A Taxonomy of the Future Internet Accounting Process

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***Abstract*—Accounting is an old term that defines the activity of keeping records of the money. However, accounting in the Internet implies not only economic principles, but also engineering aspects. Accounting has been used for studying the impact on usage quotas, for dimensioning a provider infrastructure or for registering the data flow, among others. Each evolutionary step of the Internet has its implications in how the accounting process is performed. The new challenges of the Future Internet and the Next-Generation Networks (NGN) reveal the need of a revision of the accounting process. Against this background, we present a taxonomy of the accounting process of the Internet. This taxonomy classifies all the functions involved in accounting in a hierarchical structure, representing their behaviour. The resulting taxonomy helps defining the terminology, requirements and working framework of all the accounting-related studies. Further, it helps through the learning, teaching and assessing process in the area of accounting.**

***Keywords*-Accounting; Internet; Taxonomy.**

I. Introduction

Accounting is *"the art of recording, classifying, and summarizing in a significant manner and in terms of money, transactions and events which are, in part at least, of financial character, and interpreting the results thereof"* [1]. This activity is important for business and commercial purposes but also for the Internet, when a service provider charges a client with a fee for the usage of a certain service. These services are as varied as voice, data, multimedia, e-market places or any other emerging service.

In this scenario, the accounting process implies considering both engineering and economic aspects. It is essential to enforce policies such as usage quotas, to dimension the provider infrastructure, or to make statistical analysis of the usages, among others [2]. Resource accounting has also an important role in infrastructure congestion control due to the usage fees applied to the consumers [3].

Nowadays, we can distinguish two main accounting paradigms: the telecommunications world and the Internet world [4]. In telecommunications, the accounting process consist of apportioning the charges between the home environment, the serving network and the user. On the other hand, in the Internet, the accounting process is defined as the set of functions that manages the data regarding the use of the resources. In addition, traditionally, Internet accounting was limited to transport accounting. Customers paid for the use of the network resources of certain access providers [5] and not for any other type of service. Nevertheless and despite their differences, these worlds are converging, and more accurate definitions of the accounting process are emerging.

So far, in this converging model, accounting is understood as the process of collecting the resource usage for capacity and trend analysis, cost allocation, auditing and billing [6]. However, the evolution of the Internet denotes that this definition is not enough. It needs to refer to a broader concept, considering all the possible functions and related concepts [7]. This broader concept needs to meet the new requirements of the Future Internet, helping on accomplishing the new challenges that it implies.

Against this background, we introduce a new definition of the accounting process. This definition meets the requirements of the evolution of the Internet, understood as in the Future Internet [8] [9]. We also present a taxonomy of the full accounting process, from the resource usage to the financial clearing of its use.

Originally taxonomies were used only to classify organisms. Nowadays, taxonomies are used to classify things and concepts of any indole. There are economic, biological and even military taxonomies, each one specifying its domain area. Furthermore, taxonomies can have a tree, network or linear structure. All of them have proved to be useful for learning, teaching and assessing [10] and a central part of most conceptual models (ordering the elements into a model) [11]. They are specially useful presenting limited views of a model for human interpretation, and play an essential role in reuse and integration tasks.

The remainder of the paper is structured as follows. Section II introduces the related work on taxonomies about accounting. Section III presents an integrated vision of the accounting process describing all the involved functions. Finally, Section IV concludes and glimpses the future work.

II. Related work

Accounting of service usage is one of the main tasks of service providers in their operation and management processes, providing the necessary information for the subsequent functions. Although accounting requirements are

studied in many books and articles, they rarely define a clear taxonomy of the full accounting process.

Some authors refer to the terms pricing, charging, or billing to represent the complete process of detecting the specific usage of a service [12] [13]. There is a need of disambiguating the accounting process employing a precise terminology and splitting clearly all the functions involved. In this paper, we refer to the accounting process as a meta-concept that includes all the aforementioned functions.

On the other hand, we considered the application area of each author. Different areas imply different terminology and semantics. For instance, accounting on packet-switched networks [14], micro-payments [5], grid services [15], mobile networks [16], VoIP services [17] or Wi-Fi connections [18].

Other researches tried to standardise the accounting process on the Internet [19] [20]. Nevertheless, to our knowledge, there is none that has performed a full taxonomy of the accounting process for the Future Internet accounting requirements making the learning, teaching and assessing process much harder [10].

The present taxonomy was performed following the directives to develop a taxonomy [21]. We started this method determining the requirements and identifying the concepts involved in the area of Internet accounting. After, a first draft of the taxonomy was deployed. This draft was reviewed with the users and the experts in the field providing the authors with feedback for a refining process. Once a final version was defined we started a maintaining process.

III. An integrated vision of the accounting process

The terminology regarding the billing process has always been diffuse sometimes involving contradictory semantics. The origin of this problem is not new and it dates back to the evolution of the accounting through the years and the influence of the different application areas in which it has been applied.

As terminology of the accounting process is evolving and is not standard [13], we studied the work done by other authors. Each contribution gives a different vision of the accounting process, creating a set of mixed concepts. However, after analysing the most relevant accounting process paradigms, we found out that they share some common characteristic that can be re-factored in order to have an integrated accounting process.

This integrated vision is represented in Fig. 1. The process starts with a resource usage which is registered by the metering function through the metering records. Afterwards, the mediation function intercedes by generating the accounting records for the accounting function. 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. The flow continues with

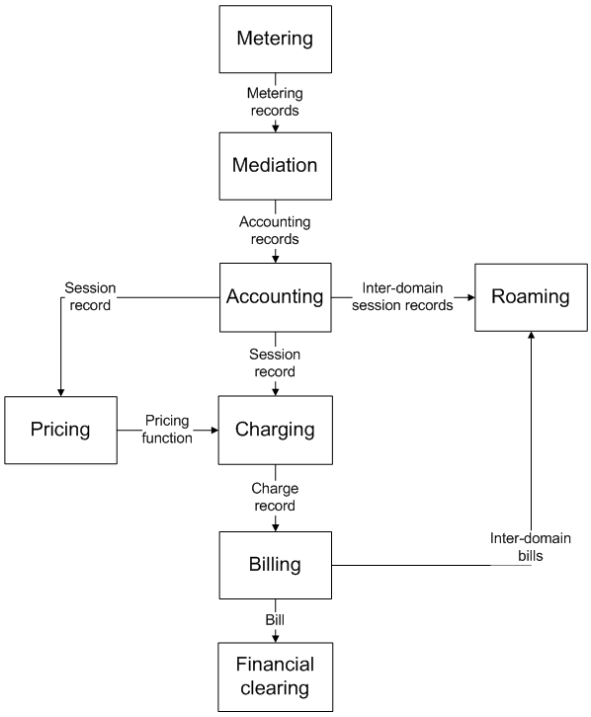

Figure 1. An integrated vision of the accounting process

the charging, which generates charge records for the billing function. There, the final bill is sent to the financial clearing function.

Throughout the accounting function, inter-domain exchanges between organizations could be performed. These interchanges could happen at the accounting and billing steps, enabling roaming capabilities and inter-organization collaboration.

A. Metering

Metering is the function that collects the information flow regarding the resource usage of a certain service by a consumer and its usage. This measurement data is formed by service usage metrics provided by the monitoring function. Fig. 2 shows an overview of the metering function.

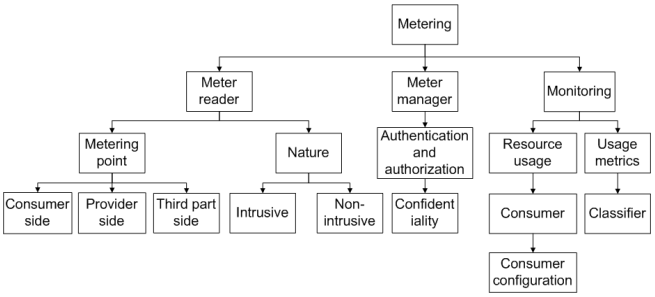

Figure 2. Metering function overview

This information is technical and is expressed in measurable quantities of consumer resources [5]. Examples of this measurable quantities are the number of data sent and received within an Internet connection, the seconds of a telephone call or the number of watts consumed.

This information is the starting point of the accounting process and will be used in the entire process. It determines the particular usage of resources within end-systems or intermediate systems on a technical level, including Quality-of-Service (QoS), management and networking parameters [22].

This function is normally implemented in a meter reader at a certain infrastructure point where the resource usage data is accumulated as long as the memory is able to. This point is known as metering point [23]. In addition, a meter reader can be classified as a consumer side meter, in which the meter reader is allocated with the consumer; or as a provider side meter, in which the meter reader is allocated in the providers infrastructure. In certain cases, meter readers are between the consumer and the provider, allocated in a third part or in a neutral infrastructure that both the consumer and the provider trust.

The meter readers can also be classified by their nature as intrusive (when there is an interface with the resource) or non-intrusive (when there is not an interface with the resource).

Additionally, the metering function is managed by a meter manager. There is a number of parameters that must be set for correct resource usage measurement. These parameters will depend on the resource itself. However, the general working procedure persists among the different resources. The manager is responsible for the authentication and authorization of the metering records, it must ensure the confidentiality of the data.

Monitoring is the function that collects the information of a resource usage as raw data and provides usage metrics to the metering function. The usage metrics reflect the use of a resource by a consumer (human, machine or other service) of a certain resource in measurable quantities. These metrics define the rules that the monitoring device apply in a classifier by defining the filtering of usage data [24].

The monitoring function can be conditioned by the consumers' configuration. That is, different consumers may have different usage metrics monitored (also known as datapoints). The consumer configuration refers to the function that configures a service for its use. Normally, this configuration is set after the user is authenticated in the service provider infrastructure [25].

B. Mediation

The metering records generated by the metering function are usually stored in a homogeneous data format (accounting records). Fig. 3 shows an overview of the mediation function.

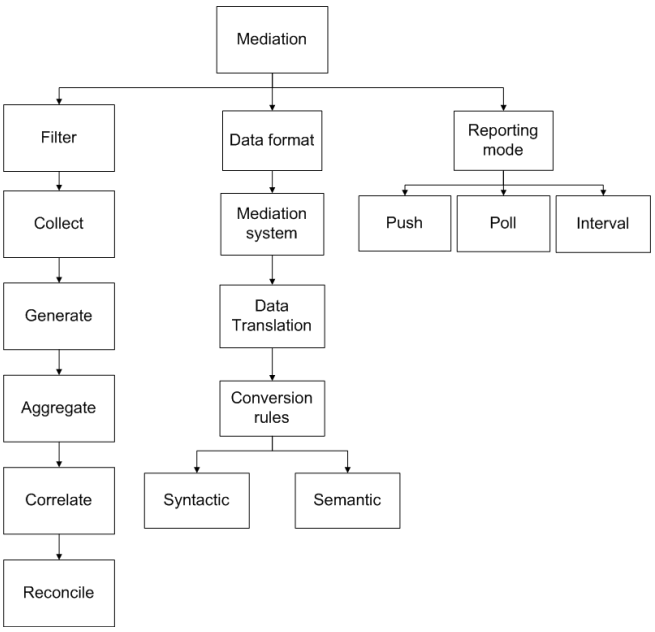

Figure 3. Mediation function overview

Mediation is intended to filter, collect, generate, aggregate, correlate, and reconcile raw technical data by transforming these metering records into a data format that can be used for storing and further processing [22] [26]. In this way, data processing is easier and the different functions of the accounting process require less mash-ups and conversions, resulting in a better performance [27].

In case different data formats are used, translation of data is necessary in order to have all the information in a homogeneous format as soon as possible. Conversion rules, both syntactic and semantic, are required in order to guarantee the integrity of the transformed data. This set of rules is also known as mediation systems [28] and is very common in the telecommunications world.

Further, the mediation can report to the accounting function in three different ways: push mode, poll mode or interval mode [19] [26]. In the push mode, the mediation function report the accounting function with accounting records as soon as it receives them. On the other hand, in the poll mode, the accounting function has to ask for the accounting records to the mediation function. Finally, in the interval mode the mediation function report to the accounting function each certain interval.

C. Accounting

Other taxonomies [6] include resource usage measurement, rating, charging, billing, and invoicing in this function. Nevertheless, we decided to split these functions in order to have a more representative organization. We also need to stress the difference between the accounting process,

which implies the full process described in Fig. 1, and the accounting function, which we are defining now. Fig. 4 shows an overview of the accounting function.

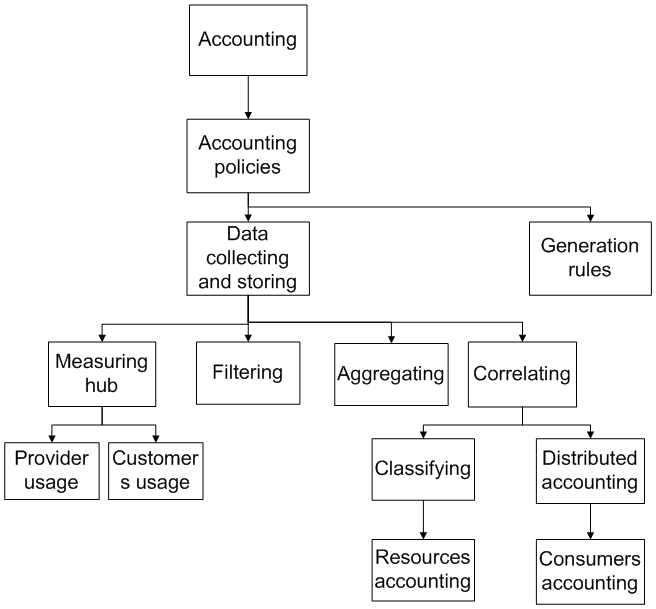

Figure 4. Accounting function overview

Accounting is the process of filtering, collecting and aggregating the information that reflects a resource usage by a certain consumer. This process will generate session records whose format will depend on the service infrastructure and the service provider [27]. 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 [6].

This accounting function is expressed in metered resource consumption, e.g., for applications, calls, or any type of connections [22], 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 [4]. Accounting policies define how these functions behave and are specified by a set of generation rules [25].

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 [12]. 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 provider and the customer. Data from the provider is created by internal and control meters, and is used to control the provider's infrastructure. On the other hand, data from the customer represents the usage consume and is used in the whole accounting process.

Data archival may be necessary because of the memory limitations of the meter readers or because the information may be needed for long 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 dictate that data to be kept confidential, regardless of whether it is to be used for billing purposes or not [6].

The concentration of the metering results in a measuring hub may be necessary to correlate information from distributed meter readers and to process the data solely in one point. The correlation are 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 organizing the data from the different consumers.

D. Roaming

Roaming is the function that allows using more than one provider while maintaining a formal, customer-vendor relationship just with one [29]. In order to offer roaming capabilities, providers need three main subsystems. The consumers' subsystem, which registers visiting consumers, the authentication subsystem, which validates the credential of the consumer, and the accounting subsystem, that has already been described [30].

In order to allow consumers to roam, providers need roaming agreements between them. They negotiate the legal aspects of authentication, authorization and billing of the visiting subscriber. There are several standards that create a work field framework for these agreements [31] [20].

Roaming can also be intra-domain or inter-domain [6]. Being intra-domain implies that there is an exchange of session records between different accounting functions but always in the same provider or administrative boundary. On the other hand, in the inter-domain roaming the session records travel from one provider to another, crossing their administrative boundaries.

E. Pricing

Pricing is the function of giving a price to a certain resource usage. It is a critical function for the full accounting process because it defines the price that a basic quantity of the service will cost. Some authors name it a rating or pricing policy [6]. This pricing policy determines the way a session record is rated. 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. Fig. 5 shows an overview of the pricing function.

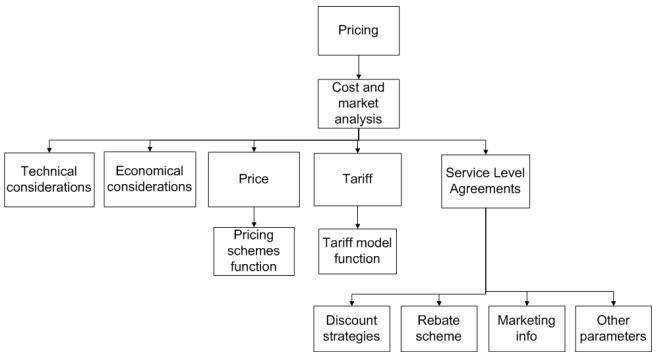

Figure 5. Pricing function overview

This process may combine technical considerations, such as resource consumption, and economical ones, such as applying tariffing theory or marketing methods [22]. The price can be calculated in many different ways (e.g. auctions, static pricing, dynamic pricing, priority pricing, cost-volume-profit analysis scheme or based on market situation analysis) [32] [33] [13]. 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 consumer resource usages.

Pricing is defined by the pricing schemes, which are a critical part of the business and are related to cost and market analysis. It is a function for calculating a price. It can be represented as a formula (pricing function) consisting of the pricing variables (consumption measure metrics of the session records) and pricing coefficients [25]. 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, among others.

Tariffs are a special case of pricing. They are normally regulated by a governmental institution and imply political economic impacts. They have been applied to the traditional telephone network, energy or gas markets. The tariffs are defined by the tariff models or functions. They determine the tariff function for a resource usage.

These functions, pricing functions or tariff functions, are applied in the charging function. They can be modified by discount strategies, rebate schemes, marketing information or any other parameter defined by the service level agreements.

F. Charging

Charging is the 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 [22]. It correlates session records, from the accounting function, and resource usage unit price to generate charge records [27] [4].

Charging acts as an umbrella term for charging options and charging mechanisms. This separation emphasises both the technical and the economic aspects of charging [15]. Some authors refer to charging as billing. Nevertheless, as we will see later on, billing implies some different processes, such as customers' data management [22].

These charge records are formed by the technical quantities of a resource usage and their corresponding monetary units. The records can 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. They define the frequency of cost allocation every time accounting data is received, at regular intervals of time (e.g. daily, each moth or each two moths) or when requested by the charging function. They also define the granularity of the billing function. Granularity is defined as how sub-divided a data field is. For example, a postal address can be recorded, with low granularity, as a single field (address) or with high granularity, as multiple fields (street address, city, postal code, country).

The charging can be distributed between multiple parties as defined in the distribution policy. This policy will split the costs between the different parties or consumers, allocating an already-known cost among several entities [6]. Each party has its own profile that could contain the client pricing function, discounts or special offers.

The consumers can also have different business relationships with the providers. This relation will define the charging mode (e.g. subscribers or pay-per-use).

G. Billing

Billing, or invoicing, is the process of transforming charge records into the final bill, or invoice, summarizing the charge records of a certain time period (usually a month) and indicating the amount of monetary units to be paid by the customer [4]. Fig. 6 shows an overview of the billing function.

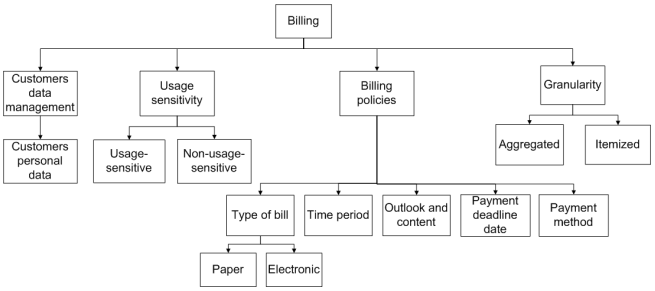

Figure 6. Billing function overview

It may include information about the customer that is gathered from the customers data management system. This

system contains all the customers' personal data. The billing function has also usage-sensitivity when depends on the resource usage of the consumers. On the other hand, a process that is not affected by the resource usage is non-usage-sensitive [6].

There are also billing policies that define the type of bill (paper or electronic), 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 [27].

As charging, billing can also have different granularity. An aggregated bill represents two or more charges together and an itemised bill has all the charges individualised.

H. Financial clearing

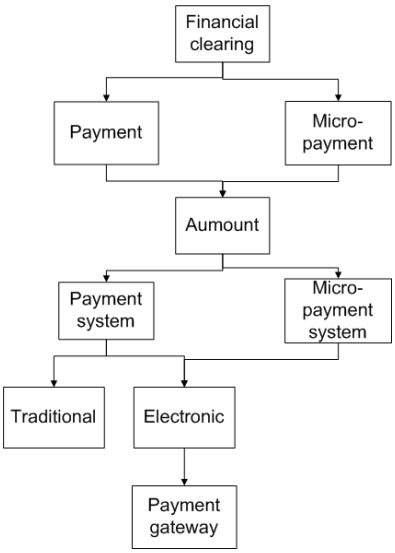

Figure 7. Financial clearing function overview

The financial clearing function includes activities from a commitment for a transaction to its settlement. In the case of resource accounting, this function implies the payment of a bill. Payment is the function of transferring the money of the client to the service provider. The amount to transfer is defined by the bill. Fig. 7 shows an overview of the financial clearing function.

The payment function will use a traditional or electronic payment system. Cash, paper checks and automatic bank clearances are in the group of the traditional payment systems. On the other hand, credit card systems are grouped in the electronic payment systems. This payment function will have a well-defined scheme specifying the way the money is exchanged between all the participants [27] through a payment gateway.

There is also a special type of payment, the micro-payments. These payments have requirements of high speed processing, delivery occurs immediately and in small sums of money. These payments use a specific micro-payment system, that are mainly electronic. A payment system also supports money transfers, which are smaller than the minimal economically feasible credit card payment [5].

IV. Conclusion

In this paper, we introduce a taxonomy of the accounting process. We have detailed all the functions involved in it, looking at all the relationships between them. We believe that the presented taxonomy contributes to the learning, training and assessing in the area of accounting because it gives an integrated vision of the process. As it defines a common vocabulary, it is also useful for the definition of the accounting requirements among different actors.

This taxonomy was defined using a developing method, as described in Section II, ensuring its quality and the maintainability of the knowledge to potential changes.

Further, we proposed an unified and controlled vocabulary that can be use in any operation related with the Internet accounting. The taxonomies have been proved to help to organize content and make connections between people and the information they need [21].

Future works include performing a proof-of-concept of the presented taxonomy by implementing it in an accounting system. Furthermore, this taxonomy defines the pillars for the developing of accounting related applications such as fraud management systems [34] or data profiling [35] among others. We also planned a validation of the proposed taxonomy, using both direct inspection and validation metrics [36] as well as updating the taxonomy itself if there are substantial changes in the area of Internet accounting.

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