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A simple distributed mechanism for accounting system self-configuration in next-generation charging and billing

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ABSTRACT

Modern communication systems are becoming increasingly dynamic and complex. In this article a novel mechanism for next generation charging and billing is presented that enables self-configurability for accounting systems consisting of heterogeneous components. The mechanism is required to be simple, effective, efficient, scalable and fault-tolerant. Based on simulation results it is shown that the proposed simple distributed mechanism is competitive with usual cost-based or random mechanisms under realistic assumptions and up to non-extreme workload situations as well as fulfilling the posed requirements.

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1. Introduction

The charging of customers is an essential aspect of any commercially successful network operation and service provisioning. Charging and billing systems in use today serve up to millions of pre-paid and post-paid customers employing mainly time-based and volume-based tariffs as well as flat rate pricing to name the most prominent examples. Their functioning, however, depends on the accurate, complete and timely collection of relevant resource consumption data caused by user activities in the network. This latter process is called *accounting* and is brought about by an accounting system normally being comprised of a large number of heterogeneous accounting resources (meters, charging trigger functions) distributed in the network and on service-level elements (e.g. gateways, application servers).

In this article we will address accounting systems for use in next-generation charging and billing. In particular how to achieve configurability is considered since configuring and administering the resources of accounting (and charging) systems has always been a work-intensive task. In order to face the ever-increasing complexity we foresee that in the years to come accounting systems require more autonomy and intelligence than the configurability approaches followed so far can provide (cf. [1]). Some examples for such necessitating developments are the fixed-mobile convergence efforts, the advent of a wide range of new value-added end-user services enabled by the deployment of the IP Multimedia Subsystem (IMS) as standardised service control platform combined with the introduction of service creation frameworks, as well as ubiquitous computing endeavours. Next-generation network and service environments therefore add a high level of heterogeneity and dynamicity to the accounting processes.

Besides this increase in system complexity, market saturation is another development in telecommunications networks that is a pressing issue today. Because of fierce competition mostly based on price, operators are facing decreasing average revenues per user. As it is not easy to increase customer bases in saturated market environments, telecommunications companies need to find other means to stay profitable. Common measures are a cut in operational and capital expenditures in particular of network management and operations to which accounting for charging and billing belongs.

For both described developments, adding *self-configurability* to accounting systems, i.e. the capability to automatically and dynamically adapt its configuration to changes in the system itself or its environment, seems a promising approach to handle increasing complexity and to keep costs under control. This autonomic property is an aspiration that is often named today with the aim to ease the burdens of administration and maintenance, to cut accompanying costs and to guarantee a more efficient and reliable operation.

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In the following, we will introduce a novel mechanism for next-generation charging and billing that enables self-configurability for accounting systems (Section 4). After a short overview of related work (Section 2), we will present requirements towards such a mechanism and that we claim our mechanism fulfils in Section 3. Based on a simulation study that we describe in Section 5 and whose results we show in Section 5, we will show that our proposed mechanism is competitive with usual cost-based or with a random mechanism under realistic assumptions and up to non-extreme workload situations as well as fulfilling the posed requirements.

2. Related work

The adoption and implementation of a new system or mechanism is normally a question of balancing the costs and the benefits of doing so. Additionally, external factors like complying with legal requirements or meeting customer wishes and demands can also be important drivers for the introduction of new systems, protocols or applications. In absence of such factors, replacing an existing system by a new one will in general be decided by answering the question whether the new system can provide the same services or functions at a considerably lower cost or allow for relevant new or higher quality of the services or functions at the same cost. In these cases, the existing system is the reference system against which the new system is compared.

However, for the problem that we address, i.e. the enabling of self-configurable accounting systems, neither existing nor proposed solutions exist. In practice, static accounting configurations are still prevalent that are often implemented as part of the respective service's introduction project and are seldom changed afterwards. Additionally, such changes often encompass a larger modification and subsequent testing effort. Research projects that have often built on standardised architectures or solutions of the 3GPP (3rd Generation Partnership Project, c.f. [2]) or the IETF/IRTF (Internet Engineering Task Force/Internet Research Task Force, c.f. [3–5]) with the aim of further development were directed at configurability of accounting and charging solutions but did not go beyond that.

Examples with respect to the 3GPP are the CAB (charging, Accounting, Billing) service [6,7] of the MOBIVAS project (Downloadable Mobile Value-Added-Services through Software Radio and Switching Integrated Platforms), which implements configurability of both accounting and billing components regarding given tariffs as well as the service-oriented and convergent charging architecture [8,9] of the 3GET (3G Evolving Technologies) project which was developed from scratch to reduce the complexity of charging in current mobile telecommunication systems by applying policy-based networking methods to configure all aspects of the system based on tariffs. Regarding IETF/IRTF's AAA (Authentication, Authorisation, Accounting) architecture, we can name as examples the generic AAAC architecture [10–12] of the MobyDick (Mobility and Differentiated Services in a Future IP Network) project, which resulted in a configurable architecture focussing on offline charging and laying emphasis on the transport level and the configurability of the corresponding accounting infrastructure, as well as Daidalos (Designing Advanced network Interfaces for the Delivery and Administration of Location independent, Optimised personal Services) whose A4C (Authentication, Authorization, Accounting, Auditing, and Charging) system [13] builds on the results of Moby Dick by now also addressing service-level charging and by integrating the online charging mechanism.

Because of this lack of a suitable reference system or more precisely of a reference mechanism from our own problem domain that could serve as basis for a performance analysis and comparison, we have decided to take a suitable mechanism from a corresponding area of research and apply it to our accounting problem. This decision is based on the fact that extensive related work that addresses approaches and methods for achieving the self-configuration or self-management of a target system in dynamic and heterogeneous environments can be found in many different areas, for instance in software engineering (adaptive applications, e.g. [14–16]; service-oriented architectures, e.g. [17–19]), in multi-agent systems (e.g. [20,21]), and in resilient networking (e.g. [22]).

As this related work shows, a wide variety of possibilities exists to tackle the problem of configuration or self-configuration of a target system. Regarding the mechanism underlying these solutions, solving an optimisation problem based on the accompanying costs (or benefits) is the technique that we most often found during our review of potential candidates for a reference system. It also represents one starting point of our investigations into charging and accounting system self-configuration that we presented in [23]. We did however not follow it up any further as one of our main objectives was the development of a simple and straightforward way of accounting system self-configuration not requiring an extensive pre-configuration.

3. Mechanism requirements and claims

To allow for a commercially successful operation of networks and provisioning of services in the future, charging and billing solutions will have to be feature-rich. Such a solution allows for a much better addressing of market needs. In particular, individual demand can be met with fitting customer-specific product offers and loyalty programmes, thus preventing customer churn as well as preserving potential revenues by offering a wide variety of services. Note that if too simplified approaches to this topic are chosen, this may lead to 'bit pipe' degradation, customer dissatisfaction and problems with customer protection legislation such as mandatory cost indications. It also becomes clear nowadays that due to finite supply networks, the often advocated flat pricing approach for reducing charging and billing complexities is not the ultimate solution but instead operators look for more differentiated pricing.

Therefore we assume that a feature-rich charging and billing solution will most likely comprise the capability to provide cost transparency, the capability to allow for online charging as part of an online-offline-converged solution, the possibility for an easy introduction of new, differentiated services, functions that provide a synchronisation of different charging processes, as well as the capacity of overall self-configurability.

These features directly impact the requirements of the underlying accounting processes, i.e. the capturing of data about consumption of network and service resources by user activities and its collection, formatting and transfer. Besides the "classical" functional requirements as described in [2,24] or [4] such as correctness, completeness, security, real-timeliness and accountability that are and will remain absolute necessities for using accounting data for charging and billing, also a series of non-functional accounting requirements will be have to fulfilled in order to realise the above-mentioned features of future charging and billing systems.

We therefore arrive at a set of (non-functional) requirements for an accounting system self-configuration mechanism. First, it should be simple, i.e. the administrative overhead required to set-up and operate the mechanism shall be as low as possible without jeopardising the fulfilment of the other requirements towards the mechanism. Consequently, simplicity leads to inexpensiveness regarding the mechanisms administration. Especially, complex parameterisations or the input of detailed knowledge about the accounting domain shall not be required.

Secondly, it should be fault-tolerant, i.e. it should be able to maintain correct service in the presence of faults. As faults, we will

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