# Cloud Computing as a Supply Chain

Frank Fischer

Dr. Freda Turner

Business Operations-Systems Perspectives in Global Organizations (DDBA - 8110 - 7)

Walden University

07/10/2009

Abstract

This paper draws a line between Cloud Computing and a supply chain. Cloud Computing is seen as one of the most basic shifts in IT in decades and still very new. The concept of a supply chain on the other hand is elaborated and researched in deep. Therefor the idea is to extract interesting analogies by comparing the two models.

First the basic ideas of a supply chain are extracted and compared with the elements seen in Cloud Computing. Then Microsoft and its cloud computing infrastructure is used as an example.

## Introduction

Cloud computing receives a lot of attention lately. Opinions differ from this being nothing new to that cloud computing will revolutionize IT. Interestingly shows the concept of cloud computing similarities to supply chains. This paper therefor should show the similarities and differences. It shall then research into the question if and how aspects of supply chain management can be applied to cloud computing.

First the term supply chain and cloud computing are introduced. Then the main aspects of a supply chain are compared with cloud computing and finally ask how the theories around supply chain management can be applied.

In preparation of this paper there were interviews conducted with two professionals within this space. First with Holger Sirtl, Architect Evangelist at Microsoft Deutschland GmbH ( (Sirtl, 2009)). He is responsible for the technical evangelism of Windows Azure – the cloud computing system – of Microsoft in Germany and has a track record as a software architect at Accenture and other companies. Mr. Sirtl provided technical insights and the links towards business strategies. Secondly with Karin Sondermann, Platform Strategy Sales Manager, Microsoft Deutschland GmbH ( (Sondermann, 2009)). She can look upon a career within software engineering and is now part of the working group cloud computing within the German BitKom. She provided insights from a business and strategic point of view.

## Definition of a Supply Chain and its Management

In order to prepare to reflect cloud computing with a supply chain the following paragraphs provide some basic characteristics of a supply chain.

(Mentzer, DeWitt, Keebler, Min, & al, 2001), defines a supply chain “as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” (p.4). Obviously the term is applied not only on physical goods but also on services like finance or information.

In (Business Dictionary, 2009) the term supply chain is defined as follows:

> Entire network of entities, directly or indirectly interlinked and interdependent in serving the same consumer or customer. It comprises of vendors that supply raw material, producers who convert the material into products, warehouses that store, distribution centers that deliver to the retailers, and retailers who bring the product to the ultimate user.

The following terms can be extracted: Raw material, conversion in product or services, storage and distribution of those products or services.

As stated in (Mentzer, DeWitt, Keebler, Min, & al, 2001), supply chains exist if being managed or not. But actively managing the supply chain can lead to competitive advantages.

Supply chain management overall is based on the following ideas (Mentzer, DeWitt, Keebler, Min, & al, 2001): (1) A systematic approach to view the supply chain from beginning to end, (2) a strategic orientation to synchronize operations and strategy within and between companies, and (3)customer focus to generate a unique and individual source of customer value.

As typical management actions are found: (1) Integrated behaviour (2) mutually sharing information (3) mutually sharing risk and rewards (4) cooperation (5) the same goal and the same focus on serving customers (6) integration of processes (7) partners to build and maintain long-term relationships

(Mentzer, DeWitt, Keebler, Min, & al, 2001) describe major drivers for the popularity of the concept: Trend to global sourcing, emphasis on time and quality-based competition. These are the second line goals behind the always present necessities to maximize productivity (reduce cost and/or increase revenue) and to maximize customer satisfaction.

Also very interesting are the steps towards supply chain management identified by (Stevens, 1989) and summarized by (Mentzer, DeWitt, Keebler, Min, & al, 2001):

> Stage 1) Represent the base line case. The supply chain is a function of fragmented operations within the individual company and its characterized by staged inventories, independent and incompatible control systems and procedures, and functional segregation.
>
> Stage 2) Begins to focus internal integration, characterized by an emphasis on cost reduction rather than performance improvement, buffer inventory, initial evaluation of internal trade-offs, and reactive customer service.
>
> Stage 3) Reaches toward internal corporate integration and characterized by full visibility of purchasing through distribution, medium-term planning, tactical rather than strategic focus, emphasis on efficiency, extended use of electronics support for linkage, and a continued reactive approach to customers.
>
> Stage 4) Achieves supply chain integration by extending the scope of integration outside the company to embrace suppliers and customers. (p.9-10)

## Definition of Cloud Computing and Computing Power

In (Erdogmus, 2009) the following definition of cloud computing is given: "…cloud computing is an emerging computational model in which applications, data, and IT resources are provided as services to users over the Web (the so-called "cloud")" (p.4)

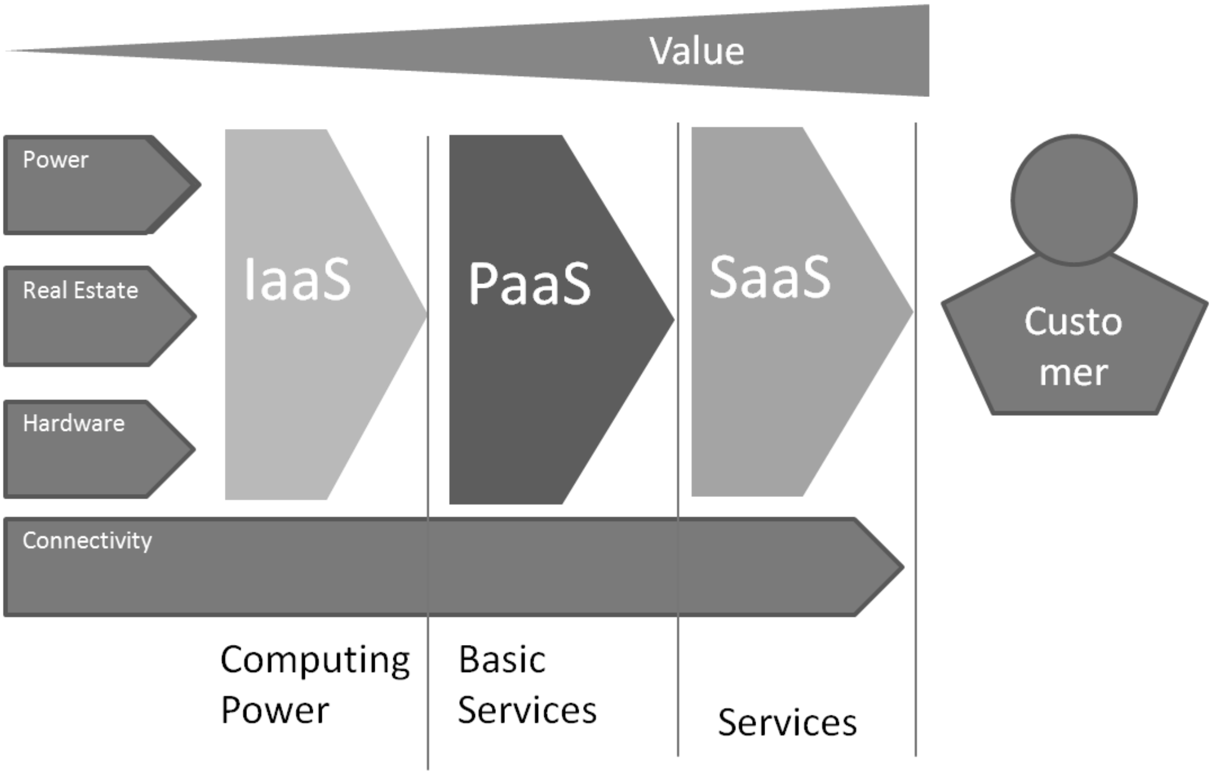
Those services divide into four distinct levels as stated in (Leavitt, 2009):

> Services. Some products offer Internet-based services—such as storage, middleware, collaboration, and database capabilities—directly to users.
> IaaS. Infrastructure-as-a-service products deliver a full computer infrastructure via

> the Internet
> PaaS. Platform-as-a-service products offer a full or partial application development environment that users can access and utilize online, even in collaboration with others.
> SaaS. Software-as-a-service products provide a complete, turnkey application—including complex programs such as those for CRM or enterprise-resource management via the Internet. (p.17)

This can be seen as a standard model for cloud computing today. Figure 1 shows a graphical representation of the model (similar graphics can be found in (Leavitt, 2009) with more details on the different services). It is also shown that customer values increases from step to step. Within the interview both Holger Sirtl and Karin Sondermann related to this model. It is also used throughout videos and presentation of various vendors in the field.

Figure 1: Cloud Computing Stacking



All levels have in common that computing power as raw material - defined in the following paragraph – is offered and used.

The value chain of IT can be described in a simplified model: The baseline is defined by hardware like Central Processing Units or CPUs, Random Access Memory or RAM, harddisk storage, and such. On top of this hardware is a layer called operating system which manages the hardware and makes it accessible to the next layer. Typical operating systems are Microsoft Windows or Linux. On the Operating System layer runs an Application Server which offers more abstract functionality like transactions and rational databases. On top of this runs the application. Each layer needs to be equipped to take full advantage – and therefor reach full scale - of its predecessor. A typical technology used here is virtualization which provides a container for an application entity.

Seeing the hardware and operating system layer as one it offers what I call computing power. Computing power is a function of amount of memory, strength of the CPU, size of the communication busses and such. For this paper a more detailed definition is not necessary and out of scope. Raw computing power needs to be used and converted into increasing higher value for the customer. This is done by using the chain shown in Figure 1.

Seeing computing power as the offering in IaaS all other layers of the model can be matched to the services layers described by (Leavitt, 2009).

Another important aspect is the differentiation on private versus public cloud. The Desktop Encyclopedia (see (Computer Language Company Inc., 2009)) defines cloud computing as using the mechanisms that usually are used in cloud computing to provide internal services within organizations. In (Babock, 2009) reasons for private clouds are discussed and also the way a customer must take step by step to find the way into using the cloud computing services. This means while public cloud describes the services described in the model offered by an external provider or supplier, a private cloud comes from an internal provider or supplier.

Holger Sirtl added the balance between scale and control (Sirtl, 2009). In a typical environment today organizations run their own infrastructure and have total control. The drawback is that the maximal level of scale is defined by the size of the company. The other extreme would be a totally cloud based infrastructure. Here the level of control is traded for maximum scale because this scale needs processes and certain ways of software architecture. From a perspective of private versus public cloud: Local installation - or on-premise as it is called – offer maximum control and minimal scale, private cloud offers more scale and less control while public cloud offer maximum scale and minimal control. These enormous cost savings in the large scale can be realized by implementing autonomous processes. Any time a supplier is asked to work outside those processes – manually change something – this directly relates to more control for the customer but higher costs that are certainly handed on to the customer.

Sometimes there a certain needs not to move services into the public cloud like locality of data or the necessity to keep IP inside corporations. Here it is necessary to balance between control and scale (equals costs). As Holger Sirtl (Sirtl, 2009) stated: "What does not delimit the provider can be used to reduce costs".

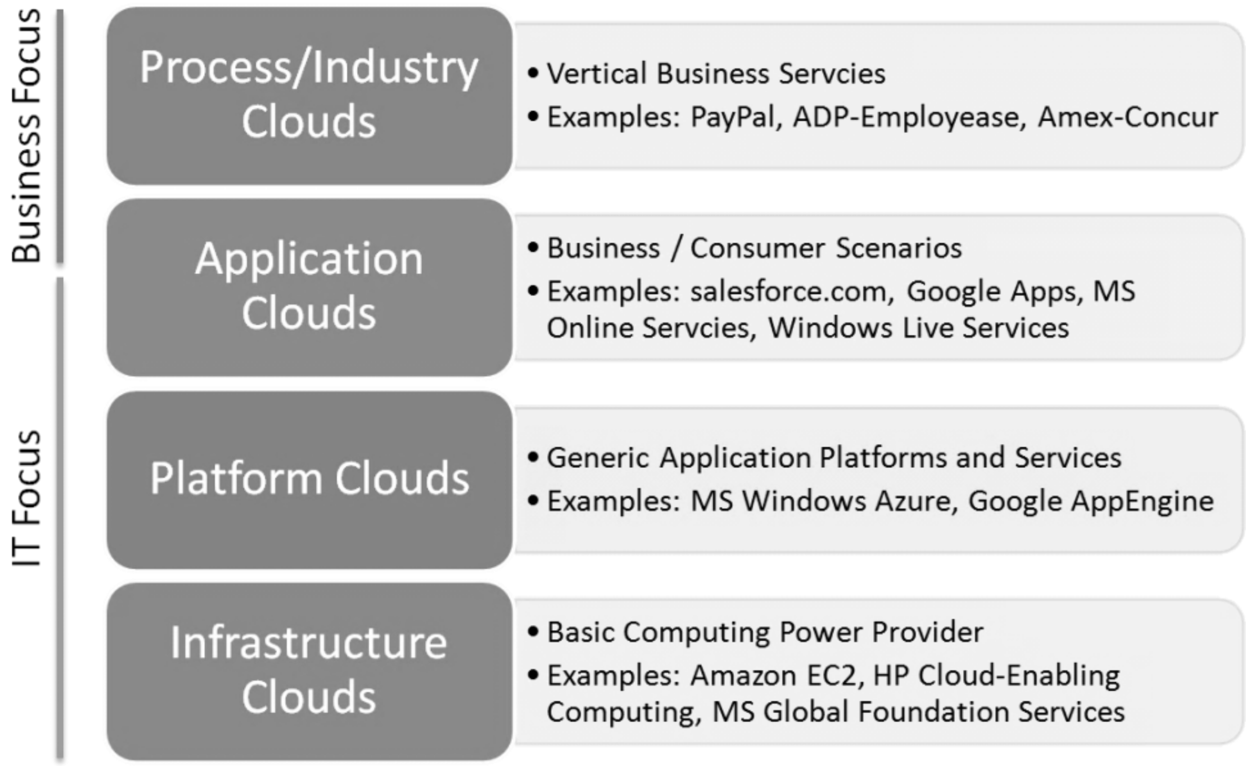
In (Venkatraman, 2009) the main drivers for cloud computing are identified as "Professionals and institutions care about cost, reach, accessibility and the scalability of services. The cloud model achieves all of these for them" (p.17).

In (Belady, 2009) another driver was identified: Carbondioxide footprint. Operating at large scale helps to reduce energy consumption. According to (Belady, 2009) in the US it is projected for 2020 to use 10% of the produced energy for operating servers for the internet. This will increase in 2030 to 30-40%. It is expected that governments will regulate here and first steps have been done. In the report to congress (US Environmental Protection Agency, 2007) the power usage effectiveness or PUE is used to describe the ratio between energy being used for producing computing power and the energy used to support this like cooling the devices. The dimension of the power consumption shows that reducing PUE – and therefor lower the energy consumption of the supporting – is both of an economic interests (lowering the cost to produce computing power) as well as of an environmental interest (reducing $CO_2$ footprint). Any customer will inherit the carbon dioxide footprint of his computing power supplier. This will be an aspect on how to choose supplier.

It is also necessary to note that while cloud computing promises interesting gains it is not the "silver bullet". According to calculation models by (Walker, 2009) there are cases were local installations gain higher profitability (especially in high-load scenarios). And – as in (Gentzsch, 2008)- there are hurdles to overcome when moving applications to the cloud. Certainly the future seems to lean towards cloud based solutions (better connectivity, lower hardware costs, higher energy costs, better tooling) but it is certainly necessary to keep a realistic approach.

The basic – and very technical- model above can be extended with an alternative view on the cloud computing stack that presented me Karin Sondermann during the interview ( (Sondermann, 2009)). As shown in Figure 2 an extension on top of the IT focused stack can be found. Here new business models can be found. A good example is PayPal – a micro-payment provider. There would neither be a market nor the ability to fulfill customer's need without cloud computing as a concept.

Figure 2 : Alternative View on Cloud Computing Stacking



## Comparing Cloud Computing with Supply Chain

In the first paragraphs some basic characteristics of a supply chain have been identified and shall now be compared with cloud computing as defined above.

The basic definition of a supply chain as given by (Mentzer, DeWitt, Keebler, Min, & al, 2001) and (Business Dictionary, 2009) apply. As shown in Figure 1 cloud computing is a chain of entities that increase value by producing and refining a product – computing power. For each entity in the chain the predecessor provides a stream of products (or service) that abstracts the process of production. So within each entity a high level of specialization can take place.

The (Business Dictionary, 2009) identified four major terms for a supply chain that can be found within cloud computing.

Table 1: Supply Chain Terms versus Cloud Computing

| Supply Chain Term | Cloud Computing Interpretation |
| --- | --- |
| Raw material | Computing power as produced by data centers |
| Conversion in product or services | Following up the software chain to higher levels of abstraction towards applications such as CRM |
| Storage | Data storage capable of holding structured and unstructured data as well as process states |
| Distribution of products or services | Connectivity (Internet in the sense of public cloud, Intranet in the sense of private cloud) |

According to this cloud computing from a business point of view is the attempt to formulate IT as a supply chain. As stated in the first paragraphs the goal for actively managing any supply chain are certainly cost efficiency and improved customer service. Those are also the two main drivers for cloud computing ( (Venkatraman, 2009), (Leavitt, 2009) ). Additionally trends towards global sourcing are supported by using the Internet as a distribution platform. It allows offering cloud based services in a global manner combined with the promise of high availability and scalability of the cloud computing model. And as shown in Figure 2 it also enables new business models.

## Applying Supply Chain Management on Cloud Computing

The following specific actions are typical for supply chain management activities ( (Mentzer, DeWitt, Keebler, Min, & al, 2001), p.8):(1) Integrated behaviour (2) mutually sharing information (3) mutually sharing risk and rewards (4) cooperation (5) the same goal and the same focus on serving customers (6) integration of processes (7) partners to build and maintain long-term relationships. In the following paragraphs I contrast those actions towards cloud computing.

The term “Integrated behavior” is described as a set of activities that coordinates the efforts between supply chain partners to dynamically respond to customer needs (Mentzer, DeWitt, Keebler, Min, & al, 2001). This is certainly less a packet of concrete actions than more a state of mind to basically accept the concept. My personal observation is that it is hard to lower the level of control to gain other benefits. This was certainly true within manufacturing industries when introducing the concept, and now holds true for IT departments. In the interview (Sondermann, 2009) Karin Sondermann identified this as the typical problem that customers face when introducing cloud computing.

Despite seeing large corporations driving the concept from a customer side (as I expect supply chain management had been introduced to other industries) within IT smaller companies are drivers and early adopters of the concept.  But – as we will see later on – the same steps that had been observed introducing supply chain management the first place can be found in cloud computing today.

“Mutually sharing information” is described in (Mentzer, DeWitt, Keebler, Min, & al, 2001) as “the willingness to make strategic and tactical data available to other members of the supply chain” (p.8). In the classical definition these are e.g. sales forecasts, marketing strategies, inventory levels. In the cloud computing model this still holds true. Since building up new capacities in large quantities takes up to years (Belady, 2009) forecasting demand is vital for providers of computing power and they invest great efforts in this. Microsoft for example operates one of the largest business intelligence infrastructures in the world to operate and control its datacenters. On the other hand the supplier needs to offer operational data to the customers to help them react on bottlenecks, to up- or downscale the used infrastructure.

Sharing Risk and rewards is a common for supply chain management. As Holger Sirtl stated in (Sirtl, 2009) crossing the organization’s security boundaries is a major concern within cloud computing. Especially since cloud computing and SaaS models blur the line between local stored data and data stored in the cloud. For example editing a text in a browser based application might store the text as the customer types into an internet based data store. There is no means if this was intended or not or if the user is aware of this. As (Schneier, 2009) states:

> IT security is about trust. You have to trust your CPU manufacturer, your hardware, operating system and software vendors – and your ISP (Internet Service Provider). Any one of these can undermine your security: crash your systems, corrupt data, allow an attacker to get access to systems. … You have to trust your outsourcer completely. You not only have to trust the outsourcer's security, but its reliability, its availability, and its business continuity.

How can suppliers overcome these concerns and build trust? Holger Sirtl (Sirtl, 2009) sees compliancy and standards as solution. Suppliers have to show that they apply to standards both in a technical way – which relates to protocols and data formats – and in a process way. Those have to be certified and presented publicly. Those certifications are costly but critical for adoption as they build the foundation of Service Level Agreements or SLA between the suppliers and consumers within the supply chain.

SLAs define the amount of reliability a supplier guarantees and on the other side what kind of penalty enforces those guarantees. In (Schneier, 2009) there are two extreme examples given:

> The first only pays a nominal fee for these services – and uses them for free in exchange for ads: eg Gmail and Facebook. These customers have no leverage with their outsourcers. You can lose everything . Companies like Google and Amazon won't spend a lot of time caring. The second type of customer pays considerably for these services: to salesforce.com, MessageLabs, managed network companies, and so on. These customers have more leverage, providing they write their service contracts correctly.

From a pure technical standpoint it is interesting to see that there are good reasons why cloud based services can even be more secure than locally hosted. The cloud datacenter offers a lot of basic features like physical safety, backup systems, rigid processes that most local installations do not. Eran Feigenbaum, Enterprise Security Director at Google, said (Ashford, 2009) “Cloud computing can be as secure, if not more secure, than what most organizations do today in the traditional environment"

Interestingly enough Google’s view here misses the capability of the client side to increase both customer experience and reliability by having an application running locally that makes use of back end services in the cloud.

How Microsoft secures its infrastructure is described in (Microsoft Corp, 2009). Herein are the description of processes and how those are set up.

The next aspect in the list is cooperation. This aspect can be seen within the three large players on the market today. Google, Amazon and Microsoft started with global online services like mail, web sites, search, online shops, CRM. All of them used the learnings that product groups did internally to define, shape, develop and refine services that are now part of their overall cloud computing offering. This kind of cooperation happened first internally but will certainly extend into external customers. Suppliers will seek out to work with their customer base to improve services and develop new services to offer.

Another interesting aspect of cooperation as stated by Sirtl (Sirtl, 2009) is that suppliers need to offer its customers access to internal training and process guidance. From a customer perspective this is critical if they wish to keep enough knowledge inside their company to be able to ask the right questions and to get the right SLA when negotiating with a cloud computing supplier.

The common focus on serving customers – as stated in the list – should be a given and can be found within the policies of most suppliers today.

Process integration is an interesting aspect since this is what higher level of cloud computing is all about. While lower levels offer interfaces to integrate the services into processes of the customer, higher levels offer to host the whole process. Today's services like PayPal are a good example how parts of a process can be transferred to a supplier – here of micro-payment. As Sirtl stated in (Sirtl, 2009) there is a trend towards higher level services and standard data models to enable quicker process design. He mentioned also the new role of System Integrators or SIs in the future. While those kinds of companies tend to be responsible for infrastructure they will now try to reach into more abstract process regions.

Another aspect here is that process integration with the help of ERP (Enterprise Resource Planning) and EAI (Enterprise Application Integration) is a complex task (Themistocleous & Corbitt, 2006). With the rise of SOA (Service Oriented Architecture) in IT architectures those ERP systems had to be adopted towards integration in those architectures. An example is given in (Parker, 2007) for Coca-Cola. SOA is an enabler for adopting cloud based services into the infrastructure. This is not an easy process a (Hoskins, 2008) shows "Even the most state-of-the-art SOA design must accommodate legacy applications, arcane but still-critical data sources and fast-growing adoption of SaaS applications" (p.2).

Cloud computing is a driver for process and service orientation since its implementation makes it necessary to be aware of processes and their implementation. This is no different than the observation of (Stevens, 1989) regarding the four stages of supply chain integration. Step 1 – the base line case – shows fragmented operations, incompatible control systems and procedures. Stage 2 is characterized by the focus of cost reduction with a focus of internal integration. I would see in the case of cloud computing to outsource basic IT services as mail and storage into the cloud. Stage 3 is where the company gains clarity about the processes and how those are linked together. Within IT this is the stage to adapt to SOA within corporate boundaries. Stage 4 extends what has been achieved in stage 3 to the outside world.

The last aspect – to build and maintain long-term relationships – is the obvious result of the six aspects before. Companies need to rely on their supplier if services provided by the supplier are woven into business processes. Also transferring large amounts of data will cost time and money to do. So choosing a supplier for cloud computing services has certainly to be done with the idea of a long-term relationship in mind.

## How the cloud computing supply chain is built within Microsoft

Within Microsoft the basic provider of computing power is a group called Global Foundation Services or GFS. Within their responsibilities is to build and run the datacenters and provide infrastructure as a service. Those services are not directly exposed to outside customers.

Today Global Foundation Services are in the need of forecast demand on a global level. The request for local computing power for example in Europe must be met as well as Microsoft introducing a new search engine and the increase in demand here. In (Josefsberg & Manos, 2009) states:

> After all, we need to continue supporting a growing base of more than 400 million Hotmail users and over a billion Live Search queries each day, plus 250 other services for Microsoft, including a fast-growing online services business for enterprise companies and the new Azure platform that software developers are beginning to use to create new services.

A major quest to GFS besides optimizing power usage is to build a system that can bridge the problem that building new computing power facilities – a.k.a. data centers – needs months or years to be setup and the fact that computing power needed can change within seconds. This is laid out in (MS Datacenters Blog, 2008):

> The worst thing we can do in delivering facilities for the business is not have enough capacity online, thus limiting the growth of our products and services.
>
> The second worst thing we can do in delivering facilities for the business is to have too much capacity online.

To do so the Gen 4 (for Generation 4) datacenter is in planning (MS Datacenters Blog, 2008):

> Gen 4 will move data centers from a custom design and build model to a commoditized manufacturing approach. We intend to have our components built in factories and then assemble them in one location (the data center site) very quickly. Think about how a computer, car or plane is built today. Components are manufactured by different companies all over the world to a predefined spec and then integrated in one location based on demands and feature requirements. And just like Henry Ford's assembly line drove the cost of building and the time-to-market down dramatically for the automobile industry, we expect Gen 4 to do the same for data centers. Everything will be pre-manufactured and assembled on the pad.

The second layer –platform as a service – is provided by means of Windows Azure and Windows Azure Services (Microsoft Corp, 2009). It is operated by GFS which is responsible to provide virtually no limit to computing power available to the system and services but reducing over capacities.

The third layer – software as a service - are the services based upon Windows Azure or provided by Microsoft Online – a service to host infrastructure components like Exchange or SharePoint at Microsoft.

## Conclusion

The intent of this paper is to show that cloud computing can be seen as a supply chain that delivers and refines computing power towards its customers. Like in all supply chains this can be optimized by actively managing the processes. And also – like in all supply chains – trust is a major issue between the parts of the supply chain.

## Interview Questions

Questions for Mr. Sirtl and Ms. Sondermann:

Q: Can you please describe a bit what your current job at Microsoft is and what were the steps in your career?

Q: Can you describe the different models of cloud computing?

Q: What are typical problems customer face when introducing cloud computing?

Q: Within a supply chain trust between supplier and customer is key. How do cloud computing provider react on this?

## Works Cited

Ashford, W. (2009, July 21). *ComputerWeekly.com*. Retrieved July 25, 2009, from Cloud computing more secure than traditional IT, says Google: http://www.computerweekly.com/Articles/2009/07/21/236982/cloud-computing-more-secure-than-traditional-it-says.htm

Babock, C. (2009, April 13). Time to Believe in Private Clouds. *Information Week* , p. 27.

Belady, C. (2009). What's behind the Cloud - Microsoft's Data Center Transformation. *TechEd 2009 US* . Los Angeles, CA, USA: Microsoft Corp.

Business Dictionary. (2009, July 11). *Supply Chain Definition*. Retrieved July 11, 2009, from Business Dictionary: http://www.businessdictionary.com/definition/supply-chain.html

Computer Language Company Inc. (2009, April 01). *Private Cloud*. Retrieved July 23, 2009, from Computer Desktop Encyclopedia: http://ezp.waldenulibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=iih&jid=D5R&site=ehost-live

Erdogmus, H. (2009). Cloud Computing: Does Nirvana Hide behind Nebula? *IEEE Software* , 4-6.

Gentzsch, W. (2008). Porting Applications to Grids and Clouds. *International Journal of Grid and High Performance Computing* , 55-77.

Hoskins, M. (2008). Solving the SaaS, SOA and Legacy Applications Sudoku. *DM Review* , 21-23.

Josefsberg, A., & Manos, M. (2009, January 23). *MS Datadenters Blog*. Retrieved July 25, 2009, from Building a Better Mousetrap a.k.a. Optimizing for Maximum Efficiency in an Economic Downturn: http://blogs.technet.com/msdatacenters/archive/2009/01/23/building-a-better-mousetrap-a-k-a-optimizing-for-maximum-efficiency-in-an-economic-downturn.aspx

Leavitt, N. (2009). Is Cloud Computing Really Ready for Prime Time? *IEEE Computer* , 15-20.

Lin, G., Fu, D., Zhu, J., & Dasmalchi, G. (2009). Cloud Computing - IT as a Service. *IEEE IT Pro* , 10-13.

Mentzer, J. T. (2007). *Handbook of Global Supply Chain Management.* Thousand Oaks: Sage Publications.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., & al, e. (2001). Defining Supply Chain Management. *Journal of Business Logistics* , 1-25.

Microsoft Corp. (2009, May). *Global Foundation Services.* Retrieved July 24, 2009, from Securing Microsoft's Cloud Infrastructure: http://www.globalfoundationservices.com/security/documents/SecuringtheMSCloudMay09.pdf

Microsoft Corp. (2009, July 25). *Windows Azure Platform*. Retrieved July 25, 2009, from Windows Azure Platform: http://www.microsoft.com/azure/default.mspx

MS Datacenters Blog. (2008, December 2). *Our Vision for Generation 4 Modular Data Centers – One way of Getting it just right* . . . Retrieved July 25, 2009, from MS Datacenters Blog: http://blogs.technet.com/msdatacenters/archive/2008/12/02/Our-Vision-for-Generation-4-Modular-Data-Centers-_1320_-One-way-of-Getting-it-just-right-.-.-_2E00_.aspx

Parker, K. (2007). ERP and SOA at The Coca Cola Company. *Manufacturing Business Technology* , 2.

Schneier, B. (2009, June 4). *The Guardian*. Retrieved July 25, 2009, from Be careful when you come to put your trust in the clouds: http://www.guardian.co.uk/technology/2009/jun/04/bruce-schneier-cloud-computing

Sirtl, H. (2009, July 17). Architect Evangelist. (F. Fischer, Interviewer)

Sondermann, K. (2009, July 17). Platform Strategy Sales Manager. (F. Fischer, Interviewer)

Stevens, G. C. (1989). Integrating the Supply Chains. *International Journal of Physical Distribution and Materials Management* , 3-8.

Themistocleous, M., & Corbitt, G. (2006). Is business process integration feasible? *Journal of Enterprise Information Management* , 434-449.

US Environmental Protection Agency. (2007). *Report to Congress on Server and Data Center Enegry Efficiency - Public Law 109-431*. US Environmental Protection Agency; Energy Star Program.

Venkatraman, A. (2009). Capture the Cloud. *Information World Review* , 16-17.

Walker, E. (2009). The Real Cost of a CPU Hour. *IEEE Computer* , 35-40.