NOVEL ACCOUNTING, PRICING AND CHARGING MODELS IN A CLOUD-BASED SERVICE PROVISIONING ENVIRONMENT

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DECLARATION

I declare that this research dissertation on **Novel Accounting, Pricing and Charging Models in a Cloud-based Service Provisioning Environment** is my work, and has never been presented for the award of any degree in any University. All the information used has been dully acknowledged both in text and in the references.

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DEDICATION

This research dissertation is dedicated to Elohim, my dear brothers;

Paul, Thomas

and **Francis**.

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Abstract

Cloud Computing, the long-held vision of Computing as a utility, has recently emerged as a new model for hosting, commoditizing and delivering services in a manner similar to traditional utilities such as water, electricity, gas and telephony. In this new model, users are able to access services according to their specific preferences without regards to where the services are hosted or how they are delivered. In a Cloud Computing environment, the traditional role of service provider is divided into two; the infrastructure providers who manage cloud platforms and lease resource according to usage-based pricing model and the service providers who rent resources from one or many infrastructure providers to serve the end users. This research report is on the development and implementation of novel accounting, pricing and charging model in a cloud-based service provisioning environment. The model implementation scheme is on the basis of pay-as-you go for the utilisation of the cloud service, as against the traditional transfer pricing method which is based on user observed value for the service. The experimental tool used was cloud analyst because of its ability to support visual simulation and modelling of large scale applications that are set out on cloud infrastructures. The significant contribution of this novel model is on its ability to reduce fraudulent charges on cloud services.

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List of Acronyms

AAA - Authentication, Authorization and Accounting

ACR – Accounting Records

CPU – Central Processing Unit

DC – Data Center

DNS – Domain Name Serve

EAP - Extensible Authentication Protocol

EVM – Effective of Virtual Machine.

Iaas – Infrastructure as a Service

IBM – International Business Machines

IP – Internet Protocol

IT – Information Technology

ISP – Internet Service Provider

NAS – Network Access Server.

PaaS – Platform as a Service

QOS – Quality of Service

SaaS – Software as a Service

SLA – Service Level Agreements.

UB – User Bases

UDR – Usage Data Records

VM – Virtual Machines.

Chapter 1

General Introduction

1.1 Introduction

The concept of Cloud Computing is not new to Information Technology. Inventors long ago visualized this concept of providing computing facilities to the general public as a utility. The phrase "Cloud" has long been included at length in various contexts relating to big networks in the 90s [2]. It proceeded in the 21st century and was included in business models to provide services across the Internet. Hence the phrase has gained in-roads in the IT industry as a marketing term to represent different ideas.

Cloud Computing refers to a model for on demand network access to a shared pool of configured computer related resources like services, storage and application that can rapidly be separated and used by end users with less effort and with negligible service provider involvement [4]. Cloud Computing encompasses both the hardware and systems software in the data centers that provide services and at the same time application delivery as services over the internet spectrum [3].

On a broader level, Cloud Computing is the web centered development and use of computer technologies where scalable and often virtual resources are provided as a service over the Internet. End users do not need to know of how, who or what goes on in the cloud [6]. The key aspects of this definition are Cloud Computing resources are accessed by front end users instantly, anywhere using any platform.

Cloud Computing came into existence due to the vast growth of the Internet recently that has produced scalable yet parallel problems. The corresponding response for companies has been to create large data centers to handle the overwhelming data load. These companies have gone to great length to get experts who have knowledge of the vast data centers. This is not only confined to the data centers but also to intangible aspects like management. Hence, Cloud Computing is a commercialization of this whole solution [5].

Cloud Computing currently is transforming into a model consisting of services delivered as in a traditional model as depicted in Figure 1.1. In this model, front end users have access to services based on their needs without knowledge of where the services are being delivered or hosted [1]. With the evolution of storage and processing technologies coupled with the inception of the Internet, computer resources has become more abundant, powerful and available at any ones disposal [2]. Numerous computing paradigms have tried to deliver utility computing as an idea like Grid and Cluster Computing and more recently Cloud Computing. The latter as a utility can transform an IT industry, making software as a service user-friendly and hardware as redesigned infrastructure [3]. Currently no enormous capital is needed to run this utility or utilize intensive labour. Hence the computing world is shifting towards reinventing software for a consumer as a service instead of storing it in their hard drive for personal use.

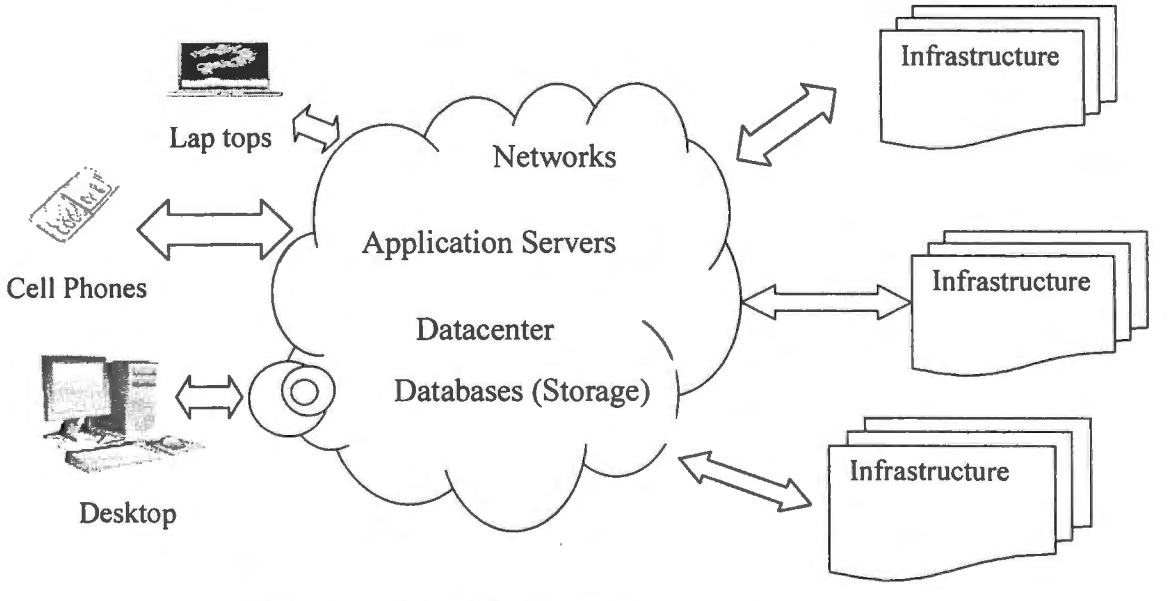

Figure 1.1 Cloud Computing Overview

With the improvement of the current social order, essential services are commonly provided to suit everyone. Currently utility services are necessary for fulfilling daily life routines. These utility services are accessed so often that they need to be available anytime at the consumer's request [1]. The consumer is then liable to pay for services rendered. With the advent of the Internet software, pioneers are facing huge challenges towards creating software for hundreds of thousands of consumers to use as a service. The Internet fused with computer utilities yields a global system of computer networks that enables individual computers to communicate with any other computer situated anywhere in the world. This occurrence of standalone computer shows the promising likelihood of utilizing endless amount of distributed computers resources owned by countless vendors. Applications that make use of this utility bring sellers and buyers closer together in virtual reality.

Cloud providers offer services that are grouped into three levels of service offerings;

(i) Software as a Service (SaaS) - This is software delivered model where consumers access the business functionality remotely as a service [12]. The costs of infrastructure, use of software, hosting and maintenance are all bundled into a single charge and the client is billed;

(ii) Platform as a Service (PaaS) –PaaS is more flexible in comparison and is based on a metering model where clients only pay for what they use [13]. It's an application development platform delivered as a service to developers over the internet.

(iii) Infrastructure as a Service (IaaS) – Unlike Paas, the vendor does very little management other than keep the data center operational and users must deploy and run the software service themselves [17]. Each cloud model has its own rational on how resource allocation is formed deviating from traditional IT business models. Improved allocation and cost of IT resources per service transforms from capital to operational expenditure for a respective service.

Cloud Computing uses the above service driven business models. Platform-level and hardware resources are used as services when required. Each level of service acts as a service to the layer that precedes it, each layer can be perceived as a client of the layer below it as shown in Figure 1.2.

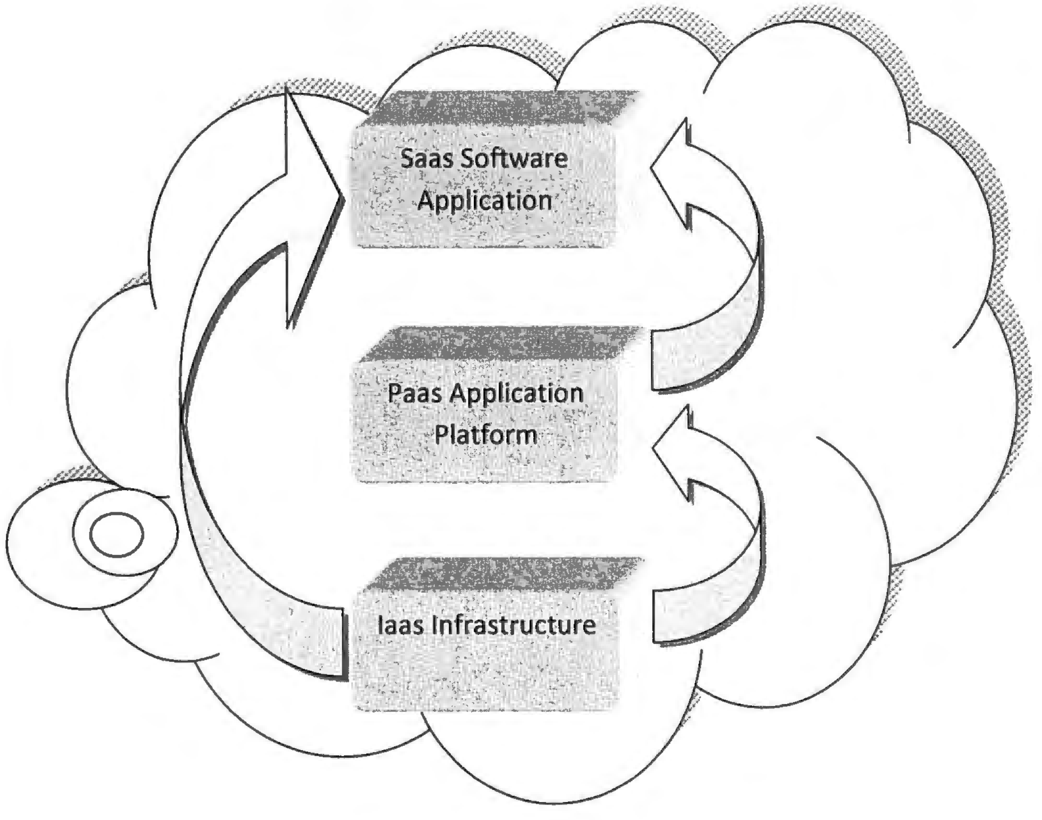

Figure 1.2 Layers of Cloud Computing

The success of this paradigm for all levels of services is based on economy of scale. The cloud provider can offer services to a vast variety of people at lower cost than users accommodating these services themselves. In addition to pricing, the quality of the service is a major motivation for using cloud services [11]. The vendor is expected to guarantee high availability and reliability of services rendered. Furthermore, cloud service users need not to worry about scalability as this is offered infinitely.

Enterprises can opt on choosing those service applications on Private (internal or service provider host), Public (external) or Hybrid (mixed) clouds types. Each cloud infrastructure has unique characteristics that can meet business objectives.

Cloud Computing promises significant benefits but currently there are privacy, security and other barriers that impede widespread enterprise adoption of an external cloud [18]. Furthermore, the cost benefits for large enterprises have not yet been clearly shown. The usage of resources in cloud architectures is as needed thereby providing the highest utilization and optimization of return of investment.

1.2 Background of Study

Cloud Computing resource vendors are different from any other institution centers because they actually charge a monetary fee in exchange for resource use [8]. Additionally, other activities are metered and a consumer is billed with the option of them having to pay up front or per resource usage. What most vendors fail to tell consumers about is what activities are involved in the metering of billing.

Big computer centers have long been charging for computational time using units of random value. The units of choice differ across systems and companies and may be directly deduced from a current or standardized system. Another setback is what metrics of units are specifically used to deduce the charges.

The cost advantages of delivering computing from a centralized or shared infrastructure has set the expectation among customers that venturing into the cloud yields lower costs as opposed to providing their own computing. Coupled with reduced operational costs of open source software and the right competition behaviour of remote computing, these expectations set the phase for fierce pressure on cloud vendors to continuously lower prices.

The price pressure results in a commoditization of cloud services that reemphasizes company's responsibilities to consumers such as assured levels of performance. Nevertheless, it is the sole requirement of management that operating expenses be reduced through the use of Cloud Computing to replace new and existing IT infrastructure. The comparison between what is expected and what the industry can deliver represent a challenge both structural and practical that will have to be overcome to ensure large-scale absorption of this phenomenon.

1.3 Problem Statement

Aligning IT resources with a company's cost can establish the profit-margin and at the same time allocation of cost per user or department [7]. However, understanding of buyer's cloud service needs to tailor pricing models is hard to achieve. Likewise renowned vendors because of their reputation and trade name set billing and pricing matric on value delivered to customers rather than hourly rates.

Venturing into the Cloud alone will not help an organization establish who will pay for required resources. It can however facilitate a podium for an infrastructure blueprint that establishes a return on investment model for billing purposes. Organizations can get a better understanding on resource use and cost when they work in the cloud [7]. Aligning of IT resources with their on-going costs can resolve the effectiveness and distribution of cost per user or department. If an organization is able to identify IT resource costs before and after their use along with how these resources are consumed then the company will have to pay for usage based pricing. In order to enable an ironed understanding of the billing process, this research provides answers to a number of research questions.

1.4 Research Questions

The research conducted and reported here provides answers to the following questions:

(i) What effective yet simplified models of billing are there at ones disposal and what will the billing process entail?

(ii) Can we develop a simplified novel model to handle accounting, pricing and charging in a Cloud-based service provisioning environment?

1.5 Research Goal

The main goal of this research is to develop a novel accounting, pricing and charging model in a Cloud –based service provisioning environment.

1.6 Objectives of the Research

In order to achieve the main goal of this research, the objectives are:

(i) Review of Literature concerning existing accounting and pricing and charging models as used in other services provisioning environment.

(ii) Develop a novel accounting; pricing and charging model that is applicable to the new paradigm cloud service provisioning environment.

(iii) Evaluate our model for what it was designed for as proof of concept.

1.7 Research Methodology

Various research methods to be used in this research are:

1.7.1 Literature Survey

An investigation of existing billing models is to be carried out with the main objective of determining how pricing and charging is done and implemented using metrics as a unit of charge. Also we will explore common components used for charging and the hidden costs that clients are not aware of.

1.7.2 Model Development

With the knowledge acquired from the literature survey and the prominent needs of a client, a pricing and charging model will be formulated to ensure that it caters for basic requirements of any client willing to venture into the cloud.

1.7.3 Model Implementation

After the development and formulation phases, the model will then be implemented through simulation using cloud analyst as a simulation tool.

1.7.4 Model Evaluation as Proof of Concept

As a proof of concept, the model will be evaluated using the following indices:

(i) Indirect and direct hosting costs which involves initial (capital expenditure) costs that are used to acquire assets or on-going costs (operating system) that are used to keep the business afloat.

(ii) Service provider components used per instances like virtual machines that have enabled technology for many large data centers and be used in Cloud Computing environments.

(iii)Unit of metrics will be used to enable scaling features to dynamically add or remove to instances. The customers will be charged by the number of monitoring instances used.

(iv)Billing method; by looking at the two common billing methods in the cloud, we will try to make a comparison and conclude which best suits our model.

1.8 Chapter Summary

This chapter gives an introductory background of information regarding Cloud Computing in relation to its utility model. The chapter further states the problem which forms the basis for conducting this research. The research questions, goal, objectives and methodology are clearly stated here.

Chapter 2

Literature Review

2.1 Chapter Overview

This chapter introduces the literature and related synopsis of work done in the area of accounting, pricing and charging. A background review and explanation will also be carried out about how billing is used over the internet.

2.2 Background Information

Cloud Computing is a new technique used to provide IT services at a fairly reduced cost in currently distributed IT environments. The potential savings are expected to be significant [16]. There are wide ranges of cloud saving estimates from various sources some of which are much more optimistic than others. It is also documented that parastatals moving to public or private clouds can save from 50 to 67 percent. Technology could make business applications cheaper hence a saving in the range of 67 to 80 percent [17]. Arguments are however raging on with these findings that fewer saving would stem from cloud migrations and moving into the cloud paradigm would actually cost more than the estimated expenditure. This deviation in return on investment shows there is considerable uncertainty in estimated costs savings and a need for further investigation at actual expenditure.

The mystery of how much it will cost to use the cloud still rages on. Questions are still being asked and answers to these questions will transform the mind-set from leverage cloud based applications to handling complex systems which will help to reveal the true costs of making the transition.

Numerous companies are still working on getting beyond the usage costs for using the cloud to comprehend the complete cost for training, migrating and implementing of people, architecture and processes. The decision making process could stall knowing the latent cost of venturing into the cloud could stall the decision making processes.

Companies that have embarked on private cloud journey find themselves in a pike of unforeseen situations. Surprisingly large sums of money have been spent more than what was budgeted for. Companies are further besieged with how not to make costs spiral out of hand [18]. These companies are synonymous with advanced IT organizations that ask tough questions and put through plans in place. For a company to venture into the cloud, it needs to blend and work with existing management infrastructure. An evaluation of cloud management platforms is a priority as well as assessment of how each tool works with the company's present and future management ecosystem. By doing this, it will have an impact on preceding investment and limit future decisions. In order to avoid some of the hidden cost in the cloud, evaluation of cloud management options to best suit and fit with the company's Information Technological ecosystem should be taken into consideration.

2.3 Pricing as a Function

Accounting, Charging and billing format systems have been simplified until lately. Pricing of services charged for Cloud Computing are either flat rate (subscription-based) or pay per use pricing mechanisms. Pricing has been based on a user's observed value instead of production costs of services. The inceptions of flat rate, consumers have been billed based on duration of use of the internet connection [19]. This model was adopted to charge clients for accessing the network and it requires no complex systems for monitoring and billing purposes. Users pay on a frequent basis to access software as an online service thus customers consume resources as a service and pay only for what they use rather than purchasing a license [20]. Cloud Computing is based on a usage model where access to computing resources is delivered through internet technologies; hence the consumer pays per use. Alternatively, cloud service users are also billed according to pay-per-use pricing mechanism. In today's dwindling budgets by management, companies are increasingly looking to cut their IT software, operational and energy costs necessary to keep abreast and sustain the level of competitiveness [21]. Thus majority are venturing into looking at a pay-as-you-go approach. This in the long run is not just a change in strategy, but a shift in the mindset of many from a view point of an IT firm about its infrastructure as a fixed capital expense to a variable cost. Pay per use pricing is typically used with PaaS and IaaS services and its rewards are that it allows customisation to specific application needs [19]. Fixed pricing mechanism which entails flat rate and pay per use, are currently widely used in cloud services. Although market pricing mechanisms could achieve more out of what it is now, both users and service providers still opt for simplified and fixed mechanisms in which it is easy to predict payments.

Pricing is one of the most critical decisions that any Cloud Computing firm can make whether repositioning an existing IT service or introducing a new one. Commercial success with cloud services can only be achieved by developing adequate pricing mechanisms.

2.3.1 Flat Pricing method

As quality rises, prices decrease, usage increases, total revenues go up, and pricing structures get simpler So far, the Internet is following this pattern. It treats all packets equally, and pricing has been mostly through flat monthly or yearly rates that depend only on the size of access links [39]. However there is strong momentum to base Internet pricing on usage and introduction of multiple service levels. The logic of paying more for higher quality is flawless, and the practice at least in theory can lead to a more efficient economy overall. Unfortunately, it also runs up against very strong consumer preferences for simplicity, especially in the form of flat rates. Such service preferences are not easy to incorporate into quantitative economic models.

Simplicity is likely to be more important on the Internet than in other communication services that service providers offer. Customers do not care about the network, they care about their applications. The internet has become the digital nervous system of most organizations. No client wants to worry about how much they are to pay for a packet of data from one site to the next that was generated by a request. Service providers should try to avoid what is known as mental transaction costs. The available choices are growing rapidly, but time is not. Cutting down on the accumulation of things is very valuable that is why clients are happy to pay extra for simple schemes that make their lives easier.

Simplicity is also recommended because of the insurance effect it carries with it. No client wants to be surprised by the size of the bill their teenagers run up. The popularity of prepaid calling cards for wired and wireless telephony shows the attractiveness of limiting risks, even for the wealthy.

When usage sensitive pricing is required, the best approach is to use a scheme that has a usage sensitive component, but at the same time provides the client with estimated flat rate pricing. One such scheme is block pricing, which provides a user with a large portion of time that is bytes for data. Moving closer to true flat rate pricing is the expected usage pricing scheme in which service providers offer users unrestricted access for duration. The link's capacity and the subscriber's usage record determine pricing. Service providers assume some growth rate in traffic, and they can specify in the yearly contract that the contract would be renegotiated if the subscriber exhibits unusual behaviour.

The idea is for the client to have the flexibility to take action that would improve service efficiency. A provider can lower fees by 10 percent if the client agrees to send their backups over the service provider's network. Such an approach would inspire usage, and it should also reduce turnover because an Internet Service Provider will attempt to lure a client from another provider knowing he/she has the same level of detailed knowledge about that subscriber.

In large part, clients' preference is why services have remained at flat rates. Prices and quality differ in distribution in some areas but in applications the most popular plans are the simple ones. Clients do not want to worry about the time of day or distance of limitations.

Flat rate pricing method also appeals to Internet users and service providers because of its simplicity and predictability. However, clogging is the expected result of flat rate pricing because Internet users who pay a fixed access fee have no incentive to limit their network usage [40]. Future applications that require timely delivery of data will require mechanisms for allocating network resources that give clients choices in services and prices while allowing service providers to recover their cost.

2.3.1.1 Smart Market approach

The smart market approach to pricing Internet services incorporates the ideas of user feedback and adaptation to achieve economic efficiency through optimal pricing. In this pricing structure, each client pays a flat fee for a connection plus a per packet charge. Flat fee can differ depending on the client's attributes and the connection's bandwidth. Most likely, this is a reasonable basis for determining connection charges because users purchase bandwidth connections that associate to some degree with their willingness to pay. The packet per charge is relinquished when the network flow is not congested.

The novel aspect of the smart market pricing mechanism is the per packet charge that is charged when the network is congested. This price for packets to access the network varies minute by minute to reflect the current network congestion. Each packet has a bid field in the header that indicates the user's willingness to pay for that packet. A user typically sets default bids for various applications that they can override in special settings.

Under a flat pricing scheme, the user is charged a fixed amount per time regardless of usage. In relation to evaluation criteria, this pricing scheme has several necessary advantages. It is simplified and suitable that is, flat pricing makes no expectations about the underlying technology that is already in place. Since charges have no relation to usage, no measurements are required for accounting and billing, and this also leads to social fairness since no distinction is made between poor and rich users [32]. As long as the flat price can be paid, clients can access the service while receiving the same service level.

2.3.2 Pay-as-you-go Pricing Scheme

Arguments still rage on that because the cloud is an economy driven distributed system, where consumers should consider the fairness in monetary costs [41]. Therefore, a proposal was put forward that a new pay as you consume pricing scheme, which charges users according to their actual resource consumption. However, due to the existence of interference, it is very hard to precisely determine the effective use of resources among different service users. Accordingly, it would be wise to define the Effective of Virtual Machine (VM) Time to finish a task such as the amount of time required when the VM is the only running on the physical machine. As for a VM, consideration has to be taken for the effective virtual machine time to be; virtual machine time less the interference time. Based on the effective virtual machine time, pricing fairness is defined: any user using the same amount of effective virtual machine time is charged at the same price as depicted in equation 2.1:

Cost New Model = Instance per Hour * EVM Time 2.1

Where EVM Time is Effective of Virtual Machine

Unlike current pricing schemes, pay as you consume pricing scheme solves the unfairness by charging the users according to their actual resources consumption. Since there are various factors affecting the interference, a proposal is put forward to use a machine learning model to predict the interference based on the resource usage during the running time and charge users for their effective virtual machine time as shown in the equation above. Thus, the same task tends to have the same cost, resulting in better personal and social fairness.

The introduction of virtual machines (VMs) and Cloud Computing in the market has raised the need for a fair pricing that suitably reflects the nature and costs of the service: providing computing resources to consumers through a data center. Presently, cloud computer providers charge consumers by the hour with a rate that varies by the allocation size of the VM ranging from small to large, the data center location, the type of the purchase, and the software used. This pricing scheme accounts for the variety in VM specifications, but overlooks the differences in resource usage and the related infrastructural costs when running different workloads on a VM.

An important percentage of data center costs come from power, power distribution and cooling methods. Power varies with changes in CPU, disk, and memory usage hence, a VM running a resource-intensive application spends more power and is more costly than a similar VM using less hardware and consuming less energy. However, since power is not factored in the per-hour rate, the latter VM must share the cost of providing for the former.

Thus a proposed pay-as-you-go per watt hour pricing model is introduced. The main advantages are:

(i) Cloud Computing providers' profit can become more stable. Profit a per hour rate, may decrease when resource usage is capitalised on.

(ii) A fairer division of cost based on VM power consumption is achieved; pricing becomes a more accurate cost estimate of the received service.

2.3.3 The Global awareness of Pricing

The emergence of the Internet elevates important price management issues. Many observers see the Internet creating downward pressure on price levels possible buyers can speedily search the internet employing shopping agents to check prices [43]. These low consumer search costs will lead to greater price competition and eventually lower prices and better value for customers. The Internet economy means inflation is slowly but surely dying creating an era of negative inflation.

The vision of price pressure and resulting slashing of margins has cooled much enthusiasm for e-commerce. It has been perceived that doing business on the internet is necessary evil. Thus, an important question is whether lower prices and margins are the expected conclusion of doing business on the internet and can the service provider do anything about it? In addition, there is a second, more general issue. The same technology behind customer search power enables other important facts driving how the e-commerce market operates, thus, the internet:

(i) Facilitates a buyer's purchase of quality information for various goods.

(ii) Allows a prospective buyer to specify in detail the product's requirements and put fulfilment out to bid to an organised market of potential sellers.

(iii) Allows a seller to create a meaningful market of potential buyers with price being the outcome of an auction process rather than prespecified by the buyer.

(iv) Enables suppliers to update prices dynamically in response to practical demand.

These impacts may be more fundamental than any effect of more customer price information. They change how exchanges between buyers and sellers take place. The how of a transaction, that is, the connecting of a buyer and a seller, has many forms.

2.3.4 Brand Loyalty

Branding and trust may take on added importance in electronic markets for several reasons. First, buyers are often purchasing from sellers they have not seen and whose physical location is neither known to buyer nor quite distant. Second, most online transactions are not immediate; they typically involve a delayed exchange of money and goods. Buyers usually have to submit their payment and then trust that they will receive their goods in a timely fashion. Third, a large percentage of buyers may be purchasing goods online for the first time; this may lead to keen concerns about being ripped off. Assurances from credit card companies about protection offered to buyers may reduce some of these concerns.

Online consumers may still be willing to pay a premium to purchase a product from a retailer they are familiar with, rather than risk dealing with an unknown seller.

Conversations with managers from price comparison sites support this view. These managers point out that many of the shoppers using their sites to compare prices end up purchasing items from branded retailers even when they are given information about dozens of other retailers offering lower prices.

2.3.5 Brick and Mortar

As in the brick and mortar paradigm, online retailers offering similar products and prices may differ significantly across a variety of other dimensions. Some websites are easy to go through than others. They contribute to the creation of a particular shopping environment that affects the likelihood that customers will enjoy shopping at the site. Firms that successfully leverage a feature like this may be able to charge a price premium.

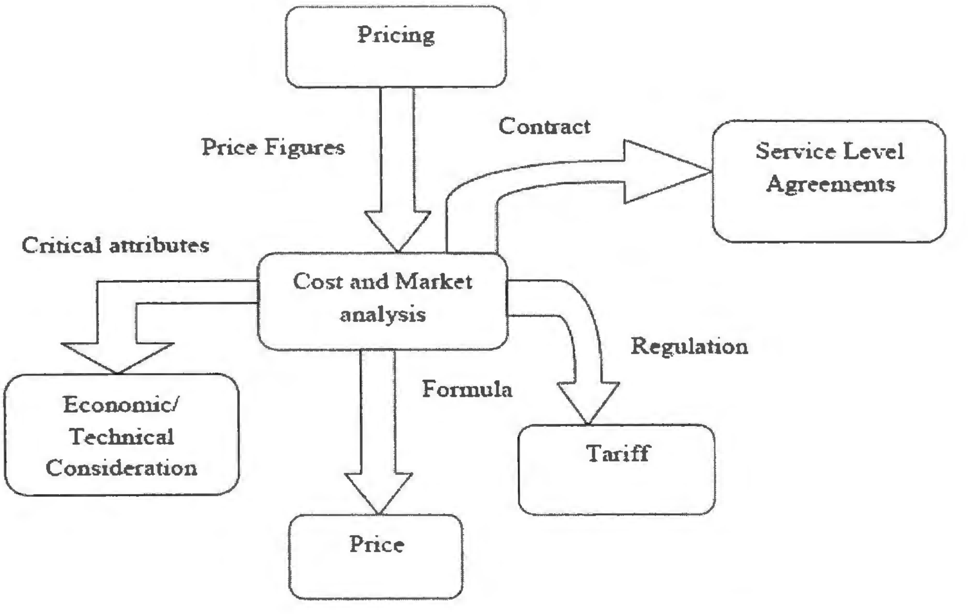

Figure 2.1 Pricing Function Architecture

Pricing does not only apply to economics as shown in Figure 2.1 but also helps to shape how systems are used. In the pay-as-you-go scheme as discussed early, becomes an important bridge between users and the service provider. The current practice among major cloud providers is to price computing based on virtual-machine hours because pricing schemes are changing and more are being introduced. For example, companies like Amazon now has a set of different pricing schemes including auction pricing. Additionally, several alternative pricing schemes have been proposed for better system behaviour in the cloud that is dynamic pricing when reserving computation resources.

Pricing plays a pivotal role in the marketplace, which has been well studied in economics, among various factors that impact pricing, competition and fairness are the most relevant. Pricing fairness consists of two aspects: personal and social fairness. Personal fairness is subjective, implying that price meets a client's personal expectation while Social fairness is objective. This means that the price is the same for all clients and does not give a service provider unreasonably high profit [33]. Competition among service provider sets loose the power of markets in economics since the monopoly from one service provider is broken. Competition among service providers cannot set their prices in a way most favourable to them. Instead, price configuration is done according to demand and supply. A competitive advantage can only be achieved through adopting new technology and lowering their cost.

Pricing is the function of giving a price to a certain resource usage. It is a critical function for the complete accounting process because it defines the price that a basic quantity of the service will cost. Some authors name it as pricing policy that determines the way a session record is rated [34]. These records come from the accounting functions and are correlated to the price that is normally represented in monetary units and depends on the pricing scheme used. This process may combine technical considerations such as resource consumption and economical ones, such as applying tariffing theory or marketing methods. The price can be calculated in many different ways however, it will always reflect the results of cost and market analysis. This function translates the previous economic considerations into technical quantities that can be merged with the measurable quantities of client resource usages. Pricing is defined by the pricing schemes, which are a significant part of any businesses and are related to cost and market analysis. It can also be a function for calculating a price that can be represented as a formula consisting of the pricing variables that are derived from consumption measure metric of the session records and pricing coefficients. Pricing schemes can be based on many different paradigms, such as pre-paid, post-paid, time-based, volume-based, flat-rate, usage-based or location-based, to mention a few.

Tariffs are a unique case of pricing that are normally controlled by a governmental institution and involve political and economic forces. They have been applied at length to the conventional telephone network and markets of scale. The tariffs are defined by the tariff models or functions. They determine the tariff function for a resource usage.

All these functions are applied in the charging function. They can be customized by discount strategies, rebate schemes, marketing information or any other parameter defined by the service level agreements.

Pricing is also known as a function of giving a price to a certain resource usage [28]. It is a significant function for the full accounting process because it defines the prices that a basic quality of the service will cost hence it is also referred to as a pricing policy. This function is seen used to calculate a price that is represented as a formula taking into consideration the pricing variables.

2.3.6 Pricing in Market Place

Recently, the big mainframes paradigm in which users own their computing resources is changing increasingly to a utility driven concept, in which users do not own resources and pay for the usage of remote resources. Cloud Computing is the most promising current execution of Utility Computing in the business world, because it provides some key features over classic utility computing, such as elasticity to allow clients dynamically scale up and scale down the resources in execution time, or the possibility of customising completely the software environment by acquiring administrator rights without putting in risk the whole system [42]. Since clouds are expandable heterogeneous, and scalable, large systems are too, complex to be managed centrally. Market based resource management is proposed to deal with the complexity because the possibility of doing business will motivate service providers to their resources in the system and give a Quality of Service (QoS) according to their real capacity. In addition, market mechanisms force the users to adjust their reservations to their real space and time requirements. It is also relatively easy to implement in a decentralised architecture, where participants enter in the Market looking for the satisfaction of their own necessities, and they do not need to know about the global status of the system to maximise their utility.

Brokers who either represent service providers or clients enter in a Cloud Computing market for selling or buying services and resources. When a client finds its requirements in the market, a negotiation process is started to establish the terms of the contract. If both parties reach an agreement, the terms of the contract are ironed out in a Service Level Agreement (SLA) and the client can use the resource. During the usage of the resources, the correct use of the terms of the SLA is watched by a neutral entity, and penalises the buyers or the sellers when either of the two breach the SLA.

Negotiating brokers must be provided with models and intelligent behaviour, so that they are able to take the best decisions for maximising the utility of clients or providers in the market

2.4 Metering

Metering, monitoring, accounting and billing are four major modules of an infrastructure for commercial e-services. Usage information must flow through these to enable accounting of service usage [28]. Service provider's resources are usually enabled to collect data for usage metering, as well as other purposes like quality of service management and load balancing. The Monitoring function shown in Figure 2.2 Metering Function Mechanism, collects the raw data and provides usage related metrics to the metering function. Metering is responsible for computing service usage metrics, using the monitored resource usage data if appropriate.

The accounting function combines the service usage by specific user's accounts, at the same time the billing function applies the service provider's pricing schemes to the accounting data, and produces bills for the users

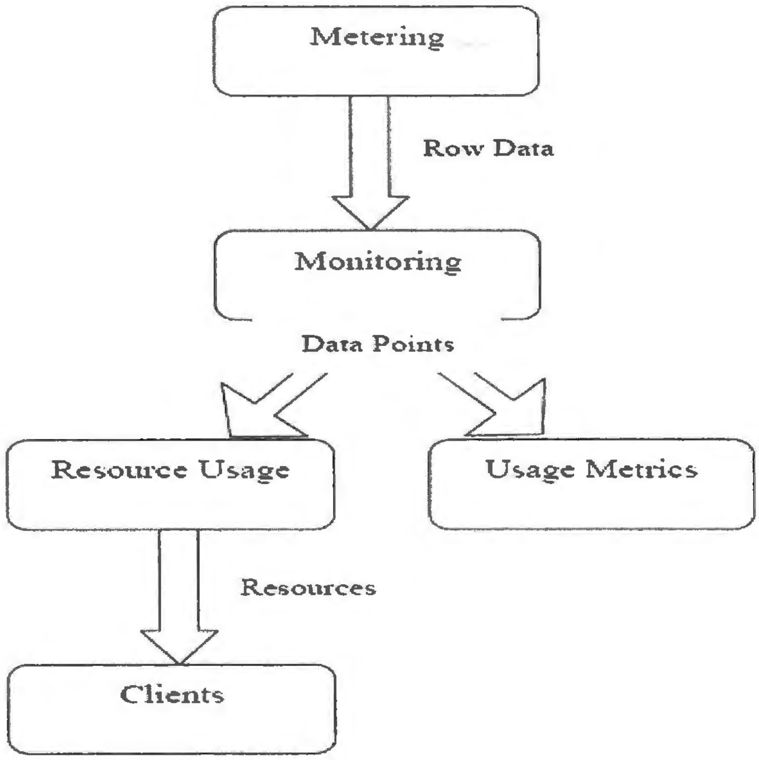

Figure 2.2 Metering Function Mechanism

Cloud Computing provides for three categories of services namely, Infrastructure as a service, Platform as a service and Software as a service. The set of cloud services such as computation, storage and network are packaged as a computing resource and provided as metered utility service [44]. Cloud services are sold on demand and are fully managed by the service providers. Multi tenancy and on demand acquisition model make it very important to have a strong metering and billing mechanism.

Smart meters in the power domain are hardware devices which perform real time registration of utility usage. They allow obtaining usage of information both locally and remotely. These meters offer a two way communication between the consumer installation and the power formation which facilitates regulating the power consumption via the meter installation.

Current implementation of metering mechanism in cloud environment is based on a service level agreement which govern the provisioned capacity. It is a fixed cost, post-paid service model. Its limitations are that consumers are billed based on a predefined tariff for the utilization.

The metering application provides for pricing of the cloud service based on the load condition of the cloud infrastructure. Resource usage per cloud occurrence is documented and the consumer is billed according to two factors, their utilisation and the load on the cloud during the period of utilisation. The smart metering application aids improving the overall utilisation of the cloud infrastructure, by implementing a tariff model based on the load principal on the infrastructure.

The metering component also calculation the raw monitoring information for the currently active user requests and changes this information into units of one or more accounting metrics [45]. It is imperative that all the services use the same accounting metrics which could be a monetary unit used to trade resources within the grid. This transformation may involve an accounting function that takes the basic resource consumption, the value addition of the service and the consumption of underlying services, as inputs, returns values of accounting metrics are however taken as outputs. The raw monitoring information is supplied by the monitoring component.

Metering and accounting systems have existed in various forms prior to the services driven world. Operating systems like Unix perform basic accounting of resource usage for example, per user disk usage is tracked and quotas can be imposed. IBM's mainframe operating systems provide detailed logs of resource usage on a per-process basis and utilities to generate accounting information using these logs. Logically, these accounting mechanisms do not apply in the services domain where per request metering is wanted.

There have been very few efforts at accounting for web services that defines a simple metering and accounting model for individual web services based upon a single metric response time. They do not support metering using resource consumption metrics or request parameters.

There are accounting systems that have been developed for computing grids. However, their focus is on resource centric accounting, and composite services have not been addressed.

2.5 Monitoring

In the monitoring function, usage information filters down the accounting process to enable accounting of service usage [27]. A service provider's resources are usually used to collect data for usage metering as well as other purposes like quality of service management. The monitoring component collects the raw data and provides usage-related metrics to Metering component. Metering is responsible for computing service usage metric, using the monitored resources usage data if necessary. It collects the information movement regarding the resource usage of certain service by a user and its usage [28]. This information is technical and is expressed in measurable quantities of consumer resources that is the number of data received and sent within a connection. This information break down is also the starting point of the accounting process and determines the particular usage of resources within end-user system.

The monitoring component is instrumental in collecting and reporting the raw information related to usage. The entity being used could be a basic resource such as storage, memory or another service or an entity. This function could either be embedded into each service or it could be accomplished through the use of external monitoring agents [45]. The former approach fixes the scope and definition of monitoring once the service has been defined and implemented assuming that the service is non-modifiable at runtime. The latter approach enables the choice of monitoring metrics to be independent of the service itself though they may be got from the information made available by the service. The advantage of external monitoring is that the monitoring functionality is not fixed and can be improved over time. The other approach, however, has the benefit of doing service specific monitoring but the sole responsibility of providing monitoring functionality lies with the service in this case.

Monitoring infrastructure of any system may be used for multiple purposes, such as for resource management, fault-tolerance and usage metering. Any monitoring system complying with the monitoring interfaces of any architecture can be used and implemented.

Monitoring is a metering function that collects the information of a resource usage as raw data and provides usage metrics to the metering function. The usage metrics represent the use of a resource by a user of a respective resource in measurable quantities. This function can be conditioned by a user's configuration that is users may have different usage metrics observed.

2.5.1 Mediation Function

Another metering function is the mediation function. Metering records generated are usually stored in a homogeneous data format known as accounting records. The mediation is intended to generate, collect and reconcile raw technical data by transforming these metering records into data format that can be used for storing and further processing. Hence data processing will be made easier and the different functions of the accounting process require less mix-ups resulting in better performance.

The records generated by the metering function are usually stored in a homogeneous data format. Mediation is intended to collect, tally, filter generate, compare, and eventually reconcile raw technical data by converting these metering records into a data format that can be used for storing and further processing [28]. In this way, data processing is made easier and the different functions of the accounting process require less mash-ups and conversions, resulting in a better performance.

In instances where different data formats are used, interpretation of data is necessary in order to have all the information in a similar format as soon as it is needed. Conversion rules, both syntactic and semantic, are required in order to secure the integrity of the changed data. This set of rules is also known as mediation systems and is mutual in the communications world.

Furthermore, the mediation can report to the accounting function in three diverse ways: push mode, poll mode or interval mode. In the push mode, the mediation function reports the accounting function with accounting records as soon as it receives them. On the other hand, the poll mode has an accounting function that has to ask for the accounting records from the mediation function. Lastly, in the interval mode the mediation function reports to the accounting function on certain interval.

2.5.2 Prospects of Pricing Models

As Cloud Computing metamorphoses, so will the pricing models being used in the cloud change as well. The challenge for the cloud industry will be to make these more complicated models easily assessable and understood.

Over time market based systems will be seen and even pure auction systems will crop up. Other possibilities that could mushroom include price comparison sites, aggregation services, group buying, and a futures market for Cloud Computing services [47].

Certain standards make it easier to move workloads between suppliers, it's possible that in the future refined deployment engines will query the market at the same time acquire a service at the lowest price and then deploy workloads to the lowest price provider.

2.5.3 Check the Fine Print

It's safe to say that the future of Cloud Computing pricing is yet to be written. We should bear in mind that this is an evolving space and changes will continue to happen and often very rapidly. Clients are to make sure they understand or try to understand whatever pricing model they are signing up for and know exactly what they are going to be billed for.

2. 6 Accounting as a Mechanism

The internet has much information that is distributed over many systems it is therefore impossible to store and analyse every piece of it. Hence it is imperative to identify what data should be stored, where and at the same time what information should be exchanged between responsible parties [22]. One of the steps taken to rectify this flaw would be to quantify accounting parameters which are a basis of the accounting and charging. These deduced attributes are used to exchange accounting information between physical entities. Another set of information used in the accounting process are accounting records. They include all relevant information acquired during the accounting process. This information has to be collected about a particular application or user. It is for this reason a particular protocol has to be integrated for the exchange of the records [23].

It is well documented in the service and customer oriented accounting that management accounting supports the dynamic aspects regarding accounting of services. Thus, its goal is to develop a management solution which supports every activity needed for service accounting in a suitable way. It is these purpose that there is a need to identify and analyse activities first. From a more abstract point of view, activities can be grouped to processes that accomplish service accounting as a whole [35]. Therefore, there is need to explore the dimension of management processes which incorporate all these activities needed for service accounting. To build and identify all relevant processes, we use the service life cycle dimension. Combining the process and life cycle dimension revealed all relevant dynamical facets of service accounting and expresses therefore the requirements regarding the flexibility of a service-oriented accounting management solution.

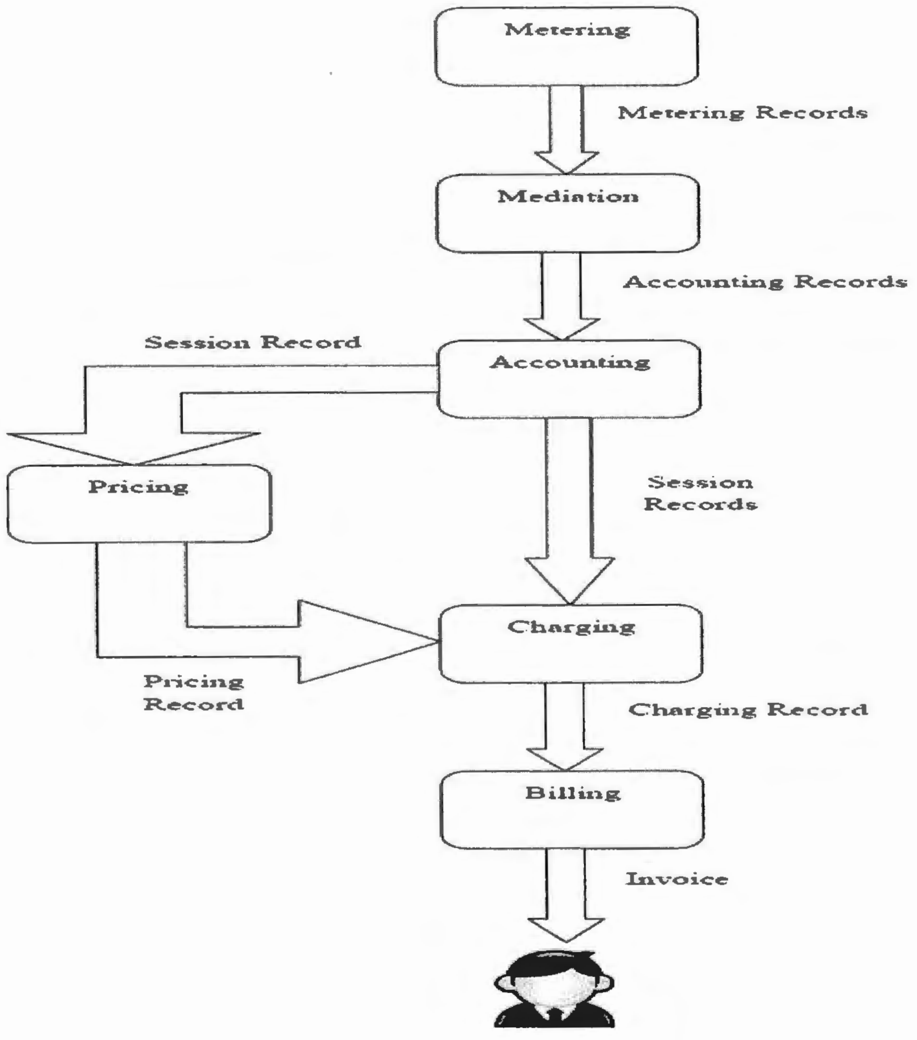

Figure 2.3 Accounting Process Model

This accounting process model that is represented in Figure.2.3 starts with a resource usage which is registered by the metering function through the metering records. Thereafter, the mediation function intercedes by generating the accounting records for the accounting function [23]. This function creates session records, which are sent both to the pricing and to the charging functions. The pricing function generates a formula defining how to price the session records that is used by the charging function.

An internet accounting system is required to give internet, application and database services with a determined and robust environment. At the same time it's also required to provide complete accounting functions to the end user when requested [24]. A web service acts as a go between the end-users and the internet accounting system. It has to be equipped at each subsidiary to keep local accounting information. The end users are not required to have knowledge of accounting but have to go through security authentication levels. The application use has to be persistent so that transactions are secure between users and the main operational database. Accounting is the process of sieving, assembling and combining the information that represents a resource usage by a certain consumer. This process will generate session records whose format will depend on the service infrastructure and service provider [23]. The session records represent the resource usage over a session. The accounting function is expressed in metered resource consumption depending on the service provided by representing the technical specifications of the service. It includes the supervision of the data gathering from the mediation function, storage and collection of data. Accounting policies define how these functions behave and are specified by a set of generation rules.

Accounting can also be referred to as a process of filtering, collecting and combining the information that reflects resource usage by a certain user. This process will create session records whose format will depend on the service infrastructure and the service provider [34]. The session records represent the resource usage over a session. Accounting gateways creating the session records may do so by processing interim accounting events or accounting events from several devices serving the same user. This accounting function is expressed in metered resource utilization that is request for information, depending on the service provided, by representing the technical specifications of the service. It includes the supervision of the data gathering from the mediation function, the collection and the storage of this data. Accounting policies define how these functions perform and are specified by a set of generation rules.

The accounting data collection and storing is also known as archival accounting and is performed at a measuring hub. This function transports the metered data to a storage point or measuring hub. The measuring hub is the point where the data from the metering readers is collected. It is also known as storage point. The measuring hub collects data from two main sources: the service provider and the user. Data from the service provider is created by internal and control meters, and is used to control the provider's infrastructure. On the other hand, data from the user represents the usage consumed and is used in the whole accounting process.

Data retrieval may be necessary because of the memory limitations of the meter readers because the information may be needed for a lengthy periods of time. It is also used to reconstruct missing entries, to prevent data loss and to archive the data for long periods of time. Legal or financial requirements frequently mandate archival accounting practices, and may often state that data to be kept secure, in spite of it being used for billing purposes or not. The concentration of the metering results in a measuring hub may be necessary to compare information from distributed meter readers and to process the data solely in one point. The connection is based on classifying functions that group the accounting records by resources. All the available resource accounts are stored by the correlating function, which can also group the accounting records by grouping the data from a distributed accounting organising the data from the different users.

2.6.1 Accounting Permanents

One of the steps for Internet accounting and charging is to collect and measure accounting data. The accounting data are collected according to the according parameters, which are the base of the accounting and charging. They are classified by two categories: content and transport accounting parameters [22]. The former is related to the delivered services, that is text, audio, graphics, picture, or video. While the latter emphases on the usage of resources which delivers packets of content. Currently several metrics are suggested: volume as the number of packets, duration as packet flow, distance as technical distance, bandwidth as Mbps, class of service as. SLA, by service providers

2.6.2 Access control framework

Since the web offers a private and public platform to a variety of services, service providers need to differentiate themselves across a wide range of content and personalised services. Commercialised services need to be authenticated, authorised and charged based on the accounting process. Additionally, all security related issues gain more and more importance with the increase of user popularity [25]. Apart from these market driven and economic features that motivate the necessity of AAA system, any company is further required to carry out a close investigation to enable the development of future AAA service and keep up-to-date with security features.

The authentication service is defined as the process of achieving an authorization decision to grant or deny a user request for services in an authorised session. User authentication is part of the authorisation process and the authentication data will be carried in the authentication request. AAA is a network security model for access [31]. This model is also referred to as "3A" standing for Authentication, Authorisation and Accounting. In the first phase; Authentication users interact with an authenticator of the system producing credentials for trust in order to gain access to the service while authorisation checks the user's authority level of access to the system. Lastly the accounting phase collects a set of accounting metrics which will be forwarded to the billing function and saved.

Offering AAA service, trusted and secure relationships between servers are of the utmost importance. By contrast the user establishes a trust relationship with a dedicated service provider that they use at their disposal. It is this service provider that operates an AAA server.

Pricing and accounting issues have lately been widely scrutinised within the internet framework. In order to support user-based charging it is essential to design an appropriate accounting architecture [26]. The term accounting is occasionally used to refer all the processes involved in charging consumers with the ultimate processes in mind; pricing, metering, charging and eventually billing. Accounting consequently concerns the collection of resource consumed data to support usage-based pricing. It is imperative to define a general model that supports both the running of internet accounts and the realisation of procedures. Consequently the costs to end users for an application service provided in the network are given by the sum of two components namely transport accounting and content accounting. The former concerns the charging for transfer services through the network while the latter deals with charging at higher level of data packets of application services delivered. The content relates to a type of service which is obsolete to date.

The basis of this AAA architecture is the assumption of a multi-domain internet topology. Each administrative domain has at least one AAA server resides. Distributed AAA servers offer user authentication, authorization, and accounting services as noted.

2.6.3 Authentication, Authorisation and Accounting as a Protocol

AAA is a security model for intranet or extranet access. In the phase where an extended authentication protocol conversation is produced between Client and Authenticator. Authentication process can be devised in two basic categories: a two-party authentication and three party authentication [31]. In two party authentication, a user interacts directly with the authenticator, making an Extensive Authentication Protocol (EAP) conversation. A three party authentication a Network Access Server (NAS) is connected between the user and the authentication server. In relatively small networks, an authentication server could be configured by the system administrator at the authenticator, so the authenticator and the authentication server are situated in the same area. However in much bigger networks, this is not feasible. Situations like this, many network points of presence, acting as NAS are arranged and the authentication must be done according to the three party models.

A user presents a set of credentials like username and a password which is then encrypted using hash functions in order to gain access to the service provider's network. A multiplexer summarises the credentials in a 128-bit length encrypted text and passes it through the internal network to the authenticator. The Authentication Server, the credentials are being checked for authenticity, using the same hash functions. Afterwards they will be stored in a SQL database for specific duration.

A three party authentication model, there would be the NAS as an AAA Client between the user and AAA server. This mode the user interacts with Authorization Server. Communication will start when the authorised access is finished for each level of the internal network provision service.

There are three different sequences which represent three alternatives scenarios; Agent Sequence, Pull Sequence and Push Sequence. The Agent sequence, the transaction entities are client, Network Access Server (NAS), Authorization Server and Resource Manager. A user sends an authorisation request to NAS. Second, the NAS forwards the request to Authorization Server. It is here that it transports the request to resource manager. After the configuration procedure is completed, the authorisation reply is sent back. In the Pull sequence, there is a direct transaction between user and service equipment. Lastly, in Push sequence, an authorisation certificate is provided by the AAA server to the end user. Every time, this certificate is produced by the user, automatically they are granted an authorisation response. In this phase of AAA, some of accounting metrics are stored locally in a SQL database running on Accounting Server for future reference.

2.6.4 Accounting in the Cloud

Venturing in to the cloud should cost less than doing business on premise [47]. It is suggested that clients should analyse whether to make the switch as a three year amortisation of upfront costs for an on premise application including servers, software licenses and installation plus estimated maintenance for three years and compare that to the cost of subscribing to the cloud version of the product for three years. This can be applied to partial versus full cloud conversions and should be done on an application by application basis to determine whether there is cost savings by moving each application to the cloud. More factors to consider include;

(i) Regular upgrades; Service providers can regularly make alterations to their products. Many cases, those improvements are made routinely in the background without disrupting the customer's work. Most providers provide advance notice to notify customers about the changes and give them the option of when to turn new features on or off.

(ii) Movement of resources, IT staff can be reallocated for more tactical projects, rather than spending time on system upgrades and maintenance.

(iii) Backup and recovery capabilities, one of the costs incurred by customers who keep their data on premise is backing up their data, via contracting a third-party backup provider. This is another area covered by the service provider in a cloud environment. Often providers have redundant backup systems so that customer data is replicated in a separate data center in case of mishaps. This infrastructure is self-healing so that when a failure occurs and the backup becomes the primary source of information, the system launches a new backup instance of the data.

(iv) Reduced supporting costs, rather than having to employ in house experts for product support, the vendor typically provides support directly for the customer.

2.7 Charging as a function

Internet charging has been put forward by a number of people over the past few years. Charging for resource usage is not new however there are a number of ways to determine charges for a service rendered at the same time a great diversity of monitoring and collecting information for charging purposes [22]. Charging determines the process of calculating the cost of resource use by using the price for a given accounting record which determines particular resource consumption [23]. Thus charging defines a function which translates technical values into monetary units. The monetary charging information is included in charging records. Most of the charging schemes have been structured into a session and subscription charges. The former is data input of duration while the latter contains access information. Because of charging for content and the use of price of discrimination between services and applications as a way of the direction of the internet community, it is imperative that three other layers of charging structures be introduced namely transport, content and service charging [22].

Charging can also be defined as a process of calculating the cost of a resource usage, the function that translates technical values into monetary units by applying a pricing function to the session records [34]. It associated session records, form the accounting function, and resource usage unit price to generate charge records. Charging acts as an umbrella term for charging options and charging mechanisms. This separation emphasises both the technical and the economic aspects of charging. Charging is sometimes referred to as billing. But billing implies different processes, such as customers' data management. These charge records are formed by the technical quantities of a resource usage and their corresponding monetary values. The records can also be used for multiple purposes of business intelligence: statistical analysis, data mining, auditing, revenue estimation, financial planning or structure dimensioning. The charging policies define when and how the billing function is invoked. It defines the frequency of cost allocation every time accounting data is received, at regular intervals of time or when requested by the charging function. They also define the granularity of the billing function.

The transport charging layer forms the basis for providing a system to deal with the transfer of data mainly based on a general nature. The content layer is tasked to handle the accounting responsibilities for information that is monetary sensitive. And lastly the service charging layer allows for the clear distinction of different services including different quality of Service requirements and resource consumptions.

The charging policies define when and how the billing function is invoked. They define the frequency of cost allocation every time accounting data is received at regular intervals of time or when requested [28]. Charging can be distributed between multiple parties as defined in the distribution policy. This policy will break the cost between the different users allocating an already-known cost among entities. Each user has their own profile that could contain the consumers pricing function or special order. The consumer also can have different business relationships with the service provider. This relationship will define the charging method of payment that is pay-per-use or flat rate.

Having acquired more bandwidth in the future as before, the control of resource utilisation will remains essential for the support of applications with special demands and for the prevention of malicious or accidental waste of bandwidth. Charging provides a possibility to control utilisation and sharing of resources. Charging in multi-service provisions can be done based on the reserved or the actual used resources [31]. Charging on reserved resources is an important concept since reservation usually prevents other users from using the reserved resources. However, if charging is limited to reservation parameters only, the applied charge depends on the ability of the user to give a good forecast of the expected traffic characteristics. This can be drawn up by using a charging scheme that is based on both the reserved and the used resources. To support usage-based charging, the collection of information about the resource reservation and utilization is required. The collection of data about resource usage is called accounting.

Service providers have various options for service differentiation, charging schemes and the provisioning of accounting services. The applied charging schemes for the provided services are one significant feature used by service providers to distinguish themselves from competitors. Therefore, providers use different charging schemes and may change the schemes in accordance with their business plan. Service providers can also offer different accounting services that are standard in order to allow users to choose one scheme that meets their needs. Furthermore, it may be beneficial for a service provider to outsource accounting functionality to a third party. Users introduce various traffic profiles and may have individual preferences regarding accounting services.

2.7.1 Charging Strategy

When a user start using a service and their account balance is inadequate to cover the basic costs of the service rendered, they will be reminded about their outstanding fees. If the users have successfully started a simulation task, the basic costs will be charged at the beginning of the service use. The end of the task if incurred, the overtime fees will be calculated and added to the user's bill. This will prompt an invoice is be billed to the user.

The characteristics of the simulation task, if a simulation task is interrupted and does not get the final result; all the previous tasks will be undone. So this kind of charging strategy ensures that the simulation task wouldn't be affected by the arrears as long as it's in the process of running. Thus the whole service quality of any given platform would be improved.

2.7.2 Charging and Pricing Strategy

At present, a lot of research has been done on models of charging. In relation to cloud paradigm, with changing demand over time and revenue relative to user hours, trade-off has been proposed for charging model. They also proposed the revenue equation for adverts-supported model in which the number of advertising served is roughly proportional to the total visit time spent by end-users on the service provider website [37]. And there is also research about inter-provider charging strategy [36]. The charging mode can be applied differently according to use that is there're metering charge, time charge, charge per use and on basis use and the monthly fee. There are different characteristics for each resource, that is, time charge is used on services which are mainly for calculation; metering charge is used primarily on file transfer services; and charge per use is used to services.

Below is a method of calculation where different variable are used to illustrate charging when reading an article over the internet:

MfC: Member fee Charge
FC: Fixed Charge
SC: Session Charge
IC: Instant Charge
FuC: Function usage Charge
Scenario 1:
Fixed based charging would be the cost that includes the member fee charge and a fixed charge as shown in equation 2.2;

$$Cost = MfC + FC \qquad 2.2$$

Scenario 2:
Session based Charging is the summation of charges for each session as shown in equation 2.3:

$$SC = \sum SCp * hp \qquad 2.3$$

Where SCp represents the charge for session p and hp is the number of Hours for session p

Scenario 3:

Volume based charging: The charge for reading an article is the summation of charge for all articles read as shown in equation 2.4

$$IC = \sum IC * n \qquad 2.4$$

Where IC is the charge for reading a magazine and n is the number of magazines read.

Scenario 4:

Function based charging is the summation of charge for all functions applied as shown in equation 2.5:

$$FuC = \sum QNi \qquad 2.5$$

Where QNi represents the charge for the function i.

2.8 Billing system

History has shown the high costs of providing servers and infrastructure limits the ability to develop Software as a Service (SaaS) applications for example to place an order to ship a product from over-seas to African [25]. Currently, new billing and metering models allow procurement of hardware and operating systems known as Infrastructure as a Service (IaaS).

The billing of the services is on monthly basis and charges that grew over the whole month include instances of servers running for the complete working period as well as servers running only up to a minute. Each compute cycle is charged a complete hour regardless of whether it ran for one minute or one hour.

The advanced billing and planning with reserved instances ensures lower monthly as well as hourly costs to make compute resource models with known usage patterns. In a model where servers are reserved in advance, a start-up investment is essential to secure exact servers in certain areas to minimise the hourly usage of virtual machines (VMs). In some instances, the initial investment can reduce the hourly price extremely.

Platform as a Service (PaaS) billing and metering are worked out by actual usage, as platforms vary in aggregate and instance level usage measurements. Real usage billing enables PaaS providers to run application code from several tenants across the same set of hardware depending on the granularity of usage monitoring that is the network bandwidth, CPU utilization, and disk usage per transaction or application can determine PaaS cost.

The bandwidth of inbound and outbound network traffic governs the usage per user and creates a metric for billing and metering. The bandwidth metric come in handy in that web applications can be larger depending on their content.

The ordinary concept for billing and metering in SaaS applications is done on a monthly fixed cost; in some cases, depending on the amount of data the billing and pricing are adjusted to. The number of users is determined by the number of users the company allows to access the SaaS applications, which increases the monthly fee; in some cases, if certain volumes are met, there is a discount offered to the users.

The monthly subscription fee is offered at a fixed cost billed per month, often for duration stipulated over a length of agreement of one year. The billing model per month changes the high initial investment from a software capital to an operational expense monthly cost

This model is especially appealing to small and medium-sized companies to help them get started with the software required for their business endeavours. Scalability, or pay-as-you-grow models, is helpful for companies that begin with a small initial investment and a few users and grow as demand grows. In some cases, these start-up companies can scale down while providing access to the same data.

Web Services accounting is only one of the many factors of SaaS billing worries. Other factors should be taken in to consideration, like storage usage, and the membership subscription to SaaS [38]. How to identify the complex values and combine different bills from different service providers with different formats and styles, are important concerns. It is therefore, a structuralised hierarchical model is proposed to organise the bill items and their relationships in a billing policy. Bill item is an atomic unit to describe the rule of billing, while the relationships in billing policy provide the power to specify how to compose a complex bill by combining atomic items recursively. The billing policy can be used to guide the metering of service usage so as to produce bill. Based on the policy, bill report structure can be standardised, hence the reports are easily consolidated into one bill for the SaaS subscribers.

The accounting, charging and billing outline used on the internet have been quite simple until recently. Consumers have been mainly billed with a flat rate based on their subscription or duration of internet connection access. Billing or invoicing is a process of transforming charge records into the final bill or invoice. A summary of the charge record over a duration and indicating the amount of monetary unit to be paid to the end user is included in the invoice [20]. A bill function may include information about a consumer that is collected from the consumer data management system. This system pertains all the relevant consumer details. The billing function has bill policies that define the type of bill process that is electronic or paper, the time period of the bill, content of payment, time and date of payment method.

It is anticipated that several role players will have active roles in the service provisioning process. Bypass a complicated charging architecture, management and processing of relevant information should be made separate for each level. Furthermore, different charging models should be applicable on each charging level. In sure charging architecture consumers require the provision of billing. Users are required to receive a single detailed bill for using the service offered. This requirement denotes that the service providers will exclusively be responsible for collecting charging data form all responsible parties and billing the users. It also denotes that the charging information should be tailored in a form understood by the average user.

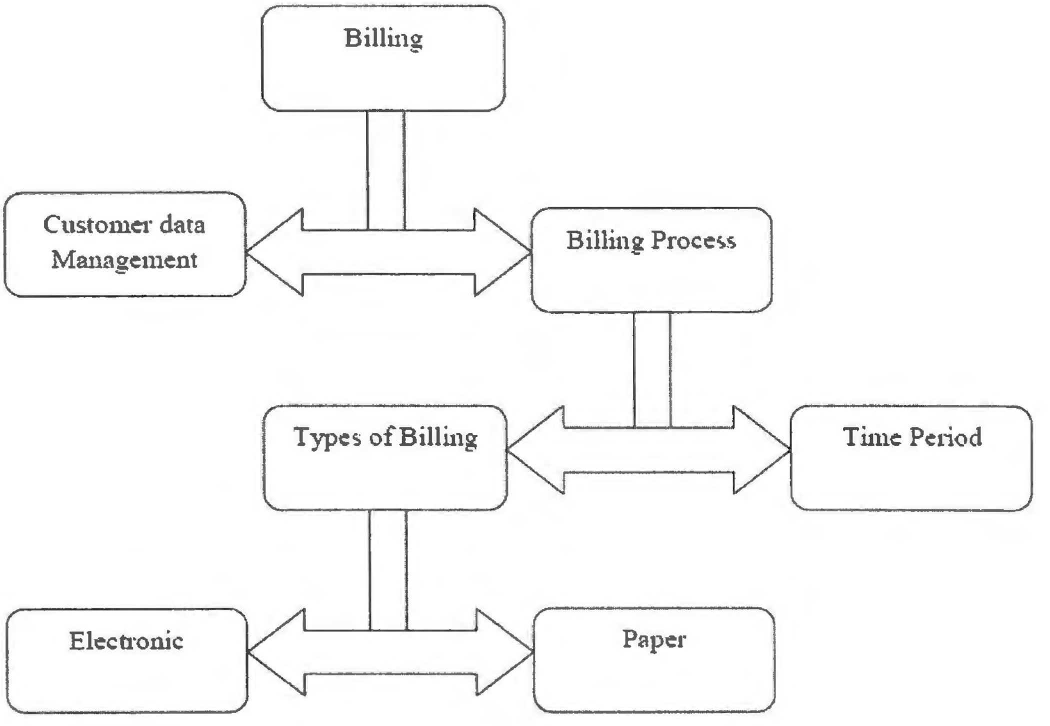

Figure 2.4 Billing Mechanism Overview

The billing mechanism as shown in Figure 2.4 includes information about the customer that is gathered from the customer's data management system. This system contains all the customers' personal data [23]. The billing function has also usage sensitivity which depends on the resource usage of the consumers.

There are also billing policies that define the type of bill, the time period that the bill represents, the outlook and content, the payment deadline date and how the financial clearing is done, specifying the payment method .

As charging, billing can also have different granularity. A combined bill represents two or more charges grouped together and a detailed bill has all the charges of an individual.

2.8.1 The future of payments: is it in the cloud?

Mobile payments and mobile wallets are a subject that has caught fire in the past months, and it seems the future does not know how far it will go but the general acceptance is that the future is mobile. The battle for mobile payments has already started.

The problem is, however, is that there is very little agreement on what mobile payments actually is in the role players. As such, the first entrants into the market are addressing the question differently. It is unclear if they are even answering the same question. As such, big role players have announced its introduction in to their Communication technology fraternity. On the other hand, other retailers opt to have developed solutions that would be classified as a cloud wallet. The only flow of this system is that the technology to be used by the clients will take time to develop, because what is best for consumers may not be preferred by service providers, and vice versa. Currently, advertisements are being placed on behalf of both methods, a spectacle that has been entertaining to say the least. It's been confusing to those watching the industry, even those well versed in the payments industry.

2.9 Service Level Agreements (SLA)

Users move towards adopting a service-oriented architecture, the quality and reliability of the service too should be taken into consideration. However the demands of the service consumers may vary vastly [29]. It is not feasible to fulfill all consumer needs from a service provider's view hence a balance has to be made through mediation process. The end result of this process consumer and provider will commit to an agreement referred to as a Service Level Agreement (SLA). This binding agreement serves as the foundation for the required level of service between the service provider and consumer.

The task of setting up and monitoring SLAs has been increasingly welcomed as one of the pivotal preconditions for the deployment of web-services. SLAs are set through collaboration between service consumers and service providers in order to specify the terms under which rendering of service satisfy these terms. The ability to monitor the compliance of the provision of a service against a service level agreement is important both from a perspective of a service provider and consumer. This necessity is important due to the need to reference against the terms of an agreement stipulated at the same time identifying the repercussion that the violations of certain terms make provision for [30]. In the case of service providers, this agreement specifies the necessary recourse when evidence gathering is needed.

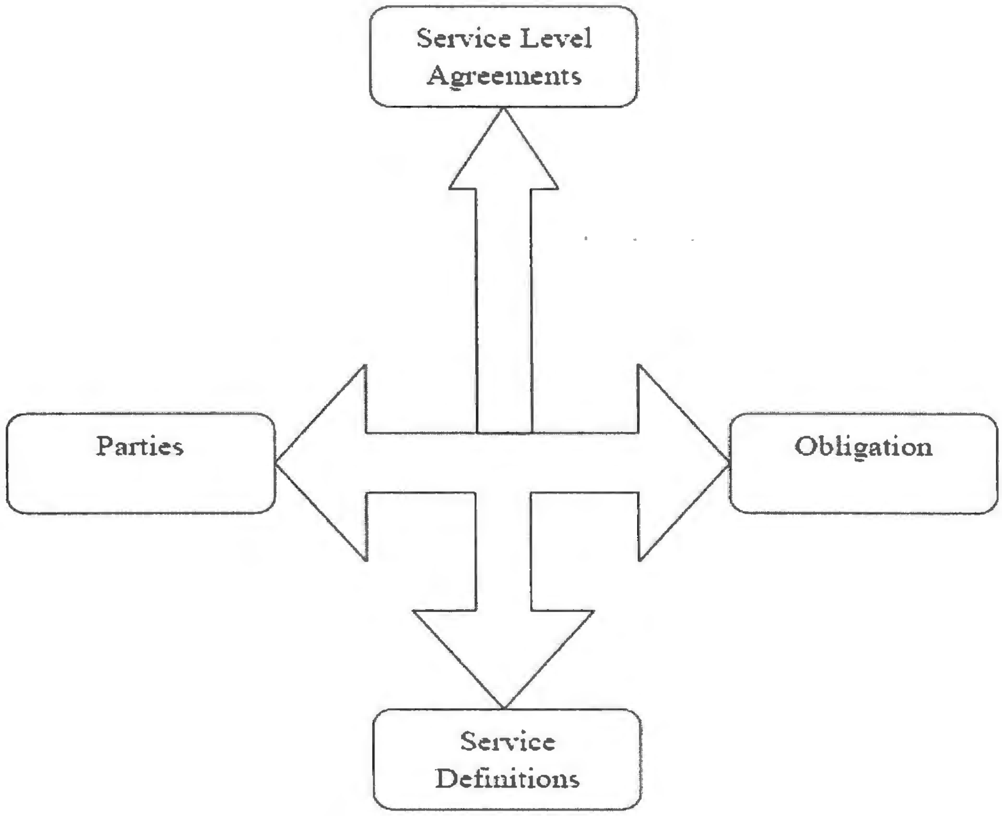

Figure 2.5 Concepts of SLA

Service Level Agreement consists of a set of concepts [29]. These concepts shown in Figure 2.5 are designed to capture service level agreements in a formal way. These concepts are:

(i) Service Level Agreement parameter: the metrics are found that define how a service parameter can be measured. It is further broken down into Composite metric that represents a combination of several resource metric calculated according to a specific algorithm and resource metrics that retrieve directly from the service provider resource and uses as is without further processing.

(ii) Parties: contains the descriptions about the service provider, consumer and a third party.

(iii) Service Level Objectives: these are a set of formal expressions that define what the agreement entails and the actions to take between the parties involved.

Under the assumption that the service provider and the client are already participated in the negotiation process and have agreed to a set of service parameters, steps are taken to consider this work. Once the SLA document is established, it needs to be deployed. The term SLA deployment is described further as the process of validating and distributing the SLA, in part or full, to the involved parties [29]. The tasks identifies that the provider and the user may not want to share the complete SLA document with supporting parties due to security concerns common SLA service can be roped in to validate the document:

(i) Management Service: This service is responsible for taking helpful actions on violation of the Service Level agreements. It is anticipated that since the cloud represents utility type computing resources, the management service would be primarily handling financial penalties similar to the real world utility industry practices.

(ii) Measurement Services: These services are responsible for measuring the runtime parameters of cloud service provider's resources. Service parameters like response time, throughput are constantly changed due to variability in service request from a user's side. In the context of the cloud however the usage and cost parameters are also active. This is due to the pay-as-you-go nature and the elasticity of the cloud. Hence we identify.

(iii) Cost per price data as two major additional services that should be added to the set of measurement services in the context of clouds.

(iv) Condition Evaluation Service: This service is responsible of getting the results from measurement services and evaluating the service level objectives. If there are any discrepancies the management service will be contacted. Due to the active nature of the cloud, the condition evaluation needs to be performed more often than in a traditional service framework. Traditionally there is little attention on the complexity of conditions.

2.9.1 Areas Covered by Service Level Agreements

Cloud hosting and SLAs may provide protection at several different levels across infrastructure, operating systems, and applications. Below are several of the important coverage areas that may be covered by cloud service level agreements [46].

(i) Operating System

The operating system is a potential area of coverage for a cloud hosting SLA. Cloud Service Providers offering an operating system level typically provide some degree of managed services to a client. This additional service allows the provider to guarantee that the operating system is properly maintained so that it is consistently available, and typically has some cautions

(ii) Platform Level

The next level of protection in a public cloud hosting agreement typically covers physical server, virtualisation platform and network hardware owned by the cloud service provider and used by the cloud hosting client. Typically, the physical server and virtualisation software are covered by a Platform SLA. The cloud network (network between Cloud servers) may be covered by a separate availability SLA

(iii)Application level

This type of SLA provides protection against application level failures up to and including the custom application running on the provider's hardware. This type of SLA is very rare in the cloud hosting market. Under this model, the cloud hosting provider is guaranteeing the availability and performance of their client's software, which is a difficult commitment to meet

2.10 Chapter Summary

This chapter gives an account of existing and related work done in the field of billing, accounting and pricing in the Cloud Computing paradigm. It further outlines what has been said about the future use in Cloud Computing under billing, accounting and charging concepts.

Chapter 3

Model Development and Implementation

3.1 Chapter Overview

In this chapter, a model is developed and a detailed explanation of the experimental set up is provided. The chapter also demonstrates how the model will be used to accomplish the main objectives of the research.

3.2 The Model

The model depicted in Figure 3.1 shows the proposed accounting, charging and pricing model. Information from the user is entered and from the user's credentials entered access is granted into the system. For a client to use the system they are to meet the policy information standards set out by the service provider.

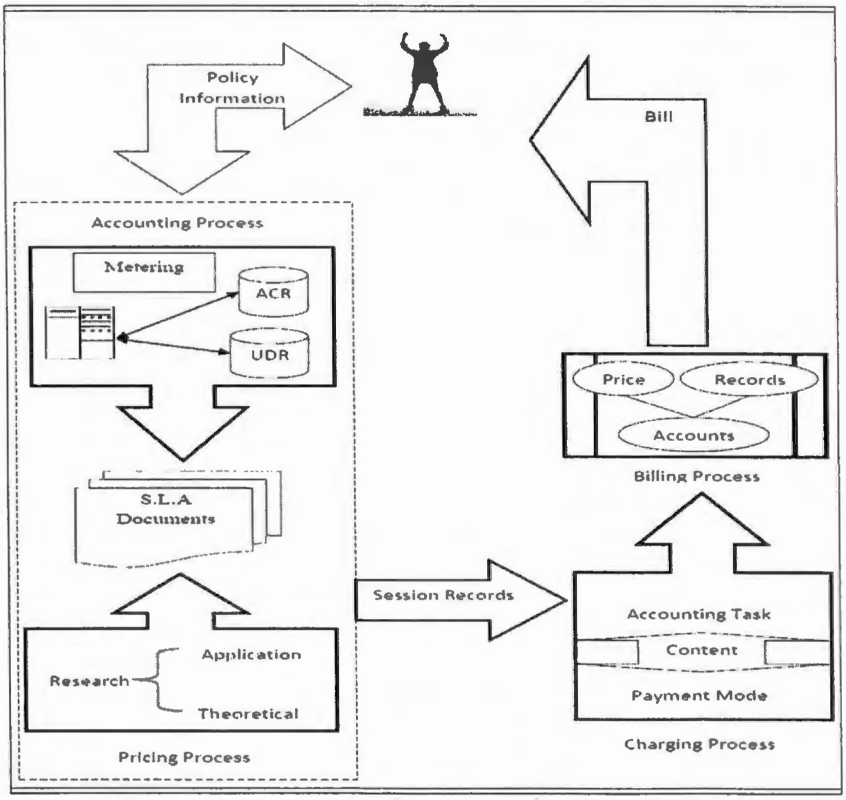

Figure 3.1 Our Novel Model

The development of our Novel model, a server is used to enforce control for access of various computing resources and verifies the uniqueness of a user. The process starts with a request query from the client to the server to deliver content. The server in turn responds with an accounting request message, users wishing to use one or more services provided by the service providers, must be authenticated and authorized. Accounting policies will be enforced by the authentication, authorization and accounting (AAA) server. The users using the server will be able to query the policies to know the pricing details of the web service offered by the service provider. A user is able to gain access to many other network services. Their credentials are used to determine authorisation levels for use based on his or her service profile. This process maintains the actual usage of resource by request so that the final cost can be computed and charged to the users.

The parameters of the accounting request message are;

(i) Accounting server information: This includes the authentication key as well as the IP/DNS address of the AAA server.

(ii) Server information: This will be used to identify users of the system.

(iii)Pricing: This entails calculating the Computing time. It also takes process instructions in hours. The scale for calculating storage will range between 10-250Mb/h at a cost of R0.50 while bandwidth that passes by any node whether outbound or inbound will range between 1 – 10 Gb/h at a cost of R0.50.

3.3 Metering Function

After the authentication process, the flow of information sieves down to the metering function. Metering function collects the information flow regarding the resource usage by any consumer. This is the starting point of the accounting process and determines the resource use within end users of the system including Quality-of-Service (QoS). The metering function intercedes by generating the metering and accounting records for the accounting function. The metering details are stored in the UDR. Authentication, Authorization and Accounting (AAA) server maintains the Usage Data Records (UDR) and Accounting Records (ACR) for web service usage.

3.4 Service Level Agreements

The accounting data drifts through SLA which serves as the foundation for the expected level of service between the consumer and the service provider. A binding agreement will be made to fulfill a set of rule governing service provision of the internet.

3.5 Pricing Process

The price of a fixed Internet connection will be used based on charges on the bandwidth. A pricing model will be determined as a variable of use in concluding price metrics. Market research will deliver input and insights in concluding price models as prices. The pricing function generates a formula defining how to price the session records that will be used by the charging functions. Under the economical dimension, we apply the Tariff and Efficiency components. While under the tariff component a once off access and usage fees of R5 respectively will be defined as part of flat-rate pricing policy. Under the efficiency component pricing, a commodity will be specifically used to maximises revenue to the service provider and economic efficiency to customer satisfaction.

3.5.1 Market Research Variable

Each pricing model we use is practical with the help of global markets as a benchmark and therefore a pricing matric was set. Both research technics, we delivered an insight for the development of internet architecture generic enough to implement different pricing models.

The pricing scheme of pay-as-you-go is used between users and providers. This pricing scheme implemented by the service provider and stored as entries in the Usage Data Records (UDR).

This pricing overhead is given by $\beta(\iota, t)$, where ι is the load at time instance of operation t.

The current price, P_t for the interval at a given load condition is given as shown in equation 3.1;

$$P_t = C_{bass} * \beta(\iota, t), \qquad 3.1$$

Where:

P_t – operational price at time t
C_{bass} – base operational cost
$\beta(\iota, t)$- pricing overhead for running the service under load ι at time t.

The practise of using price computing based on virtual machine hours will be used such as charge R0.50 per virtual machine hour.

$$CostPer_{user} = \sum Price * T + O_f + U_f \qquad 3.2$$

Where:

Price is the price per virtual machine used in an hour

T is the total running time of the virtual machine in an hour

O_f is a once off access payment fee of R5

U_f is the Usage fee of R5

The $CostPer_{user}$ is the summation of charge of each session as shown in equation 3.2.

3.5.2 Bandwidth Variable

The bandwidth pricing is based on the amount of data traffic carried from one node to the other in a given time frame. The bandwidth caters for;

(i) Sent messages/outbound transfer

(ii) Received messages/inbound transfer

The pricing scale of bandwidth formulated below is applicable on a monthly basis (R/Gb/H)

Table 3.1 Bandwidth Scale

Type of Bandwidth	Price
Inbound traffic	Free
Outbound traffic	
Next 10Gb Next 100Gb Next 1000 Gb	R 0.50 R 1.50 R 2

3.5.3 Storage Variables

In the Model, a user pays only for the amount of storage they use each month. There are neither minimum fees nor long-term commitments, and a user does not worry about buying and maintaining physical hardware. The pricing is conformed to how much virtual storage is used in an hour.

The storage scale below is applicable on an hourly basis (R/Mb/h);

Table 3.2 Storage Scale

Storage Megabyte (Mb)	Price –Rand Value
0 – 250 Mb	R 0.9
Next 500 Mb	R 0.6
Next 1000 Mb	R 0.3

3.5.4 Pricing Variable

Clients will be billed for CPU and RAM usage only when the server is actually running hence pricing is allocated to instances that are running. Servers that are dormant, a user will only pay for the storage that the server is using.

Table 3.3 Compute Scale

Compute Instance	Price Rand per Hour
8Mb RAM, 1 CPU, 20MB Hard disk	R 10
16Mb RAM, 2 CPU, 50MB Hard disk	R 15
32Mb RAM, 2 CPU, 80MB Hard disk	R 30
64Mb RAM, 4 CPU, 110MB Hard disk	R 40
128Mb RAM, 4 CPU, 140MB Hard disk	R 45
256Mb RAM, 8 CPU, 170MB disk	R 55

3.6 Charging Process

Session records from SLA are then transferred into the Charging function. Charging determines the process of calculating a price for a given accounting record which determines particular resource consumption thus; it defines a function from technical values into monetary units of rand. The monetary charging information is included within charging records. The charges for service usage are generated from UDR and ACR.

Session records from SLA are then transferred into the charging function. There, the charging process is structured into transport, service and content layers. The transport forms the basis for providing a system to deal with transfer of data within the network. Service allows for different services offered like quality of service and resource consumptions. Content caters for accounting tasks for information that is monetarily sensitive and needs to be paid for on the basis of consumption.

Total payment calculation will be deduced as shown in equation 3.3:

$$CostPer_{user} = \sum Price * T + O_f + U_f + (Bw_p + St_p + Ci_p) \qquad 3.3$$

Where:

Price is the price per virtual machine used in an hour

T is the total running time of the virtual machine in an hour

O_f is a once off access payment fee of R5

U_f is the once off usage fee of R5

Bw_p is the bandwidth in price $_p$

St_p is the storage used in price $_p$

Ci_p is the compute instance in price $_p$

3.7 Billing Process

The charging function, the charging records are sent to the billing function. There charges records are transformed into final bill or invoice. It summarises the charge record of a certain time period and indicates the amount of monetary units to be paid by the client.

3.8 Experimental Setup

To conduct the experiment, cloud analyst was used. This is because it is a tool that supports visual simulation and modelling of large scale applications that are set out on cloud infrastructures. It also concurrently executes simulations with the slight parameter variation with easy.

The experiment was conducted on an Intel Pentium machine having the following configuration: 2.10GHz with 4GB RAM running Windows 7 Home basic Service Pack1, JDK 7 with a 64bit Operating System.

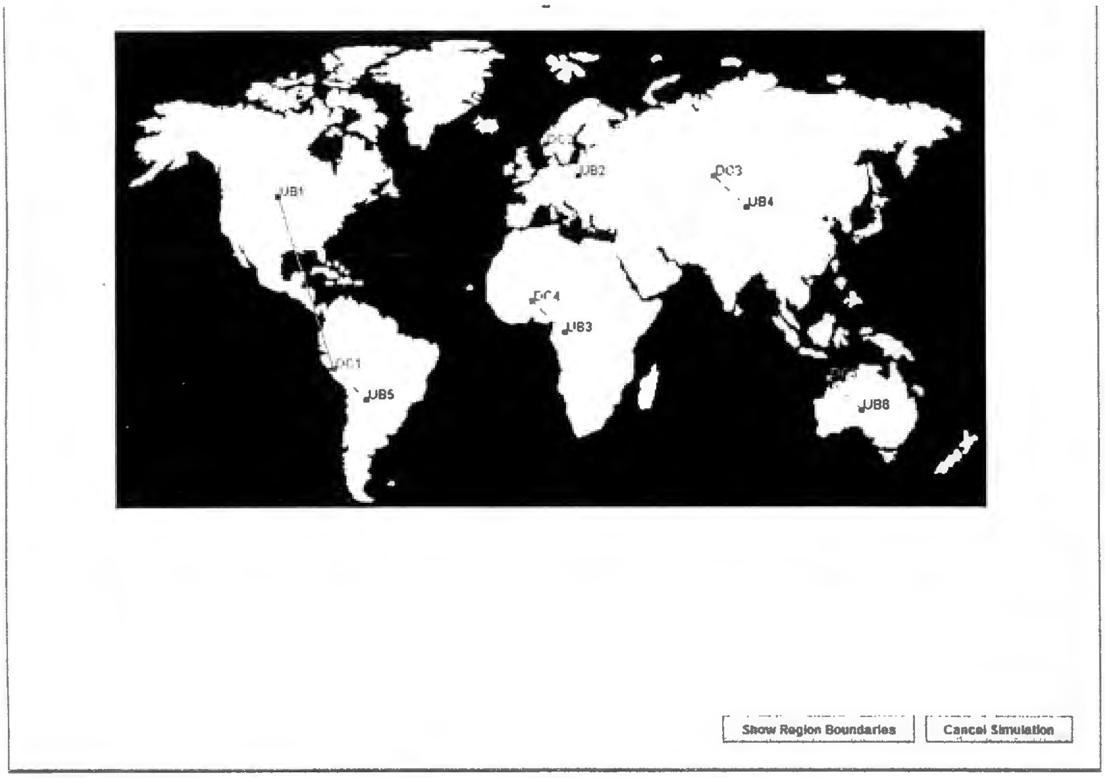

Figure 3.2 Datacenter Regions

Five Data centers were created out of six user bases each having the same memory. User bases generated traffic representation and the location of data centers including the number of users. The data centers allocated resources was utilised.

Table 3.4 Data Centers

Data Center	#VMs	Image Size	Memory	BW
DC1	5	10000	512	1024
DC2	2	10000	512	1024
DC3	3	10000	512	1000
DC4	5	10000	512	1024
DC5	5	10000	512	1024

Each data center is equipped with a Virtual Machine that houses the scheduling of resources, tasks and modelling of costs incurred in each setting. It is here that the calculations of each data center were derived.

3.9 Chapter summary

This chapter give a breakdown of the experiments we carried out and the results obtained. It also entails the methods used to deduce the results we obtained and the experimental tools used to facilitate the findings.

Chapter 4

Results and discussions

4.1 Introduction

This chapter presents and discusses the results of the experiment carried out.

4.2 Experimental Results

As a result of the experimental tool we used, the cost of data transfer was generated from virtual machines. Data was weighted in and cost figures were derived. Cost figures were generated after variables were entered in the simulation tool, cloud analyst. One of the tables that emerged from the simulation is table 4.1. This table depicts the cost of virtual machines and data transfer for all the five data centers.

Table 4.1 Data Center cost figures

Data Center	VM Cost $	Data Transfer Cost $
DC5	1.50	2.59
DC4	1.00	67.74
DC3	0.60	0.39
DC2	0.40	2.40
DC1	1.00	1.03

The service provider with these virtual machines will deliver on demand, scalable compute infrastructure when needed to quickly provision resources because of the growing business needs. Actual CPU, memory and storage information was collected as additional cost and added to the basic per virtual machine cost.

Table 4.2 Average Time (ms)

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.56	0.10	1.22
DC2	0.47	0.02	0.97
DC3	0.50	0.05	0.89
DC4	0.74	0.09	2.71
DC5	0.51	0.05	0.91

From table 4.1 and table 4.2 a comparison is made against each data center and virtual machine and the data centers against average processing time. The two tables are separately used to plot and show there comparisons.

From the average time reading we were able to deduce the average time it takes for bandwidth to flow to and fro the different data centers. Each data center because of its location displays a different reading which also showed the different time of the day the internet was accessed. Another factor that was pegged to the variation of readings was the rate of quality internet service accessed by the end user. As an example urban areas internet access was more abundant due to the facilities offered ranging from connectionless Wi-Fi to hotspots in open public areas.

4.3 Discussion

Data leaving the virtual machines from each data center vary as shown in the result in figure 4.1. Each data center because of different use of the instance per user, it is clear that data center DC4 has the highest traffic flow showing that population instances form user base 4 (UB4) use the system on a regular basis while traffic from data center DC3 are the least users of the system. The bandwidth flow from node to node was preferred in data center 4 (DC4) as these acts are a catalyst to retain customers and a steady flow of reliable internet.

The resultant output of the two tables 4.1 and 4.2 separately is shown in figures 4.1 and 4.2, data center as the common denominator. From our variable used, residence living in DC4 pay relatively high amount of money to access the internet compared to all other four data centers.

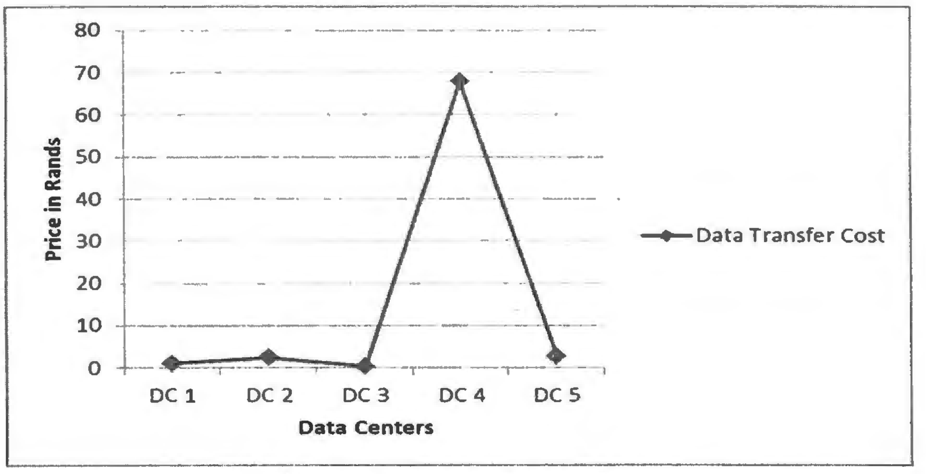

Figure 4.1 Bandwidth Cost

The processing of data was done by the virtual machines. This data that is inbound or outbound is stored for processing as refined information for immediate or future use. Figure 4.2 depicts data processing time from each data centers. DC4 because of high flow of data emanating from its nodes has a relatively high processing time while DC2 depicts the list amount of money a client will need to use the system. The relatively high amount is demand on due to the number of people accessing the system. Demand is high forcing the service provider to put a high price on the product offered. DC4 is situated in Africa

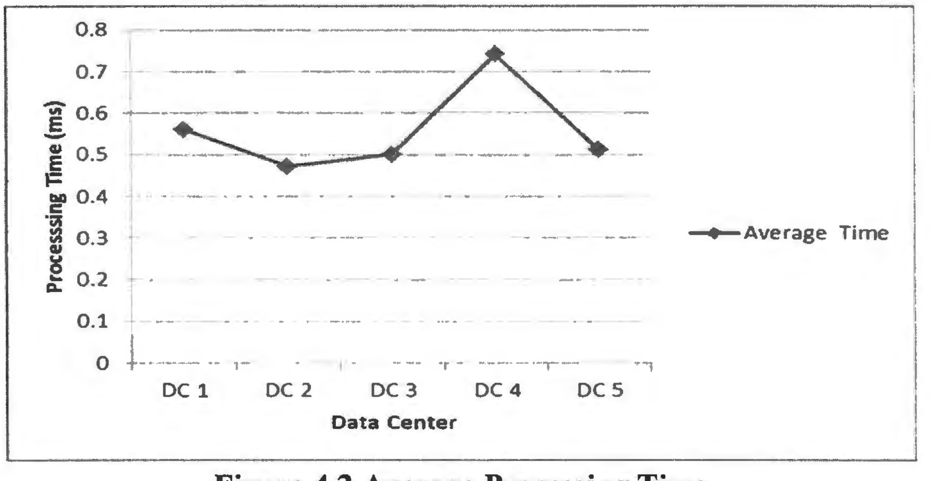

Figure 4.2 Average Processing Time

Users to the system were able to access data fast enough as communication between data center takes place. This in turn will increase performance of the system and give the service providers a clear view of what they expect out of maintenance as future reference.

Chapter 5

Summary, Conclusion and Future Work

5.1 Summary

Venturing in to the cloud has far more benefits than it has disadvantages for any company willing to take the dive in to Cloud Computing. The world seeks faster reliable information at its fingertips so does the way it is retrieved and transported. Consumers are willing to pay any amount to have fast and reliable data within the click of a button. This has been boosted with the use of media. Smart phones to hand-held PDAs, information is reachable at the speed of lightening.

Due to information overload, are emerging companies able to keep up with the demand of consumers? Service providers are hard at work trying to retain consumers with up to date website, luring them with sales offers to remain loyal. The demand is eclipsing service provision to a point that keeping up requires sacrifice on the service provider's part.

Another question that is besieged in a consumers mind is venturing into the cloud, is it reliable? The inception of technology springs internet fraud. This is an act of theft that is not physically seen by the naked eye. Consumers are wary that with their personal particulars in someone's hands this could lead to temptation of malpractice. And if something of this nature does happen, what recourse does the consumer have? Will the remedy cost more than was taken from them?

Majority of service providers blindly dive in to the cloud pool with lack of knowledge about what the market is about. Technology is a vital element in defining a product a service provider is to sell. Equipped with this knowledge, they are able to reach a vast spectrum of consumers with the click of a button. As the market gets circulated a service provider is required to pick a niche and develop a product they think will benefit both parties.

As the world over slowly but surely moves towards a global market, everyone will be expected to carry less for more. Most of our banking will be at our fingertips instead of walking in to a bank. Exchange of goods and services will cost next to nothing as better trade will be a thing of the past due to induced technology. All this is about to happen, the question we should pause to ourselves is, are we ready for the transformation? What are we doing to hasten this process?

5.2 Conclusion

Accounting, pricing and charging model in a service provisioning environment is a model that depicts how service provides break down the price allocation and how they come about allocating a price to a particular service. The charging strategy service providers provide us is suspect as users do not know how the billing is done.

In this research I have, with consideration of market dimension, worked out a formula on how to derive a pricing figure that will help facilitate the concluding of a price of a service. This price one is further able to draw a budget on how much they spend in the cloud.

A novel model was created in this research to trance how accounting, charging and billing is theoretically done by service providers. This model a procedure of steps are shown to depict the stages in which a consumer is able to track as evidence that they did carry out what was asked of them. The inclusion of Service Level Agreement, a consumer is able to pin their selves to the contract as this becomes binding between the parties. This model also shows how information, from the start, is transported from one mechanism to the other until its final destination the consumer is billed in hence a invoice.

With the help of six user bases five data centers all having the same memory, cloud analyst simulator was used to generate traffic representation. Each data center was equipped with a virtual machine that houses the scheduling of resource task and modelling of costs incurred in each setting. It is here that each data center calculation was derived. The calculation derived from our data center variables were populated to deduce the metric for each virtual machines while variable like Operation Systems and memory cost remained relatively constant.

The variables were eventually transformed into graphs and results obtained showed the comparison of data centers to virtual machine and also to average processing time. From the results we deduced that more attention should be allocates to data centers lacked behind while it also showed active data center. The processing time for a virtual machine is driven by how vast data flows from a node.

5.4 Future work

Creating a model as a theoretical mechanism is imperative in solving any process. I would like in the future to create a website and put into practise the model I have created. This will not only give credibility to the research but will take it a step further in showing that what finding we came up with can be used in practical instance.

Research of today is one sided. It is done mainly as a theoretical basis and little or nothing to back it up that it is possible to achieve. As future work I would further like to implement all the finding and practically emulate the results.

References

[1] B. Rajkumar, S. Chee, Y, Srikumar V, James B, Ivona. "Cloud Computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." Future Generation Computer System, vol. 25, pp 599-616, Dec. 2008.

[2] Q. Zhang, L. Cheng and R. Boutaba. "Cloud Computing: state-of-the-art and research challenges." Journal of Internet Services and Application, vol.1, pp 7-18, Oct. 2009.

[3] M. Armbrust, A, Fox, R, Griffith, A.D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, M. Zaharia. "Clearing the clouds away from the true potential and obstacles posed by this computing capability." A View of Cloud Computing, vol. 53, pp. 50-53, Apri. 2012.

[4] P. Mell and T. Grance. "Recommendations of the National Institute of Standards and Technology," In Proc. National Institute of Standards and Technology, 2011, pp. 2-4.

[5] P. T. Jaeger, J. Lin and J. M. Grimes. "Cloud Computing and Information Policy: Computing in a Policy Cloud?" Journal of Information Technology and Politics, vol. 5(3), pp. 269-273, Dec .2008.

[6] K. Birman, G. Chockler and R. VanRenesse, "Towards a Cloud Computing Research Agenda" ACM Digital Library, vol. 40(3), pp. 68-70, Jun. 2009.

[7] J. Meiers, "Billing metrics for Compute Resources in the Cloud." Cloud metering and billing, vol. 2, pp. 1-10, Aug. 2011.

[8] M. Woitaszek, and H. M. Tufo, "Developing a Cloud Computing Charging Model for High-Performance Computing Resources," presented at the 10th IEEE International Conference on Computer and Information Technology, Bradford, West Yorkshire, United Kingdom, 2001.

[9] C. Nichols, "4 Hidden Costs of Cloud Computing." Unitiv (Dec. 07, 2011) sec. A p. 1.

[10] D. Paulding, "Uncovering the hidden costs behind Cloud Computing." IT Strategy, pp. 1-2, May. 2012.

[11] C. Binnig et al. "How is the Weather tomorrow?" Towards a Benchmark for the Cloud," in Proc. DBTest, 2009, pp. 1-6.

[12] W. Sun, K. Zhang, S. Chen, X. Zhang, and H. Liang. Software as a service: An Integration Perspective. Berlin, Heidelberg: Springer, 2002, pp. 558-569.

[13] G. Kulkarni, P. Khatawkar and J. Gambhir "Cloud Computing-Platform as Service." International Journal of Engineering and Advanced Technology, vol. 1, pp 115-120, Dec. 2011.

[14] Sushil Bhardwaj, Leena Jain and Sandeep Jain "Cloud Computing: A Study of Infrastructure as a Service (IAAS)" International Journal of Engineering and Information Technology, vol. 2, pp 117-125, Feb. 2012.

[15] Sohan Singh Yadav, and Zeng Wen Hua, 2010 "CLOUD: A Computing Infrastructure on Demand," in Proc. Computer Engineering and Technology (ICCET), 2010, pp.423-426.

[16]. Booz, Allen and Hamilton, "The Economics of Cloud Computing: Addressing the Benefits of Infrastructure in the Cloud," Addressing the Benefits of Infrastructure in the Cloud, [online document], 2009.

[17]. D. M. West, "Saving Money Through Cloud Computing," Governance Studies at BROOKINGS April 07, 2010.

[18]. W. Sun, K. Zhang, S. K. Chen, X. Zhang and H. Liang. "Software as a service: An Integration Perspective". Springer-Verlag Berlin, Heidelberg, pp. 558-569, 2002

[19]. J. Jaatmaa, "Financial aspects of Cloud Computing business models," Master's thesis, Department of Business Technology, Information Systems Science, Aalto University 2010.

[20]. M. Koutsopoulou, A. Kaloxylos, A. Alonistioti and L. Merekos, "Charging, Accounting and Billing Management Schemes in Mobile Telecommunication Networks and The Internet", IEEE, Communication Surveys & Tutorials, Vol.6, No1 pp. 50-58, January 2004.

[21]. Wyld, D. C. (2009). The Utility Of Cloud Computing As A New Pricing - And Consumption-Model For Information Technology. International Journal of Database Management Systems, Vol. 1, No. 1, pp. 1—20

[22]. K, Hakju, “Charging & Accounting System Design for the Multi-Service Internet.” IEEE Universal Multiservice Networks, vol. 2, pp. 64-73, 2002

[23]. S Burkhard,. “Accounting, Charging and Pricing of Communication Services – An Internet-based Exemplified Study of Influences.” IEEE Global Telecommunication, vol. 2, pp. 1196-1201, November 1998.

[24]. O, Kenji, “An Internet Accounting System” IEEE Computational Intelligence and Multimedia Applications, pp. 278-283, September 2003.

[25]. R, Christoph, M. Karsten and S. Burkhard, “AAA: A Survey and a Policy–Based Architecture and Framework” IEEE Network, vol.16, no. 6, pp. 22-27, December 2002

[26]. N Blefari-Melassi, D. Di. Sorte and G. Reali, “Accounting and pricing: a forecast of the scenario of the next generation internet” Journal Computer Communications, vol. 26, no. 18, pp. 2037-2051, December 2003.

[27]. A. Vikas, N. Karnik and A. Kumar, “Metering and Accounting for Composite e-Service” IEEE E-Commerce, pp. 35-39, June 2003.

[28]. I, Ruiz-Agundez, Y. K. Penya and P. G. Bringas, “A Taxonomy of the Future internet Accounting Process”. [Online], 2010

[29]. P. Patel, A. Ranabahu and A. Sheth. “Service Level Agreement in Cloud Computing.” [Online], 2009.

[30]. A. K. Tripathy, M. R. Patra. “Modeling and Monitoring SLA for Service Based Systems.” ACM International Conference on Intelligent Semantic Web-Service and Applications, no. 10, pp. 1-6, 2011.

[31]. N. Papatheodouloau and N. Sklavos. “Architecture & System Design of Authentication, Authorization and Accounting Services.” IEEE EUROCON, pp. 1831-1837, May 2009.

[32]. M Falkner, M. Devetsikiotis and I. Lambadaris. “An Overview of Pricing Concepts For Broadband IP Networks.” IEEE Communications Surveys & Tutorials, vol.3, no. 3, pp. 2-13, November 2009.

[33]. W. Hongyi, Q. Jing, C. Rishan, H. Bingsheng, Q. Zhengping and Z. Lidong "Distributed System Meet Economics: Pricing in the Cloud," in Proc. USENIX, 2010, pp. 1-7.

[34]. I. R Agundez, Y. P. Landaburu and P. G. Bringas. "A Taxonomy of the Future Internet Accounting Process," in Proc. IARIA, pp. 111-117.

[35]. I. Radisic, "Using Policy-Based Concepts to Provide Service Oriented Accounting Management," IEEE Network Operations and Management Symposium, pp. 313-326, 2002.

[36]. L Yu and H. Zhang. "An Effective Monetization Model with Pricing and Charging Strategy on Cloud Simulation Platform," IEEE Computer Supported Cooperative Work in Design, pp. 411-415, May 2012

[37]. M Armbrust, et al. "Above the Clouds: A Berkeley View of Cloud Computing," CITESEER, 2009, [online].

[38]. W. Sun, K. Zhang, S. K. Chen, X. Zhang and H. Liang. "Software as a service: An Integration perspective," in Proc. ACM 5th International conference on Service-Oriented Computing, pp. 558-569, 2007.

[39]. A. Odlyzko, "Paris Metro pricing for the Internet," in Proc. ACM Conference on Electronic commerce, pp. 140-147, 1999.

[40]. Lee W. McKnight and J. Boroumand, "Pricing Internet Service: Proposed Improvements," ACM, vol. 33, pp. 108-109, March 2000.

[41]. S. Ibrahim, B. He and H. Jin, "Towards Pay-As-You-Consume Cloud Computing," IEEE Services Computing, pp. 370-377, July 2011.

[42]. M. Macías and J. Guitart, "A Genetic Model for Pricing in Cloud Computing Markets," in Proc. ACM Symposium on Applied Computing, pp. 113-118, 2011.

[43]. R J. Dolan and Y. Moon "Pricing and market making on the internet," ELSEVIER ScienceDirect vol. 14 no. 2, pp. 56-73, 2000.

[44]. A. Narayan, S. Rao. G. Ranjan and K. Dheenadayalan. "Smart Metering of Cloud Services," IEEE System Conference, pp. 1-7, March 2012.

[45]. V. Agarwal, N. Karnik and A. Kumar, "Architectural Issues for Metering and Accounting of Grid Services," IBM research Division, Computer Science, 2002.

[46]. Dimension data, "Comparing Public Cloud Service Level Agreements Questions to ask when evaluating public cloud SLAs," dimensiondata.com [Online], 2013.

[47]. A. Defelice (2012, October). "Cloud Computing: What Accountants Need to Know". Journal of Accountancy. [Online], 2010.