Federated Accounting: Design of an Mediation Adapter for Accounting in a Business-to-Business Environment

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Abstract

The liberalisation of the telecommunications industry has resulted in a proliferation of new services and services providers. This is particularly the case in the rapidly expanding IP-based services market. Providers include ISPs, Virtual Private Network (VPN) and application service providers, and backbone operators. The final service set delivered to the customer will result from the combination of these service offerings. From a service usage accounting perspective, this new environment creates a number of important challenges, which did not apply in the traditional monopolistic telecommunications environment. This paper addresses the issue of settlement of usage charges across several service providers when they collectively provide services to customers. The main issue is to develop standardised mechanisms that allow various business and operation support systems operating in various domains to exchange accounting information. The work presented in this paper focuses on the development of a business-to-business (B2B) service provisioning and management architecture to provide guidance to international organisations on the development of a federated accounting management solution. This architecture aims to be both open and adaptable and is based on standardisation work going on in TMForum (TeleManagement Forum), IPDR (IP Detail Record), IETF and ETSI (European Telecommunication Standardisation Institute).

Keywords

Business-to-business environment, service usage charging and billing, federated accounting management.

1. Introduction

Over the last five years, the telecommunications industry structure has changed dramatically. Deregulation has resulted in the opening the telecommunications markets worldwide. The nature of telecommunication networking has also changed because the traffic started to move away from traditional circuit-switched network onto a rather un-structured IP backbone [1]. These major changes have brought to the surface a rapidly growing worldwide B2B e-commerce market.

The IST (Information Societies Technology) project FORM (full title "*Engineering a Co-operative Inter-Enterprise Management Framework - Supporting Dynamic **F**ederated **OR**ganisations **M**anagement")* aims to provide a development framework for the management of this new B2B environment. FORM's main objective is *to engineer an open, adaptable framework to support the Management of an Inter-Enterprise Service encompassing telecommunication facilities and systems by an external provider*. A primary concern in FORM is that such an Inter-Enterprise solution will not take off if it cannot be accounted valuably. Hence, FORM accounting and billing management research area includes:

- Accounting and billing solution in a federated multi-SP environment;
- Solution for equitable cost allocation and revenue (for sharing accounting information, generating revenues and auditing revenue generation);
- Solution for differentiated charging, usage-based, application-specific accounting and billing.

There are two main objectives of this paper: firstly, to identify the principle emerging issues of service accounting in a B2B environment; and secondly, to present an architectural framework for the development of federated accounting management systems for such an environment. The paper concludes by reporting the progress of the research work done so far in the FORM project.

2. Service Usage Accounting Issues

From the point of view of service usage billing, the IP-based networks pose a number of challenges of which service usage collection in a multi-domain environment and SLA and QoS management are the most important.

2.1 Service Usage Data Exchange in an Multi-domain Environment

The IETF group defines inter-domain accounting as "an accounting process that involves the collection of information on resource usage of an entity with an administrative domain, for use within another administrative domain" [4]. Hence, in inter-domain accounting, accounting packets and session records will typically cross-administrative boundaries. In a multi-domain environment there are often different accounting systems employed and therefore different ways of representing accounting information are likely to exist in each domain. Thus, accounting packets and session records crossing boundaries is not a trivial problem.

In a B2B environment, the majority of services are operated across a multi-domain environment and hence B2B accounting systems must support inter-domain accounting. Thus the capture and exchange of usage information for billing purpose is fundamental. In such an environment accounting packet loss, in an inter-domain transaction, may translate directly into revenue loss.

3. Technological Context

This section and Figure 1 place the idea of federated accounting management in the context of the FORM project and existing technology.

The idea of **InterEnterprise Service (IES)** and **IES Provider (or IESP)** form the basis of the federated accounting concept. The IESs comprise of management services supporting dynamic federated organisations performing businesses across IP based Intranet, Extranet or Internet. Examples are SMEs (Small and Medium Scale Enterprise) participating in B2B e-commerce or application service providers (ASPs) and their customers. B2B itself is defined as commerce conducted between businesses over an Intranet, Extranet or Internet (i.e. IP networks). This trade may be conducted between businesses and its supply chain as well as between a business and other business end-customers.

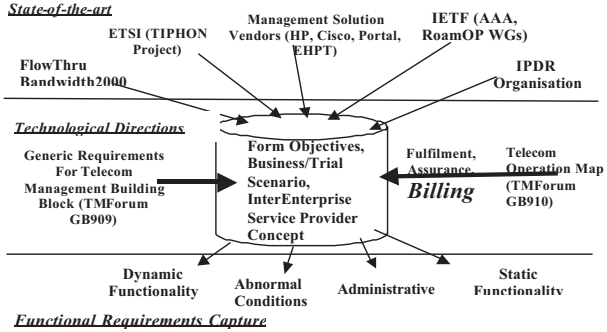

Figure 1: Technological Context for Federated Accounting Management within FORM Project.

As illustrated in the Figure 1, requirements for federated accounting management are derived from previous European research projects (FlowThru, Bandwidth2000) and organisations that are at the forefront of the charging and billing system specification (IETF, TMF etc).

In order to derive and classifying functional requirements, TMForum's TOM (Telecom Operation Maps) [7] and TIM (Technological Integration Map) [6] are used. There are four main classes of functional requirements, namely, static functionality, dynamic functionality, abnormal conditions, and administrative requirements; they are summarised in section 3.3.

3.1 State of the Art

This section briefly reports on the state-of-the-art in charging and billing within industrial and international organisations.

Developing usage accounting solution for advanced IP services is a major challenge. One of the main providers of accounting and billing services for IP based networks are the vendors of equipment, mediation and billing products. The most important vendors are HP, EHPT, Cisco, and Portal. The solutions allow ISPs and Telcos to develop and operate

operations and business support systems. However these solutions tend to be proprietary. Currently, organisations such as IPDR, ETSI's TIPHON (Telecommunications and Internet Protocol Harmonisation Over Networks) projects, IETF AAA WG (Authentication, Authorisation and Accounting Working Group), and TMForum have begun to develop more standardised accounting solutions for the IP services. The most important areas for standardisation is the settlement of service usage charging accounts among several service providers (or to be precise, the exchange of usage and accounting information across the boundaries of service providers' domains). The AAA WG acknowledges that the application services, which are in use and being developed, are diverse and therefore managing them will require various a set of standardised accounting management protocol and services [8] [9].

IPDR Organisation

The IPDR (www.ipdr.org) organisation is an industrial consortium, which has been founded by some of the prominent vendors providing management solution for IP-based network. Members include Hewlett-Packard, Oracle, Portal, Sun, AT&T, Amdocs, Compaq, XACCT, Aptis, Andersen Consulting, CableData, Clarent, Narus, Savera, and TeleStrategies. The purpose of IPDR organisation is to define the essential elements of data exchange between network elements, OSS (Operation Support System) and BSS (Business Support System). The definition will provide the foundation for development of open, carrier-grade IP support systems that will enable next-generation IP networks to operate efficiently and cost effectively.

For the specification of interfaces between OSSs and BSSs, IPDR organization has adopted the core functional roles and interfaces that TMF's Telecommunications Operation Map (TOM) has identified [7]. The specific goals of IPDR organisation are as follow:

- Define an open, flexible record format (the IPDR record) for exchanging usage information.
- Define essential parameters for any IP transaction.
- Provide an extension mechanism so network elements and support systems can exchange optional usage metrics for a particular service.
- Provide a repository for defined IPDRs.

Analysis

Frameworks and recommendations (a prime example of which is TMN, or Telecommunication Management Network) that have been produced by telecommunications standardisation work have allowed telecom industry to categorise management functions by logical layers (business, service, network and element) as well as functional areas (fault, configuration, accounting, performance and security). However, IP-based networks do not benefit from any such functional architecture and there is a lack of a concerted effort toward methodologically applying the TMN framework to IP-based networks. The projects mentioned in this section have taken strides towards applying the TMForum framework to IP-based networks. There are still outstanding issues that need to be addressed in the light of B2B service provisioning and usage environment. In this rapidly growing environment, enterprises set up inter-enterprise relationships and outsource their communication and

management needs to a B2B communication service provider (that is, inter-enterprise service provider).

Service provisioning and billing management must be augmented with tools that assure the QoS and handle SLA. Concerns for both of these issues tend to be high in B2B environment. Thus, it is important to develop an open and standardised framework that allows various BSSs and OSSs operating in domains to exchange service usage and charging information. The research work presented in this paper benefits from the results of standardisation task going on in TMForum, IPDR, IETF and ETSI in order to tackle this issue. Most importantly, TMForum's core charging and billing functional roles [7], and IPDR organisation's specification [10] and IPDR XML Schema are used. The initiative in the area of federated accounting aims to contribute to IPDR and TMForum specifications by providing the two organisations with the result of implementations of their specifications.

3.2 Functional and Technological Direction

As illustrated in Figure 2, the charging and billing business process that this paper targets is described in the context of the FAB (Fulfilment, Assurance, and Billing) of TOM (Telecom Operation Map) [7]. Figure 2 is based on an original version of FAB figure that has appeared in [7]; various aspects of FORM project have been added to original FAB figure and illustrated in Figure 2. IPDR XML Schema [10] is used to model and specify elements of accounting information that are exchanged between various business processes, operating in IESP and third-party SPs domains.

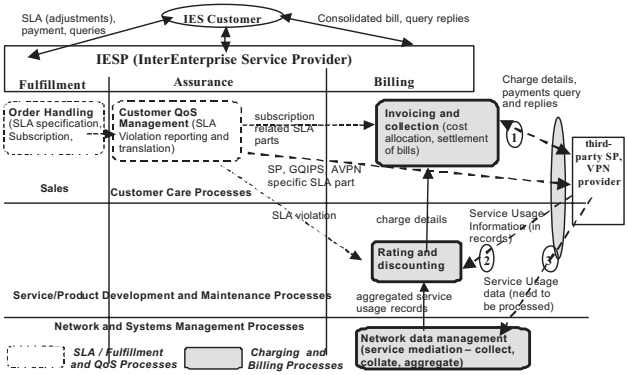

Figure 2: Charging and Billing Business Processes.

Figure 2 also illustrates a scenario where an Inter-Enterprise Service Provider (IESP) manages the outsourced B2B services for a customer. These services are provided by a number of third-party service providers (third-party SP) and a VPN provider. The role of the IESP is to monitor the service usage and produce an integrated service bill to the customer. The charging and billing business processes are divided into three sub-business processes.

The functionality of each sub-process is dependent on OSS third-party SPs use. The third-party SP and VPN provider can use at least three types of mediation, charging and billing management service from the IESP, depending on type of OSS. The three types of accounting management service are described below.

Consolidated Billing (Dotted arrow 1 in Figure 2)
VPN and third-party SP use OSSs to do full-fledged processing of charge for the services that customers use. They forward details of the charges (or bills contents) to IESP, who consolidates bills, allocates the charges, and returns the payments. The accounting information (e.g., the details of service usage and charges) that is exchanged among IESP, and VPN and third-party SP is specified in form of XML Document.

Rating, Discounting, and Consolidated Billing (Dotted arrow 2 in Figure 2)
VPN and third-party SP use mediation OSSs to produce service usage information in form of IPDR documents and forward their service-specific IPDR documents to IESP, who processes the document with rating and discounting management processes. Consolidated bills are sent to customers and payments are returned to VPN provider and third-party SP. Information exchanged between VPN provider and third-party SP, and IESP are service usage records (SDRs) in a standardised format.

Service Mediation, Rating and Billing (Dotted arrow 3 in Figure 2)
VPN and third-party SP use OSSs, which do very little information processing (e.g., collecting usage data from application servers), and the rest of mediation, charging and billing task is left to IESP. IESP does the service mediation and produces records (e.g., XML document) of service usage, applies rates and finally prepares consolidated bills. Bills are sent to customers and payments are returned to VPN provider and third-party SP. Information exchanged between IESP, VPN provider and third-party SP is service usage data, in the form that is typically fed into the service mediation process.

Having studied the state-of-the-art and taken directions from TMForum, the following subsection summarises the main functional requirements for federated accounting.

3.3 Functional Requirements

The functional requirements for the federated accounting system are mainly derived on the basis of the TMF TIM (Generic Requirement for Telecommunication Management Building Block) framework [6]. The following summarises the main requirements.

Static Functionality Requirements
Usage Information: Accuracy of service usage data must be maintained while exchanging usage data at all interfaces. For detailed charging and cost allocation, granularity of usage data must be high.
Requirement Specification and interfaces definition in a standardised specification language (e.g. use case and component diagrams created using UML).

Dynamic Functionality Requirements

Combination of charging schemes and tariffs: An IESP must be able to apply a combination of two or more charging schemes and tariffs. Customer can be charged at flat rate but only to a limited usage period. Any usage that goes over a limit can be charged at a rate. Therefore service provider should be able to ascertain: (1) The *features* of a service that are prone to be over-used; (2) The *manner* in which they over-used; and (3) The *time* when they can be over-used. An IESP should also be able to charge different services at different rates on the basis of usage.

Charges allocation: In cases of several enterprises forming a closed group and using a service, the charging and billing service must use customer information to distribute the total charges incurred among several end-users. For example, charge allocation scheme is most apt in multiparty video conferencing sessions.

Exchangeable usage record format: In order to support charging and billing in an federation SP environment, the IESP must be able to make use of usage record format that is exchangeable. The following requirements must be met: (1) syntax and semantic of record format; (2) translation mechanism for converting usage record from a service-specific format into one which is exchangeable; (3) consistency of the record format; and (4) availability of the record format to all service providers who operate in a federated environment.

SLA between IESP and customer: SLA at this level should specify the terms and conditions of the usage of the service and the level of QoS that IESPs are to maintain through out the period during which service is provided.

SLA between IESP and a third-party service provider: SLA at this level should specify the terms and conditions of the charging and billing service that IESP is to provide to VPN provider and third-party SP.

Abnormal Conditions

Detection of abnormal usage session: A usage sessions that violates the terms of SLA must be detected. If users need to use a service in an unbounded session, access to services should depend on quotas and credits they have.

Prevention of service overuse: The billing services are expected to meet the requirements of financial and legal regulations of an organisation. If charges of a service usage are high and run up quickly, it is essential to have real-time accounting to prevent users from overusing the service.

Limiting service usage: IESP should be able to limit service usage. For example, a limited number of customers should be allowed to connect to a service simultaneously.

Administrative

The system must be extensible and must allow an administrator to extend the functionality to measure the usage of new services. It must be possible to define service-specific extensions and new standard-specific and vendor-specific attributes.

4. FORM Architectural Framework

Figure 3 illustrates the model of the FORM billing business process. The main players are IES Customers, an IES Provider (IESP), a VPN Provider, a GQIPS (Guaranteed QoS IP Service) provider, and a third-party SP.

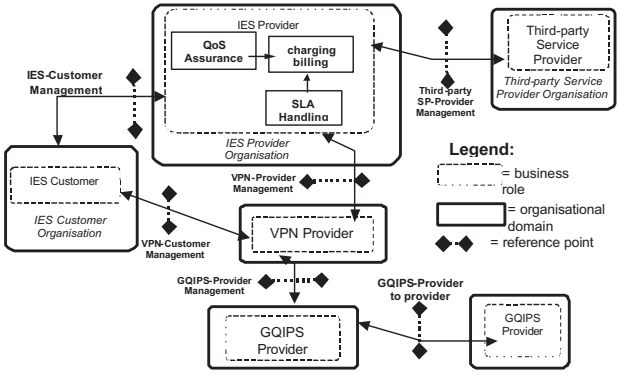

Figure 3: FORM Business Model for the Federated Accounting.

Seen from the perspective of accounting and billing functionality, it must be noted that IESP, VPN Provider, GQISP, and third-party SP may operate OSSs to carry out a range of tasks (from service negotiation and aggregated usage record generation, to full-fledged billing).

IES customer receives bills from IESP, and this bill includes the charges incurred from using application service. In this case, the role of IESP will be four-fold: (1) negotiate between one or more third-party SPs and the customer; (2) maintain customer SLA; (3) settle the charges amongst third-party SPs, VPN Provider, GQIPS, etc., for the services that they provide; and (4) bills the customer.

Third-party SP and VPN Provider may have their own OSSs and the functionality of such OSSs may range from service mediation to full-fledged charge processing. Hence, there can be various ways by which third-party SP and IESPs can co-operate. It will depend on many aspects such as level of detail of information they can exchange, inter-operable interfaces, and type of B2B relationship between third-party SP and IESP (specified in SLA).

The federated accounting in FORM is based on the idea of inter-domain accounting in which two domains exchange accounting information in form of XML-based IPDR documents for the settlement of charges. For example, an IESP and third-party SPs settle service charges by exchanging accounting information, which can be service-specific usage data in IPDR document.

This form of inter-domain accounting can be considered federated accounting, where federated accounting depends on the definition of the inter-operable interfaces and accounting information to be exchanged between IESP and third-party SP.

4.1 Example Architecture of Federated Accounting Management

An example architecture of federated accounting management solution is given the figure 4 (FORM Project Trial 1) and main building blocks of the architecture are described below.

The Billing group used it for the implementation of two services: MediaShop and Mediation Adapter. The following picture gives an overview of the components of Trial 1:

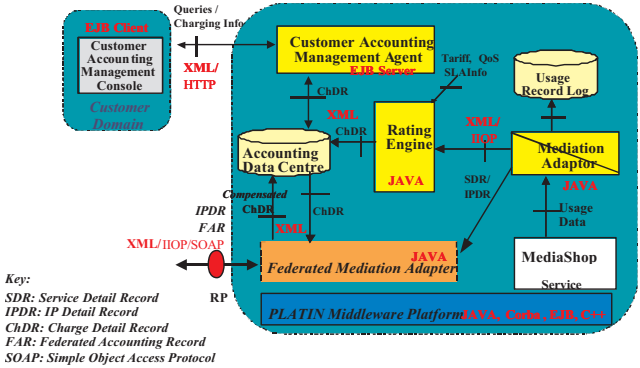

Figure 4: Accounting Management Trial-1 Overview

Middleware Platform

The middleware platform forms a processing environment for an open service market into which distributed applications can be managed, launched, and executed. This environment envisaged by TINA (telecommunications information networking architecture) [15] [16] [17] comprises heterogeneous and interconnected DPE (distributed processing environment) nodes that fulfil mainly two purposes: they hide technical and organisational heterogeneity, and they present a target system that can help to ease the tasks for application designers.

The middleware platform helps to decouple applications and the systems necessary for their support, such that both can be developed and evolve in different time lines. Also, organisational heterogeneity is not only caused by globalisation, but also by deregulation enactments enlarging the number of players on an open service market.

Mediation Adaptor Service

This component is a service based on the Platin Platform. Its main functions are usage data collection (polling or event-driven) and applying statistical methods (aggregation, correlation, collation). This manages any service usage data collection and provides the rating engine with corresponding SDRs.

This component collects usage data from other services (e.g., VoIP or MediaShop Service) and feeds the data (an standardised record format) into the Rate engine. The records are converted to a format that is suitable as an input to rating. The SDR typically contains the

session-id, user id, service-Id and service type, and the actual usage attribute values (usage duration, usage session begin-time and usage session end-time, etc).

MediaShop Service
The MediaShop service is a example content driven service which allow customers to store multimedia documents in any form. It is based on Oracle technology, completely web based and implemented as a service of the Platin Platform. If a user accesses the service, e.g. downloading some content, MediaShop will inform the accounting system of the type, size and access time of the downloaded content.

Rating Engine
It applies unit charges (different usage measurement units are used for different services), and tariffs (different tariffs are used for different QoS levels), on SDRs that it receives from service mediation. Charges are calculated (calculation formula, usage attribute values, etc.) and discounts are applied on the basis of SLA violations.

Federated Mediation Adapter Service
The federated mediation service facilitates inter-domain accounting between an IESP, VPN provider and third-party SPs. In order to calculate the charges for end-to-end service usage that takes place in the domains of two or more autonomous SPs, accounting information in form of FAD (Federated Accounting Document) is exchanged. In order to meet the requirement of federated accounting, authors have extended IPDR XML Schema by adding *CE* (Charge Entry) to current IPDR Schema V.2 and have used the extended Schema for the representation of usage data, charge, and SPs specific information. The federation mediation service distinguishes service usage information that is produced within one domain from the usage information that is produced in another domain. It routes the usage information to the IESP accounting system that wants to calculate charges from the usage. Futhermore it can collect and aggregate IPDRs from different domains to provide a combined IPDR document resulting of same contexts (e.g. usage of a federated service) and passes the result document to the rating engine.

Conclusion and Results

The research work described in this paper aims to develop and evaluate a federated accounting management architecture to support charging and billing of application, communication, and information services.

Based on the FORM architecture developed in the project phase one, a prototype of the following accounting and billing management services is being developed:

- Charging and billing management in a multi-SP environment;
- Management service for differentiated, usage-based, application-specific charging and billing;
- Management solution for equitable cost allocation and revenue (for sharing accounting information, generating revenues).

The main conclusion is that the principal contract (AcctMediation in Figure 5) between two principal building blocks (Mediation Adapter and Rating Engine) have successfully used a standard-based and implementation-independent information model.

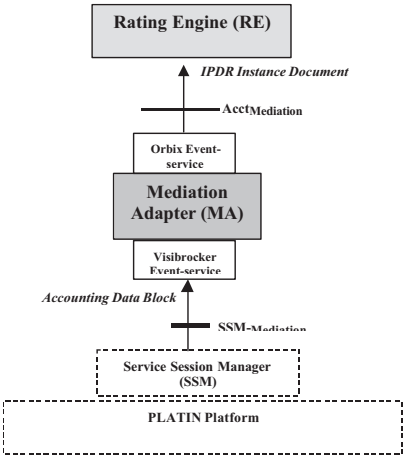

Figure 5: Building Blocks Using IPDR Instance Document

It is based on XML Schema Candidate Recommendation. XML Schemas are definitely far more complicated than DTDs but are richer and flexible in expressing a comprehensive vocabulary of accounting management. The idea behind IPDR specification is that service providers can take the skeleton of the IPDR schema and extend it to meet their requirement. FORM project has successfully done it.

The interface is kept simple because more complex structures, which are normally defined in IDL, are now defined in XML. XML instance documents still need to be parsed by a DTD. Exception should be send via CORBA when XML documents is invalid or not well-formed.

The ANY IDL types are not needed because XML types achieve the generic nature of AcctMediation contract. Use of XML Schema has yielded the following benefits:

- The integration of building blocks proved to be fairly easy and quick.
- The main contract is fairly simple but robust. Two different ORB versions (i.e., Orbix and Visibroker, shown in Figure 5) have been used without any problem; this is due to a simple and robust contract.
- Changes in the interfaces are simple because one needs to change the XML instance document and the DTD but not the CORBA interface. One does not need to recompile or generate new Java stubs and change the overlaying code.

The research work has so far developed a business model, a trial scenario, main use cases, and a preliminary information model. The results of the development of the current architecture will be used to improve the architecture in a second phase of FORM project.

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