White Paper:

Federated Accounting Management of Service Usage in a Business-to-Business Environment

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ABSTRACT

This white paper reports on the progress and achievements that has been made in the area of federated accounting management since the beginning of FORM project. Thus far, an architecture of federated accounting management system and information model has been design and specified using UML and XML. These both aim to be both open and adaptable, and are based on concepts and recommendations laid down by TMForum (TeleManagement Forum), IPDR (IP Detail Record), OMG (Object Management Group) and IETF organisation. The functionality supported includes federated mediation, charges aggregation and settlement for the services provided, online bill querying. The architecture is composed of reusable components, which are being implemented using state-of-the-art technologies and being specified.

As a part of FORM project, a prototype providing essential features of federated accounting management has been implemented, evaluated, and demonstrated.

KEYWORDS

Business-to-business service provisioning, billing business and operations processes, automation, building block, contract, composite services, accounting information model, usage-based charging, differential tariffs, NGOSS, federated accounting management, SLA and QoS provisioning, XML, IP-based services.

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1 Introduction

The telecommunications and service provisioning industries have been going through a liberalisation process and the use of IP-based services has proliferated in a number of business sectors. Demands of e-businesses have also lead to rapid innovation in user services and services providers have begun to provide new services in a B2B environment. The emergence of the B2B market has influenced the way services are provided, charged and billed. An important feature in this development is the usage of services that can composed from several types of services provided by ISPs, Virtual Private Network (VPN) and application service providers as well as backbone operators. In this environment, SPs face two important challenges. Firstly, how can services be operated and QoS maintained across multiple administrative domains of SP? Secondly, how to generate a service bill that integrates the charges for the various services of which a composed service is comprise? These challenges manifest themselves in a number of ways. For example, new types of B2B interactions mainly at the levels of service provision and service operation management have emerged. New requirements in the areas of customer support, maintenance of Quality of Service (QoS), revenue generation, charge settlement and billing have also emerged. SPs have also acknowledged the emergence of a new stakeholder to the existing business model. Within FORM project, this new stakeholder is called inter-enterprise service provider (IESP).

The IESP can function as a portal to a wide array of services (single or composed) and can form a customer base for the service provider. It can also function as a service retailer or as a specialised service provider who composes new services on customers' demand and deal with the customer queries and bills on service providers' behalf. This role of IESP adds a new dimension to the business model and activities, which is outsourcing of operations management. Outsourcing is proving to be effective in businesses because operations management is increasingly becoming a specialised and automated task and requires management services that may be provided different types of tools and technologies. Many small-to-medium size enterprises (SMEs) do not possess the resources to indigenously capture every management service that they require. Therefore, they may find it more economical to outsource their management service needs to IESP. SMEs may prefer to concentrate their resources and expertise on their core competencies, which is, developing new services.

The core management services that SPs require involve customer support, and management of service quality and charges and settlement. The IESP plays a crucial role in providing them where it deals with customer queries and establishes SLAs on behalf of SP and informs the customers of the quality of service they can expect to receive. It also contacts the SPs and inform them of customers' requirements and establishes service provisioning contracts on behalf of the customers. These service provisioning contracts can assure conformance to SLAs for the consumption of their respective services. Lastly, it calculates the charges for the service usage and settles the charges amongst SPs if they collectively provided the service and presents the bill to the customer.

Outsourcing and its benefits: The accumulated impact of this on all stakeholders involved in this B2B activity is significant and can be seen as improvement in stakeholders' expertise in their niche market and greater customer satisfaction. The IESP abstracts the operation and infrastructure costs of customer care, service quality management, and billing away from the service provider. This allows the SP to concentrate their resources on their core competencies (service provisioning), while also enabling the SP to deliver their service at a lower cost, which benefits the customer.

Present day billing systems are not able to cope with the complex billing methodologies for these next-generation network services. It is acknowledged widely that it is through its billing system that a business communicates with its customers. Furthermore, optimising billing is a crucial service differentiator in a liberalised telecommunications industry and has become a vital parameter for the survival of service providers. Hence, an integral attribute of any IESP is the ability to perform federated accounting and it is envisaged that such an Inter-Enterprise solution will not take off if it cannot be accounted valuably.

The rest of the white paper is organised as follows. Section 2 presents the concept of the federated accounting management. Section 3 presents a summary of the reports on relevant work. Section 4 describes the business context and requirement. Section 5 briefly describes how FORM Open Development Framework has been used for the development of federated accounting management system. Sections 6 and 7 present the federated accounting business model and reference architecture. Sections 8 and 9 present the system analysis model and federated accounting information model. Section 10 describes the federated accounting system architecture in details. Section 11 outlines the technology used to implement the system architecture. Sections 12, 13, and 14 discuss the lessons learnt, results of system evaluation, and future work. Section 15 concludes this white paper,

There are three Annexes provided to supplement the discussion given in the main part of the white paper. Annex A contains the full report on the relevant work. Annex B provides a comprehensive list of requirements that were capture during system analysis phase of FORM project. Annex C present a detailed description of use cases that were implemented in federated accounting management trial system.

2 Federated Accounting Management Concept

Before the development of the concept of federated accounting management could be described, the concept itself is introduced briefly by describing its main characteristics.

Distribution of operational processes and interdomain reference points: This means that service mediation, rating, and billing processes are distributed and well-defined interfaces exist between them. These processes may also be distributed in multiple domains where well-defined interfaces may exist at the boundary between domains. These interfaces are called reference points and mark a boundary between domains.

The processes mentioned here are already widely known through the Telecom Operation Map or TOM guidelines in which they are parts of the Billing process [TMForum GB 910]. Interfaces between processes have also become known through the work of IPDR Operational Model [IPDR NDU-M 2.6]. However interfaces at boundary between domains are still not covered in detail and require research. This white paper describes the purpose and functionality that is required to support the reference points in federated accounting management. Reference points are described in the section dealing with Reference Architecture (see section NN).

Inter-working of Fulfilment, Assurance and Billing Processes: In addition to Billing process, TOM includes Fulfilment and Assurance processes. These three processes take part in so-called end-to-end process flow. Although Fulfilment and Assurance are separate processes in their own right, they co-operate with Billing process. The purpose of co-operation is to enable the service provider to apply different tariffs for different types of subscriptions or QoS provided. In these scenarios, Fulfilment provides Billing with SLA information whereas Assurance provides QoS information.

A *wider* view of accounting information: Accounting information should not be regarded as merely usage data that is generated by routers and application servers as a result of usage and ready to be fed into a rating facility. Federated accounting management holds a wider view of accounting information. In this wider view, charges that are calculated form usage are also regarded as a part of accounting information that is exchanged between service provider. IPDR organisation is working on a standardised information model of usage data. However, IPDR's work is confined to producing standard specification of usage data [IPDR NDU-M 2.6]. The concept of federated accounting management complements the work of IPDR organisation by providing rationale and specification of charge details as a part of accounting information (see section titled Federated Accounting Information Model NN).

Use of differential tariffs: Charging model uses of tariffs that can vary with customers types, QoS or any other factor that service provide choose to use.

Charge Aggregation and Payment Settlement: In federated accounting management several third-party providers collectively provide their services or contents to the customers or contribute to a large composed service. A retailer or broker acts on behalf of both customer and third-party providers. It aggregates charges and invoices the customer for all the services used; a single invoice is sent to the customer. The retailer also receives payments from the customer and does the settlement for all third-party providers. This work is being addressed in eTOM [eTOM].

3 Relevant Work

This section presents a summary of the reports on the works that are relevant to the federated accounting management. Full report can be found in the Annex.

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. Some of key 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 divers and therefore managing them will require various a set of standardised accounting management protocol and services [IETF IntroAM-05-2000] [IETF Attr-04-2000].

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, the IPDR organisation has adopted the core functional roles and interfaces that TMF's Telecommunications Operation Map (TOM) [TMF GB910] has identified. The main goals of IPDR organisation are [IPDR NDU-M 2.6] to define an open, flexible record format (the IPDR Schema) for exchanging usage information and essential parameters for any IP transaction.

The objective of TIPHON project is to standardize voice communication (e.g., telephony) over the Internet. As part of overall TIPHON specifications, ETSI is also working in the area of requirements for service interoperability, technical aspects of charging/billing and security [ETSI TR 1.1.1], [ETSI TR 1.4.2].

The purpose of the Bandwidth 2000 project was to facilitate the introduction of on-line accounting, ordering, billing, and brokering of Internet services that support telecom market place [INC 2000]. The goal of FlowThru project [FlowThru-D3] was to provide the industry with a concrete guidance for building an optimum solution to specific management problems from the wide range of architectural and technological approaches that were available from bodies such as the ITU-T, ISO, TMForum, TINA-C, OMG, ETSI and EURESCOM [FlowThru-D3].

3.1 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 [TOM-GB910], and IPDR organisation's specification [IPDR NDU-M 2.6] 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.

4 Business Context and Requirements Analysis

The diagram below shows the business environment for which FORM is developing solutions. The Inter-Enterprise Service Provider (IESP) ensures that the customer has access to a variety of services that it needs and that are provided by a variety of service providers. The IESP, as the customer-facing service provider, is responsible for the order handling, SLA and tariff negotiation, customer care and accounting aspects of the services offered to the customer by the IESP's partners in the value chain.

The service providers in the FORM scenario must be able to account for service usage and charge accordingly.

These details are then sent to the IESP, who incorporates the various inputs by means of rating processes and provides a consolidated bill to the end customer. In order for interaction to occur between the service providers, a standard information schema and a set of standard interfaces, that all parties can support, are required. FORM has adopted the IPDR Master schema as the basis for its information model and has enhanced it to meet accounting management requirements.

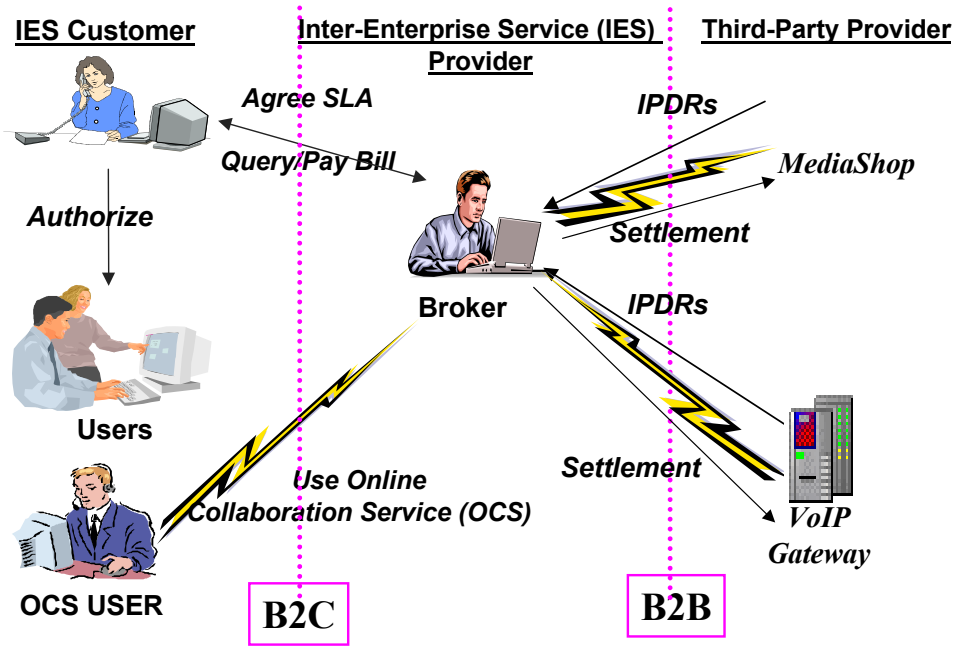


Figure: Federated Accounting Management Business Context

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 [TMF-GB909]. The following subsections summarise the main requirements.

4.1 Business Operation Processes

As illustrated in the figure given below, the federated accounting management process and activities 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 [IPDR NDU-M 2.6] 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. **In the figure given below, Bills refer to Customer Bills and Invoices refer to Settlement Invoices**

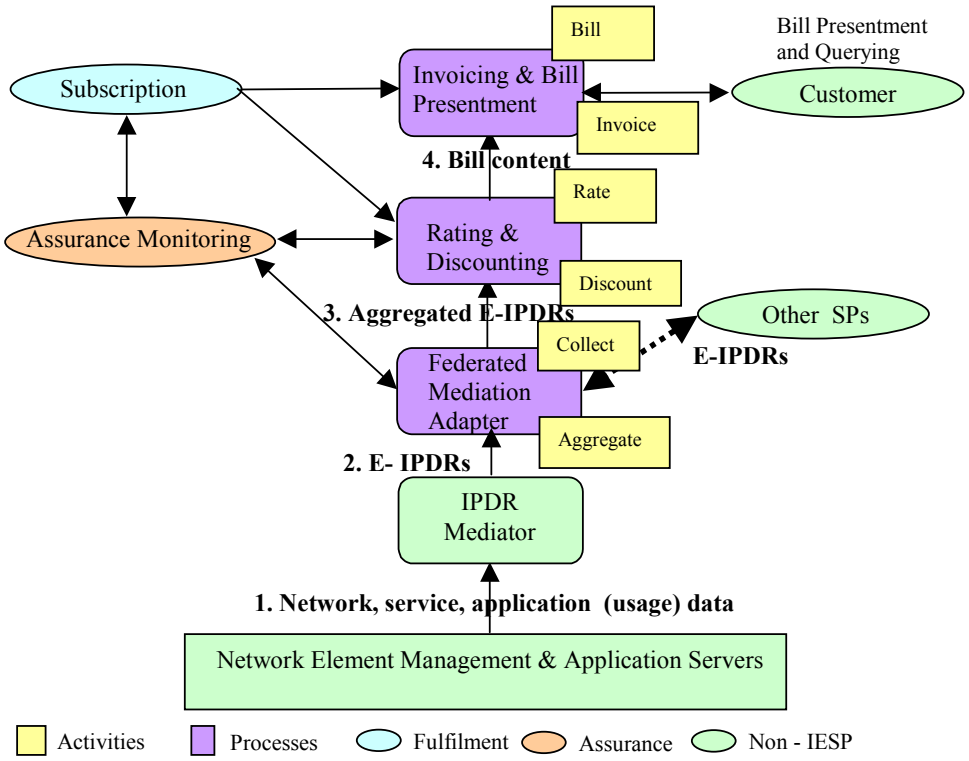


Figure : Federated Accounting Management Process

4.2 Static Functionality Requirements

Usage Information: Accuracy of service usage data must be maintained while exchanging usage data at all interfaces. The IESP should have control over the granularity of service usage data. For detailed charging and cost allocation, granularity of usage data must be high so that accurate information can be extracted from service usage records.

Specification or requirement and definition of interfaces (or contracts, as they are termed in [TMF-GB909]: The interfaces must be specified in a standardised specification language. Requirement must be specified using a standardised notation scheme. Developer must be able to trace back the source of contracts to use case and component diagrams that are created using UML notations.

4.3 Dynamic Functionality Requirements

Combination of Charging Schemes: An IESP must be able to apply a combination of two or more charging schemes. Customer can be charged at a flat rate but pricing a service is determined by the network technology that a customer uses to access the service.

Customer can be charged at flat rate but flat rate is applied to a limited usage period. Any usage that goes over a limit is 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 are prone to be over-used; and (3) **The time** when they are prone to be over-used. An IESP should also be able to charge different services at different rates on the basis of usage. Service charges may be calculated on the basis of the following broad factors: (1) Features of services offered (the parameters of services) that providers use to calculate charges; and (2) customer needs.

Charges allocation and payment settlement: In cases of several enterprises forming a closed group and using or providing a service, the charging and billing service must use customer information to distribute the total charges incurred among several service provider.

Exchangeable Usage Record Format: In order to support charging and billing in an environment in which service provider form a federation and operate, 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 exchangeable record format; (2) translation mechanism for converting usage record from a service-provider-specific format into one which is exchangeable; (3) consistency of the exchangeable service usage record format; and (4) availability of service usage record in an exchangeable format from 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 application service that IESP is to provide and customer is to receive. In a SLA, customers and IESP agree on the level of QoS that IESPs are to maintain. Customers expect to receive that level of QoS through out the period during which they use services.

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 ASP.

4.4 Abnormal Conditions

Detection of Unusual Accounting Session: Unusual usage sessions 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. Usage accounting should be completed within a defined time window.

*Limiting Service Usage***:** IESP should be able to limit usage of service by following means:

Customer: Only customers are allowed to use a service that is not available for free.

Limited Customers: Limiting the number of customers who have access to the application or service.

Number of concurrent end-users: A limited number of customers are allowed to connect to a service simultaneously.

Application capacity: The application providing the service can be configured to attenuate the usage.

4.5 Administrative

Principal computing overheads involved: Charging and billing operation must not incur data processing overheads, which are mainly due to measuring usage, maintenance, and security.

Extensions to accounting and billing system: 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.

4.6 Summary

In summary, the federated accounting work addresses the following functionality requirements:

- The capability to deal with increasing levels of complexity in usage-based charging and real-time response levels.

- Support for convergence of services (e.g., voice and data)
- Adaptable federated service mediation facility
- Support for a variety of OSS and service value chain
- Charge detail aggregation of composed services
- Automated inter SP domain accounting and settlement
- Interaction with legacy billing systems
- Increased demand for guaranteed QoS and related discounting
- Rapid service deployment

A complete set of user, functional, and administrative requirement that were captured during requirement analysis phase of FORM project are listed in Annex (see also [FORM D2]).

5 Application of FORM Open Development Framework

The development of federated accounting management system uses guidelines that were developed as a part of FORM ODF.

Logical Architecture: Used for an abstract description of the Framework users and a meta-model integrating various structural elements.

Development Methodology Guidelines: They have been used for the construction of federated accounting management components (or building blocks) and for the implementation of federated accounting management business processes. The business process is orientated towards eBusiness service market. It is based on industry guidelines (TMForum and IPDR) and specified using technology-neutral methodology and UML. Building blocks and contracts are adaptable and specified in UML (see section). Requirements are presented for the development of reusable building blocks, which are based on those currently being examined in the TM Forum.

Technology Architecture: This is used as a guide to bind technologies to the BB and contracts of the federated accounting management architecture.

Reference Architecture: As part of the Open Development Framework a high level business architecture is introduced to help in the refinement and definition of open segmented reference points between different business roles relevant to the problem domain of federated accounting management.

Reusable elements: These are specification and software items that conform to the logical and technology architecture, and methodology.

6 Federated Accounting Business Model

This section presents business use case for federated accounting management system and identified the main actors. A business model is also presented.

6.1 Business Use Case Model

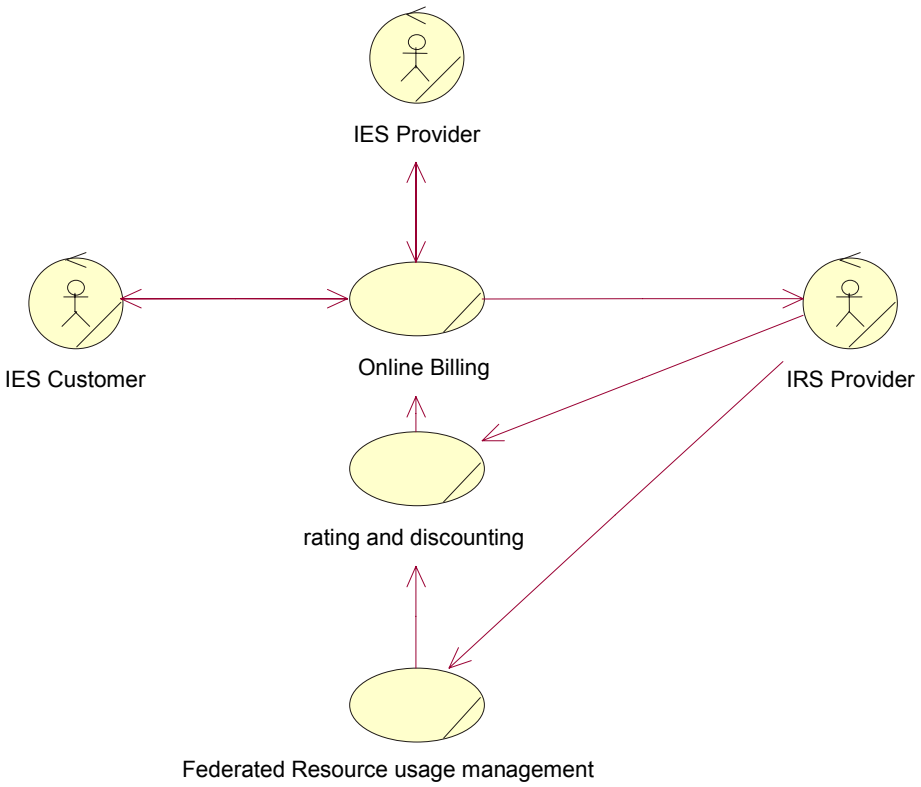


Figure 1 Federated Accounting: Business Use Case Diagram

The business case is centred around the idea that the customer are provided packages of useful services for which they pay a single consolidated bill. The bill is for all services that make up the service package. Irrespective of the location where the service is used and the service provider who provides the service, the customers may want to see a single bill for all the services they use.

Business customers, who travel frequently and use different types of services for personal and business use, will definitely prefer to receive and pay a consolidated bill of all services that they use. Customer expect that service providers providing various sorts of services and operating is different zones will settle within themselves all the charges for services that they all provided and customer. The customer will be presented with a final consolidate bill.

Business driver for this federated accounting management process is that a greater aggregation of services and service packages that can be billed as single service simplifies the charging process and in particular makes business much easier for the customer. Aggregation also helps the service providers by allowing for differentiation based on service packages. The winners will be those service providers who can identify useful services that can be packaged and can be offered on a subscription to customers.

Three main business actors can be identified in the federated accounting management business use case:

- *IES Provider:* A role that maintains relationships with a number of third-party SPs for providing services to the IES Customer. IES Customer subscribes to IES Provider and pays for the services.
- *Third Party Service Provider:* A role with which the IES Provider must collaborate in order to provide the services required by the IES Customer.
- *IES Customer:* A role that uses and pays for the service provided by third-party Service Provider.

6.2 Business Object Model

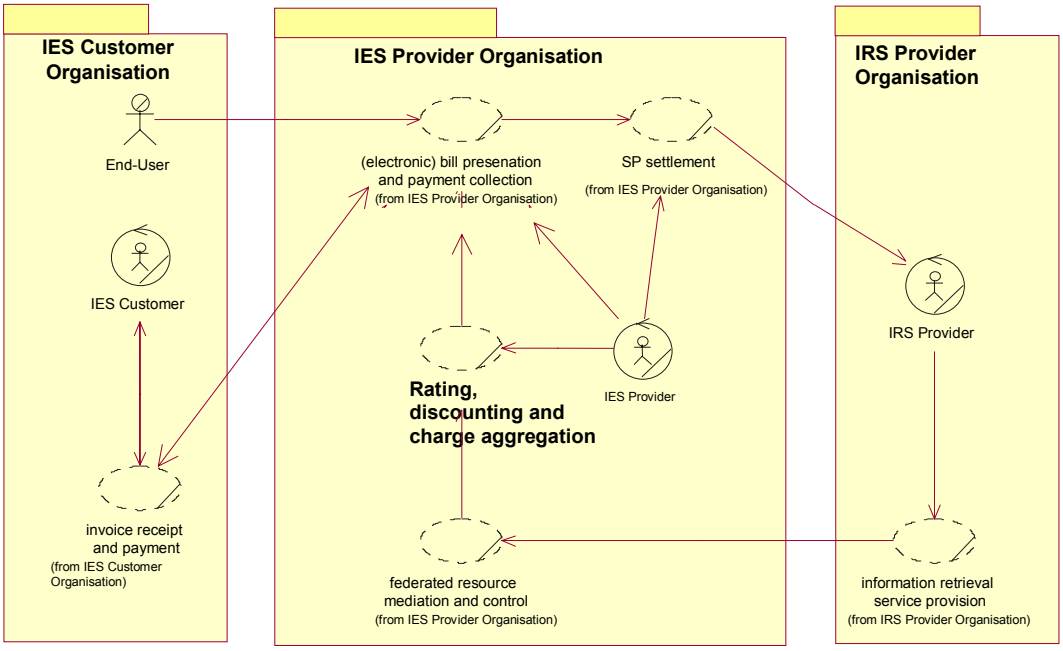


Figure: Business Object Model of Federated Accounting Management Business Process

6.3 Actors/Stakeholders

Business Worker	Description
End-User	A person who uses Inter-Enterprise service. End-user may be a private user or he/she may work for the IES Customer.
IES Customer	A business (organisation) or a private customer. The subscriber of Inter-Enterprise Services. IES Customer negotiates and signs a SLA with the IES Provider. It receives and pays bills for serviced used. It also validates, checks against the records, and controls the usage of service.
IES Provider	It provides communication, application, and information services, through third-party SPs (ie, IRS Provider). IES Provider performs the task of charging and billing of service usage and charge settlement the among IES Customer and third-party SPs. IES Provider acts as a service retailer and maintains contracts with third-party SPs. IES Provider also negotiate, finalise deals between IES Customers and third-party SP, and do final settlement (final bills, etc).
IRS Provider	A third-party SP that provides information or multimedia services (video or VoIP teleconference).

7 Federated Accounting Reference Architecture

This section presents the federated accounting system reference architecture, the system boundary definitions and a decomposition of the system into logical subsystems containing building blocks.

The relationships between these processes and the other business roles (via reference points) is outlined in Figure NN. Note that this figure show only federated accounting management business processes. It is a snapshot of the federated accounting aspects of the IES Provider system.

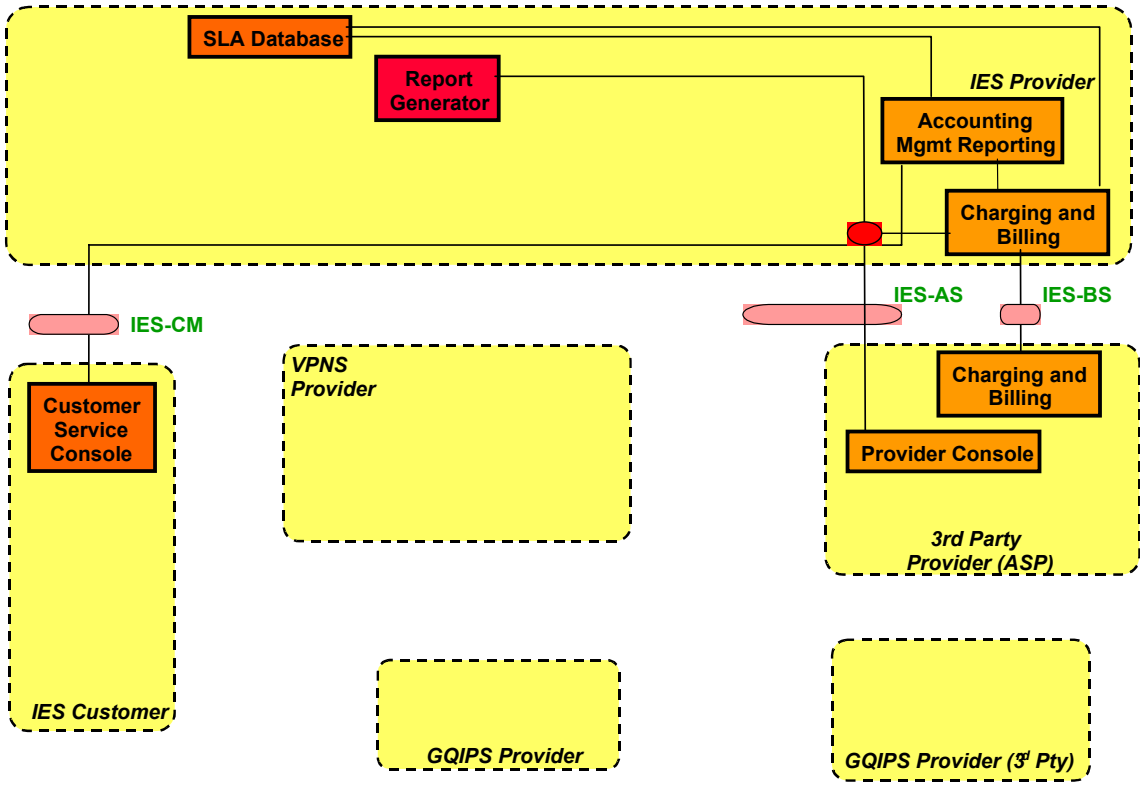


Figure: federated accounting management system within FORM Reference Architecture

Reference architecture contains two main reference points: the **IES-BS** and **IES-CM**. These serve two purposes:

1. They represent the boundaries of federated accounting management system: They serve as logical demarcation lines (boundaries) between management/administrative domains within which management business processes of IES Provider, IES Customer and third Party SP can be placed.
2. The reference points are sets of coarse-grained integration points for business entities and model the business-level relationship that IES Provider maintains with IES Customer and third Party SP.

7.1 IES-BS

This reference point represents a business-to-business (B2B) relationship between the IES Provider and one or more third-party SPs (e.g., IRS Provider). This relationship implies that the third-party SP provides the IES Provider with accounting information (i.e., details of usage and charge) on the service and contents that it provides to IES Customer. In return, the third-party SP receives payments for the services and contents provided.
If many third-party SPs provide their services then the task of IES Provider is to:

- receive usage or charge details from all of them;
- calculate charges for individual service provided; and
- merge charges into a consolidated bill, forwards the consolidated bill to IES Customer and receives payments from it.

The third-party SPs receive payments as a part of charge settlement for the services and contents that they provide to IES Customer. Charge settlement is done by IES Provider.

Third-party SP and IES Provider negotiate and sign a SLS (service level specification), which becomes an biding agreement between two co-operating parties. SLS includes terms and condition by which charge settlement is to be done. It tells the way the IES Customer payment is proportioned among several parties, that is to say, which proportion is to be kept by the IES Provider and which must be forwarded onto the third-party SP.

Equally importantly, SLS also included terms and condition for service discounts the third-party SP are to provide and QoS requirements to support.

A third-party SP and IES Provider may employ their own management processes and the functionality of these process may range from service mediation (usage data collection, record production) to full-fledged bill processing. Therefore depending upon the management process they use, third-party SP and IESPs can co-operate in a number of business-to-business scenarios.

The main activity that take place at this reference point is the exchange of accounting information whereby the third-party SP provides the IESP with accounting information (service usage data, charge details, etc) for charging and on-line billing purposes.

The IES Provider uses this information to calculate charges for the service and contents that are used by IES Customer and prepares invoices.

7.2 IES-CM

This reference point represents a business-to-customer relationship between the IES Provider and the IES Customer.

This relationship implies that the IES Provider sends invoices to the IES Customer for all the service and contents used and receives payments.

It is assumed that the IES Customer has negotiated with the IES Provider and signed a SLA with details of the services ordered. Those details of SLA that are relevant for federated accounting management process are retrieved by IES Provider and used during invoicing and payment settlement.

SLA should lay down tariffs for the services ordered. It should also contain the penalty clauses for failure to maintain the SLA commitments as well as provision for cancellation fees.

The IES Provider also manages customer relationship and on-line billing on behalf of third-part SP. This means that IES Customer can send queries on service usage and charges to IES Provider and expect replies.

8 System Analysis Model

This section presents a model and formal specification of operational requirements, which came out as the result of the analysis and design phases of the FORM project. This model has guided the assessment of the federated accounting system during evaluation phase of the project. UML is used as the notation tool therefore requirements are presented in a use case diagram. These use cases aid further in the design of the BB and contracts that will address the major management processes involved in accounting management support service to IES provider.

8.1 Federated Accounting System Boundary

The actors that interact with the federated accounting management system from the outside define the boundary of the accounting subsystem. These actors and the roles that they play management scenario are described in section NN. Here they are depicted to define the boundary of the system.

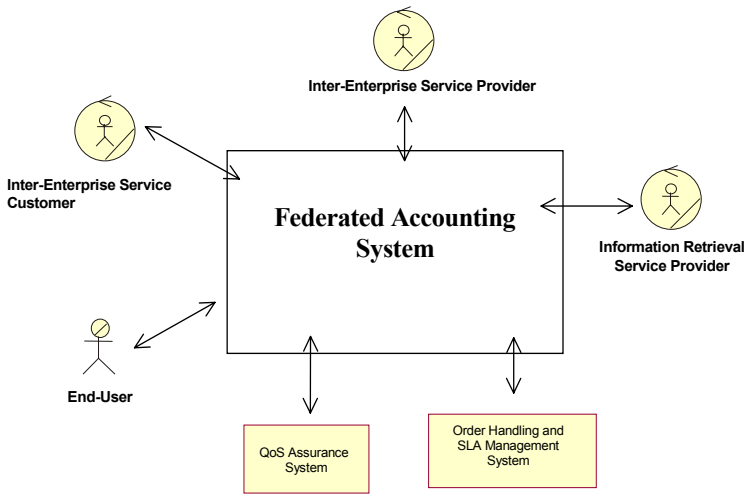


Figure Federated Accounting Management System Boundary and Actors

8.2 Federated Accounting Use Case Diagram

This section presents use case model for the federated accounting management system.

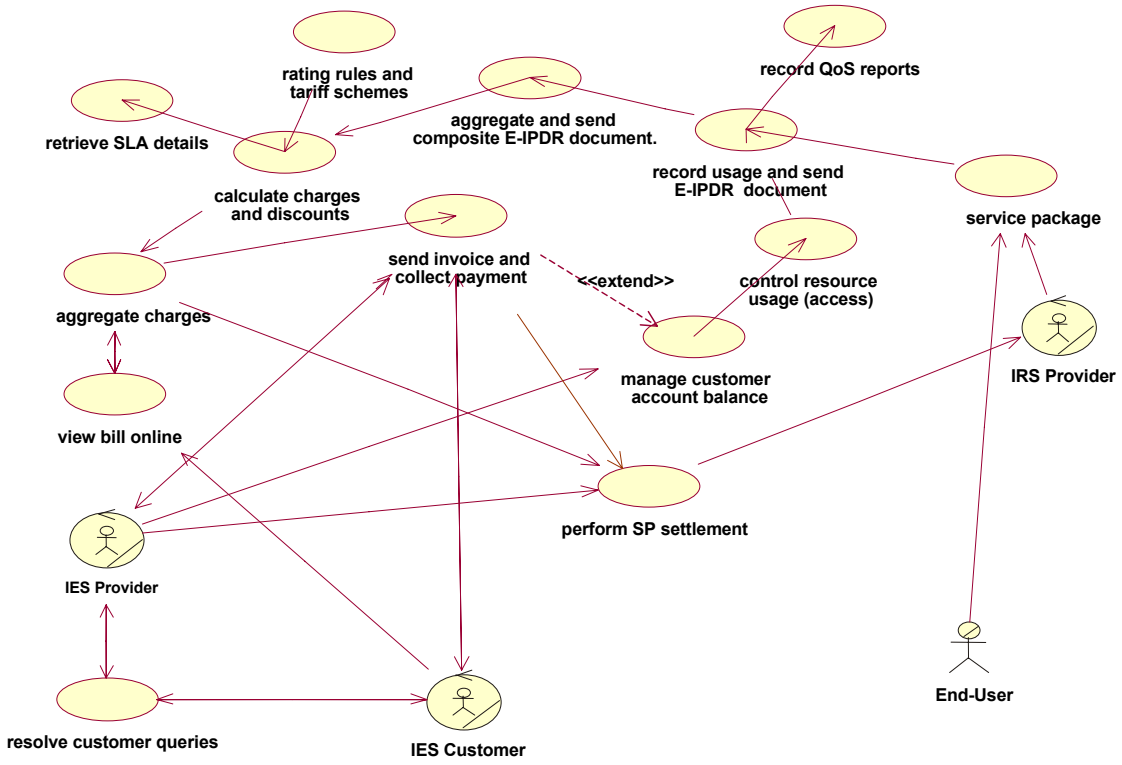


Figure: Federated Accounting Management Use Case Diagram

9 Federated Accounting information model

If accounting management facilities are to be distributed then the service providers must use an information model that allows them to structure information in an exchangeable format.

In the absence of such a model, service providers will be required to convert usage information structured in several different formats (of other service providers) into their own record format. Then the usage information can be used to feed the rating and discounting processes and to produce a consolidated bill. Clearly, the structure, semantic, and syntax of information is a crucial matter in the successful acceptance and functioning of federated accounting management. This section presents an initial structure and set of information that is being proposed as an accompaniment to this document and can be used as an information structure.

Federated accounting information model is an *enhanced* Master IPDR (IP Detail Record) Schema. (IPDR specification version 2.6)

It is worthwhile at this point to refer back to federated accounting management reference architecture and see what role accounting information model plays there. Information is exchanged in XML instance document at IES-BS and IES-CM reference points of federated accounting reference architecture. The XML documents are called E-IPDR Document. E-IPDR stands for *enhanced* IPDR.

Concerning system architecture, E-IPDR document is the information objects communicated at the interface of the building block contracts such as InterdomainAcctMgmt, RBSCtr, IPDRecCtr. Information objects (mainly usage and charge details) are integrated under a single tree-shape structure. Integration is done at the level of federated accounting management system boundary. Objects and structure are shared by all BB contracts, a *shared information schema*. A particular "view" (or set of objects) of schema meets the requirements of a particular BB (or set of BBs) of the system.

The information that is exchanged between service provider domains is modelled on IPDR (IP Detail Record) information model. For this reason and for the sake of completeness, it is necessary to describe IPDR information model.

- Master IPDR Schema (see the section 9.1): This is the output of IPDR organisation and the basis for all service-specific schemas and federated accounting information schema. This schema allows developers to specialise its elements for service-specific usage mediation.

- MediaShop Service-specific Schema (see the section 9.2): This schema inherits all the elements of Master IPDR Schema, which is specialised to provide for (and record) usage events that are specific to MyService. MyService service-specific elements added to the ones that are inherited. The usage information forms the content of **E-IPDR Document.** MyService has been used to illustrate the point that Master IPDR Schema can be used to model usage information of any services.

- Federated Accounting Information Schema (see the section 9.3): This schema is essentially Master IPDR Schema, plus an entirely new element called CE (Charge Entry) added to the tree strcuture of Master IPDR Schema. This extra piece of information (i.e., CE) is exchanged as a part of **E-IPDR document** (E stands for enhanced). This extension facilitates the charge aggregation and settlement in a multi-domain environment.

9.1 IPDR Information Model Overview: Master IPDR Schema

The main purpose of this section is to show the skeleton of IPDR information model and describe model's core elements. ***It must be noted that IPDR information model is based on XML Schema Candidate Recommendation. As the following Figure shows, all the boxes of the IPDR Information Model are in fact XML elements.***

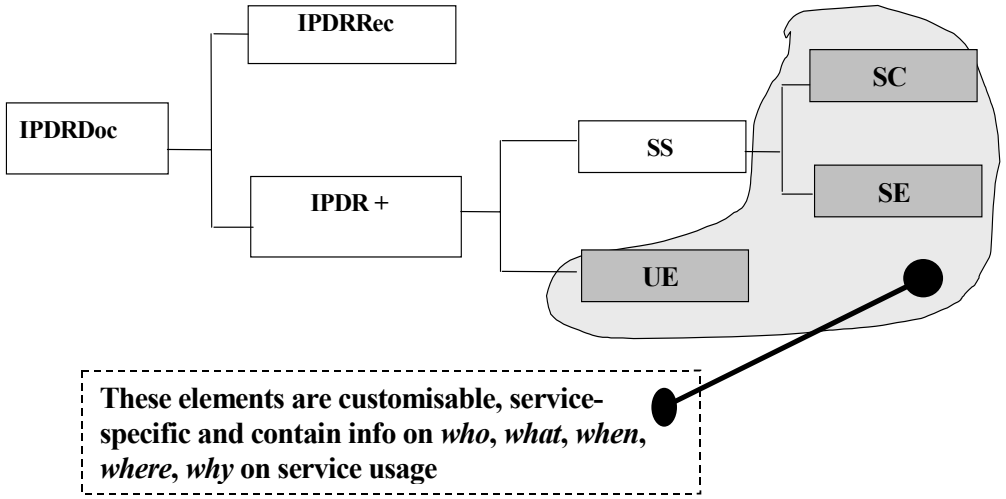


Figure: A skeleton of IPDR Information Model

The core elements are described below:

- **IPDRDoc**: This is the top-level container of a set of IPDRs elements.
- **IPDRRec**: Describes the service or network element that is responsible for creating the IPDRDoc.
- **IPDR**: This element records the event describing the actual service usage.
    - It contains pairs of SE (Service Element) and SC (Service Consumer) elements under SS (Service Session) element.
    - Describes an event between a SC and a SE.
    - Details of the usage (that is the data such times-stamps, file size, etc) are contained in the UE (Usage Entry).
- **Service Session (SS):**
    - Groups SC and SE information for structural convenience
    - Repeated pairs of SC and SE can be used in an on-going session.
- **Service Consumer (SC): Describes the Service Consumer.**
    - Examples: subscriberID, ipAddress
- **Service Element (SE): Describes the Service Element**
    - Examples: VoIP Server Address, Application Server Address, etc.
- **Usage Entry (UE): Describes the usage data.**
    - Examples: startTime, endTime, CallDuration, movieName, TerminationStatus, numberOfVideoStream, etc.

9.2 Service-specific IPDR Schema: MediaShop Schema

The main purpose of this section is to describe how Master IPDR Schema can be used to implement information model (in XML) for a particular service or network.

The following figure illustrates the main elements of Master IPDR schema specialised for an application service called ***MediaShop Service***. It shows how the IPDR XML schema can be specialised to model usage information that is generated by MediaShop.

Elements of service usage information that federated accounting management deals with are modelled on the Master IPDR XML schema.

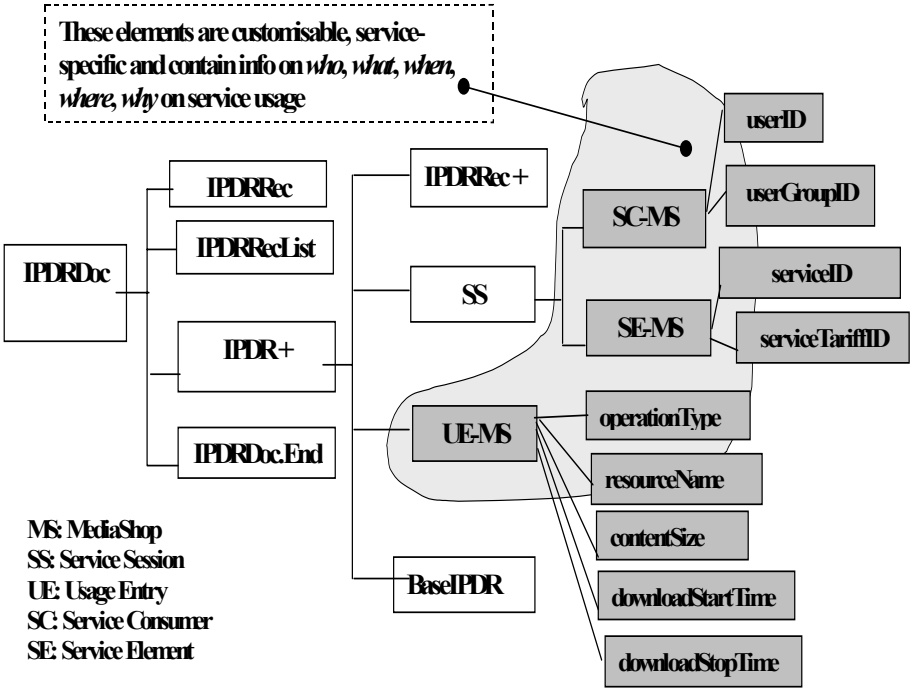


Figure : MediaShop XML Schema

The IPDR information model can be successfully used for the implementation of standard-based and technology-independent information model for the interface between two domains.

IPDR information model 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.

The use of XML Schema can yield the following benefits:

- The integration of all the interfaces of federated accounting management system can be easy.
- The implementation of interface between domains can simple but robust.
- Modification to the functionality of interfaces can be easy. This is mainly due to the fact that one needs to change the XML instance document and the service-specific XML schema but not the interface itself.

9.3 Extension to Master IPDR Schema

The governing idea behind federated accounting management is that it should enable multiple service providers in the management of charges for end-to-end service usage that takes place in their domains. This essentially requires that accounting information should also include tariffs applied and charges for an individual Service Providers. In order to meet this requirement, it is proposed that IPDR XML Schema be extended by adding a *CE* (charge entry). The position of this charge entry is shown the above diagram. It is proposed that this extended schema is to be used for the representation of usage data, charge, and service providers specific information.

The accounting information is exchanged in form of an extended accounting information document. Two things need to be explained here:

- The reason for using term accounting information, instead of usage information, is that the extended accounting document includes an entry (an XML element) listing the details of the charge incurred for the usage of a service. This entry is called charge entry or CE (see the section 9.4, which shows a UML diagram federated accounting information model).
- The reason for using term *extended* is that the IPDR organization's master schema has been extended to included charge entry. This will help service provider with implementing a regime whereby two domains can exchange information such as charge calculated and tariffs applied by a particular service provider.

9.4 Federated Accounting Information Model (IRS Provider System, Service Mediation, etc)

This is an UML diagram of information object communicated at the interdomianAcctMgmt contract, which is between MAs and FMA.

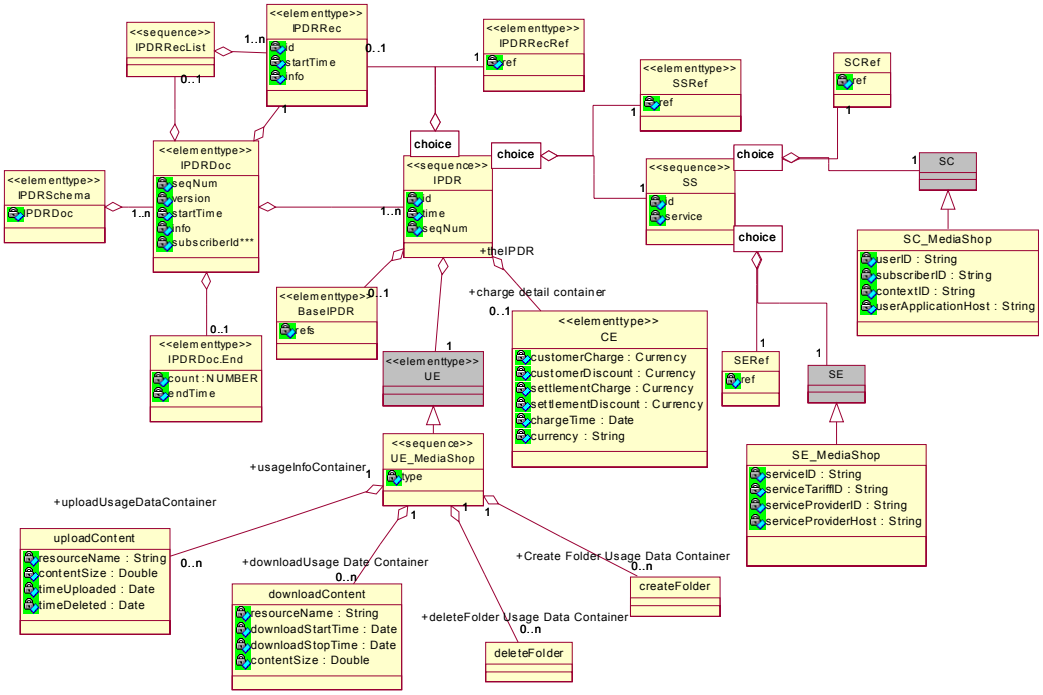


Figure: Information Model for E-IPDR document

9.5 Enhancements to IPDR Master Schema

An enhancement to IPDR Master schema was required in order to support federated accounting management at BSS level, or, the level at which rates are applied to IPDR records and charges calculated. This requirement essentially means that SPs (service providers) sending usage data in IPDR documents should have some means to send charge details too in the same IPDR document.

This is required for federated accounting business management scenario where a SPs calculate charges for the services or contents that they contributes towards a composite service (or service package). IESP's role in this scenario is to aggregate charges and do the settlement and payment.

The master schema that the IPDR organisation has produced does not cater for such requirements because it is outside the scope of the organisation. SPs can use the master schema for producing service-specific schemas that include only usage data. FORM Billing group decided to enhance the master IDPR schema and to add an element called CE (charge element). SPs can use CE to include charge details and send them to IESP. Billing group has also coined and used the term ***E-IPDR*** document, which means that an E-IPDR document contains usage data as well as charge details.

The CE holds information such as charge for which a SP can expect a payment from IESP, discount provided by the SP, etc. These details are received by IESP and used during SP settlement and payment. If several SPs send their charge details, all charges are aggregated and user pays a single bill for a service package that may consist of many services.

9.6 XML Schema Benefits

The IPDR information model can be successfully used for the implementation of standard-based and technology-independent information model for the interface between two domains.

IPDR information model 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.

The use of XML Schema can yield the following benefits:

- The integration of all the interfaces of federated accounting management system can be easy.
- The implementation of interface between domains can simple but robust.
- Modification to the functionality of interfaces can be easy. This is mainly due to the fact that one needs to change the XML instance document and the service-specific XML schema but not the interface itself.

10 System Architecture

This section provides the definition of the accounting subsystems, components (or BBs), identification of the interfaces (or contracts) between the components and their mapping to UML artefacts, namely boundary class, control class and information class.

A BB contract can be considered a boundary class. A BB itself can be considered a control class. The term *boundary* has a strong connotation of something *facing outside* or an *interface*. Among other matters, a BB contract deals with the matter related to communication protocols. If communication protocol changes, we need to change BB contract; we need not change BB itself.

The term control has a strong connotation of something that *receives things and manipulates them* without paying much attention to how they will be sent to other BBs. A BB deals with co-ordination task, leaving communication task to BB contract. BB can have its own state, change its state independently of other BB, and can send external event whenever it wishes to do. If co-ordination task changes we may need to change the BB but we can still use the same BB contract.

It co-ordination work is not complicated and "big" enough then we may not need control object at all. A boundary object will be enough to do communication as well co-ordination. The *things* that BBs manipulate are information objects.

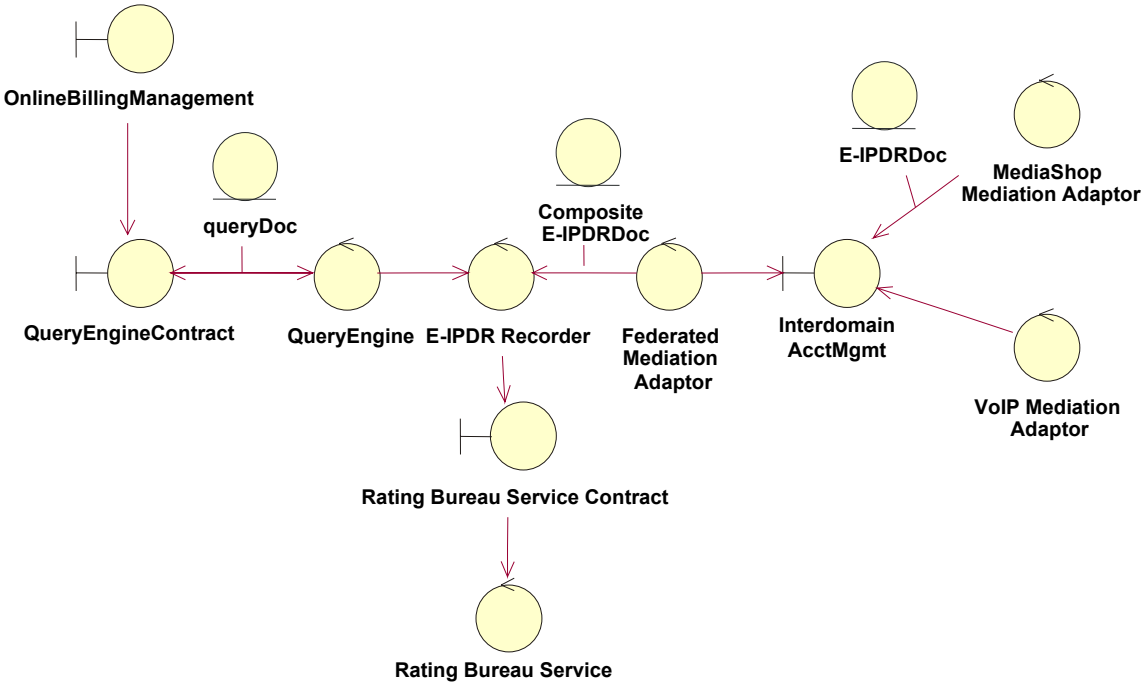


Figure 5: Collaboration diagram showing Building Blocks and Building Block Contracts

10.1 Contracts

Boundary Objects	Role Taken
InterdomainAcctMgmt	This is a service management contract and supports accounting management in a federated environment where multiple SPs provide their services to the customer. This contract is provided by the Federated Mediation Adaptor (FMA) building block. Mediation Adaptors (MAs) can use this contract to send E-IPDR documents to FMA.
BillingInteractionManager	This is the customer entry point to the accounting/IPDR information stored by the IES Provider.

10.2 Building Blocks

Control Objects	Role Taken
Federated Mediation Adaptor	This BB supports collection and aggregation of E-IPDR documents and generation of a composite E-IPDR document. The documents are aggregated under a single usage session (or a parent session), which denotes the beginning and end of service package use.
MediaShop Mediation Adaptor	The main role of MediaShop Mediation Adaptor is to collect usage data, record the usage events, generate an E-IPDR document, and send it to FMA.
VoIP Mediation Adaptor	The main role of VoIP Mediation Adaptor is to collect usage data, record the usage events, generate an E-IPDR document, and send it to FMA.
AquEX	The AQuEX contract ensures the availability to a fine-grain of all recorded IPDR information.
E-IPDR Recorder	The IPDR Recorder takes upon the role of a data recorder/transmitter. It implements method specifies in the IPDR "Protocol Primitives and Parameters" specification (Push, Pull, Subscribe, etc).
RBS	RBS supports aggregation of the charges for each usage of the constituent services of a composed service (within the composed service accounting session) into a single composed service (OCS) charge. It generates and stores a rated/discounted E-IPDR document for the OCS.

10.3 Information Objects

Entity Objects	Role Taken
Composite E-IPDR Doc	This is the enhanced IPDR document, based on Master IPDR Schema. Its main role is to carry usage information for a service package, i.e., details of usage event of Online Collaboration Service. The information model is presented below in the Boundary Information Model of IES Provider System.
QueryDoc	Support querying metadata
E-IPDR Doc	This is the enhanced IPDR document, based on Master IPDR Schema. Its main role is to carry usage information for a service, i.e., details of usage event of MediaShop or VoIP service. The information model is presented below in the Boundary Information Model of IRS Provider System.

10.4 BB Interaction Diagrams

10.4.1 Service Package Usage and Mediation

The following interaction diagram shows more details about the relations between the building blocks and the actors.

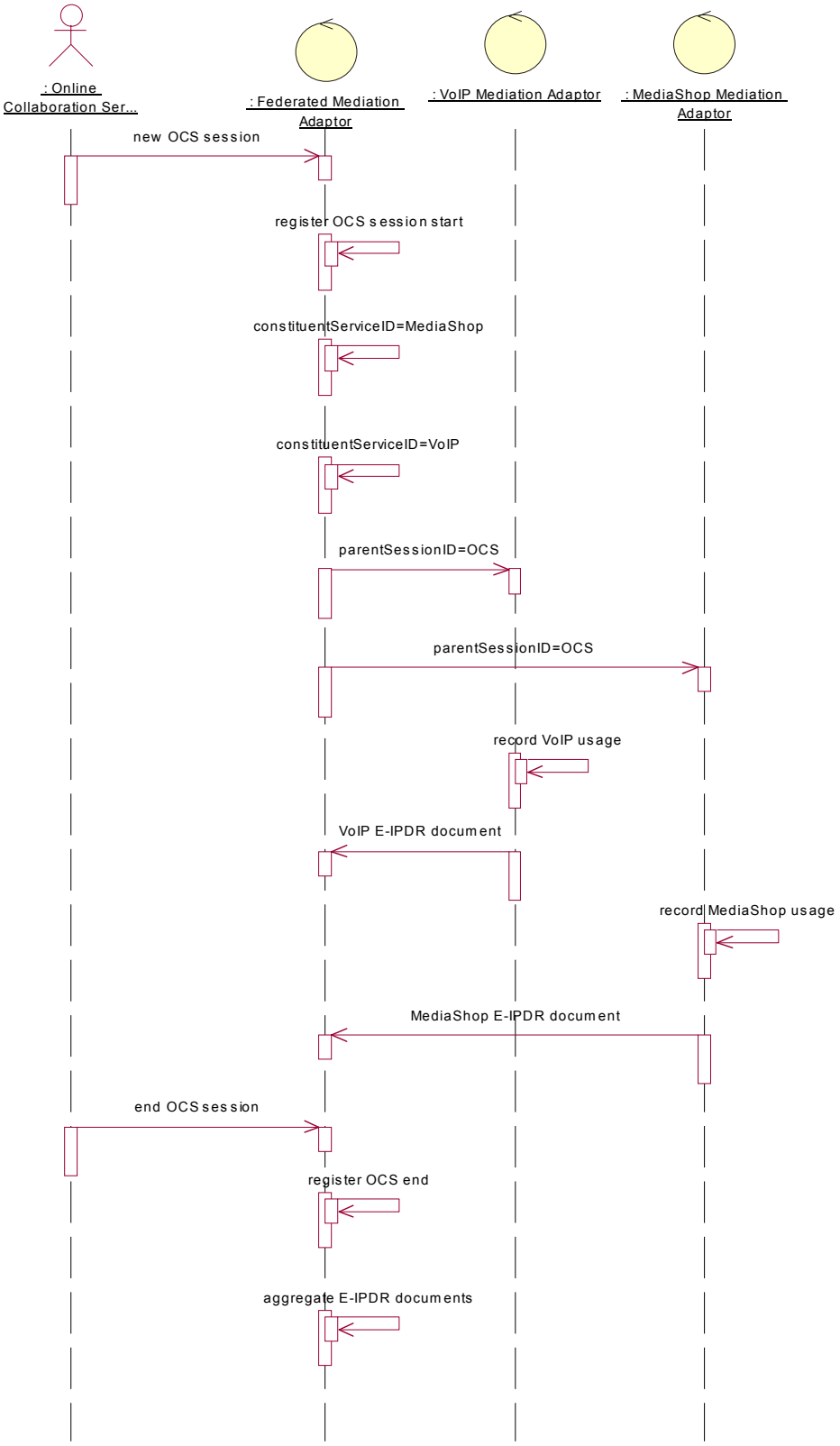

: Online Collaboration Ser...
: Federated Mediation Adaptor
: VoIP Mediation Adaptor
: MediaShop Mediation Adaptor
new OCS session
register OCS session start
constituentServiceID=MediaShop
constituentServiceID=VoIP
parentSessionID=OCS
parentSessionID=OCS
record VoIP usage
VoIP E-IPDR document
record MediaShop usage
MediaShop E-IPDR document
end OCS session
register OCS end
aggregate E-IPDR documents

Figure 7: Interaction diagram for the use case showing the use of BB (Service package provsion).

10.4.2 Charge aggregation

The following interaction diagram shows more details about the relations between the building blocks and the actors.

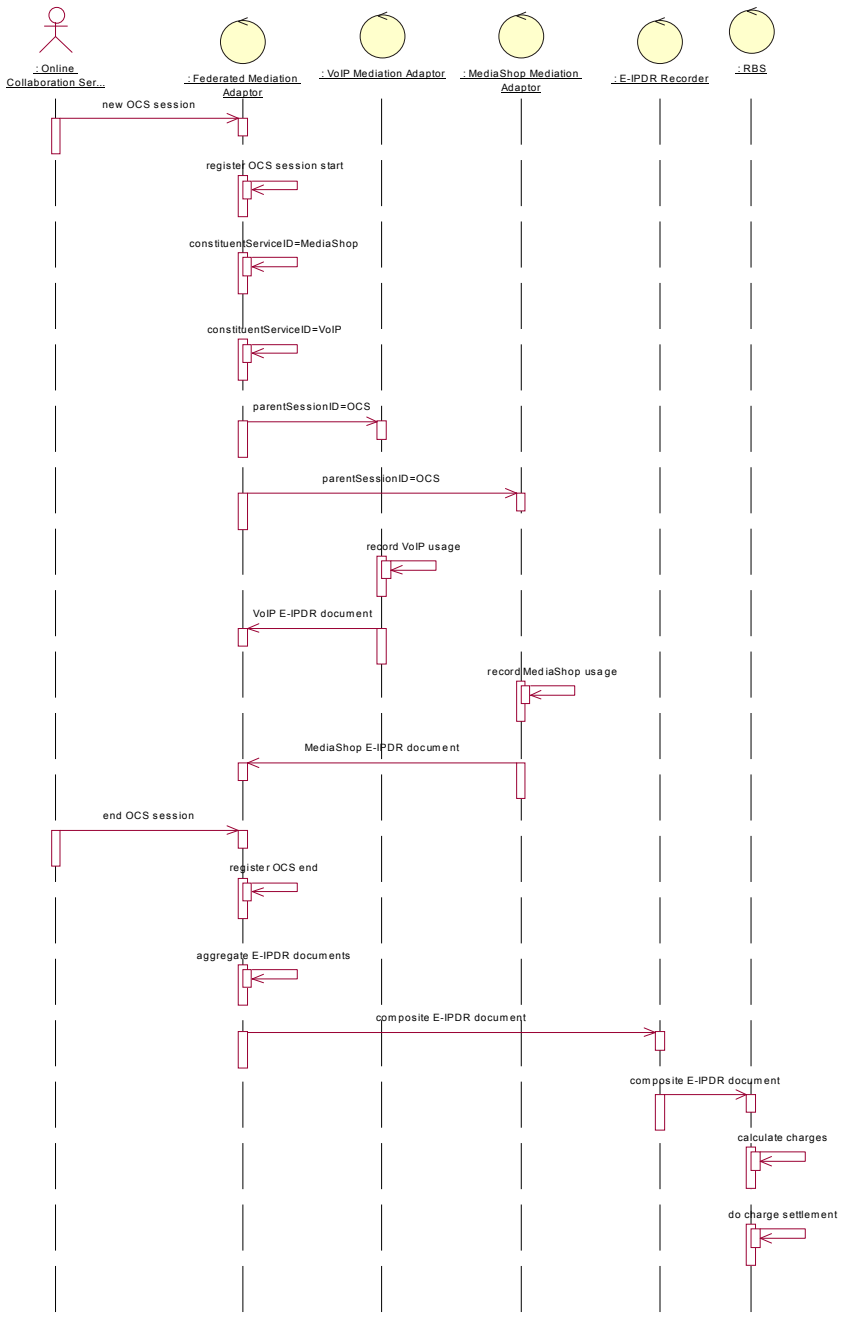
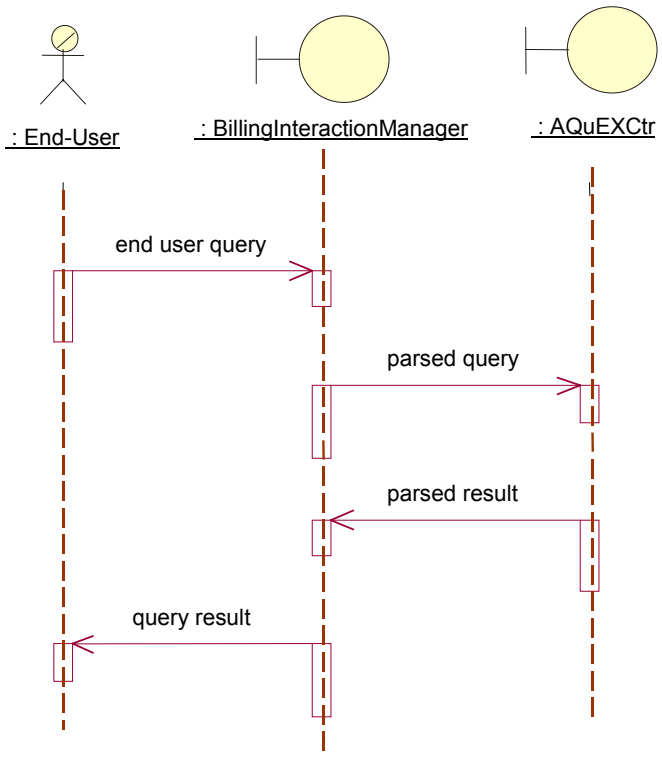


Figure 7: Interaction diagram for the use case showing the use of BB (IES System BB)

10.4.3 Online Billing



10.5 BB Contract specification examples

This section provides two examples of BB contract specifications: interdomainAcctMgmt and i_rate.

The interdomainAcctMgmt contract is provided by Federated Mediation Adaptor BB. This contract is provided at IES-BS Reference Point. The figure given below illustrates how interdomainAcctMgmt contract can be specified using UML notation.

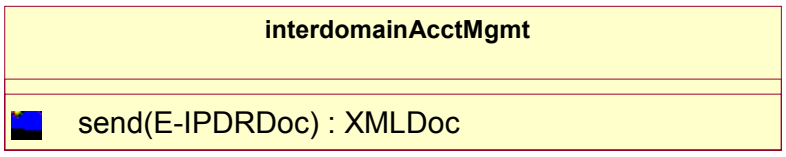


Figure: interdomainAcctMgmt Contract

The i_rate contract is provided by Rating Bureau Service BB. This contract is provided at an interface Reference Point, which is not shown in the Reference Architecture. The figure given below illustrates how i_rate contract can be specified using UML notation.

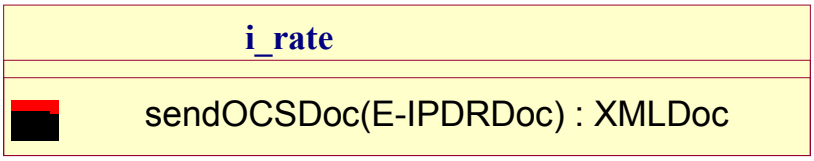


Figure: i_rate Contract

11 System Integration and Technology Architecture

This section presents how the BBs, contract, and information object presentation in system architecture were be implemented using a range of technologies.

The following diagram shows the technologies that have been used to implement and integrate federated accounting BB and contracts.

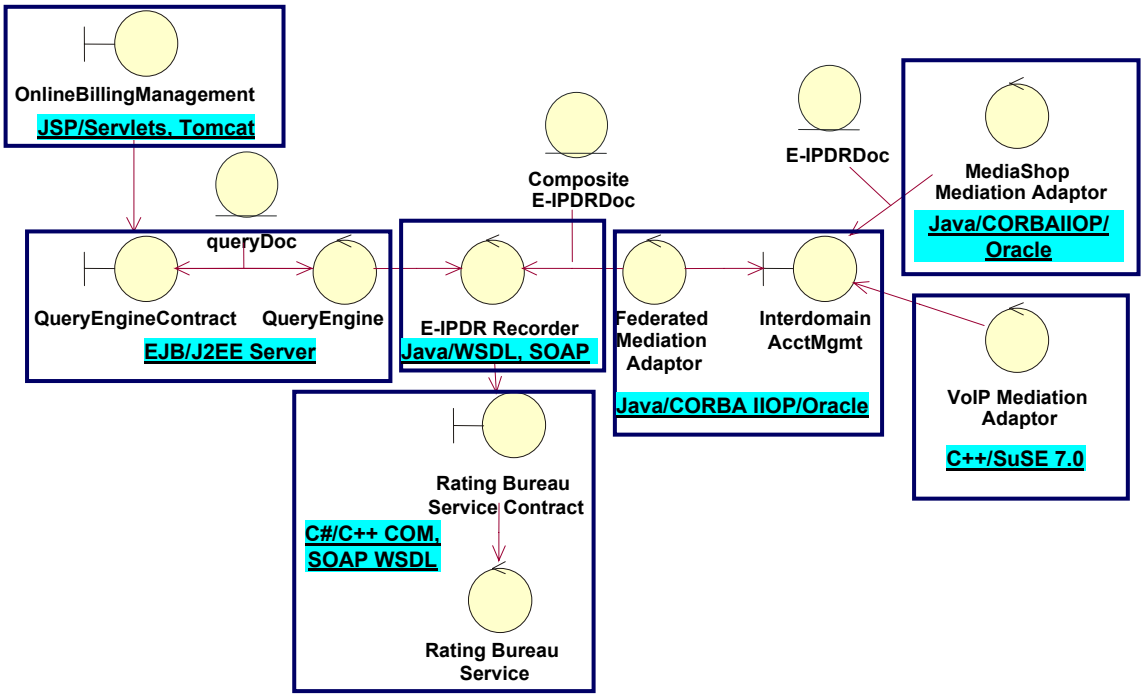


Figure: Technology Architecture

Federated accounting building blocks are CORBA and EJB components implemented in C++, Java, and C#. Contracts are specified in CORBA IDL and WSDL. Building blocks use IIOP, RPC COM/CORBA-SOAP for communication with one another.

Information objects exchanged through contracts are XML instance document and modelled on E-IPDR schema. W3C XML Schema, Structure and Data Types have been used for the specification of information objects. Oracle has been used for the storing XML document.

The technology described here has yielded many benefits. Some of them are summarised here. **Java** and **EJB** make architecture components highly portable. **XML/WSDL** allows service providers to deploy accounting components as Web-services and seamlessly exchange accounting information. **Oracle** enables direct mapping of IPDR structures (XML documents) onto database tables. **SOAP** enables tighter binding of IPDR documents and HTTP when exchanging them over internet. **OSP** is a service subscription and access management middleware platform, which is being developed by Fraunhofer FOKUS. It is based on TSAS (Telecommunications Service Access and Subscription).

12 Lessons Learnt

A number of lessons were learnt as a result of development and evaluation of the federated accounting system. Some important lessons are listed below:

- Contract supporting a reference point may possess more functionality then assigned during design phase. For example, InterdomainAcctMgmt contract may also monitoring and recording network QoS deterioration. Reference point IES-BS may also include a contract that supports payment settlement.

- Interfaces implementations are kept simple because of the more complex structures (defined in XML) that are passed.

- Standardised information model (IPDR Organisation) proved to be useful in developing Boundary Information Model. It also reconciles two differing sets of concerns (information-wise), service mediation and charge details that lead to a common goal, ie, Billing.

- A ***Contract Set*** and ***BB Group*** to perform value-based, QoS dependent charging and billing can be envisaged (A *Fulfilment-Assurance*-Billing Contract Set).

13 System Evaluation

The federated accounting management system presented in this white paper has been implemented and tested in two trials. Results arising from design and implementation have been provided to standardisation bodies. This section summarises the results of system evaluation.

In order to ensure the functionality and quality of BBs and contract test case result were mapped onto requirement captured in the requirement analysis phase. Mapping revealed that out of all requirements captured only a small set of requirements was important and addressed. They are listed in the summary of the section titled **Business Context and Requirement**.

During evaluation process, it became apparent that the Reference Architecture required changes. This also provided useful input to ODF and methodology evaluation.

Efficiency and qualities of the overall system can raise some questions because a good proportion of the system has been implemented in Java. XML is also used as a preferred way of coding information that is passed over many contracts. Though there are pitfalls when using XML, Schemas are more complicated than DTDs but are richer and useful in expressing a vocabulary of federated accounting management business process.

Federated accounting information model needed to be enhanced to support service value chain involving several domains. From the point of view of federated accounting information model, mediation and charging of composite services need further study.

14 Future Work

Several areas in which future work can be carried out have identified. They are discussed briefly in this section.

We consider use of XML and Webservice technologies (e.g., XSLT, WSDL, SOAP) an important area for future work, hence more investigation into Web service technologies will be worthwhile. These technologies can be used for building block and contract definitions. Use of XMI and XSLT in transforming technology neutral to technology specific transforms is a key to making federated accounting work appealing to E-commerce.

Another area, which is gaining acceptance, is ebXML. It can be used for the definition of federated accounting management business process.

We also envisage investigating into a generic approach to aggregated services mediation. It this generic approach, more functionality will be implemented in FMA building block and interdomainAcctMgmt contract, thus making them adaptable to several different types of communication protocol and technologies.

Several enhancements to the current design of federated accounting management can be done. Federated information model can be enhanced to include more different types of contracts. Building blocks and contracts can be further enhanced to support QoS, charge settlement and a guaranteed delivery of IPDR documents.

15 Conclusions

This white paper describes the development of a federated accounting management architecture. FORM ODF guidelines have been used as a development methodology. The development process has produced a UML specification of business process, a system architecture, and federated accounting management building blocks.

Acronym Guide

AH	Authentication Header
ATM	Asynchronous Transfer Mode
BB	Building Block
CAMI	Common Application Management Interface
CHAP	Challenge Handshake Authentication Protocol
COTS:	Commercial Off The Shelf
CPE	Customer Premises Equipment
DBMS	DataBase Management System
DMTF	Distributed Management Task Force
DTD	Data Type Definition
CIM	Common Information Model
CMIP	Common Management Information Protocol
CCM	CORBA Component Model
CPE	Customer Premises Equipment
DMI	Distributed Management Interface
EJB	Enterprise Java Beans
EIM	External Information Model
ESP	Encapsulating Security Payload
FAB	Fulfilment-Assurance-Billing
GRE	Generic Routing Encapsulation
HIT	Human Interaction Tier
PAT	Process Automation Tier
EIT	Enterprise Automation Tier
IDL	Interface Definition Language
IETF	Internet Engineering Task Force
IRTF	Internet Research Task Force
IKE	Internet Key Exchange
IPDR	Internet Protocol Detail Record Organisation
IES	Inter-Enterprise Service
IKE	Internet Key Exchange
IPSec	Internet Protocol Security protocol
IPX	Internet Packet Exchange
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider

IT	Information Technology
ITU-T	International Telecommunications Union – Telecommunications Standards Sector
ISV	Independent Software Vendor
L2F	Layer 2 Forwarding
L2TP	Layer 2 Tunnelling Protocol
LAN	Local Area Network
MPPE	Microsoft Point-to-Point Encryption
MSD	Management System Developer
NDM-U	Network Data Management Usage
NetBEUI	Network Basic input/output system Extended User Interface
NGOSS	New Generation of Operations Systems and Software
OMG	Object Management Group
OSI	Open Systems Interconnection
PAP	Password Authentication Protocol
POP	Point Of Presence
PPP	Point-to-Point Protocol
PPTP	Point-to-Point Tunnelling Protocol
PPVPN	Provider Provisioned VPN
PVC	Permanent Virtual Circuit
R&D	Research and Development
RADIUS	Remote Authentication Dial-In User Service
RFI	Request For Information
RFP	Request For Proposals
RUP	Rational Unified Process
SA	Security Association
SLA	Service Level Agreement
SLS	Service Level Specification
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
TACACS	Terminal Access Controller Access Control System
TCP/IP	Transmission Control Protocol/Internet Protocol
TDTF	Telecommunication Domain Task Force
TINA	Telecommunications Informational Networking Architecture
TML	Telecommunications Markup Language
TSAS	Telecommunication Service Access and Subscription
TTF	Telecommunications Task Force
UML	Unified Modelling Language

USDP	Unified Software Development Process
VoIP	Voice over IP
VoD	Video on Demand
VPN	Virtual Private Network
WAN	Wide Area Network
WSDL	Web Service Description Language
WBEM	Web Based Enterprise Management
XDSL	Digital Subscriber Line
XSLT	Extensible Style Language Transformation
QoS	Quality of Service