grid stakeholders are described.

However, the organizational aspect of value creation has been overlooked and more attention has been paid to value networks. Same overall value creation process in the Grid technology market was also reported in [12]. Although it addressed the complexity of the value creation in the Grid industry in its early days, this model can not capture the Cloud market and suffered from same drawbacks as described in [10].

Another related value chain model has been created and analyzed for the ubiquitous computing environment [13]. Yet, within this work, the abstraction of the value chain model to five stages (context, information devices, networks, service providers, and digital content) is too simplistic. Despite this pioneering work, the linearity and highly abstracted representations were not able to proxy the value creation processes and potential value creation paths in the Cloud. Finally, a related work presented a detailed taxonomy and description of the stakeholders and their roles in the Grid [14]. Yet, this work was not oriented towards value chains and Cloud computing.

In summary, although these models provide a solid foundation for the development of Cloud value chains, they were not cloud-centric and none of them depicts the value transactions in an organized and systematic scheme that accounts for all stakeholders' inter-relations and value creation structures in the Cloud.

3. The cloud value chain reference model

3.1 Data and methodology

The data for the value chain analysis was collected through market surveys and case studies available online at Cloud, Grid and Internet service providers, project Web sites, descriptions of tools for Cloud computing, application specifications, and business models of service providers. A data set comprises information about the product and/or service, price, business linkages between partners and suppliers, cross layer linkages, as well as a description of the value creation process. Using value chain analysis techniques of Porter [4] and Hergert & Morris [31], this data was processed as follows:

- Set the boundaries of the business segments.
- Defined the critical activities accordingly.
- Identified the product (services) value structure.
- Positioned the linkages and inter-relationships within the relative structure.
- Set the activities within the context of original Porter value chain model following upgraded value chain guidelines.

Based on this procedure, the linkage, the layers, and sub-layers were set for each service. A fraction of this list of services and products is given in annex 1, the complete is list is available on our Web site.

3.2 Model

Building on the foundations of Porter classical model, value networks, and "value grids", the following Cloud value chain reference model was developed. The model breaks activities (services) down into three main virtual layers. Within those layers, services are organized as independent sub-layers. Each layer border represents a profit and knowledge margin. Linkages between layers or independent services can take horizontal, vertical, and diagonal paths. Value is accumulated by flow of money and knowledge through these linkages. Through this organization, service packages can be created in a flexible and cost effective way. Figure 1 shows our proposed Cloud value chain reference model.

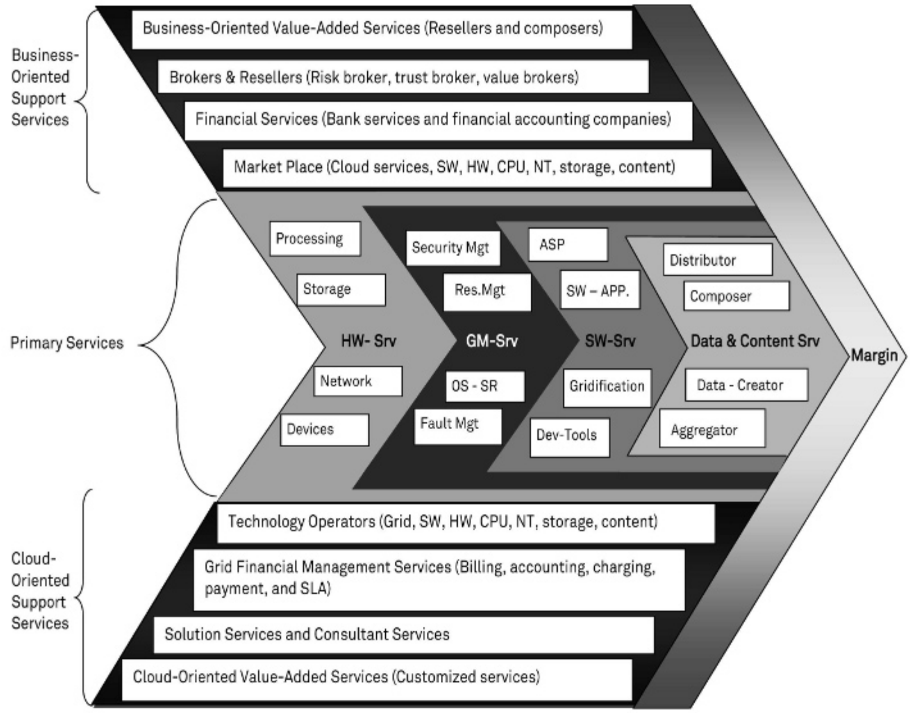

FIGURE 1. Cloud value chain reference model.

Primary (Core) Services Layer This layer incorporates core infrastructure services, required for the development of any Cloud service model (enterprise Grid, high-performance computing Grid, business Cloud, or public computing Cloud). The structure of this layer resembles the Open Grid Services Architecture (OGSA) [32].

This layer consists of the following sub-layers: The hardware services (HW-Srv) or fabric sub-layer includes networking, processing, storage, and other device services. Generally, a wide range of these services is provided as standalone systems from classical technology providers such as Sun Microsystems, IBM, CISCO, and HP.

The Grid middleware services (GM-Srv) layer is commonly considered the founding Cloud layer. This layer mainly includes resource management services (R.Mgt.-SR), security, privacy, fault management, Grid execution, and operating systems services (OS-SR). Services in this layer range from complete packages such as Globus [15, 16], Legion [17], gLite [18, 19], UNICORE [20], Xen [41], and Grid Application Toolkit (GAT) [34] to standalone system services.

As the fabric sub-layer services, the software sub-layer services are usually provided by countless software companies, ranging from big players to an open source software community. The software services (SW-Srv) sub-layer includes software applications (SW-APP), Gridification services (e.g. Grid Execution Management for Legacy Code Architecture – GEMLCA) [33], developing tools (Dev-Tools) and application support services offered by Application Service Providers (ASP).

Finally, the data and content services (Data & Content-Srv) sub-layer includes data creation, aggregation, and distribution services. Data libraries, 3D & multimedia data, and research databases are some of the technologies in this layer. Providers for such content services can vary from professional data service companies, universities, and research centers to end-users.

Note that all of the primary layer and sub-layer services are provisioned as packages or independent services, outsourced and/or built in-house. Deciding for any of these approaches always depends on the anticipated opportunity cost and the value added to the provider or customer.

Cloud-Oriented Support Services Layer This layer incorporates all activities developed solely to support and enable the Cloud in real world markets. Services in this category are normally developed and deployed based on customized or specific needs. Whereas some Clouds need all these services others may need just few. In many cases, services from this layer are bundled with core activities (particularly in Grid middleware sub-layers) and are provided as a full package offered by Cloud Service Providers.

The support services layer consists of the following service sub-layers: a) Cloud financial management services. They incorporate basic Cloud-based charging, accounting, billing, payment, and SLA management systems. An example of these services is SLA@SOI (see appendix); b) Solution providers, consultant, and composer services.

Examples of this type of service include infrastructure for service delivery from RESERVOIR (see appendix); c) Technology operator services. These operators do not own the resources but operate the resources for the benefit of another party. Their services include activities of running, operating, and troubleshooting core services (e.g. software, hardware, network, storage, and content services). This service is especially important for big businesses and industries; d) Cloud-oriented, value-added services (customized services). This layer represents support services that address emerging needs in the market by supplying niche services. An example of this service could be customization of existing support services.

Business-Oriented Support Services Layer This layer represents all (non-tech nical) business services that support businesses and Cloud industry business. This layer includes services in existing, real-world markets, customized to the business side of Grid computing.

Some of these business support services (e.g. banks and brokers) exists since a long time and served many industries. These activities include the

following sub-layers: a) Financial management services (e.g. banks and financial solution companies); b) Brokers and resellers services (e.g. sellers, distributors, insurance companies); c) Marketplace services such as GridEcon [21, 37, 40], Gridipedia [11], and Amazon [22]; and d) Business-oriented value-added services, which are anticipated for innovative future business services. These include a wide range of systems. A good example of such services is TXTDemand, a demand forecasting system provided by SORMA (see appendix).
A detailed description of many of these services and stakeholder roles can be found in [14, 38].

3.3 Model structure and relations

To maintain efficient processes, structures, and linkages in value creation and service scenarios, the reference model holds the following properties:

- Structure and Organization: The model is made up of a virtual layer of services and sub-layers, organized according to core, value-added, and support services. This will help maintaining readability and structure in value creation process.
- Inter-Layer Heterogeneity and Intra-Layer Homogeneity: Layers and sub-layers make services share common knowledge bases, comprise strong relationships, carry out related functionality, and serve closely related goals. Consequently, spillovers, bundling, and packaging has more probability to take place between direct and nearby layers and sub-layers.
- Knowledge Flow: Services of each layer and sub-layer have knowledge spillover effects that span beyond its borders, allowing value to be shared and exchanged between them. Knowledge flows will add more value and help minimize the costs. For instance, the flow of knowledge between solution providers and financial service providers or between brokers and market place service providers can have these effects.
- Flexibility in Service Composition and Value Creation: Each Grid value creation process or service scenario has its own distinctive and different requirements. Therefore, the model relaxes the linearity condition of the Porter model and allows vertical, horizontal, and diagonal combination of services. This enables anticipation of service scenarios that are simply based on value and cost effectiveness.

Figure 2 shows an instance of the proposed Cloud value chain reference model. In particular, it shows sample services available in the market in each layer of the value chain. Each service is associated with a price and attributes to meter the total cost. Service costs vary according to the service type, quality, and usage model. By matching the services available in the market to the value chain, customers or providers will be able to foresee different scenarios for deploying or developing their Cloud services.

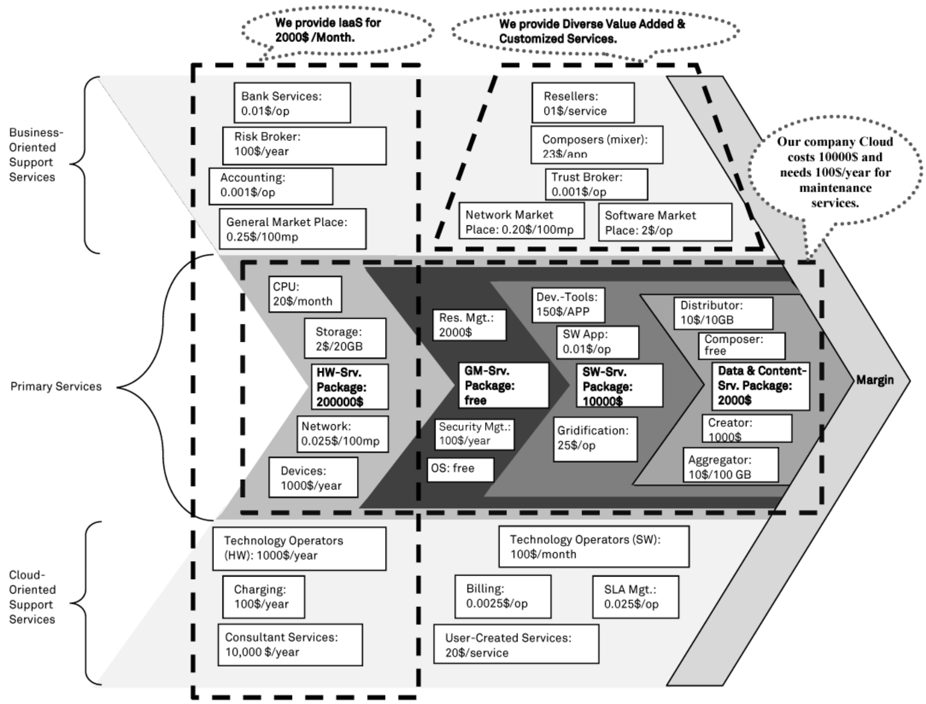

Figure 2. Instances of cloud value chains.

In detail, Figure 2 illustrates three composed services that are composed of sample services. For instance, the vertical, dash-lined rectangle shows an example of a service, which is composed of a set of infrastructure services and which costs 2000$/year. This service consists of: hardware (storage and devices), maintenance and operation, charging, and consulting, belonging to the primary and Cloud support layers. These costs are added to the costs of brokers, accountants and market services. Another service is illustrated in the upper right corner of the figure, which offers a wide set of customized and user-oriented services. Finally, the horizontal dash-lined rectangle illustrates an enterprise Cloud service that integrates all primary services. As these examples show, examining services with the proposed Cloud value chain reference model will help stakeholders in understanding value structures and foresee opportunities, while minimizing costs.

3.4 Service scenarios

To illustrate the workings of the Cloud value chain reference model, this section describes five different Cloud value creation scenarios that are explained based on the reference model. These scenarios are either existing Grid service scenarios or are potential future scenarios.

3.4.1 Utility cloud

In this scenario, services are provisioned in a similar way to any other utilities (electricity, gas, and telecommunication). The Cloud service provider offers a complete end-to-end package of Grid services that consist of primary, Cloud support, and business support services to fulfill the requirements of a targeted class of users. Services here are provided on-demand and metered based on consumption parameters (quantity and quality). Therefore, the user role here is limited to plug-and-play with no additional huge fixed investments or worries about complex structure, maintenance, or support.

Validating this scenario against the Grid value chain model, we find that the Utility Cloud Service Provider (UCSP) needs to carry out all primary activities, which include hardware infrastructure (bandwidth, servers or other special devices needs), Grid middleware (resource management system and security), and software services. Besides, the UCSP needs to provide financial services for the users of his Cloud service (such as charging, Service Level Agreement (SLA), and metering schemes). At the same time, the UCSP has to provide business support activities and define payment and billing services, broker's services, and market services. The first generation of such a UCSP (since much more comprehensive services can be offered in the future) is Amazon's Elastic Compute Cloud (Amazon EC2) and Sun's Grid Compute Utility Service [22, 23].

3.4.2 Enterprise cloud

Large enterprises (e.g. "Wal-Mart, which have more than 400-billion-row tables, which ultimately top a trillion rows" [24]) require huge computing power for intensive data analysis. Enterprise Clouds offer a cost effective solution for utilizing the internal computing resources to satisfy this huge demand. In this scenario, the Cloud is constructed for supporting internal business needs for the enterprise. The enterprise in this scenario has its own hardware, software, and business applications. That means that much of the primary activities are already in place. With dependable Grid middleware systems, which can be either in-house developed or outsourced from technology providers along with Gridification systems, the enterprise Cloud will be basically operational. Nevertheless, some business and Cloud support activities (e.g. consulting services, wrapping services, and SLA services) will still be necessary to purchase from the Cloud.

The final decisions will depend on enterprise value models and vary from case to case. Nevertheless, using Cloud value chain modeling will help technology officer to foresee their costs and justify their arguments to executive management. During the past years, many firms transformed their information systems to Clouds. Charles Schwab, the financial services provider has been using IBM servers with Globus middleware for its Grid for a while. Acxiom, a global marketing services firm, is using Red Hat Lunix operating system and JBoss Enterprise Middleware for its Grid processing environment. A list of other examples can be found in [25].

3.4.3 Research grids

In this service scenario, the Grid is constructed to support academic and research communities. Validating this scenario against the value chain model easily shows that most primary activities such as hardware resources, networks, and many other requirements are already in place. However, middleware is needed, which is developed internally in most cases rather than outsourced to the market (not considering that the research community collaborates and shares their middleware). Since applications are developed in-house as well, no additional cost is incurred. Access and usage policies are usually set on non-monetary bases (mutual sharing of resources). Consequently, services and systems are required from both, the business-oriented support layer and the Cloud-oriented support layer. For instance, while financial and broker services are not required, a clearing-house service is needed to balance accounts with respect to contributions and consumptions. However, in variation of this scenario, if research Clouds become open for businesses in the future, financial accounting, metering, and charging services will be needed.

Many examples of research Grids exists. Some of the notable examples include: TeraGrid, EGEE, LA Grid, and D-Grid. The TeraGrid is a scientific research infrastructures launched by the National Science Foundation in the United States. TeraGrid provides more than 250 teraflops supercomputing services capability, 30 petabytes data resources, as well as high-end experimental facilities for researchers from diverse disciplines. The Enabling Grids for E-science (EGEE) is an EU project connecting more than 240 institutions in 45 countries world-wide. EGEE infrastructure provide seamless computing services for e-Science that consists of 41,000 CPU in addition to about 5 PB of storage, and maintains 100,000 concurrent jobs [18]. The LA Grid is a joint Grid effort of the United States, Latin America, and Spain [26]. At a national level, the German Grid Initiative (D-Grid), which has been launched in 2004, is comprised of a number of projects that designs, builds, and operates a network of virtualized high-performance resource services [27].

3.4.4 Public clouds (desktop grids)

In this scenario, end-users collaborate in constructing their computing resources. A user-collaborative Cloud is built of what is referred to as the collective power of members. The primary activities consists of user PCs (being the main computing resources), the Internet (being the backbone network), and the freely downloadable middleware (BONIC) and application. Based on intangible incentives for participants with very little Grid supported services from project moderators (who are researcher and volunteers) and with no business-based services except SLAs, this model showed a huge success. SETI@home, a public desktop Cloud, has been standing as a symbol for successful sharing of distributed computing resources in search for extraterrestrial intelligence [28]. Following this success numerous similar projects were initiated worldwide (e.g. Einstein@home [29], Rosetta@home [30]).

3.4.5 Virtual clouds (VC)

This scenario describes a future service scenario, where the Virtual Cloud Service Provider (VCSP) is not the owner of any physical resources. The VCSP builds his value-added service by composing services from different providers and create his "Cloud services". Similar to the business model of Application Service Providers (ASP), services are provisioned on-demand to customers. Yet, in this scenario, services have a wider scope (hardware, software, applications, content). In this case, the knowledge of organizations and the management of services is crucial. Issues such as quality of service, security, and privacy would be top concerns. Yet, ideally, the user should experience a plug-and-play service without any worries about the underlying details, which will be the responsibility of the VCSP.

The Cloud value chain reference model gives a comprehensive picture of the whole market structure and supports VCSP in understanding and identifying the diverse requirements at each layer, enabling the VCSP to build a working Cloud service. Moreover, the VCSP can anticipate his potential costs, foresee how his revenue model is structured, and improve his business model by optimizing alliances with other service providers.

4. Discussion and policy implications

The reference model for value chains in the Cloud is anticipated to serve as a check-list for building Cloud services. By validating this model against existing and hypothetical service scenarios, this model could largely explain the different types of activities and service combinations by which value is created in the Cloud. Yet, this model assumes and requires that:

- More and more activities in the Cloud are developed and introduced as independent, interoperable, and standardized services, allowing to realize flexible, diverse, and cost effective service scenarios. In fact, the work of Spohrer in [35] provides a promising effort that explores this mutual understanding, the value co-evolution, and the merging of service science with new computing models.
- While vast attention has still to be paid to technical layer development, more and more business-support services are developed [39]. For example, Cloud market places need to be in place to support trading of excess resources [36]. Accounting and charging services are needed to support financial settlements between trading entities (i.e. providers and customers). In general, business-support services are needed to accelerate the transition to a business-oriented, open Cloud to generate the critical mass of users.

Realizing such a future Cloud, we can forecast the following implications for the future technology market with respect to:

- Supporting Services: In accordance with the “hourglass” model [16], we strongly believe that support activities will take the highest share of cost and profit, dominating over middleware system services.
- Service Composition: Better cost minimization and profit maximization schemes will come from services that allow diverse compositions and service scenarios built from sub-layer services.
- State-Less Stakeholders: Customers will easily be able to become service providers. Users will be able to cooperate with other users and sell user-created services into the market. Future killer services will be user-created.

5. Conclusion

Within this chapter, we analyzed existing Cloud business models, its structures, and value creation activities. Based on this analysis and the existing value chain theory, we introduced a reference model for the Cloud value chains. The reference model is used to anticipate the Grid structure costs and service scenarios.

With the help of the reference model, we analyzed some service scenarios. We found that, as more standardized, interoperable and open technology services are realized, new business models and service scenarios will be created in the Cloud. Huge opportunities for technology providers, particularly in supporting activities, are to be seen and will contribute to more Cloud adoption in business and industry. Support activities are vital for enabling user created services, developing new services, and leading the Cloud sustainability process. Finally, we believe that as the Cloud develops in both technical and business aspects, more participation and user-oriented applications will be realized in the Cloud service market.

Annex 1. Case studies

Disclaimer: Please note that due to space limitations, The following cases are just a random sample of the original list of cases studied. The full list is available on request.

Product	Provider	Description and Range of Service	Service / Product	Price / Free	Value chain layer -sub	Website	Comments
Platform Accelerate and Platform Manager	platform	Tools for High Performance Computing (HPC) management software solutions and accelerate compute and data intensive applications and manage cluster and Grid systems	Product and services	Priced	End-to-end solutions that Span over Divers level layers from primary to Cloud and business support layer	http://www.platform.com	Underplaying partnerships and Alliance with other service providers
AppLogic Grid operating system	3tera	Software, on demand and Utility computing	Product and services	Priced	Primary, Cloud and business support activities	http://www.3tera.com	Example of integrating service companies
EnFuzion	axceleon	Resource Management and Workflow Automation, Smart File Transfer and Network Utilization, job scheduler and monitoring, Intuitive GUI,, Extensive Administrative and Reporting Tools.	Product and services	Priced	Primary and Cloud support layers.-applications and software packages with horizontal and vertical integration	http://www.axceleon.com/products.html	–
JBoss Enterprise Application Platform, and Red Hat Enterprise MRG, JBoss Enterprise Middleware and cluster suite	RedHat	Wide range of Grid application and data managements systems. Cloud computing and Grid computing services.	Products and service	Priced	Primary and Cloud support layer activites: SW, MW and applications and consultation	http://www.redhat.com/products/	–
Gridworks, PBS and Portable Batch System	Altair	On-Demand Computing Software Environment, Workload management, and Resource-based scheduling	Products	Priced	Primary – Middle ware – scheduling, management,	http://www.pbsgridworks.com	Support by Multiple hardware and software -partner with intel, windows, hp, Ibm AND OTHERS

Hyperworks	Altair	Optimization, Modeling and Assembly, Virtual Manufacturing, FEA Solvers, Process Automation, Visualization and Reporting, Data Management A Complete Enterprise Simulation Suite	Product and Service	Priced	1- Primary -middleware -management 2-Gid support layer -operators and solution providers	http://www.altairhyperworks.com	Partner and supporter of multiple platforms
HiQube	Altair	Software package for high-performance business intelligence (BI)	software Product (as well Pay-For-What-You-Use" service)	Priced	Cloud support layer – software Business support layer-application	http://www.hiqube.com/	–
GridServer, Fabric-Server, VersaVision, Federato, DART	Data Synapse	Dynamic manage, and optimize scalable enterprise-class application services as well as metering and runtime control of applications across physical and virtual infrastructure	Products and services	Priced	Primary layer – SW applications and Cloud support layer.	http://www.datasynapse.com/	–
1- Sun Grid Engine, 2- Sun Blade, 3- Sun VDI Software 4- Sun Cloud	Sun	Diverise services and prodcuts including Hardware Servers and Software package for Grid management and middleware resource sharing as well as Multi-clustering, Accounting, Reporting Advance Reservation Applications.	Product	Priced	Primary activities: hardware, resource management & Cloud Support activities: Storage Software, applications, accounting	http://www.sun.com/software/sge	Wide range of Grid applications
AppZero's software	AppZero	Wide set of applications for cloud computing, and server-side application virtualization	Product	Priced	Primary: MW, SW and Cloud support activities	http://www.appzero.com	–
Aneka	Manjra soft	Enterprise Grid/cloud computing systems	Product	Priced	Primary – middleware – Cloud support – financial and economic support	http://www.manjrasoft.com	–

SIMtone SNAP	SIMtone Cooperation	Cloud computing: end-to-end Universal Cloud-Computing Platform that allows network operators, service providers and businesses of any size to deliver all types of computing as services to any device	Service DaaS/ SaaS)	Priced	End-to-end cross layer primary, Cloud and support layer services.	http://www.simtone.net/snapbook.htm	–
SIMtone's HPC ASPEED	SIMtone Cooperation	Application and software	product	Priced	Primary activities – package for resource management and – Cloud support activities	http://www.simtone.net/	–
XtremWeb	IN2P3 (CNRS), INRIA and University PAris XI	Middleware Software	Product	Free	Primary activates – Middleware	http://www.xtremweb.net/	
Oracle Grid Products	Oracle	Database management, middleware, VM and enterprize solution	Product and services	Priced	Primary layer- MW – data management, Grid applications, and Cloud support layer	http://www.oracle.com/technologies/grid/grid_products.html	
asiGRID BETA	Andre scavage Soft ware Inc.	Service-Oriented Infrastructure, to manages deployment, routing, scalability, fault-tolerance, security, monitoring, and upgrading of Gird	Product	Priced	Primary and Cloud support layer: application	http://www.gridnow.com/	
Unified Computing System	Cisco	network, storage, server and virtualization	Product and Service	Priced	Primary and Cloud support activities	http://www.cisco.com	
VMware	EMC2	Virtualization	Products and service	Priced	Cloud support activates	http://www.emc.com/services/index.htm	Provide a wide set of applications, consulting and implantation service that support the Cloud
Vine Toolkit and GridSphere 3	Grid Sphere project	Wide range of Grid applications	Product and services	Free	Cloud support activities	http://www.gridsphere.org	Many applications and service for facilitating Cloud business adoption

Dell cloud computing solution	Dell	Hardare and Applications including Designed -TO-Order Project Management and data center customized services	Service and products	Priced	End-to-end Cross layer Primary, Cloud and business. Vertical value.	http://www.dell.com/cloudcomputing	A number of other examples include: Nimbus, Cyclecomputing, etc . . .
g-Eclipse	g-Eclipse consortium	Middleware, applaictions (Migrating Desktop, the GridBench suite, the Grid Visualisation Kernel GVK) framework	Product	Free	Primary activities-middleware, SW and management	http://www.geclipse.org	–
3PAR Utility Storage	3PAR	utility storage, and enterprise IT utility services	Service	Priced	End-to-end Cross layer Primary, Cloud and business. Vertical value.	http://www.3par.com/about_us_overview.html	–
The P-GRADE Grid Portal	Computer and Automation Research Institute Hungarian Academic of Sciences	web based environment for the development, execution and monitoring of workflows	Product	Free	Primary activists – SW applications and Cloud support	http://www.p-grade.hu/	Provide support for different workflow tools. Other examples in this catagory include: Gridsphere, OGS portal, etc . . .
VIRTERA's vSpectrum	VIR TERA	Provide professional services and consulting firm delivering virtualization technology solutions and services.	Product and services	Priced	Cloud support activities and business support activities	http://www.virteratech.com/	
Globus Toolkit	Globus Alliance	Middleware, solutions and Grid systems and applications	Product	Free	Primary and Cloud support activities	http://www.globus.org	One of the most accesspted and widely adopted middleware and software Standard industry solutions
Amazon Elastic Compute Cloud (Amazon EC2)	Amazon	Hardware and software services as Application Hosting, Backup and Storage, Content Delivery, High Performance Computing, Media Hosting, and On-Demand Workforce. see Amazon Web Services	service	Priced	End-to-end Cross layer Primary, Cloud and business. Vertical value.	http://aws.amazon.com/ec2/	Multiple services for different customer classes

Grid Dynamics solutions	Grid Dynamics	Provide service consulting and development strategies, technology selection and implementation.	Service	Priced	Cloud support layer – consultants	http://www.griddynamics.com	–
COMPOSITE solutions	Composite software	Provide discovery, Federate and deliver real-time information without physical replication and consolidation. Data Virtualization Solutions	Products and service	Priced	Cloud support activities layer – added value	http://www.compositesw.com/	–
UniCluster and Grid MP products	Univa UD Inc.	Diverse product that address many if not all address of Cloud. Served as stand alone or suit of solution and products as UniCluster, UniPortal,Grid MP, Grid MP, DataCatalyst, and UniSight.	Product and services	Priced	Primary, Cloud and business, support activities	http://www.univaud.com/	Wide range of partnership with Technology Partners, Enterprise Partners, Resellers Systems Integrators
ActiveVOS	Active Endpoints	Provide standards-based visual orchestration system SOA-based process orchestration and business process management (BPM) system.	Product	Priced	Cloud support layer: applications and developers	http://www.activevos.com/	–
Cloud Computing solutions from IBM	IBM	Hardarwe and software solutions	Mainly Products, services also available	Priced	Primary layer activists and Cloud support activities	http://www-03.ibm.com/grid/	target business SME's and enterprises –
cloud-based virtual lab	Skytap	Diverse solutions for cloud computing that include applications that support and integrate with other like Xen	Product and services	Priced	Primary layer activists and Cloud support activities	http://www.skytap.com	–
OGSA-DAI	EPCC at the University of Edinburgh and at NeSC	Data management middleware	Product	Free	Primary layer activities – SW application	http://www.ogsadai.org.uk	–

MOSIX, TXTDemand, and Video Recognition Environment	SORMA (Self-Organizing ICT Resource Management)	Provide Grid management and operating system. In addition to a demand forecasting application and a motion tracking application that creates a graphic real-time presentation.	Product	Priced and Free	Primary and Cloud support activities: SLA based Resource management	http://sorma-project.org	–
SLA management framework Technologies	SLA@SOI (Empowering the Service Economy with SLA-aware Infrastructures)	Provide standard interface for e-contracting platform between service consumers and providers	Product	Free	Primary and Cloud Support activities: SLA management	http://sla-at-soi.eu	–
RESERVOIR Technologies	RESERVOIR (Resources and Services Virtualization without Boundaries)	Provide Infrastructure for Service Delivery services that seek to leverage the diversity factor and achieve economies of scale (Virtual Execution Environment)	Services	Priced	End-to-end services + Cloud support activities and business support activities: infrastructure Virtualization services.	www.reservoir-fp7.eu	–

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